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PHYSICAL EXERCISE AS A FACTOR FOR COGNITIVE ENHANCEMENT

Concepción Padilla Franco

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PHYSICAL EXERCISE AS A FACTOR FOR COGNITIVE ENHANCEMENT

Concepción Padilla Franco

Thesis Supervisor and Tutor: Pilar Andrés

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Supervision Certificate & International Doctorate Mention

Universitat de les Illes Balears

Dr Pilar Andrés, of the University of the Balearic Islands

I DECLARE:

That the thesis titles "Physical Exercise as a Protective Factor against Cognitive Deterioration", presented by Concepción Padilla to obtain a doctoral degree, has been completed under my supervision and meets the requirements to opt for an International Doctorate.

For all intents and purposes, I hereby sign this document.

Signature

Palma de Mallorca, November 17, 2015

“La posibilidad de realizar un sueño
es lo que hace que la vida sea interesante”.

Paulo Coelho

A mi familia, por darme siempre todo su apoyo
A Andrés, por su cariño incondicional
A mis amigos, por hacerme reír

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PHYSICAL EXERCISE AS A PROTECTIVE FACTOR AGAINST COGNITIVE DETERIORATION

Figures[1]

[1] NOTE. Tables and Figures from the published articles are out of the numeration.

Abstract

We aimed to explore the effects of long-term regular aerobic exercise on cognitive processes and the brain. Contrary to previous studies, we were interested in young participants, a group of participants for which research has been scarce up till now. We recruited participants who presented with extreme differences in weekly hours of exercise. Eight cross-sectional experiments were carried out to explore the relationship between chronic aerobic exercise and cognition, assessing executive functions such as inhibition control, working memory and selective attention. Other variables that could affect performance such as personality, motivation and self-regulation were also evaluated. Also, demographic variables related to age, education and intelligence were controlled. Furthermore, neuroimaging studies were undertaken to investigate the actual processes differing in physically active and passive participants. We also explored whether groups showed different brain morphometry and myelin integrity. The results indicated that active participants showed better cognitive control and more attentional resources when facing highly demanding and strategic tasks. The neuroimaging experiments pointed out to active participants having greater attentional resources, showing greater activation in the right superior parietal lobe than passive participants.

Resumen

El objetivo de nuestro trabajo consistió en evaluar los efectos del ejercicio aeróbico realizado de manera regular a largo plazo en las funciones cognitivas y el cerebro. A diferencia de la literatura previa, nos interesamos en el estudio de participantes jóvenes, puesto que la investigación en este tipo de población ha sido muy escasa. Con este propósito, seleccionamos a jóvenes que se diferenciaban de manera extrema en el número de horas semanales que han realizado ejercicio físico a lo largo de su vida. Se llevaron a cabo ocho experimentos transversales en los que se investigó la relación entre el deporte aeróbico realizado a largo plazo de manera regular y las funciones cognitivas, evaluando distintas funciones ejecutivas como capacidad de inhibición, memoria de trabajo y recursos atencionales. Asimismo, evaluamos cómo los distintos rasgos de personalidad, la motivación de logro y la capacidad de autorregulación podrían influir en los resultados obtenidos. Las variables demográficas edad, educación e inteligencia se controlaron en todas las muestras de participantes. Finalmente, se realizaron estudios de neuroimagen para investigar en qué proceso difieren realmente los jóvenes activos y pasivos, y si mostraban diferencias en la morfometría cerebral y en la integridad de la mielina. Los resultados indicaron que los participantes activos mostraron mejor control cognitivo y más recursos atencionales cuando se enfrentaron a tareas estratégicas altamente demandantes. Los estudios de neuroimagen que llevamos a cabo sugieren que los participantes activos tienen mayores recursos atencionales, observando en ellos mayor activación en el lóbulo parietal superior derecho que en los participantes pasivos.

Resum

L'objectiu del nostre treball va consistir en avaluar els efectes de l'exercici aeròbic realitzat de manera regular a llarg termini en les funcions cognitives i el cervell. A diferència de la literatura prèvia, ens vam interessar en l'estudi de participants joves, ja que la investigació en aquest tipus de població ha sigut molt escassa. Amb aquest propòsit, vam seleccionar a joves que es diferenciaven de manera extrema en el nombre d'hores setmanals que havien realitzat exercici físic al llarg de la seva vida. Es van dur a terme vuit experiments transversals en què es va investigar la relació entre l'esport aeròbic realitzat a llarg termini de manera regular i les funcions cognitives, avaluant diferents funcions executives com capacitat d'inhibició, memòria de treball i recursos atencionals. Així mateix, vam avaluar com els diferents trets de personalitat, la motivació d'assoliment i la capacitat d'autoregulació podrien influir en els resultats obtinguts. Les variables demogràfiques edat, educació i intel·ligència es van controlar en totes les mostres de participants. Finalment, es van realitzar estudis de neuroimatge per investigar en quin procés difereixen realment els joves actius i passius, i si mostraven diferències en la morfometria cerebral i en la integritat de la mielina. Els resultats van indicar que els participants actius mostraven millor control cognitiu i més recursos atencionals quan es van enfrontar a tasques estratègiques altament demandants. Els estudis de neuroimatge que vam dur a terme suggereixen que els participants actius tenen més recursos atencionals, observant en ells major activació en el lòbul parietal superior dret que en els participants passius.

INTRODUCTION

Chapter 1. Cardiovascular exercise effects on the brain and cognitive functions

Chapter 1. Cardiovascular exercise effects on the brain and cognitive functions

1. Physical exercise as a protective factor

It has been clearly stated that exercise has a positive effect on health, wellbeing and cognitive function (Kramer & Erickson, 2007a). The effects of exercise depend however on several variables such as the type of sport, intensity, frequency, duration along life and age. One of the main distinctions made in the literature differentiates between aerobic and anaerobic exercise. Aerobic or cardiovascular exercise is defined as the type of activity that produces an expenditure of oxygen to meet the energy demands required by muscles in order to exert movement. Examples of this type of activity are enduring activities such as swimming, walking, running, or cycling. It is opposed to anaerobic or resistance exercise, which consists of short and high-intensity activities that depend on the oxygen stored in the muscles, instead of the one coming from breathing. Aerobic exercise is the type of exercise that has been related to cognitive and neural structure improvements, while resistance exercise has not been associated to such change (Voss, Nagamatsu, Liu-Ambrose, & Kramer, 2011).

Most studies looking at the effects of cardiovascular exercise have been carried out with children, preadolescents and older adults. Little research seems to have been undertaken in healthy young adults. One of the reasons that have been put forward to explain the lack of studies in young adults is that they are at their maximal cognitive level (Salthouse & Davis, 2006), resulting in a ceiling effect (Hillman, Erickson, & Kramer, 2008). However, some beneficial effects have been found (Hillman, Buck, Themanson, Pontifex, & Castelli, 2009) in young adults with extremely different levels of fitness using demanding tasks, in which strategies must be applied (Voss et al., 2011). Furthermore, studies with young adults that applied psychophysiological measures revealed some differences among active and passive participants. These are discussed below.

Exercise is presented then as an intervention to prevent cognitive deterioration in aging, since it helps to potentiate the cognitive reserve (Barulli & Stern, 2013). Cognitive reserve is the product of all the experiences that the individual has faced along their life. The more demanding and challenging – without reaching a stressful extreme- those situations were, the more cognitive resources were implemented to resolve them, and thereby, the more enriched the cognitive reserve will be, allowing the individual to endure better aging or potential neural damages (Stern, 2009).

Proxy variables such as educational and professional attainment, crystallized intelligence, socioeconomic status, involvement in leisure, intellectual or sport activities, and level of socialization prevent the risk of dementia, and when pathology occurs, cognitive reserve slows its onset (Barulli & Stern, 2013; Pérez, Padilla, & Andrés, 2012; Scarmeas, Levy, Tang, Manly, & Stern, 2001; Stern et al., 1994; Wilson et al., 2002). Pathology tends to occur later, but when it does, appears more abruptly (Barulli & Stern, 2013).

2. Experimental designs in the physical exercise research field

Physical exercise research is divided also according to the frequency and duration of the exercise regimes. Studies are differentiated according to the dichotomy acute vs. chronic exercise. However, there is no consensus about the range of such regimes. Acute exercise spans from 10 to 40 minutes and the cognitive tasks can be applied during or after the aerobic exercise is performed. Chronic exercise, instead, ranges from 3-week (Griffin et al., 2011) to 10 years (Ballesteros, Mayas, & Reales, 2013) interventions. In the case of longitudinal intervention studies, most studies have an experimental aerobic group, an active control group performing stretching, toning or balance exercises, and a sedentary group. Concerning cross-sectional studies about long-term aerobic exercise, they are important because they provide information about long-lasting habits that can affect behavior and brain structures.

Taking into account the existing literature, different effects of acute and chronic exercise have been found. Acute exercise is related to an increase in brain blood flow, as well as in the levels of vasopressin, β-endorphine, catecholamines, and adrenocorticotropic hormone in plasma (Chmura, Nazar, & Kaciuba-Uscilko, 1994; McMorris, Collard, Corbett, Dicks, & Swain, 2008), which is thought to reflect neurotransmitter levels in the brain and lead to an elevated arousal that would enhance cognitive performance. A recent meta-analysis (Verburgh, Königs, Scherder, & Oosterlaan, 2014) also revealed a moderate positive effect (d = 0.52) of acute exercise on executive functions in children, adolescents and young adults, being more pronounced in inhibition/control processes than working memory tasks.

However, it has been argued that it is more likely that chronic exercise induces brain cognitive reserve than acute exercise. Several reviews in chronic exercise have shown its role on cognitive and neural protection (Howie & Pate, 2012; Tomporowski, Davis, Miller, & Naglieri, 2008; Voss, Vivar, Kramer, & van Praag, 2013a). This type of intervention presents as a promising treatment to prevent or alleviate the symptoms of dementia (Ahlskog, Geda, Graff-Radford, & Petersen, 2011; Smith, Potter, McLaren, & Blumenthal, 2013).

3. Chronic exercise studies carried out with different age populations

3.1. Children

Executive functions and prefrontal cortex develop during childhood. As a consequence, children show inferior levels of attention and executive control compared to adults. However, it has been demonstrated that physical exercise can accelerate these functions' development (Best, 2010; Chaddock-Heyman, Hillman, Cohen, & Kramer, 2014; Tomporowski et al., 2008). Cross-sectional studies of physical activity have shown that it is related to better academic achievement (Castelli, Hillman, Buck, & Erwin, 2007) and processing speed. For example, fitter preadolescent children obtained better accuracy in all conditions of the Stroop Task (Buck, Surico, Wnek, Castelli, & Hillman, 2007) and the Flanker Task (Hillman et al., 2009), although they did not achieve a specific effect on interference control. Buck, Hillman, and Castelli (2008) also applied the Stroop Task to children aged between 7 and 12 years old, finding as well that active children presented with better performance than passive in all conditions. These results show that active children are faster in general, but not that they control better the interference produced by a more automatic response like word reading.

Regarding psychophysiological studies, Hillman, Castelli, and Buck (2005) compared preadolescents and young active adults applying a unimodal visual oddball task. They showed that fit preadolescents had a P3 component with greater amplitude and shorter latency in the Oz area than the unfit-preadolescent and fit and unfit adult groups. Hillman et al. (2009) also observed that active children showed a smaller "error-related negativity" (ERN), an electrophysiological component related to error evaluation during the task; and a greater "positivity error" (Pe), associated with the awareness of committed errors and better post-error accuracy. The larger the Pe, the better the accuracy in the active group. These results were interpreted as reflecting that active participants reacted against error in a more adaptive and flexible way, being aware of their mistakes avoiding that they affected their performance in the following trial.

3.2. Older adults

The effect of exercise on behavior has been robustly investigated in older people (see Colcombe & Kramer, 2003; Dustman, Emmerson, & Shearer, 1994; Etnier et al., 1997 for reviews). Spirduso and Clifford (1978) observed that older active adults had shorter reaction times than passive older adults in tasks measuring decision and psychomotor speed. Later, Clarkson-Smith and Hartley (1989) showed outperformance of active participants in nonverbal reasoning and working memory. These findings have been corroborated by subsequent studies (Hillman et al., 2009; Etnier et al., 1997), indicating higher cognitive functioning in attention, working memory, and speed of processing for high-demanding executive and memory tasks, even with active people above 70 years old (Netz, Dwolatzky, Zinker, Argov, & Agmon, 2011; Newson & Kemps, 2006).

The benefits of exercise in older adults have also been demonstrated using evoked related potentials. The difference between young and older adults' neuroelectric pattern is that P3 amplitude is greater and its latency larger in the older group. Regarding conflict monitoring, active older adults showed smaller global switching cost, decreased ERN amplitude and increased post-error slowing during a task-switching task (Themanson, Hillman, & Curtin, 2006b).

Epidemiological studies are also a rich source of information allowing studying the potential variables affecting cognition throughout life. Deary, Whalley, Batty, and Starr (2006) evaluated whether physical fitness influenced cognitive decline in a longitudinal study that spanned 68 years. They concluded that physical fitness influenced cognition and prevented deterioration. Rovio et al. (2010) studied whether the level of activity performed during midlife influenced the grey and whiter matter volume 20 years later. Effectively, previous physical activity frequency and duration along the years were negatively correlated with gray matter loss. Moreover, Erickson et al. (2010) investigated whether aerobic exercise predicted brain volume and cognitive impairment 9 to 13 years later. Results indicated that gray matter volume was greater in prefrontal, occipital and temporal cortices, as well as in hippocampus and entorhinal cortices after those years. In addition, participants showed three times lower probability of developing cognitive impairment. In another study, Pahor (2006) followed up a group of participants that formed part of a one-year-physical activity intervention and compared them to a sedentary group. The active participants showed better performance in the digit symbol substitution task, being the performance dose-dependent. In addition, self-reported sport frequency predicted higher right inferior prefrontal and right superior temporal gyrus activation.

The effects of long-term exercise are also studied in genetics, investigating its influence in APOE gene expression. This gene has three alleles, of which the ε4 allele is linked to a higher probability (50%) to develop late-onset Alzheimer's disease (Farrer et al., 1997) and cardiovascular diseases (Raichlen & Alexander, 2014). Some studies have observed that exercise may revert the ε4 allele expression (Deeny et al., 2008; Etnier et al., 2007; Rovio et al., 2005; Schuit, Feskens, Launer, & Kromhout, 2001), demonstrating for example that ε4 carriers who did cardiovascular exercise in midlife showed better cognitive status than non-carriers in old age after having controlled for other demographic variables (Rovio et al, 2005).

Finally, meta-analysis studies (Colcombe & Kramer, 2003; Etnier, Nowell, Landers, & Sibley, 2006) carried out with interventional studies have confirmed the effects of aerobic exercise. Colcombe and Kramer (2003) found a moderate effect size of fitness on general cognitive functioning, which was higher for executive control. Etnier et al.'s (2006) meta-analysis found similar results.

3.3. Young adults

Some authors (Jedrziewski, Lee, & Trojanowski, 2007; Middleton, Barnes, Lui, & Yaffe, 2010) have stated that being more physically active, especially during adolescence, benefits cognitive performance in late adulthood. A literature review reveals that there are few studies so far carried out in young people (Cox et al., 2015; Guiney & Machado, 2013; Hillman et al., 2008). Most of the time, only differences on physiological measures such as evoked related potentials are observed (Hillman et al., 2008; 2009; Kamijo, O'Leary, Pontifex, Themanson, & Hillman, 2010). One of the reasons is probably that cognitive functions during youth are excellent (Salthouse & Davis, 2006), and there is little room for improvement by physical exercise (Hillman et al., 2008). Nevertheless, a recent review (Cox et al., 2015) showed a significant positive effect of physical activity on executive functions in young to middle-age adults. Some other studies showing the effects of exercise on behavioral tests will be described below (see Hillman et al., 2009).

One of the first studies investigating the effect of exercise in young and middle age adults was performed by Young (1979). It showed that after 10 weeks of stretching plus cardiovascular exercise young and middle-aged participants improved processing speed, executive functioning and episodic memory. Hillman et al. (2006b) observed that active young and older adults showed shorter reaction times than sedentary people in the congruent and incongruent conditions of the flanker task. Using the unimodal oddball paradigm with active and sedentary young adults (average 19.5 years old) and preadolescents (average 9.6 years old), Hillman et al. (2005) found that both groups of young adults were faster and showed better accuracy than the preadolescent group, but there were no differences in reaction times or accuracy between the two groups of young adults.

The most widely explored event-related potential (ERP) in this research field is the P300 component, also known as P3. This component reflects attentional processes in two different subcomponents. P3a is elicited in fronto-central areas when an alerting distracter occurs without a previous warning from the experimenter. However, when the warning is provided and the participant has been instructed to respond to it, P3b is observed with maximum amplitude in the parietal cortex (Johnson, 1993). Hillman et al. (Hillman, Belopolsky, Snook, Kramer, & McAuley, 2004; Hillman, Kramer, Belopolsky, & Smith, 2006a) found differences between fit and unfit young adults in the P3 component using task switching and flanker task paradigms. P3 component showed shorter-latency and higher amplitude in fit young adults.

The results are confusing when the oddball paradigm is applied. Applying a unimodal visual oddball task, Hillman et al. (2005) found that fitter young adults showed shorter latency in the P3, while Polich and Lardon (1997) observed higher amplitude in this component using the same task. Nevertheless, other studies (see Dustman et al., 1990; Hillman, Weiss, Hagberg, & Hatfield, 2002; Magnié et al., 2000) did not find any difference in P3 latency or amplitude. The disparity of results may be due to the fact that aerobic exercise might affect only the P3b component, which is related to stimulus updating and allocation of attention; and not the P3a; related to attentional orienting. In this vein, Pontifex, Hillman, and Polich (2009) observed this different effect of exercise in the P3b component using a simple and complex visual discrimination oddball task.

Other event-related components have been studied, for example, Themanson et al. (2006a; 2006b) showed smaller amplitude in the ERN component and greater amplitude of the Pe component in active people. These two components are related to learning, and would indicate a higher neuroelectric frequency in action monitoring control (ERN) and greater attentional resources allocation just after committing an error (Pe). ERN is thought to emerge from anterior cingulate cortex (ACC); with higher amplitudes reflecting more neural resources assigned to alert the cognitive control system in the prefrontal cortex for triggering a top-down regulation of conflict resolution. Along with these results, there was a slowing in reaction times after committing an error in the active group, being indicative of increased cognitive control in the following essays, thus preventing a new error. The active people would have a lower threshold to detect conflict or error, allocating more attentional resources and time to conflict resolution. Finally, Kamijo, Takeda, and Hillman (2011) detected that active young adults presented increased cortical coherence, indicating more neural synchrony just when task conditions were difficult.

4. Critical views on the effects of cardiovascular exercise on cognition and brain

Some authors have argued that exercise by itself does not have a causal effect on cognition, but that it promotes other factors that benefit executive functions (Diamond, 2015; Luders, Thompson, & Kurth, 2015; Voelcker-Rehage & Niemann, 2013; Wang & Young, 2014). As Wang and Young (2014) defended, exercise should be seen from a more general point of view, since anything that challenges cognitively our brain, causes an increase in myelination. In this vein, it has been shown that activities involving motor learning such as physical exercise or juggling (Boyke, Driemeyer, Gaser, Büchel, & May 2008; Scholz, Klein, Behrens, & Johansen-Berg, 2009), or cognitive engagement such as practicing music (Öztürk, Tascioglu, Aktekin, Kurtoglu, & Erden, 2008; Schmithorst & Wilke, 2002), socializing (Sánchez, Hearn, Do, Rilling, & Herndon, 1998) or cognitive training (Gebauer et al., 2012; Takeuchi et al., 2010) potentiate myelination through changes in white matter microstructure.

Diamond (2015) has recently reviewed the studies on exercise and executive functions that met the conditions of being interventional, had an activity-control group, and assigned participants randomly to every group. She concluded that few of the studies obtained post-intervention gains in executive functions, and that the ones where cognitive changes were obtained had applied exercises in which indirectly executive functions were trained as the case of martial arts (Lakes & Hoyt, 2004) or meditation (Luders et al., 2015). Thereby, she -as Kramer and Erickson did (2007b)- suggests that the cognitive components of the exercise training are the real cause of cognitive improvement and not the aerobic or resistance exercise per se. She also suggested that exercise benefits might be due to mood or sleep improvement, as it has been proposed in other studies (Best, 2010; Penedo & Dahn, 2005), which in turn affect executive functions.

Voelcker-Rehage and Niemman (2013) have also suggested that brain plasticity changes observed in physical activity studies depend on the type of task carried out in the exercise intervention, and that major structural changes in the brain are due to learning of new coordinative motor tasks. Although interventional studies are designed to establish causal-effect relationships, they cannot control for other factors that accompany exercise practice that may influence cognitive or brain improvements.

To conclude, a growing number of studies is demonstrating that coordination exercise is becoming an alternative type of intervention for improving cognitive and neurological changes (Diamond, 2015; Voelcker-Rehage, Godde, & Staudinger, 2011; Voss, Prakash et al., 2010a), and that resistance training is also effective (e.g. Cassilhas et al., 2007; Liu-Ambrose et al., 2010).

5. Neurological changes underlying cognitive enhancement

Chronic exercise is postulated not only as a long-term intervention that prevents cognitive impairment due to normal aging, but also as an inexpensive way to improve mental health and ameliorate certain cognitive problems in children and young adults. There are several neurological changes that are thought to be involved in the cognitive enhancement produced by chronic aerobic exercise. Between these possible factors, it is believed that brain derived neurotrophic factor (BDNF) is the one with the most important role, since it is involved in the majority of the subsequent neural changes that happen in brain plasticity.

5.1. Brain derived and other neurotrophic factors

BDNF is a neurotrophin involved in neurogenesis, dendritic growth, and long-term potentiation of neurons (Gorski, Zeiler, Tamowski, & Jones 2003; Lu, Pang, & Woo, 2005). This neurotrophin facilitates encoding and memory, increasing pre-synaptic neurotransmitter release and modifying post-synaptic N-methyl-d-aspartate (NMDA) and α -Amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid (AMPA) receptors. BDNF also influences important downstream activity such as cAMP response element-binding protein (CREB; Christie et al., 2008; Vaynman, Ying, & Gomez‐Pinilla, 2004).

Moreover, BDNF prevents hippocampal degeneration in aged animals, enhancing presynaptic densities and increasing hippocampal connectivity (Siette et al., 2013). This neurotrophin also reduces the effects of some stressors than can damage the neuron (Yang, Lin, Chuang, Bohr, & Mattson, 2014; Zagaar Dao, Alhaider, & Alkadhi, 2013). In humans, higher levels of BDNF have been associated with better spatial, recognition and verbal memory (Egan et al., 2003; Erickson et al., 2009; Grassi-Oliveira, Stein, Lopes, Teixeira, & Bauer 2008), as well as with better hippocampal functioning (Erickson, Miller, & Roecklein, 2012).

Erickson et al. (2010) suggested that BDNF is involved in the increment of volume experimented on the anterior hippocampus by active people, given that it mediates neurogenesis, promoting the dendritic expansion and memory formation (Erickson et al., 2011). This mediation has been proven robustly only in rats through brain tissue analyses (Creer, Romberg, Saksida, van Praag, & Bussey, 2010). In the case of humans, Pereira et al., (2007) showed that there is a high correlation between BDNF in blood and hippocampus volume, as well as between neurogenesis and cognitive improvement. This finding is important, since the level of this neurotrophin decreases with aging, so aerobic exercise presents as a type of intervention to prevent brain deterioration. Authors such as Kemperman (2010) and Fabel et al. (2009) have suggested that cardiovascular exercise facilitates the integration of new neurons into existing cortico-hippocampal networks. The specific potentiated cortico-hippocampal network will depend on the type of activity that the individual carries out. If normal routine is followed, networks implemented in every day tasks will be enhanced. This explains why when exercise is accompanied by cognitive training, the networks involved in such activity are potentiated (Voss et al., 2010b).

Szuhany, Bugatti and Otto (2014) carried out a meta-analysis indicating that BDNF increases following acute aerobic exercise after just a bout of exercise. Curiously, the results also showed that people following a regular exercise program released greater amounts of BDNF after a bout of exercise compared with people with no previous physical activity experience, thus a sensitization in BDNF release is produced.

Other neurotrophins released after exercising are insulin-like growth factor 1 (IGF-1) and vascular endothelial growth factor (VEGF). IGF-1 increases its levels in different parts of the brain and its function consists of enhancing the spontaneous firing of neurons, making them more sensitive to afferent stimulation. VEFG increases in hippocampus and it is involved in angiogenesis. In a randomized controlled trial with older adults in a one-year-exercise program including a walking group and a flexibility, toning and balance group (Voss, Erickson et al., 2013b), it was shown that levels of BDNF, IGF-1 and VEGF did not change in either group after the 12-month intervention. However, there was a positive correlation between the change in these neurotrophins' levels and the change in the joint activation of the bilateral parahippocampal and bilateral medial temporal cortices, both placed in the default mode network (Voss, Erickson et al., 2013b). These results are consistent with previous animal studies (Gómez-Pinilla, Vaynman, & Ying, 2008), where it has been shown that these neurothophins contribute to the positive effects of exercise on learning and memory.

5.2. Neurotransmitters

Monoamine systems mediate the exercise effects. Increment of the catecholamine release in the brain explains better execution in procedural and simple decision tasks, contributing to shorter reaction times, which potentiate early sensory and motor processes (Lin & Kuo, 2013). In the case of dopamine, exercise increases the release of this neurotransmitter in the central nervous system, increasing the protection against neurotoxicity and preventing motor diseases such as Parkinson's (Tanaka et al., 2009; Xu et al., 2010). Stroth et al. (2010) investigated the role of dopamine in visuospatial memory enhancement. After seventeen weeks of running three times a week improvements of cognitive flexibility and control were found. The results also revealed that participants with a Val allele of the gene catechol-O-methyltransferase, which is related to lower extracellular levels of dopamine, obtained greater cognitive scores than those with the Met allele. This means that aerobic exercise exerted its effects partly through the dopamine system.

Regarding norepinephrine, exercise causes noradrenergic neurons placed in locus coeruleus to decrease its firing rate over other neurons in the amygdala and frontal cortex, decreasing anxiety (Legakis et al., 2000; Sciolino & Holmes, 2012). However, exercise produces an increase in norepinephrine in hippocampus and amygdala giving rise to an improvement of learning and memory processes (Lin & Kuo, 2013). All these neurotransmitter systems interplay with BDNF (Lin & Kuo, 2013).

5.3. Vascular system and cerebral oxygenation

It has been shown that aerobic exercise also increases perfusion in the hippocampus, which is normally accompanied by a volume increment (Erickson et al., 2011). It is not clear yet whether such increment is due to cell proliferation, synaptogenesis and dendritic changes, or increased vascularization, or both (Erickson et al. 2011).

Using angiography, Bullitt et al. (2009) observed that older adults with higher level of fitness had more vessels of less than 0.5 mm in diameter, but the same number of greater diameter vessels than individuals with lower level of fitness. Low-fitness participants also showed more tortuous vessels in both medial cerebral arteries.
Moreover, Guiney, Lucas, Cotter, and Machado (2015) applying cerebral blood-flow (CBF) regulation in a sample of young participants with different levels of self-reported physical activity found that frequency of physical activity would be affecting cognitive control through improved CBF regulation, that is, the capacity of cerebral vessels to proportionate oxygen in the brain, measured through change in the speed of blood-flow.

In conclusion, changes in blood volume and brain activation resulting from increments in the maximum volume of oxygen consumption (VO_2 max) might cause higher oxygen supply. In this vein, greater capillary density and vessel diameter would produce that blood reaches neurons involved in a cognitive process faster, increasing their metabolism (Bullit et al., 2009; Voelcker-Rehage & Niemann, 2013).

5.4. Neuroimaging studies

Most of the neuroimaging studies carried out to explore the neurological changes produced by aerobic exercise have been performed with older adults.

Studies using ‘resting state’ methods (see for example Voss et al., 2010a) have established aerobic exercise as a way to prevent aging-associated deficits in local and distributed functional connectivity in the default mode network (DMN). DMN is a network of interacting regions that show activity when the participant is not involved in a task (Mars et al., 2012). These regions show an activity during resting state (daydreaming or mind-wandering) that is highly correlated between them. The core nodes are posterior cingulate, medial frontal, and bilateral inferior parietal and posterior temporal cortex (Mars et al., 2012).

Voss et al. (2010a) compared cognitive performance in older adults at 6 and 12 months after an aerobic or toning intervention, showing enhanced functional connections in both groups. The aerobic group showed increased connectivity between frontal and temporal areas included in the DMN and the fronto-parietal (FP) networks after 12 months. Interestingly, the toning group also showed increased connectivity in regions from the DMN and FP networks at 6 and 12 months respectively. Both groups’ connectivity patterns became more similar to the young adults’ connectivity pattern. These changes were accompanied by enhanced executive functions. The fact that the toning group also benefited from intervention -contrary to expectations- was explained by the progressive increasing of difficulty of the balance and toning exercises included in that intervention program. This would mean that exercise exerts a neurological effect on the brain that combined with other types of cognitive intervention leads to increases in connectivity in networks related with such a task (Diamond, 2015; Voelcker-Rehage & Niemann, 2013; Voss et al., 2011). Moreover, enhancement in both groups of DMN is encouraging, since aging has been associated with difficulties in deactivating this network in order to activate other networks related with task demands (Miller et al., 2008).

Furthermore, MR-Spectroscopy studies (Erickson et al., 2012; Gonzales et al., 2013) have shown that middle-age and older adults with high levels of fitness present with greater levels of N-Acetylaspartate’s (NAA) in the inferior frontal gyrus, insula, basal ganglia and ACC, indicating more neuronal density (Voss et al., 2013a) in those areas.

We will review studies applying structural, functional and diffusion magnetic resonance imaging in Chapter 9, where we will describe three experiments carried out with these techniques.

COGNITIVE FUNCTIONS AFFECTED BY AEROBIC EXERCISE

Chapter 2. Executive Functions

Chapter 2. Executive Functions

As previously mentioned, aerobic exercise seems to be specially related to executive functions (Colcombe & Kramer, 2003), an elusive construct that is not easy to define. We will present different characterizations in the following sections.

1. Executive functions definition

"Executive functions" is an umbrella term that refers to those resource-demanding and complex cognitive processes dealing with attention and control of several subprocesses to achieve a particular goal (Nyberg, Brocki, Tillman & Bohlin, 2009). They play a central role in general cognition, and are related to intelligence, social skills and academic performance. They are linked to prefrontal cortex, which acts as an orchestra director, working with other several cortical areas (anterior cingulate cortex) as well as subcortical neural systems (cerebellum, thalamus, and the basal ganglia) to coordinate complex tasks (Andrés, 2003).

Diamond (2013) defines executive functions as a family of top-down processes involved in goal-directed tasks or behaviors where sustained attention and concentration play an important role. According to this author, there are three core executive functions: a) Working Memory, b) Inhibition, and c) Cognitive Flexibility. From these, other higher-order functions are built, that is, reasoning, problem solving, and planning. They are also involved in the regulation of emotions (Bell & Deater-Deckard, 2007; Blair & Diamond, 2008; Lewis, Hashimoto, & Morris, 2008).

Norman and Shallice (1986) were among the first to talk about these functions as part of the Supervisory Attentional System (SAS). They proposed two control modes, one automatic, based on routine and habits activated in familiar circumstances, known as the contention scheduling. The second system, the SAS, depending on limited attentional resources, and activated in novel situations, is necessary to create a new strategy to solve problems by searching alternative solutions. Other functions of this SAS are behavior monitoring -correcting inappropriate actions-, rule abstraction, planning, inhibition, selective, divided and focused attention, and shifting (Norman & Shallice, 1986). Baddeley (1986) borrowed the idea of this controlled attentional system to describe the functions of the working memory's central executive, a model that will be described later.

Rabbitt (1997) described executive functions as processes dealing with novelty, applying to this aim planning and strategies to improve performance, as well as using feedback to modify, if required, subsequent responses. Similarly, Hughes and Graham (2002) argued that executive functions overcome automatic responses in situations that can be difficult or dangerous, carrying out planning, decision making, correcting errors and implementing novel series of actions.

Thus, all these definitions indicate that executive functions are essential for coping with novel situations where it is precise to suppress automatic well-learnt behavior. After that, attempts to identify and describe the executive functions subcomponents have relied on psychometric, and neuropsychological techniques.

Under the psychometric account, Miyake et al. (2000) divided executive functions in three basic processes: mental set shifting ("shifting"), information updating and monitoring ("updating"), and inhibition of prepotent responses ("inhibition"). According to Miyake et al., although the three executive functions are moderately correlated, they are also clearly distinguishable. Moreover, common variability between these three factors may be explained by the need to maintain information and goals active in working memory, but also to common inhibitory processes involved in suppressing irrelevant incoming information, as well as representations that are no longer necessary. Finally, Miyake et al. assumed that these three basic executive functions are not the only ones, but rather the most representative, leaving open the possibility that other basic functions, such as coordination of multiple tasks (Baddeley, 1996; Emerson, Miyake, & Rettinger, 1999) exist. Over these three core components, other higher order functions such as planning or reasoning are built.

Other authors have defined executive functions by considering the pattern of symptoms observed in patients with frontal lobe damage when they undertake neuropsychological tasks (Duke & Kaszniak, 2000; Keil & Kaszniak, 2002; Romine & Reynolds, 2005). In that sense, frontal lobe and executive functions have been often used as synonyms, although there exists nowadays clear evidence that other areas are involved in those functions (Andrés, 2003; Collette et al., 2002; Niendam et al., 2012).

It must be noted that psychometrical approaches are also being questioned. Salthouse (2005), for example, has claimed that executive functions are frequently difficult to separate from other cognitive processes, which calls into question whether they actually exist independently. Executive functions are highly correlated to reasoning, perceptual speed abilities and fluid intelligence (Salthouse, 2005; Salthouse & Davis, 2006), and fit with the idea that they constitute a metacognitive factor that manages other more basic cognitive functions (Alvarez & Emory, 2006; Baddeley, 1986; Salthouse, 2007).

2. New perspectives about frontal lobe and executive functions

The models that follow go beyond specific cognitive processes and try to explain more generally how the brain can integrate executive functions with each other and with other cognitive functions (Stuss & Knight, 2002).

2.1. A superordinate cognitive control network

Studies using functional magnetic resonance (fMRI) have suggested a brain network common to all executive functions (e.g. Duncan & Owen, 2000), denominated cognitive control network. Its function would be related to coordination between multiple processes. This network comprises dorsolateral prefrontal cortex (DLPFC), frontopolar, orbitofrontal, ACC, superior and inferior parietal cortices, caudate, putamen, thalamus, and cerebellum (Bellebaum & Daum, 2007; D'Esposito, 2007; Fuster, 2002; Niendam et al., 2012).

Cognitive control is achieved through the coordination of temporal activation of prefrontal and posterior brain regions, supporting working memory, inhibition, initiation, flexibility, planning, and vigilance (Niendam et al., 2012). Thus, the network is highly distributed, but shares cognitive control functions. In turn, there are specific networks inside the more general one, specialized to discrete executive functions, but other functional networks as default mode network or dorsal attention network can also be engaged by the cognitive control network.

2.2. A Revamped Attentional Model

Stuss (2011) argues that the frontal lobes have three functions: a) Energization/Executive, b) Emotional/Behavioral, and c) Regulation/Metacognition.

a) Energization, monitoring and task setting are processes involved in attention.

Energization is associated with areas in the dorsomedial frontal cortex, and is involved in the process of initiation and maintenance of responses. Monitoring and task setting conform the higher order construct of “Executive Functions”. Monitoring is related to areas placed in the right lateral frontal cortex, and is involved in monitoring errors, keeping track of the task, and maintaining an invariant performance during the task. Finally, task setting, placed in the left lateral frontal cortex, is responsible for conditional logic and adjustment of action scheduling.

b) Behavioral/emotional self-regulation refers to the capacity to integrate motivational, reward/risk, emotional and social aspects of behavior, which are associated with ventromedial cortex (VMPFC). Patients with deficits on these processes are able to solve executive tasks properly, except those related to evaluation of deception, empathy and gambling.

c) Last, metacognition/integration is a higher-order process that integrates and coordinates all the frontal lobe functions: energization, executive functions, motivation and emotion. They are related to polar regions. When these functions are deteriorated, it is difficult to understand humor, to empathize with others or to take into account their beliefs, and separate them from ours.

Thereby, according to Stuss (2011), there are two main frontal systems: a lateral one (monitoring and task setting) connecting with posterior cortices and involved in executive functions; and an inferior/lateral one (self-regulation) that connects with limbic system, in charge of emotion regulation (also see Pandya & Yeterian, 1996). The superior-medial-frontal region would energize these systems. Finally, the frontopolar area (metacognition) would integrate the executive and emotional processes, and it is connected just with frontal regions (Petrides & Pandya, 2006).

2.3. The Cognit Model

Fuster (2013) considers that cognitive functions cannot be ascribed to any particular cortical module, less at all basing it in double dissociations inferred from damaged brains. He suggests that although there are certain areas that have been demonstrated to play an important role on specific cognitive functions, those areas reflect located predominant location of such functions, but not all neural circuits involved in it. Based on this idea, prefrontal cortex plays an important role in preadaptation, carrying tasks such as anticipation, planning, decision-making and organization of goal-directed actions, which operate within the perception/action (PA) cycle integrating all cognitive functions.

According to Fuster (2013), human beings come with a predisposition to form very simple perceptive and motor cognits, placed near sensory or motor areas. As the ontogenesis progresses, more complex cognits are formed combining the more simple ones, placing themselves in associative areas. In turn, perceptive and motor cognits interact between them. All of this causes the creation of higher hierarchies structures – heterarchical cognits-, which abstractly represent reality, memory and thoughts, and thereby, are distributed along the brain. Strict separation of memories would not be possible according to this model. Furthermore, cognits are constantly adding or losing connections according to the person’s experience, which can strengthen some connections and weaken others. According to Fuster, more complex cognits will be more resistant to brain injury, since they are formed of multimodal connections of simple cognits.

Fuster (2013) applies the concept of cognit to describe the assembly of interconnected neurons that sustain a representation learned through experience. This representation goes from very simple to very complex abstractions of reality or thoughts. A cognit would be originated as a product of synchronic activation of neurons that can be located close or distributed along the brain. Executive cognits refer to actions, strategies, programs, plans or rules and are related to frontal areas, while perceptual cognits represent memories related to sensorial, episodic and semantic information and are located in the posterior areas of the brain. The brain might be divided in two structural hierarchies: perceptual and executive, respectively located in the post-rolandic and frontal cortex. The former is associated with processes related to sensorial information, and the later to the knowledge of doing. Both hierarchies serve as a memory of the present acting as a scaffold on which attach new experiences, providing us with a guide to perception and memory.

2.4. Incentive Monitoring Model of Cognitive Control

According to Duncan and Koechlin (2013) there are two opponent systems called multiple-demand (Duncan, 2013) and task-negative (Raichle et al., 2001). The multiple-demand system is located in the lateral and dorsomedial frontal cortex, dorsal anterior cingulate cortex, the anterior insula, frontal operculum and intraparietal sulcus. This system gets activated compared to rest when the individual is performing a task; the more demanding it is, the more activation this system shows. However, the task-negative system shows the opposite pattern when a task is being accomplished. The areas related to this system include the ventromedial prefrontal cortex, frontal pole, superior and medial frontal gyri, posterior cingulate and inferior parietal lobe (Shulman et al., 1997).

The concept of multiple demand system is very similar to the inhibition control network included in recent models of inhibition (Aron, Robbins, & Poldrack, 2004; Neubert et al., 2013). Motivation and executive control are involved in decision-making. When task expectations are not met according to past experiences or present task goals, motivation engages executive control. Medial prefrontal cortex (MPFC) is the area specialized on evaluating motivational values of action (Behrens, Hunt, Woolrich, & Rushworth, 2008; Matsumoto, Matsumoto, Abe, & Tanaka, 2007). Moreover, areas rostrally in front of the premotor area in the lateral prefrontal cortex (LPFC) are involved in selection of actions. The most anterior part of the LPFC, the frontopolar cortex, is considered the highest level of cognitive control. Koechlin and Hyafil (2007) called it “cognitive branching” and it is in charge of multiple functions such as general fluid intelligence, multitasking, mathematic calculations, reasoning, and learning by trial and error (Koechlin, 2013).

3. Inhibition and working memory as executive functions

3.1. Inhibition

As we will see in the empirical section of this thesis (see Padilla, Pérez, Andrés, & Parmentier, 2013; Padilla, Pérez, & Andrés, 2014; Pérez, Padilla, Parmentier, & Andrés, 2013), effects of cardiovascular exercise seem to be strongly related to inhibitory processes. In the following sections we will define the concept of inhibition, the types of processes included under this term and their possible neurophysiological correlates.

3.1.1. *Concept of inhibition*

Inhibition is a construct used to describe a covert process meant to decrease the activity of a mental representation or another process running at the same time. This concept encompasses different inhibitory mechanisms that affect different cognitive functions such as attention, memory, language and perception (MacLeod, 2007).

The term was first used to explain the negative deviation from the baseline observed in cognitive tasks, which reflects a cost that is due to interference between processes (MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003). Interference has been used as a cause for inhibition processes; however, this has been challenged lately by alternative-inhibition accounts claiming that there is a possible alternative explanation in terms of process competition, which involves decision-making giving rise to longer latencies (MacLeod et al., 2003).

3.1.2. *Classification of the inhibition construct*

According to Carr (2007) there are two opponent views in inhibition research: "inhibitophilos" vs. "inhibitophobics". Inhibitophilos researchers must resolve whether inhibition is a unitary cognitive process or whether it accounts for a set of multiple processes with a similar function. The unitary-inhibition account is based on psychometric measures and is dedicated to analyze the common variance explained by several tasks that measure inhibition. The multiple-processes account is denominated "isolable subsystem approach" and studies the individual components of inhibition. On the other hand, inhibitophobics must resolve whether their list of alternative accounts of inhibition is enough to explain all cognitive control processes.

A) Multicomponent-inhibition account

The multicomponent-inhibition view (Dempster, 1993; Harnishfeger, 1995; Nigg, 2000) defends that there are multiple types of inhibition processes depending on the cognitive process that must be stopped. There is a set of inhibitory processes that can be classified in two categories -automatic and executive- that might actually be considered within a continuum (Andrés, Guerrini, Phillips, & Perfect, 2008; Harnishfeger, 1995; Nigg, 2000). Executive or controlled inhibition would depend on frontal networks and would be affected by developmental changes as aging. It would be involved in the effortful and controlled inhibition of dominant or more automatic behaviors, thoughts or stimuli, in order to execute other less automatic, keeping the task goals in mind. Tasks that involve executive inhibition are Directed Forgetting, Think/No-Think, Stroop, Go/No-Go, Stop Signal Task or Flanker Task. In addition, automatic inhibition is produced unconsciously, and suppresses information that is not relevant before it achieves awareness (Andrés et al., 2008; Nigg, 2000).

Furthermore, other authors have classified inhibition following different dimensions. For example, Dempster & Corkill (1999) defined resistance to interference as the inhibition exerted while a task is being carried. Dempster (1993) explained that resistance to interference is not a unitary construct since it is developed and reflected in motor, perceptive and language processes with a different rhythm.

Moreover, Harnishfeger (1995) classified inhibition following three dimensions:

a) Intentional/Unintentional: it depends on the degree of awareness or attentional control exerted on inhibition. When intentional inhibition occurs, the stimulus is identified as non-relevant and suppressed. Unintentional refers to inhibition performed before awareness.

b) Behavioral/Cognitive: behavioral inhibition refers to control of motor responses or impulses, while cognitive concerns about control or suppression of non-needed cognitive processes.

c) Inhibition/Resistance to interference: inhibition is in charge of suppressing contents from working memory (WM); while resistance to interference is a process that avoids entering of non-relevant information or stimuli to WM. They may be controlled by the same neural mechanism.

Furthering the distinction between controlled and automatic inhibition, Nigg (2000) distinguished four types of effortful inhibition: a) Interference control: suppression of stimulus competition; b) Cognitive inhibition: suppression of irrelevant information; c) Behavioral inhibition: suppression of prepotent responses; and d) Oculomotor inhibition: suppression of reflexive saccades. Nigg also classified automatic inhibition in two types: a) Inhibition of return, and b) Covert attentional orienting.

Despite these multiple classifications of inhibition, little research had been done to demonstrate this reality empirically until Friedman and Miyake's study (2004). They distinguished three components of inhibition based on the classifications by Dempster (1993), Nigg (2000) and Harnishfeger (1995) (see Table 1).

Table 1

Correspondences between inhibition taxonomies

Dempster (1993)	**Nigg (2000)**	**Harnishfeger (1995)**
Control of motor interference	Behavioral inhibition & Oculomotor inhibition	Intentional behavioral inhibition
Control of verbal – linguistic interference	Cognitive inhibition	Intentional cognitive inhibition

Friedman and Miyake (2004) studied the relations between these three components applying latent variable analysis. They distinguished between prepotent response inhibition (PRI), resistance to distractor interference (RDI) and resistance to proactive interference (RPI). PRI refers to the active suppression of an already scheduled action that at the last moment the individual decided to stop because it is not adaptive to the environment demands. It also refers to the stopping of a more automatic response in favor to another more elaborated. This type of inhibition will be further explained later when the stop signal task (Verbruggen, Logan, & Stevens, 2008) is described.

Regarding the remaining inhibition components, Friedman and Miyake (2004) preferred the term of resistance to interference because it does not imply active suppression; instead they refer to a mechanism of conflict resolution. Thus, RDI is the capacity to control the interference caused by external distractors; and RPI describes the effort to avoid that previous learnt or used information in a task interfering with upcoming material or new demands of the task at hand.

Two clear problems concerning the concept of inhibition have been repeatedly mentioned. The first is the low construct validity (Rabbitt, 1997), due to the lack of agreement on the concept of inhibition and the tasks that better measure this/these process/es, which causes that correlation between tasks is low (Friedman & Miyake, 2004). However, some authors interpret this lack of correlation as a sign of the existence of different inhibitory processes (Grant & Dagenbach, 2000). The second problem is that inhibitory tasks also suffer from low internal reliability, with low correlations between first and second halves of the task. However, low reliability can also be due to participants developing strategies as the task progresses. The same problem is also observed with other executive tasks (Rabbitt, 1997).

It is interesting to note that all the tasks used by Friedman and Miyake (2004) significantly loaded on their respective factor (PRI, RDI or RPI), however, the variance explained by the set of tasks that conformed each factor was not high in any of them. The same problem appeared in other studies (Kramer, Humphrey, Larish, & Logan, 1994; Shilling, Chetwynd, & Rabbitt, 2002), where low values of correlation between inhibition tasks were found. It seems that the variance explained by inhibition in these tasks is small, and the remaining variance is due to other cognitive aspects or variance error, leading to a task impurity problem. For this reason, design of new reliable inhibition tasks, based on validated constructs, is important for research purposes.

Friedman and Miyake's (2004) study results showed that prepotent response inhibition and resistance to distractor interference were correlated (r = .67) conforming a common factor not related to resistance to proactive interference. This study provides evidence in favor of a fractionated concept of inhibition including at least two components: response – distractor inhibition, and resistance to prepotent intrusions.

B) Unitary-inhibition account

The authors who defend a unified inhibition network (for example, Anderson & Levy, 2007; Aron et al., 2014; Logan, Van Zandt, Verbruggen, & Wagenmakers, 2014; or Wimber, Alink, Charest, Kriegeskorte, & Anderson, 2015) consider that there is an inhibition control network placed mainly in the right inferior prefrontal cortex, which is in charge of either effortful or automatic inhibition, and its function consists in reducing the activation of actions, processes, representations, or external stimuli to avoid interference with the current goal. This inhibition network is part of the executive system and interacts with other components to coordinate other cognitive processes such as perception, attention, memory, or language.

Aron and Poldrack (2006) were amongst the first authors to propose the existence of a unitary inhibitory network. They were interested in the neural correlates of the stop signal task (Verbruggen et al., 2008), which measures inhibition of motor actions, and is considered by some authors as the most reliable inhibitory task (MacLeod et al., 2003). However, a growing body of research is demonstrating that not only physical responses can be suppressed and that this inhibition network may be common to other forms of inhibition related to the suppression of covert processes.

Logan et al. (2014) have recently defended that several acts of control may be exerted by the cognitive system in order to accomplish a goal. These acts of control refer to attention switching, conflict management, or strategies application among others, and are not limited to physical and explicit responses. They propose a mathematical theoretical framework to account for a great variety of control acts. The same idea is pursued by other theorists (see for example, Anderson & Levy, 2007; Aron Behrens, Smith, Frank, & Poldrack, 2007), who bet on a control mechanism that goes beyond mere inhibition. These alternative views will be explained in the following section and in Experiment 5, when the phenomenon of retrieval induced forgetting (RIF) will be introduced.

Going back to the work by Logan and his collaborators, Logan and Cowan (1984) explained stopping of a physical response attending to the horse-race model, where two processes -stopping and go- run together. In order to stop a response, the stop process must be faster than the go process. The probability of a response being stopped depends on the go process speed and on when the stop process started –stop signal delay (SSD)-. The estimation of the stop signal response time (SSRT) corresponds to the subtraction of the mean SSD from the go RT (Go RT). More information about the mathematical model underlying stop signal task will be provided in Experiment 7 (Chapter 9), where this task was used while participants were scanned applying functional magnetic resonance imaging.

The brain areas supporting inhibition mechanisms have also been extensively studied using neuroimaging and transcranial magnetic stimulation (TMS) techniques, contributing to alternative models of cognitive control. These studies will be explained in the next section.

3.1.3. Neural circuits of inhibition

Since part of this thesis will address the neural substrate of inhibition (Experiments 7 and 8), the existing literature on this topic will be briefly summarized in this section. As mentioned before, it is thought that the right inferior frontal gyrus (rIFG) and the pre-supplementary motor area (pre-SMA) play a role in inhibitory control. Nevertheless, there is no clear understanding about the relationship between behavior and physiological inhibition. According to studies using psychophysiological measures, executive control would be carried out through cortico-cortical connections and through different cortex-basal ganglia-cortex loops (Neubert et al., 2013). There can be three types of basal-cortical connections playing different roles in motor control (Neubert et al., 2013). While the direct pathway is related to response execution; indirect and hyperdirect pathways are associated with response inhibition.

a) The direct pathway (Figure 1) consists of an inhibitory pathway from the striatum (Str: putamen and caudate) to the interior part of the globus pallidus (GPi) and substantia nigra reticulata (SNr) that in turn have inhibitory connections to the superior culliculus (brainstem) and thalamus. Through this pathway, GPi gets inhibited, so it cannot inhibit the thalamus, getting this therefore activated and, in turn, activating the cortex, releasing then the programmed motor action.

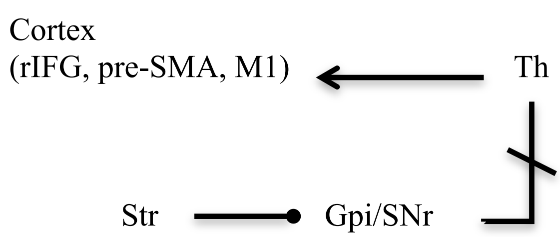

Figure 1. Direct pathway. Arrows refer to activation, while circles refer to inhibition, which in turn suppresses subsequent connections signaled by a line crossing. rIFG: right inferior frontal gyrus; pre-SMA: pre-supplementary motor area; M1: primary motor area; Gpi: interior globus pallidus; Th: thalamus; SNr: substantia nigra pars reticulate (Neuber et al., 2013)

b) The indirect pathway (Figure 2A): the striatum inhibits the external segment of the globus pallidus (GPe), producing the disinhibition of the subtalamic nucleus (STN), which activates the GPi and SNr, giving rise to the inhibition of the thalamus and cortex.

c) The hyperdirect pathway (Figure 2B): the cortex activates the STN, and thereafter, the GPi, inhibiting the thalamus (Aron et al., 2007, Isoda & Hikosaka, 2008).

The basal ganglia have an important role resolving competition between possible movement programs, allowing the initiation of the selected program, while other programs are inhibited. The indirect pathway holds potential responses in check, until one of them is chosen and the direct pathway releases that action activating the thalamus and M1. In the meantime, all other potential responses are inhibited via indirect pathway projections.

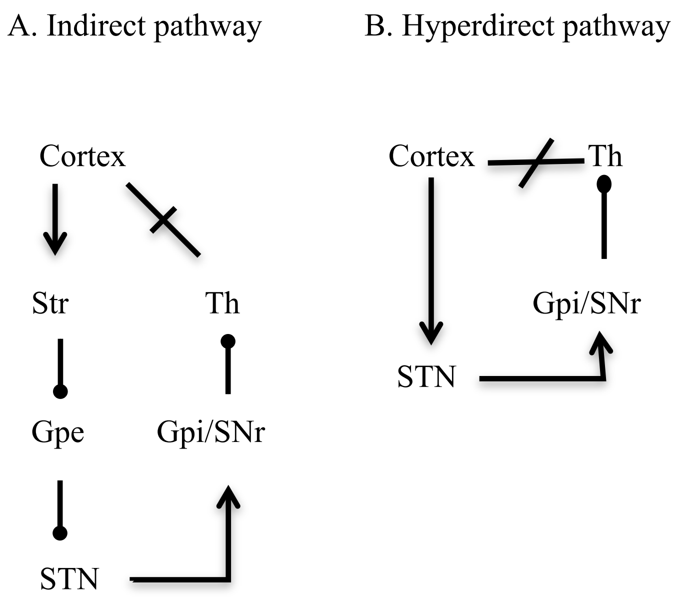

Figure 2. Pathways involved in response inhibition. Arrows refer to activation, while circles refer to inhibition, which in turn suppresses subsequent connections signaled by a line crossing. Th: thalamus; STN: subthalamic nucleus, Gpi: globus pallidus interior; Gpe: exterior globus pallidus; SNr: substantia nigra pars reticulate (Neuber et al., 2013)

It has been suggested that these cortex-basal functions could be involved in higher order executive control processes, not only playing a role in initiation and inhibition of motor actions, but also being involved in updating and maintenance of working memory information as well as in reorienting of attention in the prefrontal cortex (Hazy, Frank, M., & O'Reilly, 2007). Reward history would help to choose when to initiate movement or update information through the direct pathway and when to inhibit motor actions or stop maintenance through the inhibition loops.

rIFG and pre – SMA are associated with the inhibitory aspects of cognitive control and exert their inhibitory influence through basal ganglia (Aron et al., 2007). rIFG includes the pars opercularis, pars triangularis and pars orbitalis (Brodman areas 44, 45 and 12/47) and is interconnected with temporal and parietal areas. Pre-SMA is interconnected to prefrontal areas (Lu, Preston, & Strick, 1994). During response inhibition, pre-SMA, rIFG and STN are activated (Aron et al., 2007, Aron & Poldrack, 2006). Using the stop signal task (Verbruggen, Logan, & Stevens, 2008), Aron et al.

(2007) found that activity in rIFG and STN was correlated with the SSRT, and using tractography, they showed that these areas were interconnected. Thus, inhibition is exerted through the hyperdirect pathway between rIFG and STN (Nambu, Tokuno, & Takada, 2002), which in turn is connected to the pre-SMA. Pre-SMA monitorizes response conflict, control demand or uncertainty, and subsequently recruits rIFG and STN inhibitory control system. Other studies using the stop signal task have found similar results (Congdon et al., 2010; Simmonds, Pekar, & Mostofsky, 2008). Furthermore, Fleming, Thomas and Dolan (2010) observed that rIFG and STN were involved in decision-making, mostly when it is required to make difficult decisions and change behavior. In that case, rIFG influences the STN to produce a change.

Therefore, the research on neuroimaging and inhibition suggests that response inhibition could be considered to be a unitary cognitive function mainly localized in the IFG. However, this might be an oversimplistic view, and some authors have suggested that response inhibition is part of a cognitive system involved in "predictive coding" (Friston, 2005; Rushworth, Mars, & Summerfield, 2009). According to this account, our brain is always making predictions and decisions about what surrounds us, comparing actual events with its predictions and correcting the plan established (den Ouden, Daunizeau, Roiser, Friston, & Stephan, 2010). The cognitive system also makes predictions about its probability of success (Preuschoff, Quartz, & Bossaerts, 2008). These would be the typical functions carried out by executive and inhibitory control, which would help to guide behavior (Neubert & Klein, 2010), making statistical inferences about regularities in the environment to predict the actions that could be needed, preparing them in advance, so they can be executed quickly and efficiently. This current view considers IFG as part of a system involved in action prediction also involved in detecting prediction errors that need to be corrected by reprogramming the action plan.

Chikazoe et al. (2009) wanted to distinguish the areas involved in action certainty using a modified stop signal task with a certain go condition, where no stop signal was followed, versus an uncertain go condition, that could (or not) be followed by a stop signal trial and required an inhibitory response. Chikazoe et al. found that when there was uncertainty, the insula, inferior frontal junction (IFJ) and pre-SMA were activated. These areas were similar to the ones activated when performing the stop signal trials, i.e., insula, posterior IFG and pre-SMA. IFG would therefore be involved in capturing statistical stimuli regularities. Vossel, Weidner and Fink (2011) showed similar results using a combined oddball plus a location cueing task, in which IFG activity reflected the number of trials where cues had been valid. Repetition of valid cues provides information about how valid a cue is, inferring a stronger rule. Activity in IFG, along frontal and parietal cortices, increases with uncertainty (Huettel, Song, & McCarthy, 2005). In addition, it has been suggested that it may form part of a more general network (Bode & Haynes, 2009; Hampshire, Chamberlain, Monti, Duncan, & Owen, 2010) conformed of IFG, pre-SMA and other frontal and parietal areas involved in action reprogramming, attentional reorienting, information updating, task switching, response selection and motor control (Mars, Piekema, Coles, Hulstijn, & Toni, 2007). Verbruggen, Aron, Stevens, and Chambers (2010) also showed that rIFG disruption with TMS affected motor reprogramming.

Mars et al. (2009) and Neubert, Mars, Buch, Olivier and Rushworth (2010) have investigated the networks involved in inhibition using TMS and diffusion tensor imaging (DTI). They studied the interaction between IFG, Pre-SMA and M1 during a task of action selection and action reprogramming, showing that the pre-SMA acts on M1 previous to rIFG when action reprogramming is required. The IFG exerts an inhibitory influence over M1, while Pre-SMA facilitates M1 action in switch trials. However, IFG facilitates M1 action in stay trials where prepared actions are executed. Pre-SMA influences the connection between IFG and M1, since when a pulse of TMS is exerted over Pre-SMA, IFG does not inhibit or facilitate with the same intensity.

In summary, research in motor inhibition points to a inhibition system inserted in a higher order network that is involved in cognitive control.

3.2. Working memory

As it happens with inhibition, whereas some models defend a unitary view of working memory (Engle, Cantor, & Carullo, 1992), others privilege a multicomponent nature (Daneman & Tardif, 1987).

In an attempt to simplify, we present here the most relevant models for our empirical work:: a) Baddeley and Hitch's (1974) model, b) the Executive Attention Theory (Engle & Kane, 2004; Kane et al., 2007), c) Cowan's Embedded Processes Theory (Cowan, 1999), and d) the Binding Hypothesis (Oberauer et al., 2007).

A) Multicomponent models

Baddeley and Hitch's (1974) model

Baddeley and Hitch's (1974) model described working memory as a system consisting of three components: two slave systems and a central executive (Figure 3). Later, Baddeley (2000, see Figure 2) included a forth component called the episodic buffer.

a) The phonological loop is the verbal slave system in charge of verbal short-term memory (STM). It works with acoustic elements and sequences associated with speech. This component consists of the phonological store, which is a buffer where the verbal information is stored; and the phonological loop, responsible for rehearsing the verbal information to avoid decay. This component plays an important role in action sequencing (Emerson & Miyake, 2003; Miyake & Shah, 1999; Saeki & Saito, 2004) because is involved in the articulation of instructions to carry out a task properly (Baddeley, Chincotta, & Adlam, 2001).

b) The visuospatial sketchpad, the second slave system, is in charge of maintaining sequences of visual and spatial elements. It consists of the visual cache, where visuospatial elements are stored; and the inner scribe, responsible for visual rehearsal processing (Logie, 1995). Visuospatial sketchpad provides a visuospatial workspace that serves for developing complex visual tasks.

c) The central executive controls the entire set of working memory. It is described as a limited attentional system that selects the information to be focused on, managing its manipulation in one of the subsystems that conforms the working memory. The idea of the central executive was inspired by Norman and Shallice's (1986) SAS. As mentioned earlier in this chapter, this system is activated in face of novel situations, in which an automatic behavior is not suitable to solve a problem, and the system must decide between competing solutions or seek strategies to look for alternative solutions. Other functions of the central executive are monitoring behavior to correct it when necessary; focusing and dividing attention.

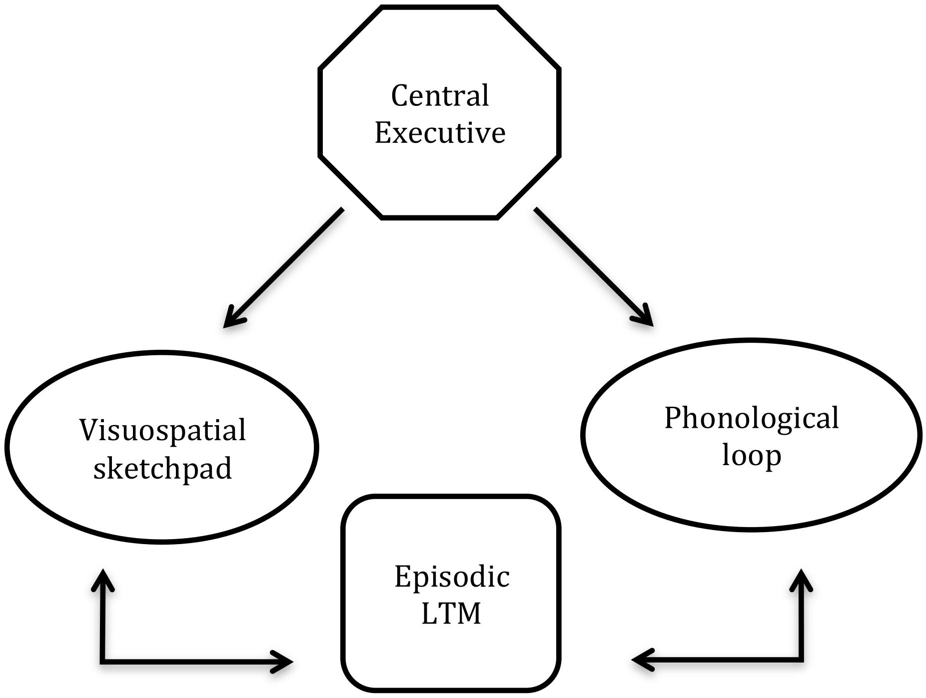

Figure 3. Baddeley's (2000) model of working memory

d) The episodic buffer was later proposed (Baddeley, 2000) given the need to explain how working memory interacted with long-term memory (LTM). It is a component that serves as a storage system and is able to keep up to four blocks of information. It connects information from working memory to long-term memory and perceptual systems. Each system uses different codes that are combined inside this multidimensional buffer. The information is recovered consciously, activating different types of representations at the same time and integrating them in one, giving rise to consciousness (Baars, 2002). In this space, called working memory, is where complex cognitive activities are possible to be performed.

The remaining models of working memory, either multicomponent or unitary models, are built based on individual differences in measures of working memory applied to normal participants.

Executive Attention Theory (Engle & Kane, 2004; Kane et al., 2007)

According to this model, WM is a system where memory traces from the long-term are activated by controlled and limited focused attention. In this system domain-free controlled attention and domain-specific-code components are involved. Thereby, this WM system contains two subcomponents (Kane & Engle, 2002): executive-attention and short-term memory and individuals may differ either in the general or in the specific components.

Executive attention allows for the proper allocation of attentional resources and the active maintenance of information needed to accomplish goal-directed behavior, avoiding at the same time the interference from external stimuli or thoughts. In this online processing, several processes come into play, being important the storage and rehearsal of domain-specific information, as well as other executive processes (Conway et al., 2005) and controlled attention to sustain, divide and switch the focus of attention (Engle, Tuholski, Laughlin, & Conway, 1999).

Executive attention is similar to Baddeley's (Baddeley & Hitch, 1974) central executive, to Norman and Shallice's (1986) SAS or the construct of controlled attention of Posner and Snyder's (1975). From a neural perspective, it would be related to Posner and Petersen's (1990) anterior attention system.

Working memory capacity (WMC) refers to the capacity of the controlled attention component. It is involved in memory and selective attention tasks.

The typical working memory tasks applied consist of dual-tasks that combine storage with manipulation. According to Engle et al. (1999), dual-task procedures reflect daily life demands and predict performance in other higher-level cognitive tasks. Differences in WMC will be revealed in high interference situations, where controlled attention is necessary for successful performance and irrelevant information must be suppressed. Low WM-span individuals will have difficulties in this kind of tasks.

Kane, Conway and Engle (1999) and Duncan, Burgess and Emslie (1995) have considered WMC as a synonym of controlled processing highly correlated with fluid intelligence (Horn & Cattell, 1967). People with low fluid intelligence are less able to deal with tasks in which it is necessary to face interference, switch or divide the focus of attention (Duncan et al., 1995; Morrin, Law, & Pellegrino, 1994). Engle and collaborators (see for example, Kane & Engle, 2003; Redick & Engle, 2006; or Rosen & Engle, 1998) have also investigated the association between WMC and other cognitive tasks where controlled attention is required, revealing that low WMC participant obtain lower scores.

One of the main limitations of Engle's (Engle & Kane, 2004) WMC model is that it is based on the extreme groups procedure, which consists on the application of regressions and ANOVAs in groups with extreme scores placed in the upper or lower quartile, removing those participants with an averaged performance, which leads to removal of variability from the regression analysis (see for example, Wilhelm et al., 2013).

B) Unitary models

These models agree that working memory implies executive control of attentional resources in order to retrieve and maintain active selected representations from long-term memory, while a goal-directed task is being carried out. Although non used for the purpose of our experiments, two of these models will be explained for their theoretical interest.

According to Cowan (1995; 1999, 2012) working memory is a unitary system formed by a set of attentional processes that keep accessible specific information in the LTM. This activation may decay, unless it is remained active through continued attention or verbal rehearsal. This activation of the LTM is limited to four blocks (Cowan, 2005).

WM might be described as a system where several cognitive processes maintain the information active in several degrees according to the level of significance of such information. A key point of this model is that attention and memory are explicitly integrated. There are four main components: a) long-term store, b) short-term store, c) focused attention, and d) central executive. The information activated in the focus of attention is the most accessible and conforms awareness. The information out of that focus and placed in the short-term store is activated, but not so accessible. Finally, the information in the long-term store is not in active state, but can be part of WM easily if a proper cue is used in the focus of attention. The central executive controls the allocation of attention and voluntary processing. This model conceptualizes memories as a multicode representation, and explains interference as the intrusion of similar representations.

Oberauer (2002), however, although inspired by Cowan's WM model (1995; 1999), defends a three-layer model, in which long-term memories are processed in a different way. At the first level, perceptive input or representations in WM spread their activation to relevant associated long-term memory representations, which are activated above their thresholds. At the second level, some part of that long-term representations are held in the "region of direct access", where they are linked to positions in a cognitive coordinate system. This system can work in different dimensions: spatial, time, or relative positions inside a schema. This temporary binding is limited to the number of elements/representations that can be held at the same time, but unlike Cowan's model (2001) it is not restricted to four chunks. These elements are related and coordinated in the region of direct access. At the third level, the focus of attention selects a chunk from the region of direct access and manipulates it applying cognitive operations. Oberauer et al. (2007) explain that the long-term memory representations activated at the first level, although non-placed in the focus of attention, are easy to be accessed. They also have an effect on the cognitive operations or actions that are taking place in the focus of attention, as occurs with familiarity in the case of recognition. However, only the contents placed in the region of direct access will be picked out by the focus of attention to be involved in cognitive operations.

3.3. Relationship between inhibition and working memory

As we have described earlier, inhibition is considered to be an executive function that appears involved in many cognitive processes. In addition, it has been argued that it strongly interacts with working memory (Hasher & Zacks, 1988; Redick, Calvo, Gay, & Engle, 2011). Thus, they are complementary processes that act simultaneously much of the time.

Engle and collaborators (Redick, Heitz, & Engle, 2007; Redick et al., 2011) describe inhibition as an active mechanism of suppression acting on interfering memory representations. In that sense, they agree with Bjork's (1989) construct of inhibition, suggesting that inhibition is exerted in a controlled and effortful manner, and requiring attentional resources. Engle, Conway, Tuholski and Shisler (1995) illustrated this assumption with a negative priming task combined with a short-memory task, in which a set of one (load 0) to five (load 4) negative priming trials were followed by a different word that the participants had to serially recall at the end of the set. Negative priming is produced when the current trial's target was a distractor in the previous trial, causing a slowing down of RTs. Results showed longer RTs in the negative priming condition compared to the control condition (the target did not appear in the previous trial) when there was no WM load (load 0), but it disappeared as WM load increased, mostly in the conditions of load 3 and 4. Therefore, when attention was divided, suppression of distractor was affected up to its disappearance or conversion into a facilitator. This result established a clear relationship between inhibition (the mechanism putatively behind negative priming) and working memory.

Under this model it is also stated that WMC influences inhibition capacity. In a similar experiment, Conway, Tuholski, Shisler, and Engle (1999) demonstrated that participants with high WMC showed negative priming in the load 0 condition of the dual negative priming task, while the low WMC group did not, since they were unable to suppress distraction even in the easiest condition. Conway et al. therefore concluded, that a certain WMC is required to be able to deal with distraction.

This relationship between WMC and inhibition can be explained because WMC reflects the capacity to control attention, which is also involved in the inhibitory capacity. This relationship was explicitly mentioned by Hasher and Zacks (1988) in their inhibitory theory of aging, where it is argued that the reduction in WMC observed in older adults is due to an impairment to inhibit non-relevant information. In later proposals, Hasher, Zacks, and May (1999) distinguished three stages of processing where inhibition could intervene: access, deletion and restrain. These are briefly described below:

a) Access. In the perceptive stage, inhibition suppresses irrelevant information from the external world or internal thoughts and avoids that it gets *access* to working memory. For example, high WMC participants are more capable to focus their attention on the relevant stimuli in the flanker task, avoiding distractors to enter the cognitive system (Gratton, Coles, Sirevaag, Eriksen, & Donchin, 1988; Heitz & Engle, 2007; Redick & Engle, 2006).
b) Deletion. Inhibition also acts suppressing those memory traces that have been activated in parallel to relevant memory representations, but do not have any utility to carry out the task at hand. High WMC participants are better at suppressing proactive interference (Kane & Engle, 2000; Rosen & Engle, 1998), which allows them not to commit intrusions in tasks of high interference, but as a side effect, suppression has a cost, causing them to be slower when learning again material that was already learnt.

According to Redick, Heitz and Engle (2007), WMC supports inhibition. In their experiment (Kane & Engle, 2000), four lists of words were learnt, the first three contained related material, and the forth new unrelated material. A proactive interference (PI) buildup was expected from list 1 to 3 and a release of interference in the list 4. In addition, attentional resources were loaded using a simultaneous tapping task with three conditions: no tapping, simple tapping and complex sequence tapping. In no and simple tapping conditions, high WMC participants showed lower PI buildup than low WMC participants. However, both groups obtained similar PI buildup in the complex condition. This shows that high WMC participants were allocating attentional resources to inhibiting PI in simple conditions, but when they divided their attention between the two complex tasks, they were unable to suppress interference.

c) Restrain. Finally, inhibition also suppresses inadequate automatic responses in favor of others that are more elaborated or more adaptive for a new situation. For example, low WMC participants showed more interference in a Stroop task (Kane & Engle, 2000), indicating that they tended to read words instead of saying the color.

Thereby, according to Engle and his collaborators WMC and inhibition are interdependent, the higher the WMC, the better the inhibitory control. Both are the core of executive functions (Nyberg et al., 2009), and determine other higher order processes, like reasoning and intelligence. Instead, Hasher, Zacks, and May (1999) defend that inhibition capacity is what determines WMC.

Chapter 3. Long-term memory

Chapter 3. Long-term memory

Memory processes have been traditionally classified into encoding, consolidation and retrieval (Baddeley, Eysenck, & Anderson, 2015; Craik & Lockhart, 1972; Squire & Alvarez, 1995; Tulving, 1967; Tulving & Thomson, 1973). This classification was potentiated by neuropsychological data from patients with brain damage that affected particular areas and caused specific deficits.

Following the double dissociation method many (see for example, Milner, 1962; Tulving, 1985) models of cognitive processing were established and helped developing cognitive science. In the case of memory, it was subdivided in two wide systems: procedural/implicit and declarative/explicit. These are presented below.

1. Implicit memory

Broadly speaking, implicit memory stores information in a way that makes its content difficult to be verbalized, either because the individual is not aware of having perceived that information before, or because it relates a behavior that has been highly automatized with practice. Depending on the type of implicit memory it will or not demand intentional learning at encoding. On the contrary, all types of implicit memory retrieval occur without awareness and under low attentional control (Tulving & Schacter, 1990). Three types of implicit memory have been described (Baddeley et al, 2015): classical conditioning, facilitation or priming, and procedural learning. In the context of our research, only facilitation/priming will be relevant.

1.1. Facilitation/Priming

Facilitation (Schacter, 1992) refers to the faster perception, processing and/or recognition of an element after having been presented before. All sensory modalities manifest this phenomenon, which is called perceptual priming (Roediger & McDermott, 1993; Tulving & Schacter, 1990). Moreover, conceptual priming is also possible and consists of the facilitation produced by the previous presentation of an element that was processed semantically and thereby, encoded under a more elaborate processing (Roediger & McDermott, 1993). Neurologically, facilitation is manifested by a decrement in activation in the brain area where the representation of the item in question was allocated (Schacter, Dobbins, & Schnyer, 2004). The previous processing of the item makes that no further activation is required (Baddeley et al., 2015).

Thus, facilitation may be measured through two indirect tasks:

a) Perceptual priming: faster perception of superficial features of an element once it has been perceived before. The benefit obtained in the recognition is sensitive to the perceptual similarity between encoding and testing, and a change in the perceptual modality (visual encoding vs. auditory recognition) can reduce those benefits.

b) Semantic priming. Once an element has been semantically processed, decisions about the same item become faster. An example of a conceptual priming task will be used in our Experiment 3.

2. Declarative memory

Declarative memory refers to the information that can be explicitly recovered, making possible the verbalization of the memories. There are two types of declarative memory: episodic and semantic (Baddeley et al., 2015). Episodic memory encodes autobiographical information in an intentional and incidental manner; however, recovery is totally explicit and requires cognitive effort, with the involvement of attentional and executive processes. The stored representations contain an experienced episode compounded of general knowledge, emotional information as well as their temporal order (Baddeley et al., 2015). On the other hand, semantic memory refers to the general knowledge about the world, which is broken away from temporal or emotional links. This type of knowledge is stored in hierarchical networks, built according to the relations that the representations have between them (Baddeley et al., 2015; Loftus & Suppes, 1972). These networks are conformed of nodes (bird, fish) organized hierarchically according to their degree of generality, ranging from more to less general. As we reach the lowest levels, the meaning becomes more specific. Each node is linked to characteristics (fly, feathers, swim) that define it.

According to the Spreading Activation Model (Collins & Loftus, 1975), when a node is activated, this activation is largely spread to concepts that are highly related, decaying this activation as more unrelated the concept is.

Craik and Tulving (1975) demonstrated that memory may be encoded with different degrees of elaboration by showing that recognition improves as the degree of elaboration in encoding increases. Considering that semantic memory is organized hierarchically, the memory trace will be stronger when more effort is made to integrate it into the semantic hierarchy containing our knowledge of the world.

Recovering of a memory trace is carried out progressively through retrieval cues, since memory is associative. Through these associations, memories are reached through the process of spreading activation. Each memory trace has an internal state that reflects their level of activation, which varies and reflects the degree of access to the memory representation. The memory trace increases its activation if an external or internal stimulus is associated with it, or if attention is focused on it. The activation lasts for a time even after removing the attentional focus. This activation spreads to related memory representations.

There are some factors that determine recovery from long-term memory. First, when information is being encoded it is important to pay attention to the cue/s that accompany it; otherwise, the cue/s will not serve as a way to prompt memory targets (Craik, Naveh-Benjamin, Ishaik, & Anderson 2000). The cue must be relevant and be strongly related to the target, but also it must be present when the target is encoded. The participant must realize about this relationship in order for the cue to be useful. In addition, the number of cues increases the likelihood of target activation. When the target is encoded in a more elaborative way, it has been related to more internal cues that later will help to recover the target. Furthermore, it is worth noting that the target memory trace must be strong enough to be reachable through its cue. If the memory trace is weak, it will be difficult to spread activation from a cue, reaching the threshold that allows recovering (Moscovitch & Craik, 1976).

Also, encoding strategies facilitate recovering, since the same strategies may be applied when the target information is being searched (Baddeley et al., 2015). In addition, our mind must be set to remember certain information, which will make the cues significant for this purpose; otherwise, cues will not be helpful at all. Finally, the context where encoding took place, acts as a strong cue for recovering. This context refers to emotions, mood, or thoughts that occurred in the moment when the target was learnt (Baddeley et al., 2015).

Furthermore, long-term memory can be measured through different direct memory tests, which assess intentional recovery. This means that it is necessary to recover the context, which serves as a cue. Direct tests vary in the number of cues provided, in the amount of information to be retrieved, and the kind of recovery strategies that must be carried out. These direct memory tests are: a) Free recall, in which recall is highly dependent on the context of recovery, which will be used as a cue to track the target information, and on searching strategies to recreate the memory stored in a given order. This test is sensitive to individual skills in organizing information during encoding. b) Cued recall tests instead provide cues to assist recovering, focusing the search on specific elements. They make recovery easier and less dependent on recovery strategies than in free recall. c) Recognition tests constitute the simplest type of recovery, since they only require making a decision. Recognition tasks can be very context dependent or very little depending on the design of the task.

2.1. Recognition memory

Recognition memory requires the participant to distinguish whether any information presented has already been presented or, on the contrary, is new. This decision can be made through a forced choice recognition task, that is, the 'old' item is presented along with new ones (distractors) and participants must choose the old one; or through a yes/no recognition task, where old and new items are presented one by one and participants must decide whether they have been previously seen or not. In this case, the distractors (new items) provide information about the participants' level of memory trace recall, which is reflected in the degree of discrimination between new and old items.

In both cases, people manifest a certain tendency to guess, that is, to respond as recognizing the item as old despite expressing some doubt. The pressure to produce an answer to a question provokes that decision-making is based on the familiarity of the information presented. The tendency to guess depends on the response bias of individuals, since some are more conservative in their decisions than others. It is important to distinguish between what is due to memory and what is due to guessing. Therefore a theoretical model of memory processes is necessary to accurately determine the degree of recognition.

The theoretical model that accounts for this problem is the "Signal Detection Theory" (Green & Swets, 1966). Four types of response can be given in a recognition task: a) Hit: the person is aware that an item has appeared before, and therefore, it is considered correctly old, b) Miss: an old item is presented, but the person does not recognize it as old, saying that it is new, c) False alarm: a new element is presented, but the person believes incorrectly that is old, and d) Correct rejection: a new item is presented, and the person correctly recognizes it as new.

According to this theory, the memory traces have activity-strength values, which reflect their level of activation in memory and determine how familiar a memory trace is. The more attention was paid to the item during encoding and the more repetitions of the same item occurred, the more familiar the item will be. Interestingly, the new items will also show a certain degree of familiarity, mostly when they have any relation to the actual targets.

According to Green and Swets (1966) the familiarity of a set of old items is normally distributed, as is the familiarity of the new items. Each set has a different average familiarity, being greater the average for old items. Even so, both distributions overlap, since some old items are weakly encoded and their memory traces have little activation. Contrarily, some new items could be particularly familiar. For some participants, the distributions would be very close to each other, with a minimum difference in the familiarity average between them. For others, the familiarity average of each distribution would be very distant and not overlapping, when old items were studied well. Increasing study time or repetition rate move away those distributions. The recognition performance depends on the difference between the familiarity averages of both distributions. The difference between the distribution averages is known as the “d prime” index.

Green and Swets (1966) explained that decisions in a recognition task are made based on a critical level of familiarity, over which the person will consider an item as studied, and below which, it will be considered new. This critical level is called "criterion" and is calculated through "Beta" (ß). This parameter indicates the exact level of familiarity in which the person places the criterion and estimates the tendency to guess. If the criterion (ß) is placed between the averages of the two distributions, the person does not present any bias.

Some authors state that other additional processes must account for recognition apart from familiarity (Atkinson & Juola, 1974; Mandler, 1980; Jacoby & Dallas, 1981; Aggleton & Brown, 1999; Yonelinas, 1999). According to this dual-process account, recognition is the result of carrying out two types of processes that may occur at the same time or alternatively. There is a process of recognition based on familiarity, which refers to the possibility to recognize something without remembering the source, despite the stimulus is familiar. This process is automatic, fast and depends on the strength of the memory trace, but lacks episodic details. The signal detection theory accounts for this type of recognition.

On the other hand, recognition may occur by retrieving the details of the episode in question, which is a slower and effortful process, similar to recall. A more elaborated encoding would lead to a “recall-to-reject” strategy, whereas an encoding based on superficial information, would lead to a “distinctiveness heuristic” strategy, that is, to reject items that do not elicit those details. The recall-to-reject process is an exclusion strategy that consists on recollecting the information excluding that item from having occurred, while the distinctiveness heuristic is a failure to recall the needed information (Schachter, Gallo, & Kesinger; 2007), so decisions about the item having occurred are made on superficial or familiar features.

Yonelinas (2002) has argued that recollection requires attention and controlled processing; therefore, if an item is encoded while attention is divided, it will be less likely for the subsequent recognition to be based on recollection. In this manner, people will rely on familiarity.

2.2. Forgetting

Memories are forgotten in a diverse way. Since one of our experiments (Experiment 5) deals with forgetting, we present here the main relevant data concerning forgetting.

2.2.1. Incidental forgetting

A memory trace may be available, and not accessible, but also it can become weak with time. Connections between the item, its characteristics and other representations may also decrease in strength along time. In addition, when encoding and recovering contexts change, it is more difficult to access previous memories. Over time, our context and mind change, making more difficult to cue old memories (Mensink & Raaijmakers, 1988). Moreover, when new items are added to our memory, it also makes the access to previous memory traces more difficult, especially if they are very similar.

This gives rise to interference, which becomes greater as the cue giving access to the memory trace is associated with additional memories (Anderson, Bjork & Bjork, 1994). If a cue is associated with many competitors, cue recovering is less effective (Watkins & Tulving, 1978). Interference can be retroactive, causing forgetting of old memories by learning new elements that prevent the recovery; or proactive, interfering old memories with the recovery of more recent memories.

Interestingly, recovery of certain information may decrease the access to other related information (Anderson et al., 1994). This was studied with the Retrieval Induced Forgetting paradigm (RIF). This paradigm is studied with a task that consists of three phases. In the study phase, participants study exemplars from several categories. In the practice phase, they are presented with only half of the previous categories, and only half of the exemplars from these categories –repeated practiced exemplars (Rp+)-. Participants have to retrieve these words using as a cue the category name and the two first letters of the exemplar (FRUIT-Or______). Finally, participants carry out the test phase, where they perform a recognition task, in which several types of exemplars are presented one by one. These exemplars are: a) Rp+, b) Rp-: exemplars from the practiced categories, but not included in the practice phase; c) Nrp: exemplars from the non-practiced categories; and d) new items. In this test phase there are two blocks, in the first, Rp- and Nrp are presented, and in the second, Rp+ and Nrp. Participants have to decide whether these exemplars appeared or not in the study phase. The results in this task show that individuals recognize fewer Rp- than Nrp exemplars (RIF), while Rp+ are better recognized than Nrp (facilitation). It seems that the presentation of part of the items associated to a category cue strengthens those exemplars increasing their activation (Rp+), but impairing subsequent recovering of exemplars (Rp-) that interfered with Rp+ in the practice phase. A variant of this task, the “dual RIF”, will be used in Experiment 5.

Attempts to explain the interference produced in the RIF task postulated two mechanisms called associative blocking and associative unlearning. Associative blocking (Anderson et al., 1994) is described as the competition between memories for access to consciousness when a cue that they shared is given. Competition is dependent on the association strength between the cue and the competitor, so there will be more interference when the competitor is more strongly associated with the cue than the target, because they have been presented together more often. In the case of RIF, blocking explains why it is more likely to recover more Rp+ items in the recognition phase than Rp- items, since the association between Rp+ and the cue is stronger. In addition, every time that the Rp+ is retrieved, the activation of its memory trace is strengthened. Thereby, it will be even more likely to recover Rp+, and much less Rp-. For this reason, this effect is controlled placing the block with Rp+ items at the end of the recognition task.

On the other hand, associative unlearning (Melton & Irwin, 1987) explains why the association between a memory trace and a cue weakens over time, so a fragmentation of the components that make up a memory is produced, which may be due to the storage of new information. According to this hypothesis, the individual penalizes the recovery of the old memory associated to a cue, instead of the new one, causing their connections to weaken over time. RIF is explained under this hypothesis as the penalty made during the practice phase to the interference of Rp- over Rp+ items. This fact weakens the association between cue and Rp-, in favor of Rp+.

However, the dominant and simpler view proposes an active mechanism of inhibition as the cause of forgetting (Anderson & Levy, 2007; Levy & Anderson, 2002; Wimber, Alink, Charest, Kriegeskorte, & Anderson, 2015). Similarly to the inhibition that it is exerted for stopping an automatic behavior (Verbruggen, Logan, & Stevens, 2008), it is possible to inhibit internal actions like recovering memory traces associated to a cue.

According to Levy and Anderson (2002), inhibition explains more accurately certain events that occur in forgetting than blocking association and associative unlearning. Inhibition theory of RIF is based on four assumptions that suggest that its effect is due to inhibition and not to interference:

a) Cue independence: inhibition reduces the memory trace activation, which can be observed when retrieval is aided with the studied cue, but also when a non-studied but target-related cue is presented.

b) Retrieval dependence: inhibition occurs only in a situation of interference, in which it is necessary to retrieve an item from several candidates. When an extra-study phase is provided and Rp+ are studied –instead retrieved-, no RIF effect occurs. It is therefore the active recovery what induces inhibition. Blocking assumption is refuted, since over-activation of Rp+ per se do not cause forgetting of Rp-.

c) Interference dependence: the frequency of Rp- exemplars with respect to their category affects the interference that produces, so that Rp- items with higher frequency need to be more strongly inhibited than those with lower frequency. RIF is stronger when the exemplars to be inhibited (Rp-) are strongly related to the category. When the exemplars are weakly related to the category, there is no RIF, or even a facilitation effect is given. The strength of the Rp- item is what determines whether RIF is or not produced, and not the strength of the Rp+ as the strength-dependent competition assumption stated (Anderson et al., 1994).

d) Strength independence: the amount of forgetting is not related to the strength of the association between an Rp+ item and a cue. Actually, when an extra-study list is provided instead a retrieval practice phase, the association strength between Rp+ and cue is increased, but Rp – exemplars are not suppressed. For RIF to occur, it is not enough with Rp+ repetition, which it is always going to produce facilitation, but Rp- must be strongly associated to the category. Stronger relationship of Rp+ with its category does not affect either to retrieval of Nrp.

To summarize, it is argued that the process underlying the typical RIF results is an active mechanism of suppression applied directly to competing exemplars interfering with retrieval of target exemplars at retrieval. Then, if the Rp- item is strongly related to its category, it provokes interference and must be actively suppressed, something that does not occur when the Rp- and category association is weak, since it does not produce interference. Also, results are not better explained by an automatic inhibition mechanism caused by the inhibition of the target over competitors, since the strength of the target does not affect the size of the inhibition exerted over the competitors (Anderson et al., 1994).

In conclusion, it has been argued that the interference models of RIF as blocking have underestimated the individual, defending that forgetting is something passive, in which the person does not intervene. However, the inhibition model has highlighted the individual's role in decision-making when approaches the recovery process. The individual fights against interference, and thus reduction of the accessibility of memory traces is adaptive, facilitating recovery.

It is worth noting that the inhibition account of RIF also has opponents (see for example, Jonker, Seli, & MacLeod, 2013). According to these authors, context change is what would explain RIF and not inhibition. Jonker et al. (2013) argued that the retrieval impairment disappeared when the studied phase was reinstated before the test phase. It was necessary to cue the practice context in order to observe the RIF effect. In addition, they found that when a change of context was included between the study and the extra-study phases, a RIF-like effect was observed. However, this contextual-cuing account has been challenged in several studies (Buchli, Storm, & Bjork, 2015; Miguez, Mash, Polack, & Miller, 2014) finding no replication.

Verde (2012) has also argued that there exists data contradicting each of the assumptions of the inhibitory account and that some aspects could be better explained by the competitor interference account. He proposed the coexistence of both models. The competitor interference account would explain a memory mechanism of forgetting, whereas the active inhibition account would explain the suppression of a representation following a temporal and contextual task demand (Storm & Angello, 2010) or unwanted memories in the long-term memory (Anderson & Levy, 2007).

2.3. Inhibition and declarative memory

According to Anderson and Levy (2007), controlling the access of unwanted memories to awareness is similar to the control exerted when a motor action is cancelled in favor to other more adaptive ones for the new situation. Both mechanisms of control are exerted by the same prefrontal areas and may be considered similar inhibitory processes. In the case of memory, the inhibitory control suppresses a covert process or response. The retrieval process is carried out selecting the proper memory representation among several that have been cued by the same stimulus. It is necessary to override prepotent competitors suppressing them actively. This long-lasting suppression allows performing a task correctly by avoiding interference from non-relevant memory traces. Suppression only takes place when retrieval is exerted and there is a situation of interference that must be solved. Once the trace is inhibited, it will be difficult to recover it even when other cues or memory tests, different to the ones used in the previous study phase, are applied.

This retrieval override also happens when a memory trace must be suppressed intentionally, as it has been shown through the think/no think paradigm (TNT, Anderson & Green, 2001), which is also cue-independent. Anderson et al. (2004) demonstrated through functional magnetic resonance that the same control network involved in stopping a motor response was involved in stopping retrieval of unwanted memories. The results show that control areas of the LPFC were more active during suppression trials. They also showed a correlation between level of deactivation in the hippocampus and behavioral inhibition, supporting the hypothesis of active suppression of memories.

Some authors (see for example, Zellner & Bäuml, 2005) have stated that the type of inhibition exerted in RIF does not need attentional control and that the prefrontal cortex (PFC) is not involved, since forgetting is observed in frontal and Alzheimer's disease patients (Conway & Fthenaki, 2003; Moulin et al., 2002). However, Anderson & Levy (2007) explained these results alluding to the cost-benefit problem. This problem arises after having exerted suppression upon a competitor, for example, during the retrieval or think/no-think phases. When the participant is confronted to the probe that cues the suppressed item, a high interference emerges and blocks the access to the inhibited element. In order to respond, the participant must suppress such interference to find the required item. Participants apply suppression either at retrieval or think/no-think phases, but they also exert inhibition during the test phase, when interference arises. The amount of inhibition applied is the same for both phases. However, this trade-off is different for patients with inhibitory deficits, since they are not able to inhibit during retrieval or think/no-think phase, but the over practice causes them to suffer from high interference that they cannot suppress when they undertake the test phase. As a cause of blocking in the test phase, they do not retrieve Rp- or no think items, performing at the same level as control participants. As a consequence, Anderson and Levy (2007) recommend to use independent probes to solve the correlated costs and benefits problem, not only when dealing with inhibitory processes in memory, but also in any other processes such as executive control, attention or language.

Further support for the cost-benefit problem (Anderson & Levy, 2007) comes from studies using the TNT paradigm with participants of different ages (Anderson, 2004), where same and independent cues were used in the test phase. It was found that participants who show inhibition deficits just had difficulties suppressing unwanted memories when independent cues were applied, while all participants performed similarly under the same-cue condition. Anderson & Levy (2007) defended that applying independent probes was the best way to control the correlated cost and benefit problem.

Finally, the involvement of attentional control in RIF has been demonstrated in studies (Ortega, Gómez-Ariza, Román, & Bajo, 2012; Román, Soriano, Gómez-Ariza, & Bajo, 2009) that have combined RIF with a dual task. These studies will be explained in more detail in the Experiment 5, where physically active and passive participants will be compared when performing a dual RIF task.

OBJECTIVES

Project objectives

Our purpose with this project was to explore the effects of chronic cardiovascular exercise in young participants' cognition and brain, in order to establish this intervention as an inexpensive practice to enhance cognitive functions and prevent cognitive and brain deterioration since early adulthood.

To this aim, we conducted a series of cross-sectional studies with several samples of young adults. They were distinguished by their frequency of cardiovascular exercise and their level of fitness. We tried to create extreme fitness groups to overcome the fact that young people are at their cognitive peak, being difficult to find differences between them.

Participants were assessed measuring different subcomponents of executive functions, such as working memory capacity, inhibition, and executive control. The aim was to explore the specific mechanisms contributing to the executive enhancement found in the research carried out in older adults and children.

In addition, we examined how modulation of these subcomponents -selective attention and working memory load- might affect long-term memory.

Self-control, personality, and achievement motivation were also explored to investigate to what extent these variables explain the effects of physical activity on cognition.

Finally, we investigated whether long-term exercise could be related to brain morphometry. Grey and white matter volume, concentration, as well as white matter myelin integrity were compared between physically active and passive groups. Besides, the pattern of brain activity was studied in both groups of participants while they were performing a motor inhibition task.

EXPERIMENTS

Experiments

1. Padilla, C., Perez, L., Andres, P., & Parmentier, F. B. (2013). Exercise improves cognitive control: evidence from the stop signal task. *Applied Cognitive Psychology*, 27(4), 505-511. doi:10.1002/acp.2929

2. Padilla, C., Pérez, L., & Andrés, P. (2014). Chronic exercise keeps working memory and inhibitory capacities fit. *Frontiers in Behavioral Neuroscience*, *8*, 49. doi:10.3389/fnbeh.2014.00049

3. Padilla, C., Mayas, J., Ballesteros, S., & Andrés, P. (In preparation). The role of chronic exercise on memory and selective attention.

4. Padilla, C., & Andrés, P. (In preparation). Self-regulation and personality traits in physically active and passive young adults.

5. Padilla, C., Andrés, P., & Bajo, T. (Submitted). Improving memory inhibition: a study of RIF, executive control and fitness.

6. Padilla, C., Bajo, T., & Andrés, P. (In preparation). Aerobic exercise effects on the brain in active and passive young adults.

Chapter 4.
Experiment 1: Exercise improves cognitive control: evidence from the stop signal task

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Exercise Improves Cognitive Control: Evidence from the Stop Signal Task

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Summary: The aim of this study was to test the hypothesis that exercise improves executive control. We compared the performance of physically active and passive young participants in two versions of the stop signal task: a strategic (more executive) and a standard version. The results showed that active participants were more efficient than passive at inhibiting a response in the strategic version, suggesting that (1) physical exercise appears positively associated with improved cognitive control in healthy young participants, adding to evidence gathered in children, aging and clinical populations; and that (2) the strategic version of the stop signal task constitutes a more sensitive task than executive tasks previously used. Although the data point out a link between physical activity and executive control, they also have potential practical implications for health authorities and the general public by strengthening the view that exercise, beyond its physical health benefits, also has positive effects on cognitive functioning. Copyright © 2013 John Wiley & Sons, Ltd.

INTRODUCTION

Executive functions refer to those complex cognitive processes dealing with attention and control of several subprocesses to achieve a particular goal. They play a central role in general cognition and have been linked to intelligence (Barbey et al., 2012; Cole, Yarkoni, Repovš, Anticevic & Braver, 2012), social skills (Stuss & Levine, 2002) and academic performance (Latzman, Elkovitch, Young & Clark, 2010). Moreover, research has established that they are supported by the prefrontal cortex (Kane & Engle, 2002; Shallice, 1988) and global connectivity (Andrés, 2003; Cole et al., 2012). Finally, they are sensitive to multiple forms of brain damage (Stuss & Knight, 2002) and developmental changes (Anderson, Jacobson & Anderson, 2008).

Given the importance of executive functions in efficient cognitive functioning, it is of both theoretical and practical interest to investigate whether such functions can improve in certain circumstances. Basing their work on the principle of neuroplasticity, some researchers have recently suggested that executive functions can be enhanced through cognitive training (e.g., Klingberg, 2010). Interestingly, researchers have suggested that executive functions might also be enhanced through physical activity, which is supported by the fact that frontal areas mediate the cognitive benefits of exercise in active people (e.g., Colcombe et al., 2004; Weinstein et al., 2012). A number of studies have, for example, demonstrated the benefits of aerobic exercise on executive functions in cognitive aging (see Hertzog, Kramer, Wilson & Lindenberger, 2009; Hillman, Erickson & Kramer, 2008; Kramer, Erickson and Colcombe, 2006 for reviews). Developmental studies with children converge in showing that executive functions seem more sensitive to the effect of exercise than other functions (see Tomporowski, Davis, Miller & Naglieri, 2008 for a review). Finally, exercise has also proven beneficial for executive functions in clinical populations such as children with attention deficit/hyperactivity disorder (Chang, Liu, Yu & Lee, 2012), mild cognitive impairment patients (Baker et al., 2010) and overweight children (Davis et al., 2011).

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Whereas some evidence points out the cognitive benefits of physical exercise in old age or certain clinical populations, there has been little research investigating such benefits in young healthy adults. It is of interest to note that several past studies focused on the impact of acute (for example, a bout of intense cycling) physical exercise on executive functions in young adults, giving rise to diverging results. Huertas, Zahonero, Sanabria and Lupiáñez (2011) found no significant benefit in executive control as measured in a flanker task. In contrast, other studies reported significant improvements in executive functioning as measured in a Stroop task (e.g., Sibley, Etnier & Le Masurier, 2006).

We focus on chronic exercise, rather than on the transient effects that might be observed during or immediately after a session of acute exercise. Chronic exercise refers to exercise routines carried out for a number of years. Because this type of exercise is more likely to create permanent changes in the brain, and on the basis of the idea of cognitive reserve (Stern, 2009), one may hypothesize that it should benefit executive functions to a greater extent than acute exercise. To our knowledge, only a few behavioral studies have focused on the topic of chronic exercise and executive functions in young healthy adults and have been inconclusive (see Guiney & Machado, 2013 for a similar conclusion). For example, using a flanker task, Hillman, Kramer, Belopolsky and Smith (2006) found that increased levels of chronic exercise reduced the negative impact of incongruent stimuli in older but not in the younger participants. In a different study, Hillman et al. (2006b) were also unable to find a specific improvement in the incongruent condition in active compared with non-active young adults using the same task.

One potential reason why some studies failed to measure an impact of exercise, acute or chronic, may stem from the complexity and multidetermined nature of executive functions, as well as the difficulty to operationalize them (Burgess, 1997). Furthermore, and perhaps most critically, tasks designed to measure executive functions typically exhibit low reliability (Rabbit, 1997). In relation to the role of physical exercise, Etnier and Chang (2009) have shown that effect sizes greatly differ between studies and have recommended that only strongly theoretically driven tasks be used. Finally, in relation to the potential link between executive functioning and regular exercise, Guiney and Machado (2013) have also recently claimed that 'the multi-faceted nature of these tasks makes it difficult to discern which cognitive functions underlie the reported links' (p. 75).

The aim of the present study was to look for the first time at the effects of chronic exercise on executive functions in healthy young adults using a highly reliable and theoretically driven task: the stop signal task (SST; Logan, 1994), a task that has proven especially useful for the study of response inhibition and considered a hallmark of executive control (Verbruggen & Logan, 2008). It has also been argued that the SST is the only inhibitory task that is difficult to explain in terms of non-inhibitory mechanisms (MacLeod, Dodd, Sheard, Wilson & Bibi, 2003). Moreover, it heavily depends on the frontal cortex, a region that seems to mediate the benefits of exercise on cognition (Colcombe et al., 2004; Weinstein et al., 2012).

The SST is designed to measure how efficiently one can interrupt the production of a response upon the presentation of a signal to do so. Its reliability has been proven to be the highest among executive tasks (.92; Miyake et al., 2000). According to the Horse Racing Model (Logan, 1994), GO and STOP processes compete in this task, the winner being determined by its speed relative to the other. Specifically, to inhibit a response already underway, inhibition processes initiated upon the appearance of the stop signal need to be faster than the processes in charge of producing that response. Among several measures of performance, the SST provides one relating directly to one's efficiency in interrupting an already initiated response, namely the stop signal reaction time (SSRT). This measure is defined as the difference between the time taken by a participant to produce a response in GO trials and the interval required between stimulus and stop signal in STOP trials for that participant to successfully withhold his or her response.

The SST has proven to be sensitive to cognitive aging (e.g., Andrés, Guerrini, Phillips & Perfect, 2008), numerous pathologies (from frontal lesions, Aron, Fletcher, Bullmore, Sahakian & Robbins, 2003, to attention disorders, Alderson, Rapport & Kofler, 2007), as well as pharmacological manipulations (e.g., Rubia, Halari, Mohammad, Taylor & Brammer, 2011). Given the task's established sensitivity and reliability, and the diverging results found in the literature regarding the possible impact of physical exercise on executive functions, our study sought to use the SST to establish whether chronic exercise may improve one's inhibitory control processes.

Recent studies employing the SST have unearthed important differences in performance as a function of strategic factors. In particular, response slowing seems to be a strategic approach commonly adopted by participants to perform the task, whereby participants slow down responses in GO trials to increase the chance of withholding their response should a stop signal be presented (Leotti & Wager, 2010; Liddle et al., 2009; Sella, Bonato, Cutini & Umiltà, 2013). In line with the notion that performance is subject to strategic factors, Verbruggen and Logan (2008) demonstrated that reaction times (RTs) in GO trials can be modified by instructions, namely by asking participants to disregard or process stop signals. Indeed, participants produced faster RTs in the first instance relative to the latter. Studies with neuropsychological patients also support the view that the task instructions are important. For example, differential frontal activity has been observed for the two versions (Aron et al., 2003). In the *standard* version of the SST (e.g., Verbruggen et al., 2008), participants are instructed that 'they should not postpone the responses while waiting for the potential occurrence of the stop signal (tone), and to respond as fast as possible in all trials', thereby discouraging a more strategic approach to the task and resulting in faster RTs and more errors on stop signal trials. Thus, two versions of the SST can be distinguished: a standard one in which participants are asked to privilege speed, and a strategic one in which they are allowed to adopt a more conservative approach in order to improve accuracy.

In this study, we compared physically active and passive participants in the standard and strategic versions of the SST. The key measure was the SSRT, considered to be the most reliable index of motor inhibition (Logan & Cowan, 1984; Logan, Schachar & Tannock, 1997) because it is thought to be independent, given its adaptive nature, of the individual response speed. A short SSRT reflects a shorter internal inhibitory response to the stop signal (i.e., faster stopping process) independently of the early or late occurrence of the stop signal itself. Our prediction was that exercise would improve inhibitory control, that is, would reduce SSRT, and that this effect would be more easily observed under the strategic instructions because it increases the executive demands of the task.

METHOD

Participants

Two groups of participants were included in this study: 36 active and 36 passive healthy young adults randomly subdivided into two groups according to the instructions they received (strategic or standard, see Table 1 for demographic details). The inclusion criteria for the active participants was that they should have been exercising for at least 10 years following a minimum pattern of 6 hours per week, distributed across a minimum of 3 days a week. The inclusion criteria for the passive young adults were that they should not have practiced exercise more than 2 hours per week for the last 4 years. Level of physical activity was assessed applying a structured phone interview. Participants were asked about the sports and physical activity routines they performed along their lives, as well as the days per week and hours per day they engaged in such activities. Participants were students recruited from the University and from the general public. All participants gave their informed consent and were paid or given course credits in exchange for their participation in the study, and the experiment was performed in accordance with the ethical standards stated in the 1964 Declaration of Helsinki.

The four groups of participants did not differ in terms of age [$F(3, 68) = .398$, $p = .755$, $\omega^2 = .008$] or years of formal

Table 1. Demographic variables

	Active		Passive	
	Standard	Strategic	Standard	Strategic
N	22	14	22	14
Age	22.82 (3.42)	23.93 (3.05)	23 (4.11)	22.57 (3.37)
Education	12.45 (0.86)	12.29 (0.73)	12.18 (0.59)	12 (0)
Vocabulary	44.59 (4.15)	42.86 (9.96)	42.59 (5.00)	41.57 (6.78)
Rockport	56.61 (8.40)	55.08 (6.45)	48.19 (7.10)	48.00 (4.18)

Note: Average and SDs (in brackets) for Age (age of participants at the moment of testing), Education (number of completed years of formal education), Vocabulary (Wechsler Adult Intelligence Scale Vocabulary subtest score) and Rockport (Rockport Fitness Walking Test score).

education [$F(3, 68) = 1.468$, $p = .231$, $\omega^2 = .028$] (Table 1). The latter observation was corroborated by identical vocabulary levels measured with the Vocabulary subtest from the Wechsler Adult Intelligence Scale (Wechsler, 1999), [$F(3, 68) = .719$, $p = .544$, $\omega^2 = .002$]. Active participants had practiced sport for an average of 210 months (17.5 years) and a frequency of 11.7 hours ($SD = 7.02$) per week. The passive participants had practiced sport during their childhood in an average of 79 months (6.5 years) with a mean frequency of 5 hours ($SD = 3.38$) per week. Averages of years of sport [$t(70) = 7.062$, $p < .001$, $d = 1.688$] and of frequency in hours per week [$t(50,405) = 4.874$, $p < .001$, $d = 1.37$] were significantly different.

Cardiorespiratory capacity

In addition to the interview used to assess history of physical activity, the Rockport 1-mile Fitness Walking test (Kline et al., 1987) was used to assess cardiorespiratory fitness. This submaximum cardiovascular stress test provides an accurate estimate of the maximum level of oxygen consumption (VO_2max), with a correlation coefficient of .88 between VO_2max estimated based on performances during the test and a direct measure of VO_2max during an increment test on a treadmill (Kline et al., 1987; Weiglein, Herrick, Kirk, & Kirk, 2011). Higher values of VO_2max are considered to reflect higher aerobic capacity, because it means greater oxygen consumption.

Design and procedure

Once participants were recruited following the phone interview, they came to the university to take part in the study. They first completed a health questionnaire including medication history, and the vocabulary test. They then performed the SST, after which their height and weight were measured. Finally, they performed the Rockport 1-mile Fitness Walking Test (Kline et al., 1987). As part of this test, participants were required to walk 1 mile, and the time they took to do so was recorded using a stopwatch. VO_2max was estimated using the Equation (2) (Appendix) provided in Kline et al. (1987).

Stop signal task

The SST was presented on an LG computer running E-Prime (Schneider, Eschman & Zuccolotto, 2002) and using a 19-inch Phillips monitor with a resolution of 1024 × 768 pixels. Participants were seated approximately at 50 cm of distance from the screen and wore headphones. The fixation sign (+) and stimuli were presented in the center of the screen, in white, on a black background. Two types of trials were presented at random: the GO (75%) and STOP (25%) trials. In the GO trials, participants had to decide as fast as possible whether a geometric figure displayed on the screen was a square or a circle. They responded by pressing 'Z' or '-' of the keyboard with the index fingers. In the STOP trials, the procedure was the same with the difference that a tone was presented shortly after the geometric figure, and participants had then to inhibit the production of a response. The interval between the geometric figure and the STOP signal was varied by the task following an algorithm taking into account the participant's performance in the latest STOP trial. When participants successfully withheld a response in a STOP trial, the interval between the figure and the stop signal was incremented by 50 ms. When participants failed to withhold their response, it was decreased by 50 ms. Doing so, the program sought to establish the interval for which participants withheld their responses with an accuracy of 50% (see Verbruggen et al., 2008 for more details).

Every GO trial started with a fixation point located in the middle of the screen that lasted 250 ms, after which, one of two geometric figures (square or circle) was displayed for 1250 ms. The fixation point then re-appeared for 2000 ms. Participants therefore had a maximum of 3250 ms to responded upon the onset of the geometric figure. In the first STOP trial, the stop tone was presented 250 ms after the visual stimulus' offset. In later STOP trials, this interval was adjusted on the basis of the participant's performance as described earlier.

Two sets of instructions were compared in the SST. Participants were told that in the 25% of the trials, a tone would be presented and that in such situation they should withhold their response. In the *strategic instructions* condition, no additional information was provided. In the *standard instructions* condition (Verbruggen et al., 2008), participants were told that on half of the occasions where a tone was presented, it would be presented very early and that it would therefore be relatively easy to withhold a response. They were also told that on the other half of the STOP trials, the tone would come late, making it more difficult to inhibit a response. Importantly, participants were also warned that they should not postpone the responses while waiting for the potential occurrence of the stop signal.

Performance in the SST was assessed using several measures (Verbruggen et al., 2008):

(a) go RT: time to respond to the go trials.
(b) stop signal delay (SSD): mean delay between visual and auditive stimuli along all stop signal trials;
(c) stop signal RT (SSRT): latency of the inhibition process, calculated by subtracting the mean SSD from the mean RT in go trials;
(d) signal respond RT (SRRT): mean time to respond incorrectly in the stop trials;
(e) percentage of correct responses in the go trials; and
(f) percentage of missed responses in the go trials.

RESULTS

First, and as expected, active participants showed higher scores in the Rockport test [$F(1, 68) = 21.087$, $p < .001$, $\omega^2 = .217$] reflecting better VO_2max indexes as a consequence of their exercise routines, confirming that the active participants were physically fitter than the passive ones.

As described earlier, the two critical measures to test our hypothesis were those assessing whether participants' RTs did vary as a function of instructions (GO RTs) and the time they required to inhibit an already initiated response (SSRT). These measures are presented in Figure 1, whereas all other measures (SSD, SRRT, percentages of correct and missed responses) are reported in Table 2.

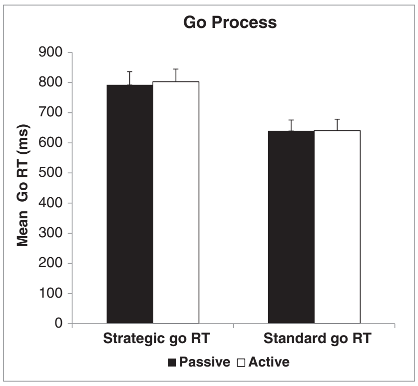

Figure 1. Go RTs for active and passive participants in the stop signal task

A univariate 2 (group) × 2 (instructions) ANOVA carried out on the GO RTs revealed a significant effect of instructions [$F(1, 68) = 14.977$, $p < .001$, $\omega^2 = .166$], whereby the strategic version yielded longer RTs. No significant effect of group [$F(1, 68) = .017$, $p = .896$, $\omega^2 < .012$] or instructions × group interaction [$F(1, 68) = .015$, $p = .902$, $\omega^2 < .012$] were found.

A univariate 2 (group) × 2 (instructions) ANOVA on the SSRT data revealed significant effects of instruction [$F(1, 68) = 4.289$, $p = .042$, $\omega^2 = .039$], group [$F(1, 68) = 5.087$, $p = .027$, $\omega^2 = .049$], as well as an instruction × group interaction [$F(1, 68) = 7.131$, $p = .009$, $\omega^2 = .074$]. The *t*-tests revealed that active participants exhibited faster SSRT than passive participants in the strategic [$t(26) = 2.806$, $p = .009$, $d = 1.1$] but not in the standard condition [$t(42) = .363$, $p = .718$, $d = 0.1120$]. Furthermore, active participants inhibited responses faster under strategic instructions compared with standard instructions [$t(34) = -3.269$, $p = .002$, $d = 1.12$], whereas passive participants showed similar SSRTs regardless of instructions [$t(34) = .435$, $p = .666$, $d = .435$] (Figure 2).

Further univariate 2 (group) × 2 (instructions) ANOVAs were carried out on the remaining measures (SSD, SRRT, percentage of correct responses and missed responses). They all revealed main effects of instructions (all *p*s < .005) but no significant effect of group or group × instructions interaction (all *p*s > .120)

DISCUSSION

The aim of this study was to examine the extent to which exercise is associated with inhibitory control in healthy young adults using two versions of the highly reliable and theoretically guided SST designed to measure response inhibition (Verbruggen et al., 2008; Verbruggen & Logan, 2008).

Three key findings are worth highlighting. First, both passive and active participants slowed down their go RTs in the strategic version of the task, compared with the standard version. This confirms that, when not prevented from doing so, participants trade speed for accuracy and slow down their RTs. Under this condition, participants carry out both tasks properly, dividing their attentional resources between the go process and the stop process. However, in the standard version, as they are told that 'they should not worry about making mistakes in the stop signal trials' (Verbruggen et al., 2008), participants adapt their responses to the instructions and trade accuracy for speed. In that sense,

Table 2. Stop signal variables

	Active		Passive	
	Standard	Strategic	Standard	Strategic
SSD	353.68 (204.36)	568.75 (176.35)	358.71 (186.81)	504.60 (189.52)
SRRT	574.92 (165.45)	712.01 (159.51)	563.80 (139.90)	698.87 (158.34)
Go Accuracy	96.83 (4.39)	94.50 (7.69)	96.83 (6.05)	89.93 (13.39)
Go Miss	2.43 (4.57)	5.20 (7.85)	2.71 (6.12)	9.32 (13.69)
Go Error	0.74 (1.20)	0.30 (0.76)	0.64 (0.96)	0.71 (1.01)
Stop Accuracy	52.45 (5.11)	53.59 (4.09)	49.57 (12.38)	55.61 (3.53)

Note: SSD, delay between visual and auditive stimuli; SSRT, inhibition process latency; SRRT, RT incorrect responses in the stop trials; Go Accuracy, % correct responses in Go trials; Go Miss, miss responses in Go trials; Go Error, response errors in Go trials; Stop Accuracy, correct inhibited responses in stop trials.

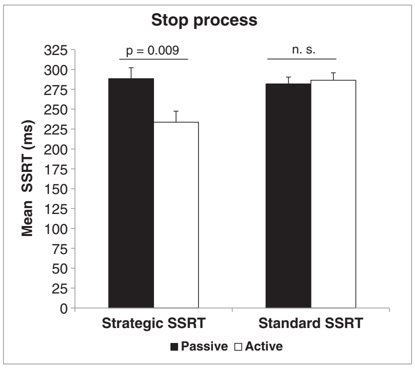

Figure 2. Latency of the inhibition process (SSRTs), calculated by subtracting the mean stop signal delay from the mean RT in go trials, for active and passive participants in the stop signal task

the strategic version of the task requires more 'executive' inhibition than the standard version (Andrés et al., 2008). Importantly, active and passive participants did not differ statistically in the go RTs in any of the versions of the task, because RTs were similar among groups in each condition (see however Renaud, Bherer & Maquestiaux, 2010 for evidence of faster motor responses in active older participants). This finding precludes any explanation of any possible difference between passive and active participants in executive functions in terms of a general change in speed of processing, because if it were the case, it would be reflected both in go RTs and SSRT in both conditions (Salthouse, 1996).

Second, and most important, active participants showed faster inhibition times (SSRT) than passive participants in the strategic version of the task but not in the standard version. This finding confirms our hypothesis that exercise can improve cognitive control in circumstances in which the task instructions increase the demand on executive control.

Third, it is interesting to note that active (but not passive) participants showed better SSRTs for the strategic than for the standard version of the SST, revealing a more flexible use of inhibitory resources and a better adaptation to task demands.

Whereas other studies failed to detect differences in executive control between young passive and active participants in behavioral measures (e.g. Hillman et al., 2005; Polich & Lardon, 1997; Themanson and Hillman, 2006), and the few that have found any difference were in terms of faster reaction times (Hillman et al., 2006a; 2006b; Pontifex, Hillman & Polich, 2009), our study is original in a number of respects worth emphasizing. First, we concentrated on the effect of chronic (as opposed to acute, e.g., Huertas et al., 2011) exercise. This may be important because chronic exercise induces brain cognitive reserve (Stern, 2009) and is accompanied by physiological changes in the cortical areas supporting executive functions. In particular, neuroimaging studies have shown that physically fitter people exhibit larger volumes of prefrontal and anterior gray and white matter (e.g., Colcombe et al., 2004; Floel et al., 2010; Gordon et al., 2008; Weinstein et al., 2012), commonly related to inhibition.

As part of this effort to concentrate on chronic exercise, we used a strict selection criterion for the recruitment of participants. Indeed, our active participants had practiced aerobic exercise for at least 10 years with a frequency of at least 6 hours a week distributed in at least 3 days a week. This exercise routine is more intensive than, for example, the dose recommended by the American Centre for Disease Control & Prevention (CDC, 2000) and the frequency of exercise used in most previous studies. Furthermore, we corroborated the difference in fitness between our two groups of participants by using an objective estimation of cardiovascular capacity, the Rockport 1-mile Fitness Walking Test (Kline et al., 1987)

Second, and equally important, we used the SST (Logan, 1994; Verbruggen et al., 2008), known for being the most reliable measure of executive control (Miyake et al., 2000), and adopted a version increasing the demand on such functions (strategic version). It is important to note that the benefit observed was fairly specific to executive control. As mentioned before, there was no general decrease in response times in active participants, which suggests that the difference between active and passive participants cannot be explained in terms of a general factor (Salthouse, 1996). Also, active participants presented a more efficient SSRT, but only for the strategic (more executive) version of the task, which may give additional support to the idea that there may be different types of inhibition requiring different levels of attentional resources (Andrés et al., 2008).

It is also important to note that the dissociation observed between active and passive participants for strategic and standard SST is compatible with the idea that the strategic version of the task may require more working memory resources than the standard. Indeed, using the operation span, Padilla, Pérez and Andrés (2013) have recently shown that active participants present with a higher working memory capacity than passive participants.

From an applied perspective, our results should encourage public authorities to consider exercise as a contributor to cognitive as well as physical health. Our data reveal for the first time that young adults practicing physical activity exhibit, specifically, better inhibitory control, a function that is included under the umbrella of executive functions. Because executive functions play a central role in general cognition and high levels of executive functioning have been related to cognitive reserve (e.g., Bialystok, Craik & Luk, 2012; Stern, 2009), our findings are of general public interest. Moreover, demonstrating exercise benefits in young adults is important to make young populations aware of the advantages of keeping active to improve academic achievement during early years, and health policies should be implemented accordingly.

Finally, a possible limitation of our study is that it used a quasi-experimental design, that is, participants were not randomly allocated to the passive and active groups by the experimenter. This limitation is arguably inherent to any study involving ecologically valid groups (in a similar way as researchers in neuropsychological studies cannot randomly allocate participants to certain clinical conditions). Such limitation could only partially be overcome using longitudinal studies. However, we argue that the link we established between chronic exercise and executive control in young healthy participants constitutes an important finding nevertheless. We adopted a neuropsychological perspective and argued that the differences between active and passive participants in the SST are mediated by physiological factors. We controlled for the effect of factors such as educational level and crystallized intelligence and showed that the differences between groups cannot be explained by such factors. However, future research should control for alternative factors such as personality traits as possible mediators between chronic exercise and executive functioning.

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APPENDIX

VO_2max formula (Equation 2 in Kline et al., 1987)

$$VO_2max = 132.853 - (0.0769 \times Weight)$$
$$(0.3877 \times Age) + (6.315 \times Gender)$$
$$(3.2649 \times Time) - (0.1565 \times Heart\ rate).$$

Note: Weight was measured in pounds (lb), gender was accounted for (male = 1 and female = 0) and time was expressed in minutes. Heart rate was measured in beats/minute, and age was taken in years.

Chapter 5.
Experiment 2: Chronic exercise keeps working memory and inhibitory capacities fit

frontiers in
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Chronic exercise keeps working memory and inhibitory capacities fit

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Padilla et al. (2013) recently showed that chronic aerobic exercise in young adults is associated with better inhibitory control as measured by the strategic Stop Signal Task (SST). The aim of the current study was to explore whether better inhibitory abilities, associated with high levels of physical fitness, were also associated with higher working memory capacity (WMC) in young healthy adults. Participants aged between 18 and 30 years and showing different levels of fitness confirmed by the Rockport 1-mile walking fitness test took part in this study. Active and passive participants were administered the SST to measure inhibitory control, and the Automatic Operation Span (AOSPAN) to measure verbal WMC. We first replicated Padilla et al.'s results showing that exercise specifically modulates strategic inhibitory processes. Our results also showed that active participants presented with better WMC than sedentary ones, showing a better capacity to manage simultaneously two verbal tasks and to inhibit interference. The results point to an association between chronic exercise, inhibitory abilities, and WMC. The theoretical relationship between these variables will be discussed.

Keywords: working memory, inhibition control, aerobic exercise, young adults

INTRODUCTION

Executive functions can be described as an umbrella term including a family of controlled (in opposition to automatic) processes, which can be separated in three core functions: working memory, inhibition and cognitive flexibility (Diamond, 2013). The conjunction of these functions allows carrying out more complex functions as reasoning, problem solving and planning.

Executive functions and one of its subcomponents – working memory capacity (WMC) – have been shown to be relevant in the efficient cognitive functioning and in the progression of several developmental and neuropsychological disorders, which has resulted in a pursuit of therapeutic ways to decelerate the deterioration of such capacities. This is the case of cognitive training (e.g., Klingberg, 2010) and cardiovascular activity (e.g., Colcombe et al., 2004; Weinstein et al., 2012), both based on the principle of neuroplasticity across the lifespan. In the case of cognitive training through computer programs, transfer to other tasks that are not directly trained has not yet been clearly demonstrated in any age group (Owen et al., 2010; Shipstead et al., 2012). However, cardiovascular exercise has shown its involvement in the improvement of a wide range of executive functions in children (Hillman et al., 2011), young (Padilla et al., 2013; Pérez et al., submitted), and older populations (Erickson and Kramer, 2009), which is believed to be mediated by the release of neurotrophic factors, such as brain-derived neurotrophic factor (BDNF), insulin-like growth factor type 1 (IGF-1) and vascular endothelial growth factor (VEGF). In turn these factors are associated with the increase of the temporal (Voss et al., 2013) and prefrontal lobes' (Colcombe et al., 2003, 2004, 2006) volume and connectivity. Furthermore, aerobic exercise has been related to an increment in brain vascularity in cortical areas and the hippocampus (Lopez-Lopez et al., 2004). Nevertheless, the effects obtained with both interventions, cognitive training and cardiovascular exercise, have not yet been demonstrated to be maintained in the long-term (Lustig et al., 2009).

Prefrontal areas and associated executive functions (Colcombe et al., 2004, 2006), seem more sensitive to the beneficial effect of exercise than other areas, as several studies with seniors, children, or clinical population have revealed (Tomporowski et al., 2008a; Hertzog et al., 2009; Davis et al., 2011; Chang et al., 2012). Even short-term aerobic exercise programs performed over a 6 months period by older populations have proven to exert an improvement in executive functions and increase in volume of some areas of the brain (Colcombe et al., 2006). However, in a recent review Guiney and Machado (2013) revealed that there is a lack of studies investigating the effects of aerobic exercise on a young cohort and the few that have been published have revealed mixed results. Differences among active and sedentary groups are found using evoked potentials, but not in behavioral data (Hillman et al., 2006; Themanson et al., 2006; Guiney and Machado, 2013).

Previous studies with young participants have mainly concentrated on the effects of acute exercise, the immediate effect of a range of intensive exercise like cycling or running carried out before or while the participant is doing the cognitive task (i.e., Themanson and Hillman, 2006; Huertas et al., 2011; see Guiney and Machado, 2013 for a review). The effects of this kind of exercise are temporary and not representative of the brain changes produced by long-term exercise. Besides, these studies do not control the level of exercise that participants carried out throughout childhood, which has been shown to exert an important influence in brain development (Chaddock, 2012). Etnier and Chang (2009) have also noted that previous studies have focused in a broad range of executive tasks, resulting in mixed results.

Arguably, well theoretically grounded tasks would enable to extract the specific processes affected by exercise. In addition, it is necessary to focus on the effects of chronic exercise compared to short-term exercise on cognition because it is more likely to produce permanent changes in the brain since it is undertaken following a long-lasting routine that will generate a protective cognitive reserve (Stern, 2009). Finally, it is important that the selection criteria for participants and the difference between active and passive participants in amounts of exercise and levels of fitness may also contribute to an effect of exercise on executive control. The higher the difference between active and passive participants in these variables, the more likely it will be to observe differences in cognition.

To address these problems, Padilla et al. (2013) investigated for the first time the effects of chronic exercise on executive functions in young adults using a highly reliable executive control task: the stop signal task (SST; Logan and Cowan, 1984; Verbruggen and Logan, 2008), which assesses motor inhibitory control associated with frontal lobe functions (Weinstein et al., 2012). In this case, participants were assessed using standard and strategic versions of the SST, and the results revealed better inhibitory abilities in active participants when the task was more executively demanding (strategic version). Pérez et al. (submitted) obtained similar results using the Attention Network test (ANT, Fan et al., 2002), with physically active participants revealing better performance in the executive network.

Trying to know the cause of these results, in the current study, we wondered to what extent these differences in inhibition control were related to a better WMC in physically active participants. WM is a system for temporarily storing and managing the information required to carry out complex cognitive tasks such as learning, reasoning, and comprehension. According to Kane and Engle (2002), WMC is a hierarchical system that consists of two components: executive-attention and short-term memory. These authors equate WMC to executive functions, making the differences between them blurred. They sustain that this system allows for the proper allocation of attentional resources and the active maintenance of the information needed to accomplish a goal-directed behavior or reasoning, avoiding at the same time the interference from other external stimuli or thoughts. In this online processing, several processes come into play; the storage and rehearsal of domain-specific information, as well as other executive functions (Conway et al., 2005) and controlled attention to sustain, divide and switch the focus of attention (Engle et al., 1999). A crucial point in this model is the relationship between WMC and inhibition. Engle and collaborators argue that inhibition and WMC correlate with each other, and Redick et al. (2007) suggest that WMC affects the ability to inhibit at any of the following stages: access, deletion or restraint (see Hasher et al., 1999 work for this distinction of inhibitory functions). In this vein, several studies using the extreme groups method (i.e., selecting the participants whose scores in a working memory task are under the 25th percentile and above the 75th percentile of the normal distribution), have shown that high WMC participants present with better inhibitory abilities than low WMC on tasks such as the flanker task (Redick and Engle, 2006), antisaccades (Unsworth et al., 2004) and proactive interference (Redick et al., 2007, 2011). Moreover, WM and inhibition have been associated to dorsal prefrontal cortex activation (Kane and Engle, 2002; Andrés, 2003).

Few studies have focused on the role that WMC could be playing in the associations between physical exercise and executive functions. In the case of young populations, Hansen et al. (2004) demonstrated that fitter young adults showed better accuracy in a 2-back task and Lambourne (2006) observed that active participants showed a higher WMC than passive participants in a reading span task. However, Kamijo et al. (2010) did not find better performance in a Stenberg task in fitter young adults compared to sedentary ones. Finally, it is important to note that none of these studies measured concurrently WMC and inhibition.

To this aim, we used Engle and colleagues' WM tasks, which involve the performance of two tasks at the same time. They require maintaining a variable number of items in mind while resolving complex problems. They are good predictors of performance on other higher level cognitive tasks, such as stroop or fluid intelligence tests; as well as disorders such as Alzheimer's, alcohol consumption or stress management (Engle et al., 1999; Unsworth et al., 2005). It has been shown that WM tasks have high reliability and validity (Conway et al., 2002). In the case of the Automatic Operation Span Task (AOSPAN; Unsworth et al., 2005), it measures the phonological loop and the central executive component of WM, which is highly associated with controlled processing and attention (Baddeley, 1986, 1996).

In the present study we investigated three hypotheses. First, we wanted to replicate the results observed in our previous study (Padilla et al., 2013) showing better inhibitory abilities in physically active participants using the strategic version of the SST, which makes greater demands on executive resources as will be explained in the method section. Second we predicted that aerobic exercise would enhance WMC. Third, we evaluated to what extent the active group's better inhibitory control could be linked to a greater WMC, as suggested by Kane and Engle (2002). Thus, we expected a high relationship between the inhibitory control showed under the strategic instructions, and the WMC. A wider WMC should be associated to a better ability to inhibit interference.

The results confirmed the advantage in inhibition of active participants previously observed (Padilla et al., 2013), i.e., the physically active group showed a speeded inhibitory response when strategic instructions were applied, but most importantly, the whole active group exhibited a greater WMC. The possible relationship between these variables will be discussed.

METHODS

PARTICIPANTS

Fifty eight participants ranged between 18 and 30 years of age ($M = 22.26$, $SD = 3.26$) were assigned to the active or passive groups according to their fitness levels (see **Table 1** for demographic details). The active group was formed by 29 participants with an average age of 22.21 ($SD = 3.28$), while the passive group consisted of 29 individuals with an average age of 22.31 ($SD =$

Table 1 | Demographic variables.

	Active		Passive	
	Strategic	Standard	Strategic	Standard
n	14	15	14	15
Age	22.71 (3.49)	21.73 (3.11)	21.14 (3.09)	23.40 (3.20)
Education	15.36 (3.41)	14.13 (3.68)	14.57 (3.98)	13.13 (1.89)
Vocabulary	42.29 (9.12)	43.40 (3.78)	42.79 (7.31)	48.33 (5.09)
Rockport*	57.82 (7.04)	57.24 (9.71)	47.26 (5.93)	44.43 (9.72)

*Average and SDs (in brackets) for Age (age of participants at the moment of testing), Education (number of completed years of formal education), Vocabulary (WAIS' Vocabulary subtest score) and Rockport test (Rockport Fitness Walking Test score). *Effect at $p < 0.001$.*

3.29). Each of these groups were further subdivided into standard ($n = 14$) and strategic ($n = 15$) subgroups according to the version of the SST that they performed. Participants were allocated to the active group if they had been doing aerobic exercise for at least 10 years, following a minimum routine of 6 h per week, distributed across at least 3 days a week. On the other hand, participants were allocated to the passive group if they had not been exercising for the last 4 years more than 1 h per week. The type of exercise that had been practiced during the last 4 years by the passive group could not have been cardiovascular (e.g., yoga, stretching, etc. were allowed). Also, they should not have done more than 6 h per week of aerobic exercise during their childhood (from 0 to 12 years old). This criterion was applied taking into account the fact that children in Spanish schools have at least 3 h per week of physical education.

Before the participants started the testing, they were interviewed by telephone following a questionnaire about demographic data, lifelong exercise routines, medical history and education. If they fulfilled the requirements to participate, they were invited to come to our university facilities to perform the testing in a 2 h session. All participants gave their informed consent and were paid or given course credits if they were students. The experiment was performed in accordance with the ethical standards stated in the 1964 Declaration of Helsinki. Each activity group was subdivided in two other groups depending on the SST instructions they received: strategic or standard.

CARDIORESPIRATORY CAPACITY

As in Padilla et al.'s (2013) study, maximal oxygen uptake was measured with the Rockport 1-mile Fitness Walking Test (Kline et al., 1987). This test was chosen due to its high correlation coefficient (0.88) with a direct index of VO_2max, carried out using a treadmill (Kline et al., 1987; Weiglein et al., 2011). VO_2 max is the maximal oxygen uptake that the organism is able to consume when it is carrying out a sub-maximal exercise. The higher the score, the higher the aerobic capacity and oxygen uptakes.

DESIGN AND PROCEDURE

First, a telephone interview was carried out to gather information about the demographic data of each participant. They were asked about their level of education, and medical history to exclude participants who suffered or had suffered in the past from any mental disorder or physical illness that could affect the results. In addition, they were asked about the frequency of exercise they had done along their whole life. If they met the criteria to participate, they were invited to come to our facilities to take part in our study.

In a 2 h session, participants completed a more detailed health questionnaire with an experienced clinical psychologist, where they had to specify whether they were having any mental or physical problem and/or taking any medication at that time. After that, they carried out the SST and AOSPAN tasks in a quiet room. Later, they completed the Wechsler Adult Intelligence Scale Vocabulary subtest and finally they completed the Rockport 1-mile Fitness Walking Test on the University campus, where they had to walk 1 mile as fast as possible to measure their initial and final pulse and the time they took to complete the distance.

SST task

The SST (Verbruggen et al., 2008; Padilla et al., 2013) task was presented on a LG computer with a 19″ Phillips monitor with a resolution of 1024 × 768 pixels. The task was programmed using the E-prime software (Schneider et al., 2002). Participants were seated approximately at 50 cm of distance from the screen and wore headphones.

As can be seen in Verbruggen et al. (2008), SST begins with the appearance of a fixation sign (+) followed by a stimulus drawn in white color presented in the center of a screen in black. Two types of trials were presented at random: the GO (75%) and the STOP (25%) trials. In the GO trials, participants had to decide as fast as possible whether a geometric figure displayed on the screen was a square or a circle. They responded by pressing "Z" or "−" on the keyboard with the index fingers. In the STOP trials, the procedure was the same with the difference that a tone was presented shortly after the geometric figure, and participants had then to inhibit their response. The interval between the geometric figure and the STOP signal followed a tracking procedure: when participants successfully withheld a response in a STOP trial, the interval between the figure and the stop signal was incremented by 50 ms; however, when participants failed to withhold their response, it was decreased by 50 ms. Doing so, the probability to inhibit a response is random, thereby, there is a 50% of likelihood of correctly withdrawing a response (see **Figure 1**).

The assessment procedure was the same as in Padilla et al.'s (2013), maintaining the same task conditions: standard and strategic. Both tasks were similar; the only difference between them is the instructions. In the standard condition (Verbruggen et al., 2008), participants were told that on the 25% of trials a tone was going to be presented. For half of these trials, it would appear very early and it would be relatively easy to withhold a response. On the other half of the STOP trials, the tone would come late, increasing the difficulty to inhibit the response. Importantly, participants were also warned that they should not postpone the responses while waiting for the potential occurrence of the stop signal. However, in the strategic condition participants were just told how to respond to the stimulus that would appear on the screen, and asked to withdraw their response when a sound appeared. They were asked not to wait to know whether the sound would appear or not, allowing them to apply the strategies they decided.

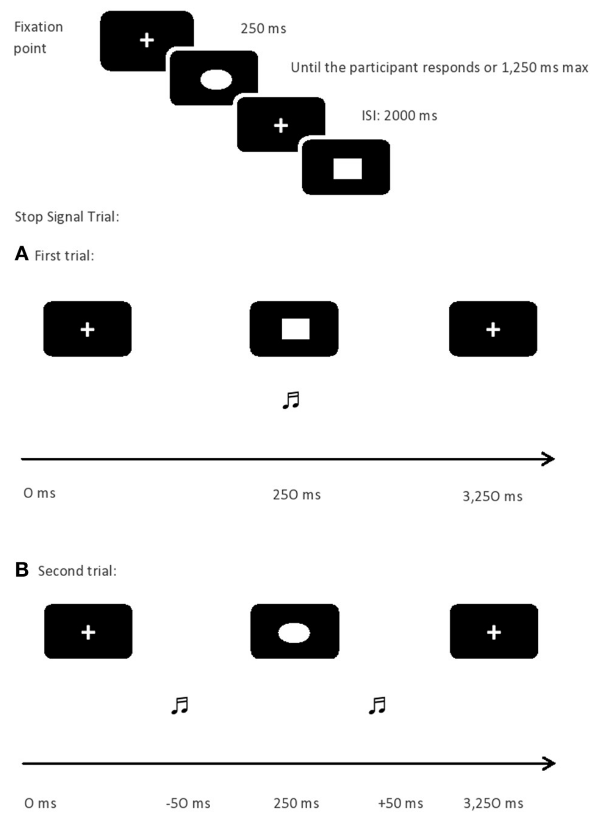

FIGURE 1 | Stop Signal Task design. Note: ISI, Inter Stimulus Interval; ms, milliseconds.

The variables measured by this test were: (a) the go RT: time to respond to the go trials; (b) the stop signal delay (SSD): mean delay between visual and auditive stimuli along all stop signal trials; (c) the stop signal RT (SSRT): latency of the inhibition process calculated by subtracting the mean SSD from the mean RT in go trials; (d) the signal respond RT (SRRT): mean time to respond incorrectly in the stop trials; (e) the percentage of correct responses in the go trials; and (f) the percentage of missed responses in the go trials.

Automatic operation span

AOSPAN (Unsworth et al., 2005) began with three blocks of practice. First, the letter practice block trained the participant to remember different sets of letters that could contain from 2 to 5 letters. Once the participants had completed a set, 12 letters were displayed in a matrix of 12 and they were asked to mark in order the letters that had been shown previously. After that, a feedback message was shown to inform participants about the number of letters correctly remembered. The second block was to practice solving a series of additions, subtractions, multiplications or divisions of one digit numbers as fast as possible. In this block, participants were presented with the operation, then had to click on the mouse left button once they had the solution in mind and then, a screen with a number appeared, in which the participant had to decide whether that number was the right solution to the problem ("false" or "true"). During this block, the software calculates the averaged time to solve these operations to set the maximum exposition time of the operation task in the experimental block. In the third practice block, both tasks were combined as with the experimental block. Individuals had first to remember in order the letters presented and then solve the arithmetical problems as fast as possible. This was followed by a variable number of trials, from two to five. Finally, participants had to say in order the letters that they remembered. The experimental block was similar to the last practice block, but the time to solve the arithmetic problem was limited to the averaged time calculated in the second practice block. The dependent variable was the total number of letters correctly recalled in all sets. This measure reflects WM *capacity* relatively uncontaminated by the processes involved in serial recall, which tend to be executive.

RESULTS

The resulting four groups of participants did not differ in terms of age [$F_{(1, 54)} = 0.003$, $MSE = 0.033$, $p = 0.955$, $\eta_p^2 = 0.000$] or years of formal education [$F_{(1, 54)} = 1.046$, $MSE = 11.546$, $p = 0.311$, $\eta_p^2 = 0.019$] (see **Table 1**). They showed similar vocabulary levels measured with the Vocabulary subtest from the Wechsler Adult Intelligence Scale (Wechsler, 1999), [$F_{(1, 54)} = 2.469$, $MSE = 106.887$, $p = 0.122$, $\eta_p^2 = 0.044$]. Active participants had practiced cardiovascular exercise for an average of 204.621 months (17.052 years) and a total of 8488.107 h ($SD = 5008.938$) during their lives. The passive participants had practiced aerobic exercise during their lives, that is, before the past last 4 years and mostly during their childhood, which we consider from 0 to 12 years old; in an average of 67.414 months (5.618 years) with a mean of 1559.079 h ($SD = 1646.452$) across the lifespan. Averages of months [$F_{(1, 54)} = 70.575$, $MSE = 269507.589$, $p < 0.001$, $\eta_p^2 = 0.567$] and hours of sport [$F_{(1, 53)} = 46.882$, $MSE = 680356813.058$, $p < 0.001$, $\eta_p^2 = 0.469$] were significantly different between passive and active participants.

As expected, physically active participants showed higher scores than passive in the Rockport test: 57.517 ($SD = 8.381$) against 45.795 ($SD = 8.100$) [$F_{(1, 54)} = 28.515$, $MSE = 1976.772$, $p < 0.001$, $\eta_p^2 = 0.346$], which means active participants presented higher cardiovascular capacity as a consequence of their exercise routines.

The most important measures of the SST, which were used to test our hypotheses, were GO RTs (the time taken to respond to the primary or go task) and SSRT (the time required to inhibit an already initiated response, that is, inhibition control). These measures are presented in **Figures 2**, **3**, while all other measures (SSD, SRRT, percentages of correct and missed responses) are reported in **Table 2**.

A univariate 2 (group) × 2(instructions) ANOVA carried out on the GO RTs, revealed a significant effect of instructions [$F_{(1, 54)} = 22.407$, $MSE = 546152.009$, $p < 0.001$, $\eta_p^2 = 0.293$], whereby the strategic version yielded longer RTs ($M = 838.678$, $SD = 140.506$) than the standard one ($M = 644.487$, $SD = 164.513$). No significant effect of group [$F_{(1, 54)} = 0.004$, $MSE = 107.863$, $p = 0.947$, $\eta_p^2 = 0.000$] or instructions × group

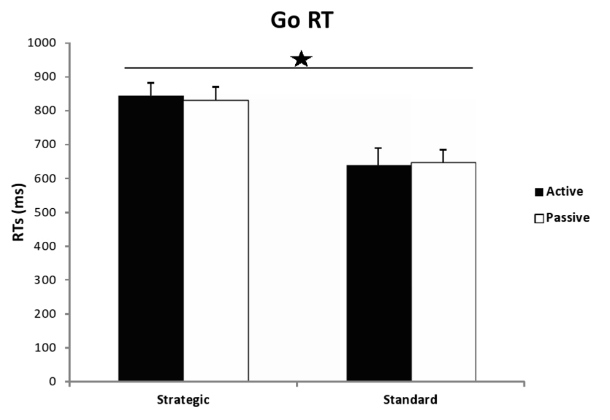

FIGURE 2 | Go RTs in milliseconds for active and passive participants in both conditions of the Stop Signal Task: strategic and standard. The star indicates significance (instruction effect) with $p < 0.05$.

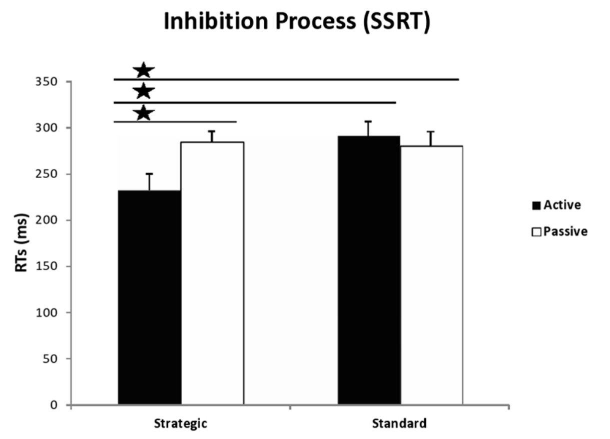

FIGURE 3 | Latency of the inhibition process (SSRTs) in milliseconds, calculated by subtracting the mean SSD from the mean RT in go trials, for active and passive participants in both conditions of the Stop Signal Task: strategic and standard. The stars indicate significant differences between strategic active group and the remaining groups with $p < 0.05$.

interaction [$F_{(1, 54)} = 0.066$, $MSE = 1609.640$, $p = 0.798$, $\eta_p^2 = 0.001$] were found.

A univariate 2 (group) × 2(instructions) ANOVA on the SSRT data revealed a trend for the effect of instruction [$F_{(1, 54)} = 3.190$, $MSE = 10824.943$, $p = 0.080$, $\eta_p^2 = 0.056$], and, most importantly, a significant instruction × group interaction [$F_{(1, 54)} = 4.227$, $MSE = 14344.243$, $p = 0.045$, $\eta_p^2 = 0.073$]. As in Padilla et al.'s (2013) study, t-tests revealed that active participants exhibited faster SSRT than passive participants in the strategic [$t_{(26)} = -2.460$, $p = 0.021$, $d = -0.965$], but not the standard condition [$t_{(28)} = 0.488$, $p = 0.630$, $d = 0.184$]. Furthermore, active participants inhibited responses faster under strategic instructions compared to standard instructions [$t_{(27)} = -2.489$, $p = 0.019$, $d = -0.958$], while passive participants, in contrast, showed similar SSRTs regardless of instructions [$t_{(27)} = 0.212$, $p = 0.834$, $d = 0.082$]. Finally, the comparison between SSRTs from the active participants in the strategic condition and the passive participants in the standard condition was just significant [$t_{(27)} = -2.057$, $p = 0.050$, $d = -0.79$]. In sum, active participants from the strategic condition presented with better inhibitory responses than the remaining groups, as can be seen in **Figure 3**.

Further univariate 2 (group) × 2 (instructions) ANOVAs were carried out on the remaining measures (SSD, SRRT, percentage of correct responses, and missed responses). They all revealed main effects of instructions (all $ps < 0.005$), but no significant effect of group or group × instructions interaction (all $ps > 0.341$). It is noteworthy that the number of responded trials decreased in the strategic version, but the number of errors remained the same between standard and strategic conditions (see **Table 2**).

Regarding WMC (**Figure 4**), a univariate 2 (group) × 2 (SST condition: strategic vs. standard) ANOVA showed a significant group effect [$F_{(1, 54)} = 4.309$, $MSE = 539.745$, $p = 0.043$, $\eta_p^2 = 0.074$], revealing greater WMC for the active ($M = 54.414$, $SD = 8.471$) than for the passive participants ($M = 48.379$, $SD = 13.116$) [$t_{(56)} = 2.081$, $p = 0.042$, $d = 0.556$]. There was no SST condition × group interaction [$F_{(1, 54)} = 0.480$, $MSE = 60.159$, $p = 0.491$, $\eta_p^2 = 0.009$]. There were no differences among SST conditions, participants who belonged to the strategic group, showed a similar WMC than those who belonged to the standard group [$F_{(1, 54)} = 0.013$, $MSE = 1.656$, $p = 0.909$, $\eta_p^2 = 0.000$]. A separated ANOVA was performed with just the participants that carried out the strategic version, finding here also significant differences [$F_{(1, 26)} = 4.254$, $MSE = 464.143$, $p = 0.049$, $\eta_p^2 = 0.141$].

Once we observed a greater WMC in the physically active group, we ran an ANCOVA to evaluate the extent to which WMC could explain the differences between active and passive participants observed in the SSRT scores. The results showed that the instruction × group interaction [$F_{(1, 53)} = 3.754$, $MSE = 12578.461$, $p = 0.058$, $\eta_p^2 = 0.066$] did no longer reach statistical significance after controlling for WMC, indicating that WM capacity and SSRT scores were related to some extent. When the ANCOVA was applied only to the sample from the strategic version, the group effect did not reach statistical significance either [$F_{(1, 25)} = 4.162$, $MSE = 13485.547$, $p = 0.052$, $\eta_p^2 = 0.143$].

Finally, the relation between exercise, WMC and inhibition (SSRT in the strategic condition) was evaluated with a hierarchical multiple regression analysis that entered group (active and passive) as the predictor variable in the step 1, and WM capacity in the step 2 to evaluate its additional contribution. Simple correlation values of all pairs of variables are shown in **Table 3**. The *R square* in step 1 was 0.189, which was highly significant [$F_{(1, 26)} = 6.054$, $MS_{residual} = 3155.189$, $p = 0.021$], indicating a relationship between exercise and inhibition. However, the R^2 change in step 2 was 0.010, which was not significant [$F_{(2, 25)} = 3.105$, $MS_{residual} = 3240.495$, $p = 0.062$], indicating no significant relationship between inhibition and WM.

DISCUSSION

The aim of this study was to investigate inhibitory/executive control and WMC in physically active compared to passive

Table 2 | Stop signal task variables.

	Active		Passive	
	Strategic	**Standard**	**Strategic**	**Standard**
SSD*	611.91 (175.30)	348.98 (181.84)	547.28 (157.70)	368.43 (150.03)
SRRT*	752.49 (165.76)	569.67 (167.42)	743.96 (136.37)	545.43 (112.29)
Go Accuracy*	90.94 (11.34)	97.55 (3.24)	90.06 (12.89)	98.32 (1.67)
Go miss*	8.46 (11.48)	1.79 (3.44)	9.34 (13.12)	0.89 (1.20)
Go error	0.60 (1.02)	0.65 (1.11)	0.60 (0.91)	0.79 (0.87)
Stop accuracy	48.36 (6.63)	52.10 (5.19)	50.01 (8.36)	50.05 (5.55)

*Average and SDs (in brackets) for SSD, Delay between visual and auditive stimulus; SSRT, Inhibition process latency; SRRT, RT incorrect responses in the stop trials; Go Accuracy, % correct responses in Go trials; Go Miss, Miss responses in Go trials; Go Error, response errors in Go trials; and Stop accuracy, correct inhibited responses in stop trials; *Effect of instructions at p < 0.005.*

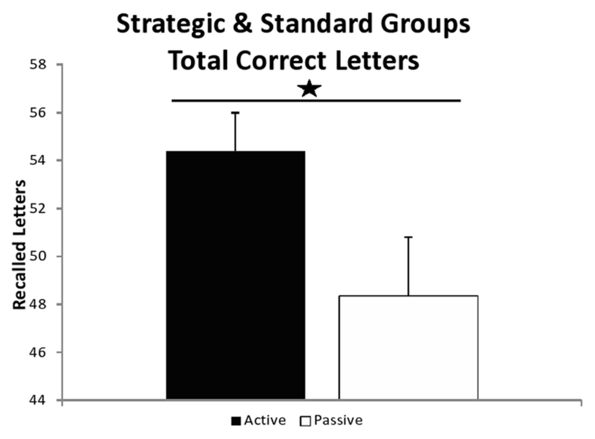

FIGURE 4 | Recalled correct letters. Recalled correct letters in the whole sample (strategic and standard groups). *Effect at $p = 0.042$.

Table 3 | Correlations found between inhibition and multiple variables.

	Correlations						
	Age	**Total months**	**Total hours**	**Rockport**	**Wais**	**Education**	**Total correct letters**
r SSRT	−0.11	−0.45	−0.19	−0.20	−0.06	0.08	−0.26
p SSRT	0.59	0.02	0.34	0.31	0.76	0.69	0.19

R is the Pearson Correlation and p is the p-value indicating the level of significance.

participants. To this aim, we used the SST (Verbruggen et al., 2008; Padilla et al., 2013) and the AOSPAN task (Unsworth et al., 2005) to evaluate inhibition and WMC respectively. We also investigated to what extent the group differences observed in inhibition/executive control could be related to WMC.

Our results were in line with expectations in regard to the effect of task manipulations on performance: the strategic version of the SST gave rise to longer GO RTs than the standard version, replicating Padilla et al.'s (2013) findings. These results confirm that the strategic and standard versions of the SST are measuring different ways to deal with the task, with the strategic one allowing for the implementation of the "goal priority strategy" (Leotti and Wager, 2010; Sella et al., 2013), which consists of the lengthening of the GO RTs in order to improve the performance in the stop signal trials. When instructions allowed participants to apply a trade-off as in the strategic version, SST was analogous to a dual task, where each task must be carried out at the same level of accuracy and speed. The cognitive resources must be divided to control the performance in both tasks. The consequences of "the goal priority trade-off" are that participants wait longer to produce their response in the go trials to make sure the stop signal is not going to appear. This gives rise to an increased number of omissions, as participants produce their response after the maximal interval they are allowed to respond (see **Table 2**). This pattern of results reflects a different (more executive) way to deal with the task in its strategic version (although the different instructions did not affect the stop accuracy or the number of errors in the go trials).

Second, the results replicated Padilla et al.'s (2013) in showing that the physically active participants obtained a better inhibitory control (shorter SSRTs) than the passive ones, but only under the strategic condition of the SST. It is important to note that both groups of participants in the strategic condition had the same number of errors than the standard condition groups, but just the active participants in the strategic condition were faster withdrawing their responses in the stop signal trials compared to the remaining groups. Also, active participants were faster inhibiting their responses in the strategic version of the task than active participants in the standard condition, but this difference was not observed in passive participants. This is consistent with the findings by Pérez et al. (submitted) showing a relatively specific relationship between exercise and executive attention when using the ANT task (Fan et al., 2002). Since active and passive participants showed similar go RTs within each version of the SST (strategic and standard), it is important to note that both groups did not differ in terms of general speed of processing (Salthouse, 1996), which means that the benefit induced by chronic exercise is specific to the inhibition process.

Third, the results also revealed higher WMC in active compared to passive participants as we expected. A recent review studying the effects of acute aerobic exercise on working memory in young adults (Verburgh et al., 2013) revealed a very low effect size ($d = 0.05$), however, we obtained a medium effect size ($d = 0.556$). Importantly, the results showed that controlling for WMC as a covariate, reduced the group differences in inhibition to the point that the group effect on inhibition (active group in the strategic condition) no longer reached statistical significance.

However, although WMC explains a percentage of inhibition variance (strategic SSRT), this did not result in a strong relationship, since the regression between WMC and SSRT did not reach significance. It could be argued that this might be linked to the size of our sample. Nonetheless, using a significantly bigger sample ($n = 262$), Wilhelm et al. (2013) did not find correlations either between tasks that assess inhibition and interference control, such as Flanker and Simon tasks, and those that evaluate WM, although they did find a high correlation between updating, complex-span and binding tasks. One of the possible explanations that Wilhelm et al. (2013) raised about Engle's group findings showing correlations between WMC and inhibition is the use of the extreme-groups method, which removes most of the variability from the group, increasing in turn the likelihood to find correlations between WM and inhibition (Preacher et al., 2005). Here, it is worth mentioning that other studies that did not apply the extreme-groups technique did not find correlations between WM and inhibition (Friedman and Miyake, 2004; Hofmann et al., 2009). It is therefore likely that inhibition and WMC show some processing overlap and support each other, but they are also independent and none seems to be the unique cause of the other.

Our results are consistent with the suggestion by Davidson et al. (2006) and Zanto et al. (2011) claiming that WMC and inhibition, although independent, are interrelated and work together. These authors suggest that WM supports inhibitory control holding the task goal in mind. Focusing on the task decreases the probability of interference from irrelevant stimuli. At the same time, inhibitory control supports WM in different ways, for example, preventing recovery of related but unwanted memories, or avoiding the emergence of distractors. If this kind of information is not inhibited, it may result in mind-wandering (Diamond, 2013).

Roberts and Pennington (1996; also see Nyberg et al., 2009) attempted to understand the interaction between WM and inhibition attending to the premise that they are independent processes sharing limited resources. They suggest that inhibitory performance results from a dynamic interaction among one's WMC, the strength of the competing prepotencies or inhibitory task demands, and the WM task demands. It is only when demands on inhibition and/or WM reach high enough levels that this competition for common limited resources, or resource sharing, takes place. The individual differences in capability will therefore only be observed when the task demands are high (when they exceed a certain threshold). The implication of this is that "tasks that require both (WM and inhibition) are more likely to tax the PFC, although tasks that have a very high demand for either are also hypothesized to be prefrontal tasks" (Pennington and Ozonoff, 1996, p. 338).

The pattern of results observed in our studies is well explained under this model. We did not find any difference between active and passive participants in the standard condition of the SST (nor did we in Padilla et al.'s 2013 study), given that the attentional and WM demands are relatively low. However, the groups differed in the more executive version of the SST, where the physically active group showed better inhibition control. That the standard version of the SST does not require great deal of attentional or WM resources is supported by the finding by Yamaguchi et al. (2012) that response inhibition does not suffer from dual task interference. Since active participants present with higher WMC, this enables them to deal with the higher WM demands of the strategic version of the SST. However, when little WMC is required by the task, as it is the case in the standard version of the SST, the higher WMC observed in the active participants does not come as an advantage to contribute to the inhibitory process, resulting in no differences in inhibition between active and passive participants.

We emphasize that in our study we focused on the effect of aerobic chronic exercise as opposed to aerobic acute exercise as examined in past studies with young adults (e.g., Huertas et al., 2011). There are few studies studying the effects of chronic exercise in this age group (Verburgh et al., 2013), given that cognitive functions at this period of life are at their maximum level (Salthouse and Davis, 2006), and they are less likely to be affected by exercise interventions as a ceiling effect may be observed. Most of the studies with young adults have failed to demonstrate differences among active and passive participants with behavioral data. Those that have found an effect of exercise have used psychophysiological measures, demonstrating different patterns of brain activation. For instance, Hillman et al. (2006) and Themanson and Hillman (2006) revealed differences in the P3 component between young active and passive adults using the task-switching paradigm. Themanson and Hillman (2006) and Themanson et al. (2006) showed a lower error related negativity amplitude (ERN or Ne) and a higher error positivity (Pe) in the active group. Nevertheless, further studies using neuroimaging techniques are necessary to elucidate the positive effects of aerobic exercise on brain structure and connectivity in this group of age. For this reason, we used a strict selection criterion for the recruitment of participants, with active participants having practiced aerobic exercise for at least 10 years with a frequency of at least 6 h a week. We also decided to apply a more strategic task to deal with the likelihood of a ceiling effect.

Acute and chronic exercise has different effects on the brain. Acute exercise spans from 10 to 40 min and the cognitive tasks may be applied during or after the aerobic exercise is being performed. Chronic exercise, instead, range from periods of training of 3–6 weeks (Griffin et al., 2011), 6 months or 1 year, up to 10 years in our case. Acute exercise is related to an increase in brain blood flow, as well as the levels of vasopressin, β-endorphine, catecholamines, and adrenocorticotropic hormone in plasma (Chmura et al., 1994; McMorris et al., 2008), which is thought to reflect neurotransmitters levels in the brain and lead to an elevated arousal that would enhance cognitive performance. A recent meta-analysis (Verburgh et al., 2013) has found a moderate positive effect of acute exercise ($d = 0.52$) on executive functions in children, adolescents, and young adults, that was more pronounced in inhibition/control processes than working memory tasks. It is worth noting to remark that these effects are temporary, since the tasks are applied during or just before participants are doing the exercise. On the contrary, chronic exercise is accompanied by more permanent physiological changes in the brain, such as the formation and extension of new vessels, which result in the improvement of brain perfusion. Also, neurogenesis and release of neurotrophic factors take place increasing the chances of neural growth and survival, which affects learning and memory learning capabilities (Voss et al., 2011). Larger brain volumes have been shown in active children (Chaddock et al., 2011) and old adults (Colcombe et al., 2006), while there is a lack of research using neuroimaging in young adults. Thereby, it is more likely to induce brain cognitive reserve with chronic compared to acute exercise (Ahlskog et al., 2011; Smith et al., 2013), as several studies with healthy children or old adults have suggested (Tomporowski et al., 2008b; Howie and Pate, 2012; Voss et al., 2013). These interventions have promising results for combating mental disorders such attention deficit hyperactivity disorder (ADHD) (Gapin et al., 2011) or dementia (Ahlskog et al., 2011; Smith et al., 2013).

Regarding the cognitive processes measured in our study, previous results (see Hillman et al., 2008 for a review) have shown that long-term high cardiovascular fitness gives rise to significant volumetric and functional improvements particularly in prefrontal areas, which underpin inhibition and executive processes. Recent research has revealed for example that gray matter volume of the right inferior frontal gyrus mediates the relationship between higher cardiovascular fitness and interference control in the Stroop task in older adults (Weinstein et al., 2012). It is therefore possible that the functional network that supports inhibitory mechanisms is preferentially boosted by the cardiovascular effects of exercise, which is consistent with the pattern of results observed in our studies revealing a relatively specific effect of chronic exercise on tasks requiring inhibitory control (Padilla et al., 2013; Pérez et al., submitted).

The results from the current study show that inhibition and WM can be potentiated by the chronic practice of physical exercise, which can be defined as a kind of exercise performed under a high frequency and long-term routine; in comparison with individuals who have a very sedentary lifestyle.

Our results also suggest that inhibition and WM are independent processes, but dependent on a limited shared capacity. This capacity is the quantity of information that can be held active, and that makes us self-aware. WM and inhibition processes are necessary to carry out a goal-directed task. However, in most cases, inhibition processes depend on WM, since it is crucial to keep in mind what must be inhibited (executive processes are "superordinate" in relation to inhibition, Nyberg et al., 2009).

Concerning our experimental design, cross-sectional studies that explore the influence of long-term aerobic exercise on cognition, brain function, and structure, along with cognitive reserve would be necessary in future studies. Most of the studies that are carried out under the category of chronic exercise do not span the range of more than 1 year and do not explore the effects once the intervention has finished. The present study is a better way to evaluate how exercise gives rise to cognitive reserve, since it accounts for the true chronic exercise that is performed throughout life, although not all variables can be controlled for.

Future research should establish how different ranges of physical activity in terms of frequency and years of aerobic exercise can affect cognitive performance, brain volume or connectivity, instead of being chosen arbitrarily. For example, it can be differentiated between acute, short-term, and long-term interventions.

Moreover, more executive tasks are recommended to challenge executive functions in a way that inhibition and WMC demands are high enough to see the benefits of exercise in young populations, as we have demonstrated in our study. Neuroimaging studies would also be required to establish the functional and structural brain changes produced by chronic aerobic exercise in young populations.

Finally and to conclude, the present study has demonstrated that chronic aerobic exercise benefits not only physical, but also cognitive functions across the lifespan.

AUTHOR CONTRIBUTIONS

Pilar Andrés and Concepción Padilla designed and planned the study, analyzed, and interpreted the data and wrote the manuscript. Laura Pérez collaborated in the design and planning of the study and helped in data collection.

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Chapter 6.
Experiment 3: The role of chronic exercise on memory and selective attention

The role of chronic exercise on memory and selective attention

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Abstract

We aimed to investigate the effect of chronic exercise on long-term memory in physically active and passive participants. Attention at encoding was manipulated in a similar way in implicit and explicit memory. At both encoding phases, the picture outlines of two familiar objects, one in blue and the other in green, were presented, and participants were asked to pay attention to only one of them. Implicit memory was assessed through conceptual priming and explicit memory through a free recall task followed by recognition. The results did not reveal significant differences between active and passive participants in conceptual priming or free recall. However, in recognition, while both groups showed similar discrimination levels for attended stimuli, the active participants showed lower discrimination levels between unattended and new stimuli. We suggest that active participants may suppress non-relevant information better than passive participants, making the discrimination between unattended and new/distractor items more difficult.

Keywords: cardiovascular exercise, long-term memory, inhibition

Introduction

Physical activity stands as a way to enhance some cognitive functions, especially when they involve executive control (Colcombe & Kramer, 2003). For example, it was recently showed that participants with a story of chronic exercise performed better on inhibitory (Padilla, Pérez, Parmentier, & Andrés, 2013) and interference control (Pérez, Padilla, Parmentier, & Andrés, 2014) tasks, as well as in speeded perception, visuospatial attention and dynamic visual acuity (Muiños & Ballesteros, 2014; 2015). There is also evidence that these improvements in physically active people are accompanied by greater working memory capacity (Padilla, Pérez, & Andrés, 2014). Guiney and Machado (2013) recently summarized the existing literature by showing that regular aerobic exercise improves executive processes such as task switching, selective attention, inhibition and working memory. The current study will specifically consider the role of selective attention at encoding in memory and how they are affected by exercise.

Previous research has also suggested that cardiovascular exercise may trigger a cascade of neurological changes that may enhance long-term memory performance. Some studies implementing exercise interventions have revealed volume increases in memory-related areas such as the hippocampus, dentate gyrus, frontal and superior temporal cortex, cuneus and basal ganglia (Chaddock et al., 2010; Colcombe et al., 2006; Holzschneider, Wolbers, Roder, & Hotting, 2012; Maass et al., 2014; Pereira et al., 2007). However, despite this evidence of neurobiological changes, it is remarkable that research on physical exercise and long-term memory using experimentally controlled tasks has been rather limited, and the few studies that have been carried out have found no differences in memory scores between the pre- and post- interventions (for example, Erickson et al., 2009; 2011)

Among the few recent studies that have investigated the role of chronic exercise on long-term memory, Déry et al. (2013) compared the performance of a group of sedentary participants before and after a 6-week exercise intervention on two memory tasks that differed in their sensitivity to measure neurogenesis. The first was a memory task that generated high levels of interference between previously learned and subsequently tested stimuli, the “pattern separation task” (Kirwan & Stark, 2007), a three alternative forced choice visual recognition memory task. The second was the “paired associate learning task” (PAL, from CANTAB®), a well-established visuospatial associative learning that is sensitive to hippocampal pathology (Beddington et al., 2008; Blackwell et al., 2004; Jager et al., 2008; Rover et al., 2011). A feature that differentiates the two tasks is the greater executive control required by the first compared with the second task. The results revealed that exercise, measured by improvement in VO_2 peak, specifically improved the ability to distinguish similar lures from previously studied targets, an ability that strongly depends on executive control (control of interference). However, exercise did not improve memory *per se* in any of the two tasks.

Ballesteros, Mayas and Reales (2013) also studied the effect of chronic exercise on long-term memory using a perceptual priming task in two groups of older adults, one group who practiced regularly exercise and another that did not. The results showed repetition priming for both groups, but it was not enhanced by chronic aerobic exercise. For their part, Maas et al. (2014) observed a relationship between exercise-related changes in perfusion and early recall for configural spatial object memory, but not for verbal memory nor delayed recall.

Finally, a recent review and meta-analysis investigating the effects of cardiovascular exercise on human memory (Roig et al., 2013) suggested that although acute exercise programs may cause an improvement in verbal and visual free recall, visual recognition and procedural memory, chronic exercise does not lead to better long-term memory.

Given the contradiction between the changes observed at the neural level (e.g., in the hippocampus) and the lack of empirical evidence for a behavioral long-term memory improvement induced by chronic exercise, we aimed at investigating the extent to which cardiovascular exercise might affect long-term memory in a group of young participants.

Among the different distinctions that have been proposed, the one between explicit (declarative) and implicit (non-declarative or procedural) memory (Tulving, 1985; Tulving & Schacter, 1990) is crucial for the present study. Whereas explicit memory requires the conscious or intentional recollection of previous experience, implicit memory refers to previous experience with stimuli that does not require intentional, conscious retrieval of previously encountered stimuli. In neuropsychological terms, different parts of the brain are in charge of these memory systems. Declarative memory depends on hippocampus and medial temporal lobe (Reber, 2013) and is sensitive to brain damage and aging, while implicit is more resistant to these changes (Graf & Masson, 2013). Since explicit memory requires more executive control than implicit memory and previous research has shown greater effects of chronic exercise on executive functions (Colcombe & Kramer, 2003; Guiney & Machado, 2013), one could expect greater effects of exercise on explicit than implicit memory.

It is important to note that implicit memory does not imply that it is completely an automatic process. A recent review and meta-analysis including 38 effect sizes extracted from 21 empirical studies indicated that divided attention produced a small, but significant, negative effect on implicit memory (Spataro, Cestari, & Rossi-Arnaud, 2011). Previous studies using pictorial stimuli to investigate the influence of selective attention at encoding in perceptual priming tasks across the life span (Ballesteros et al., 2008) have also shown that both types of memory require some attention at encoding as priming (a measure of implicit memory) was always modulated by attentional manipulations.

The implicit and explicit memory tasks used in the present study were the same as the ones used by Ballesteros and Mayas (2015) to investigate the effects of aging and selective attention at encoding on implicit memory, assessed by priming effects in a speeded conceptual classification task (Experiment 1), and explicit (episodic) memory, assessed by an old-new recognition task (Experiment 2). Consistent with previous findings with perceptual priming tasks, Ballesteros and Mayas found that conceptual object priming, like explicit memory, required some degree of attention at encoding since significant priming was obtained only for those pictures that were attended at encoding.

As mentioned before, Ballesteros et al. (2013) also found perceptual priming for attended pictures but not for unattended in either sedentary or physically active older adults. It is well established in the literature that perceptual and conceptual priming can be dissociated. Indirect memory tests based on conceptual processes require deeper processing as they require the extraction and retention of the meaning of the stimuli, whereas indirect tests based on perceptual processes require more superficial analysis and processing. It would therefore be interesting to assess whether conceptual priming is also immune to the effect of chronic exercise, especially when attention modulates encoding processes.

The main aim of this study was therefore to investigate the effects of chronic physical exercise and selective attention at encoding on conceptual repetition priming and on explicit long-term memory. We predicted that, given that explicit memory relies on encoding and retrieval strategies that depend on executive processes, it might be affected to a greater extent by chronic cardiovascular exercise than implicit memory. Since previous results with similar participants have revealed better inhibitory abilities in active participants (Padilla et al., 2013; Guiney & Machado, 2013) we also considered the possibility that active participants might filter or suppress better the to-be-ignored stimuli, making them more difficult to be differentiated from the new, never presented items and giving rise to differences in discrimination scores.

Method

Participants

Participants were recruited through advertisements placed across the university campus and its sports center, as well as from other sports facilities throughout the city. The inclusion criteria to recruit the active participants were inspired by Padilla et al.'s (2013; 2014) studies: they should have been doing aerobic exercise (running, football, swimming, etc.) for at least ten years, with a minimum of six hours per week, distributed in at least three different days. Non-active participants could not have been exercising for the last 4 years more than 1 h per week, being that little exercise non-cardiovascular (i.e. yoga, Pilates, etc.). Besides, they could not have been practicing more than 6 h per week of aerobic exercise during their childhood (from 0 to 14 years old, taking into account that it is mandatory to have at least 3 hours per week of physical education at primary and secondary school). They were categorized as physically active or passive by completing a questionnaire (see Padilla et al., 2013; 2014; Pérez et al., 2014) exploring the frequency, intensity and type of physical activity carried out along their life.

Thirty seven active and thirty seven passive undergraduate students participated in this study (see Table 2 for demographic details). History of neurological disease, psychiatric illness, head injury, stroke, substance abuse (excluding nicotine), learning disabilities, or any difficulty that could interfere with cognitive testing were criteria for exclusion. All participants reported normal or corrected-to-normal vision. They gave their informed consent and were paid or given course credits in exchange for their participation. This experiment was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Apparatus, Stimuli and procedure

An LG computer with a 19 inches Phillips screen was used to run the experimental tasks, which were programmed using SuperLab 4.0 software (Cedrus Corporation). Before participants came to the lab, an experimented psychologist interviewed them by phone to administer the physical activity questionnaire. Once participants were selected, they came to the university facilities and completed the Vocabulary subtest of the Wechsler Adult Intelligence Scale-III (WAIS-III, Wechsler, 1999), a questionnaire to assess their educational level, health status and medication history and carried out the implicit and explicit memory tasks. Finally, the participants performed the Rockport 1-mile Fitness Walking Test (Kline et al., 1987) to assess cardiovascular fitness of both active and passive participants. This sub maximum cardiovascular stress test provides an accurate estimate of the maximum level of oxygen consumption (VO_2 max), with a correlation coefficient of .88 between VO_2 max estimated based on performances during the test and a direct measure of VO_2 max during an increment test on a treadmill (Kline et al., 1987; Weiglein, Herrick, Kirk, & Kirk, 2011). Higher values of VO_2 max are considered to reflect higher aerobic capacity, since it means greater oxygen consumption. The Rockport Test was performed in the University campus surroundings. The whole evaluation procedure lasted for approximately two hours.

Table 2

Sample demographic variables averages and standard deviations in brackets in Experiment 3.

	N	Age	TAM*	Rockport*	WAIS	Education
Active	37	23.7 (3.5)	200.6 (77.8)	56.0 (7.9)	44.0 (6.6)	12.5 (0.9)
Passive	37	23.7 (3.7)	81.6 (75.4)	46.8 (8.5)	43.9 (6.1)	12.4 (0.8)

Note. Age, total activity months of exercise along the whole life (TAM), scores on the Rockport fitness walking level test, scores on vocabulary test (WAIS), and years of education. * = $p < .05$

There were two computerized tasks to evaluate implicit and explicit memory consecutively (see Ballesteros & Mayas, 2015). The stimuli were 240 standardized outline pictures of natural or artificial objects, 120 selected from the Snodgrass and Vanderwart's (1980) stimuli set, and 120 selected from Bonin, Peereman, Malardier, Méot, and Chalard's (2003). The total set of 240 stimuli was divided randomly into two sets of 120 stimuli to be used one in the implicit and the other in the explicit memory task. Each 120-stimuli set was subdivided in 36 attended, 36 unattended and 48 new items. Before the study phase of each memory task began, there were 10 practice trials for which 20 additional pictures were used. In the study phase, just the attended and unattended items were displayed, but in the test phase the previous attended and unattended stimuli were shown along with the new ones. In order to counterbalance color and visual stimuli presentation, 4 different versions were designed using the same material, but combining it in a different way.

The design of both tasks was similar. In the study phase every trial consisted of two stimuli, one blue and one green (see Figure 4a), displayed 1 cm apart inside a rectangular box of 9.5 x 22.6 cm. One stimulus appeared at the left and the other at the right of the fixation cross. Visual stimuli set subtended a visual angle of 8.5º x 16.5º, measuring ~ 4.3º x 4.9º each visual stimulus. Participants were instructed to look at just one of the two stimuli colors (blue or green).

In the test phase, single black picture outlines were displayed every trial, one after another (see Figure 4b). The visual stimulus was placed in the center of the screen and subtended a visual angle of ~ 4.3º x 4.9º.

Experiment 1: Implicit memory

The experimental design consisted of a 2 (Group: active versus passive) x 3 (Study condition: attended, unattended, and non-studied). The experiment began with a fixation cross appearing during 20 seconds. After this, participants had to look at the picture drawn in the color that they had been told to attend to (see Figure 4a) and respond as accurately and quickly as possible whether the object was artificial or natural by pressing the keys ("m" and "n"). The two keys had a sticker showing the initial of the

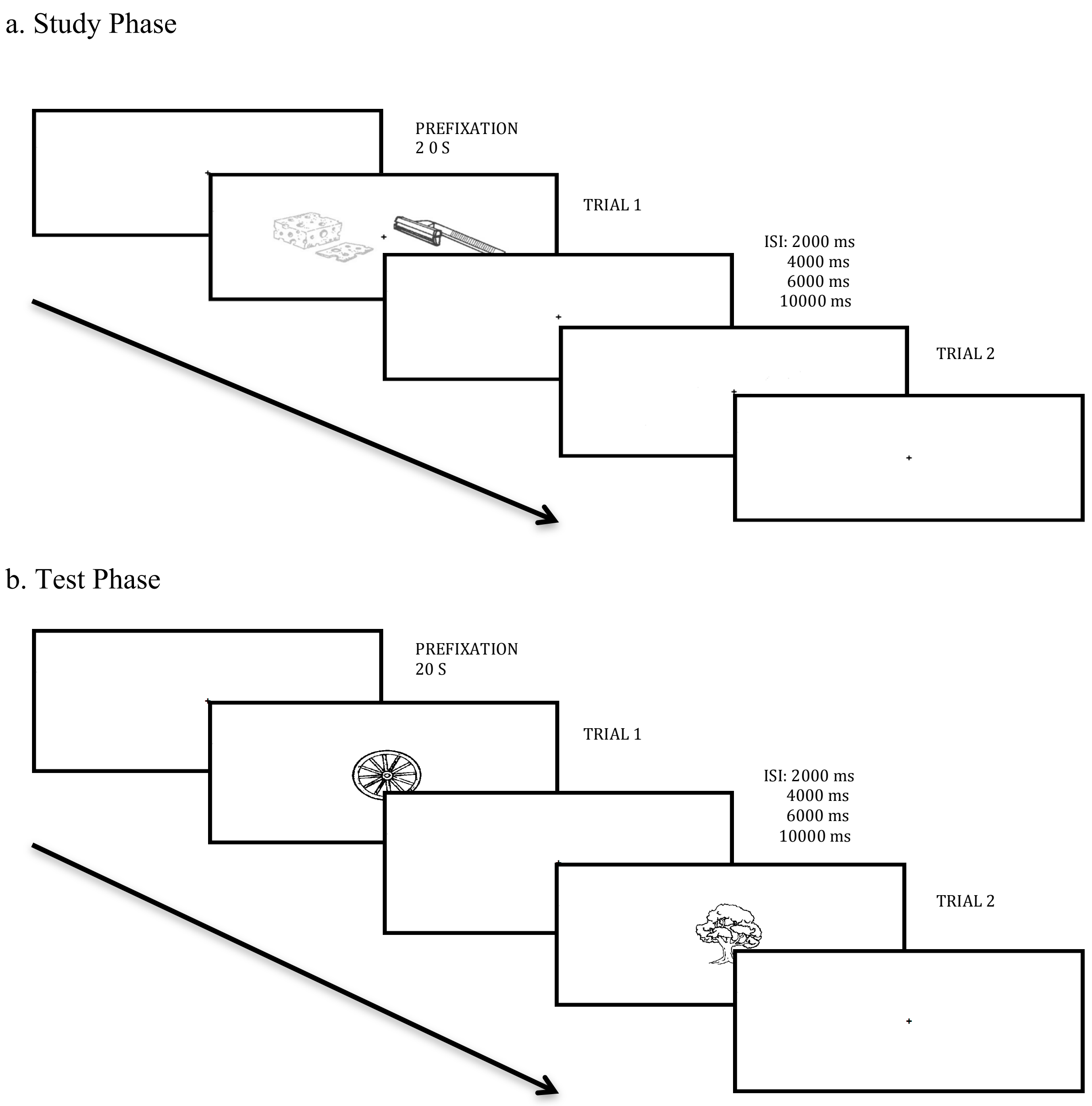

Figure 4. Details of the experimental procedure. a) Study phase: after a pre-fixation cross of 20s, two picture outlines drawn on blue (light grey) or green (black) were presented inside a box, on each side of the fixation point, for 1000 ms. After that, a fixation cross appeared for a variable stimulus interval and a new trial started again. Participants had to categorize the attended picture outline (just one color during the whole task) as natural or artificial as fast and precisely as they could. b) Test phase: a fixation cross appeared for 20s, after that a picture outline in black appeared in the center of a box for 1000 ms. Later, it was replaced by a fixation cross remaining on the screen for a variable stimulus interval. Participants had to categorize the items as artificial or natural in the implicit experiment, but as old or new in the explicit experiment.

category (A and N respectively). The stimuli were presented for 1000 ms in random order, plus a variable inter stimuli interval (ISI) of 2000, 4000, 6000 or 10000 ms, which averaged 6500 ms among attended, unattended and non-studied conditions[2]. The stimulus disappeared after the first 1000 ms and was replaced by a fixation cross during ISI. After that, a new trial started. The study phase included 1 run of 36 trials. When it finished, there was a three minutes distraction task, where participants had to produce words starting by the letter "b".

Test Phase. When the test phase started participants had to classify again as quickly as possible the object that appeared in black and white on the screen (Figure 4b) as natural or artificial pressing the keys "m" and "n". In this phase there were three runs of 40 trials each containing 36 attended (previously outlined in the color that should be attended to), 36 unattended (previously outlined in the color that had not to be attended to) and 48 new pictures. The order of presentation of the 120 stimuli (36 attended, 36 unattended and 48 non-studied) was randomized for each participant.

A fixation cross was displayed for 20 seconds and replaced by an outlined picture in black that remained on the screen for 1000 ms. A fixation cross then appeared for a variable ISI that could be of 2000, 4000, 6000 or 10000 milliseconds with an average of 6500 ms for attended, unattended and new stimuli). After that, another trial started.

Response times (RTs) were measured from the time the picture appeared on the screen until the participant's response (see Figure 4b). Performance was assessed by the RT at which the stimuli were correctly classified.

Results

To investigate whether both groups of participants were similarly accurate in the classification task at encoding, we calculated accuracy proportions for both groups (see Table 3). The ANOVA revealed that there were no significant differences between conditions, F (1, 72) = 0.69, MSE = 0.00, p = .41, η^2_p = .01, or groups, F (1, 72) = 0.07, MSE = 0.00, p = .79, η^2_p = .00. The group x condition was not significant either, F (1, 72) = 0.02, MSE = 0.00, p = .88, η^2_p = .00.

Table 3

Implicit memory accuracy measured in correct responses proportions

	Attended	Unattended	New
Active	.95 (.03)	.93 (.05)	.95 (.05)
Passive	.96 (.04)	.94 (.05)	.95 (.04)

Note. Averages and standard deviations in brackets are provided.

Extreme RTs were removed before the results were analyzed, following a method that takes into account the median, since most of the RT distributions have a negative asymmetry and contain extreme values, which would distort the average. The limit to consider an atypical value was calculated adding or subtracting 1.5 times the interquartile range to the third or first interquartile (q3+ or q1 - 1.5 x (q3 - q1); Laurikkala, Juhola, & Kentala, 2000). RTs higher or lower than these limits were removed (less than 6%). After that, averages were calculated for each condition (attended, unattended and non-studied trials).

2 This variable ISI was included to increase signal sensitivity in an fMRI study, for which this task was also designed.

Mean RTs in attended, unattended and new conditions are presented on Figure 5. The 2 (Group: active and passive) x 3 (Condition: attended, unattended, non-studied) repeated measures ANOVA carried out on mean RTs revealed a significant effect of condition, F (1, 72) = 38.28, MSE = 883.45, p = .00, η^2_p = .35, but not of group, F (1, 72) = 1.85, MSE = 45,307.43, p = .18, η^2_p = .03, or group x condition interaction, F (1, 72) = 0.00, MSE = 883.45, p = .99, η^2_p = .00.

The priming or facilitation effect is measured as the difference in RTs between the attended or unattended and non-studied (new) trials. The difference between attended and non-studied conditions was significant, t (73) = 6.23, p = .00, d = 1.49, revealing facilitation by having previously seen the attended stimuli compared to a condition where the stimuli were never presented before. Moreover, this effect was statistically equivalent for active and passive participants, as shown by the non-significant group x condition interaction (p > .05). RTs in attended and unattended conditions were also significantly different, t (73) = 4.73, p = .00, d = 1.11, indicating a significant selective attention effect. Finally, priming for unattended stimuli (unattended – non studied) was not significant, t (73) = 0.23, p = .82, d = 0.53.

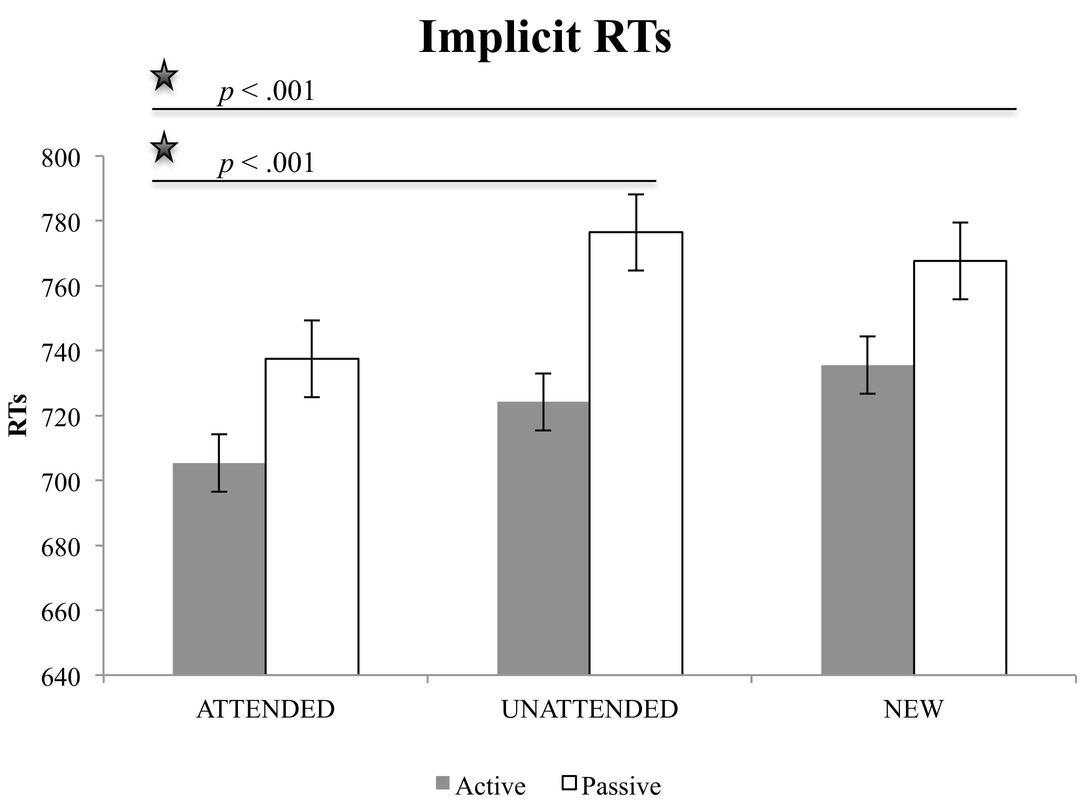

Figure 5. RTs in the attended, unattended and new conditions of the implicit memory task. Averages and standard deviations in error bars are indicated. Attended condition is significantly different from unattended and new ones (p < .001), while unattended and new conditions are not different between them (p = .41).

Discussion

Our results did not reveal any difference between groups or conditions for accuracy rate. Response times, however, revealed differences between conditions: participants responded faster to repeated attended stimuli, but not to repeated unattended ones, compared to the new stimuli, demonstrating conceptual priming only for the attended stimuli. This finding suggests a significant role of selective attention at encoding for priming to occur (see also Ballesteros & Mayas, 2015). Moreover, as anticipated, passive and active participants did not differ in any of the measures, revealing equivalent performance in the implicit memory task. Thus, chronic exercise does not seem to have an effect on conceptual implicit memory.

Experiment 2: Explicit memory

The *Study Phase* had exactly the same structure as the study phase from the implicit memory task, with the only difference that the instructions mentioned that participants would have to categorize the attended stimuli (green or blue) into natural or artificial as fast and accurately as possible at the same time as they tried to remember the attended stimuli. After the encoding classification phase, a 3-minute distracting task consisting of counting from 1000 to 0 by twos was carried out.

Test Phase. When the distracting task finished, all participants performed two explicit memory tests to evaluate explicit memory. First, they were required to recall in writing as many objects (attended or not attended) as possible from the latest study phase. When this task was finished, participants performed an old-new recognition test. It was similar to the test phase of the implicit task. This time, however, they had to classify the single outlined picture presented in black as old or new as quickly and accurately as possible. Participants were told to classify as old those items that had been attended and unattended. Different keys from the keyboard were used ("x" for new and "z" for old; also labeled with the initials of the categories "new" or "old") to categorize the presented stimulus.

Results

Encoding. We analyzed first the classification task performed at encoding. Univariate ANOVAs revealed no significant differences between groups on accuracy, F (1, 72) = 0.51, MSE = 55.19, p = .48, η^2_p = .01, and RTs, F (1, 72) = 1.78, MSE = 131,505.47, p = .19, η^2_p = .02. This result suggests that active and passive participants accomplished the study phase at the same level.

Free Recall. A 2 (Group: active versus passive) x 2 (Study condition: attended and unattended) repeated measures ANOVA demonstrated that recall was different among conditions, F (1, 67) = 54.32, MSE = 14.77, p = .00, η^2_p = .00, being the attended items better recalled than the unattended stimuli (see Table 4). However, there were no significant group, F (1, 67) = 0.41, MSE = 14.82, p = .52, η^2_p = .01, nor interaction, F (1, 67) = 0.17, MSE = 14.77, p = .89, η^2_p = .00, effects.

Recognition. Accuracy levels in explicit memory were also analyzed within the context of signal detection theory of recognition (Green & Swets, 1966). This theory quantifies the participant´s ability to discriminate between stimulus and noise using a confusion matrix including 'hits' (old items recognized as old), 'misses' (old items recognized as new), 'false alarms' (new items recognized as old) and 'correct rejections' (new items recognized as new).

Within this context, sensitivity or discrimination index *d'* is the difference between hits and false alarms, previously converted to z scores. The higher the index, the better the discrimination between old and new items is. In the current experiment both the attended and unattended items were considered 'old' items, so *d*' was calculated for attended items and for unattended items independently in each group, taking into account the same number of new items recognized as old (false alarms). Table 4 presents *d'* for active and passive participants. A 2 (Group: active versus passive) x 2 (Study condition: attended and unattended) ANOVA for repeated measures revealed a significant difference between attended and unattended conditions, F (1, 72) = 61.23, MSE = .72, p = .00, η^2_p = .46, with the attended items (M = 1.80, SD = 1.27) being better recognized than the unattended (M = 0.70, SD = 0.74). The group effect was marginally significant, F (1, 72) = 3.88, MSE = 1.41, p = .05, η^2_p = .05, but no significant group x condition interaction was observed, F (1, 72) = 0.06, MSE = .72, p = .80, η^2_p = .00.

Table 4

Mean d', criterion and free recall proportion of items in attended and unattended conditions

	Active	Passive	
	M (SD)	M (SD)	T test (*p*)
d' attended	1.59 (1.47)	2.01 (1.02)	.160
d' unattended	0.53 (0.62)	0.88 (0.81)	.041
Criterion attended	-0.06 (0.27)	0.09 (0.49)	.109
Criterion unattended	0.25 (0.66)	0.39 (0.52)	.308
Free recall attended	0.21 (0.11)	0.20 (0.15)	.774
Free recall unattended	0.08 (0.07)	0.07 (0.07)	.407

Note. Standard deviations are shown in brackets. P values for t tests are also provided; FA = False alarms

To explore further the trend suggesting that groups might differ in their discrimination performance, pairwise comparisons were calculated. The results revealed a significantly lower discrimination in the unattended condition for the active (M = .53, SD = .12) than for the passive participants (M= .88, SD = .12) ($p < .05$). No significant differences between groups were found in discrimination for the attended condition (p = .160).

Decisional criterion (*c*), an index that describes how flexible or conservative a participant is, independently of discrimination (see Green & Swets, 1966), was also estimated. The higher the criterion, the more conservative the participant is. The repeated measures 2 (Group: active versus passive) x 2 (Study condition: attended and unattended) ANOVA revealed a significant effect of condition, F (1, 72) = 17.92, MSE = .19, p = .00, η^2_p = .19, while the group, F (1, 72) = 2.45, MSE = 0.32, p = .12, η^2_p = .03, or interaction, F (1, 72) = 0.00, MSE = 0.19, p = .96, η^2_p = .00, effects were not significant. These results reveal that participants were generally more conservative when they respond to unattended than attended items (see Table 4).

Response times. Only the correct trials were considered for the analysis of RTs. Extreme reaction times (RTs) were removed before the results were analyzed following the interquartile range method applied in our previous implicit memory experiment (Laurikkala et al., 2000). Thereafter, averages were calculated (see Figure 6). A 2 (group: active versus passive) x 3 (Study condition: attended, unattended and non-studied) ANOVA for repeated measures revealed a non-significant condition effect, F (1, 70) = 2.84, MSE = 5258.45, p = .10, η^2_p = .04. No significant group, F (1, 70) =

1.18, *MSE* = 59,525.36, p = .28, η^2_p = .02, nor interaction, F (1, 70) = 1.77, *MSE* = 5,258.45, p = .19, η^2_p = .03, effects were found either.

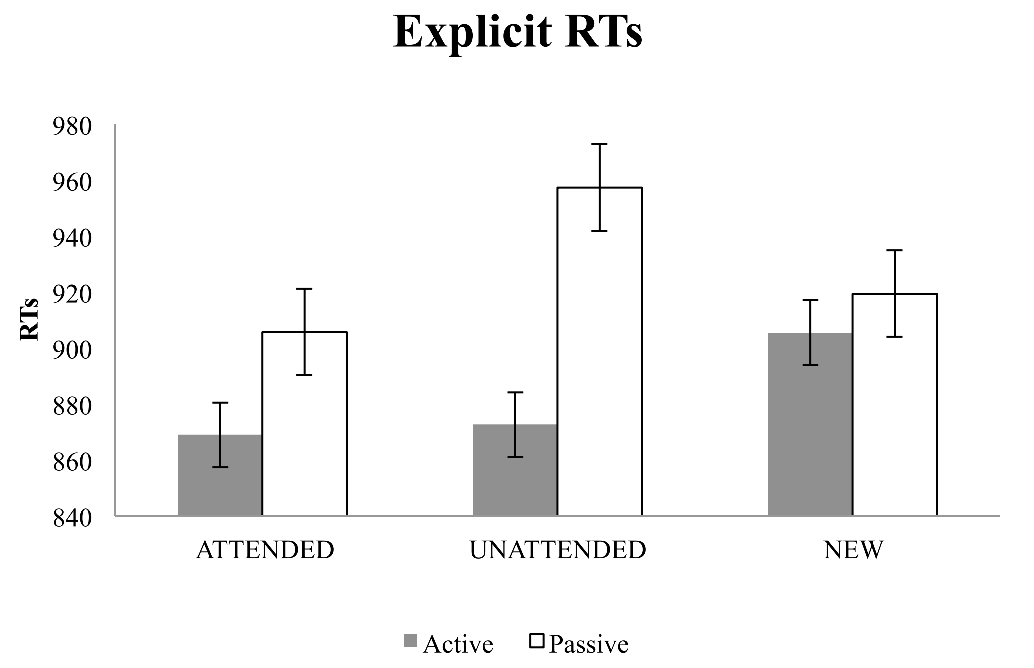

Figure 6. RTs in the attended, unattended and new conditions of the explicit memory task. Averages and standard deviations in error bars are specified. No significant differences were found in explicit RTs.

Discussion

In Experiment 2 active and passive participants performed at the same level in the encoding phase of explicit memory. Unsurprisingly, the results in the free recall task revealed that both groups recalled better attended than unattended items. Also, attended items were better discriminated than unattended in the recognition task by both groups. Finally, a significant difference was observed between active and passive participants for unattended items, i.e., for active participants it was more difficult to discriminate between unattended (but presented) and new (never presented at encoding) items. Active and passive participants could however equally discriminate between attended and new items.

General Discussion

The aim of this study was to explore the extent to which chronic aerobic exercise could affect long-term memory capacities through selective attention. Two experiments were carried out to measure implicit and explicit memory, expecting significant effects of physical activity on recognition and recall but not on repetition priming. We also manipulated selective attention at encoding with the aim to introduce higher attentional demands in the task, a feature that seems to be required to increase the likelihood to detect effects of exercise on cognitive tasks (Guiney & Machado, 2013).

We first found that conceptual priming was only observed for attended stimuli, replicating the effect of selective attention on conceptual implicit memory observed by Ballesteros and Mayas (2015). This shows that the unattended stimuli were filtered out by the attentional system and not deeply encoded. Thereby these results confirm that implicit memory, although incidentally built, needs at least some attention to be created (Ballesteros, Reales, Mayas, & Heller, 2008). Furthermore, the attended items were better recalled and recognized than the unattended by both groups, which means that participants successfully suppressed the unattended pictures.

Regarding the effects of cardiovascular exercise, the analyses of RTs revealed no significant differences between groups in either implicit or explicit memory tasks. This result replicates previous studies looking at attentional and executive tasks, where differences between active and passive participants observed in executive processes could not be attributed to group differences in processing speed (Padilla et al., 2013, 2014; Pérez et al., 2014).

In terms of conceptual priming, no group effects were observed for neither of the comparisons made (attended versus non attended, attended versus new and non attended versus new), confirming also previous studies looking at the effects of exercise on perceptual priming in older adults (Ballesteros et al., 2013). Therefore, the current study looking at conceptual priming, which requires more elaborated processing than perceptual priming, shows that there is, at least so far, no evidence of an effect of chronic exercise on priming.

In the current study, discrimination indexes were also calculated for attended and unattended items, revealing similar indexes between active and passive participants for attended but different for unattended items. Discrimination for unattended items was significantly lower for active participants, suggesting that for them the strength of the memory traces of the unattended and new items were closer together than for the passive participants. It is suggested that the weaker memory traces for unattended items for active participants resulted from suppression strategies. According to Lustig, Hasher and Zacks (2007), inhibition can be involved in any of the three stages of processing: access, deletion or restrain. Since there was no evidence of differential suppression of unattended pictures at encoding in the implicit task (no group x condition interaction was observed), where no encoding strategies are applied, it is likely that suppression mechanisms were similar at the access stage. However, when participants were explicitly asked to encode the information at the same time as they ignored unattended pictures, it is likely that they applied strategies in order to retrieve the to-be-remembered information later. Active participants might have applied strategies to encode attended stimuli, but also to suppress the unattended material accessing the cognitive system in order not to interfere with the to be attended pictures, reducing their activation levels and making them more similar to the lures.

In terms of the possible limitations of our study, it is worth noting that interventional (as opposed to cross-sectional) studies are better suited to investigate the effect of exercise on cognition. We also note however that significant differences in an objective measure of cardiovascular fitness as well as in frequency of aerobic exercise performed along life support the characterization of the passive and active groups as distinct groups with different cardiovascular levels. Future research might look at memory functioning before and after an exercise intervention to confirm the results obtained in our study using a cross-sectional design.

To conclude, physically active and passive participants performed at the same level in conceptual priming and recall. However, active participants obtained a lower discrimination index for unattended stimuli, suggesting that they were more able to suppress the non-relevant stimuli for the task. This finding is consistent with previous results revealing better inhibitory control in active participants (Padilla et al., 2013, 2014; Pérez et al., 2014), and provides additional support to the hypothesis that regular cardiovascular exercise taps on executive control.

Chapter 7.
Experiment 4: Self-regulation and personality traits in physically active and passive young adults

Self-regulation and personality traits in physically active and passive young adults

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Abstract

Previous research has established a link between exercise and cognition. However, the possible mediation of personality, motivation and self-regulation on these effects has been little studied to date. The aim of this study was to look at the possible impact of these factors by comparing them in physically active and passive participants. The Big Five Questionnaire, two different motivation inventories - the Intrinsic Motivation Inventory (IMI) and Achievement Motivation (ML-1 & 2) – and the Adult Temperament Questionnaire (ATQ) were administered for this purpose. The results showed that active and passive participants did not significantly differ in any type of motivation. However, they differed significantly in inhibitory control, one component of effortful control involved in self-regulation. Interestingly, significant differences were also found in several dimensions (emotional stability and energy) and sub-dimensions (dynamism, dominance, emotion control, impulse control and openness to experiences) of the Big Five Inventory. We discuss whether better control of emotions and impulses might be the reason why exercise enhances executive functions, concretely inhibition and interference control.

Introduction

It is well established that exercise has a positive effect on our mind, emotions and body (Erickson, Gildengers, & Butters, 2013; Nagamatsu et al., 2014, Torres et al., 2015). Studies looking at the effects of exercise on cognition have shown that chronic aerobic exercise tends to specially enhance executive functions such as inhibitory control, task shifting and working memory (Colcombe & Kramer, 2003; Cox et al., 2015; Guiney & Machado, 2013). In addition, research has also shown that exercise interventions can be used to treat certain clinical conditions in which mood, anxiety and/or depression disorders are presented along with diminished cognitive performance (Asmundson et al., 2013; Malchow et al., 2013).

However, the mechanisms through which cognitive and emotional effects are exerted are still not well understood. In this study we aimed at investigating the extent to which the cognitive benefits of exercise observed in previous studies (Padilla, Pérez, Parmentier, & Andrés, 2013; Padilla, Pérez, & Andrés, 2014; Pérez, Padilla, Parmentier, & Andrés, 2014) might be explained by personality, motivation and self-regulation differences between active and passive young participants.

Personality may be understood as a set of dynamic but stable characteristics that make a person unique. It is a set of features about the self, social and world functioning conformed along life, in which genetics and nurture factors are involved, affecting how an individual perceives, interprets and behaves with regards to the world, making them somehow predictable (Rothbart & Rueda, 2005; Winne & Gittinger, 1973).

According to the big five theory (Caprara, Barbaranelly, & Borgogni, 1993; Digman, 1990; John, 1990) personality can be divided into five general dimensions (see Table 5): Extraversion (E), Affability (A), Consciousness (C), Openness (O), and Emotional Stability (ES), that in turn can be each separated in two other subdimensions. According to Caprara et al. (1993), an extravert person is active, dynamic, energetic, enthusiastic, talkative, and manifests positive emotions. The Extraversion dimension is formed by dynamism (Dy) and dominance (Do). Dy refers to the enthusiasm and energy that an individual shows, while Do relates to how he or she influences other people and whether is able to impose his/her ideas to be asserted. The second dimension (Affability) refers to cordiality, cooperation, generosity, or empathy. It includes the subdimensions of cooperation/empathy (Cp) and cordiality/kindness (Co). The third dimension (Consciousness) is described as the capacity for self-regulation. People with high scores on this dimension are reflexive, perseverant, meticulous and organized. Moreover, this dimension is subdivided in scrupulosity (S) and perseverance (Pe). Then, Openness defines a person who enjoys learning and being updated on cultural or intellectual matters (Oc: openness to culture) and/or open to new experiences, activities, customs or cultures (Oe: openness to experience). Finally, emotional stability refers to the capacity to control emotion and impulses to maintain a low level of anxiety and vulnerability. It is opposed to the concept of neuroticism and it includes control of emotions (Ce) and impulses (Ci). The big five questionnaire (Caprara et al., 1993) will be the personality questionnaire used in the current study.

Table 5

Big Five dimensions and subdimensions

Dimensions	Subdimensions	
Extraversion (E)	Dynamism (Dy)	Dominance (Do)
Affability (A)	Cooperation/empathy (Cp)	Cordiality/kindness (Co)
Consciousness (C)	Scrupulosity (S)	Perseverance (Pe)
Openness (O)	Openness to culture (Oc)	Openness to experience (Oe)
Emotional Stability (ES)	Control of emotions (Ce)	Control of impulses (Ci)
Distortion scale (D)		

Some authors have argued against the idea of an "athlete personality", based on the fact that athletes present with diverse personalities (Van den Auweele, De Cuyper, Van Mele, & Rzewinicki, 2001). In that vein, Brinkman (2013) has argued that what is likely to happen is that personality traits affect the level and type of motivation of the person, and then indirectly, the effort exerted to practice any kind of physical exercise.

Furthermore, motivation can be described as the reason why an individual initiates a behavior and maintains it along time to achieve a goal (Nevid, 2013). In the current study we were interested in achievement motivation, i.e., the need to excel in an activity for which an individual wants to surpass him/herself or others (Nevid, 2013; Seara, 1987). It can be driven by internal motivation, aiming just at self-satisfaction; or by external motivation, pursuing an external reward that can be social or material (Nevid, 2013; Ryan & Deci, 2000). Achievement motivation is highly associated with the participant's interests. For example, someone may have a high achievement motivation at work, but not for sport. For this reason, it is necessary to delimit the activity the participant is asked about. This perspective is followed by Ryan and Deci (2000), who created the "Intrinsic Motivation Inventory" (IMI; Ryan, 1982), containing questions about how motivated the participant was during performance of a specific activity, that will be used in the current study.

Other authors such as Mehrabian (1968) or Morales-Vallejo (2006) describe achievement motivation as a general trend for risk taking and ambition. Individuals showing this general trend are able to perseverate and self-regulate themselves until achieving their goals. Mehrabian created the achievement motivation scale and Morales-Vallejo (2006) adapted it creating two scales: ML1 and ML2, in order to achieve a better construct validity. In these scales, individuals are asked about work, social, or academic achievement, putting more emphasis in risk taking in the second scale. These two scales will also be administered to physically active and passive participants in the current study.

Finally, we were also interested in investigating whether active and passive participants would differ in their self-regulation abilities. Self-regulation refers to processes triggered to control behavior, cognition and emotional states (Vohs & Baumeister, 2011). The concept includes effortful/executive control, referring to the emotional, behavioral or/and physiological control of responses to focus attention on a goal-directed task, suppressing non-relevant information or actions (Rothbart & Rueda, 2005; Derryberry & Rothbart, 1997).

Thereby, effortful control is the dimension of temperament in charge of controlling emotional reactivity (positive and negative; Rothbart & Bates, 2006; Rueda, 2012), and can be measured applying the Adult Temperament Questionnaire (ATQ, Evans & Rothbart, 2007). This questionnaire measures three subcomponents of effortful control: activation, attentional, and inhibition control. Rothbart and Rueda (2005; see also Posner & Rothbart, 1998; 2007; Rothbart, Sheese & Posner, 2007; Rueda, Posner & Rothbart, 2011; and Rueda, 2012) considered effortful control as part of the anterior attentional network system and highly related to executive control. Activation control refers to the capacity to carry out a task, despite a natural tendency to avoid it, since such activity is very demanding or frightening for the individual (Evans & Rothbart, 2007). Attentional and inhibition control can be identified with working memory and inhibition respectively (Miyake et al., 2000; Hofmann, Friese, Schmeichel, & Baddeley, 2011). The difference between executive and effortful control is that the first is involved in cognitive control and flexibility, whereas the second in the regulation of emotional reactivity (Rueda, 2012). It is also important to note that certain temperamental dimensions correlate with certain dimensions from the Big Five's questionnaire (Evans & Rothbart, 2007). In the case of effortful control, for example, it is negatively correlated with neuroticism, and positively correlated with consciousness (Ahadi & Rothbart, 1994; Evans & Rothbart, 2007).

Some authors (see for example Buckley, Cohen, Kramer, McAuley, & Mullen, 2014; Hall, Fong, Epp, & Elias, 2008; or Best, Nagamatsu, & Liu-Ambrose, 2014) have suggested that cognitive control is the antecedent of self-regulation, and therefore of physical activity adherence. In other words, it is argued that the reason why people exercise on a regular basis is that they have more cognitive control, which allows them to self-regulate better, and so keep training for longer periods of time. According to this view, poor cognitive control would lead to lower self-regulatory capacity and greater tendency to be driven by routine reactions, succumbing to temptation or impulsive behavior (overeating, unsafe sex, sedentariness; Gyurak, Goodkind, Kramer, Miller, & Levenson, 2012; Hagger, Wood, Stiff, & Chatzisarantis, 2010; Hofmann, Friese, & Wiers, 2008; Nigg et al., 2006).

The objective of this study was to investigate possible differences in personality, achievement motivation and self-regulation between the physically active and passive participants studied in our previous experiments (Padilla et al., 2013, 2014; Pérez et al., 2014). One might think that people who exercise regularly (keeping a frequency of at least 6 hours per week during at least 10 years, Experiments 1 to 3) show more perseverance and better emotional control. Besides, active people might have greater achievement motivation and self-regulatory capacity that may be reflected in cognitive tasks measuring their cognitive control.

We therefore hypothesized that young adults showing higher levels of physical activity and fitness would present with higher scores in the Big Five dimensions of perseverance and emotional control, greater achievement motivation and better self-regulation. Finally, we also expected that these variables would be positively related to higher cognitive control.

Method

Participants

Seventy-one participants aged between 18 and 30 years (M = 22.42, SD = 3.33) were selected from previous studies (Padilla et al., 2013; 2014). They were 36 active and 35 passive participants allocated to each group according to their frequency of aerobic exercise and fitness levels. Cardiovascular fitness was measured with the Rockport 1-mile Fitness Walking Test, which presents with a high correlation coefficient (0.88) with a direct index of VO_2max carried out using a treadmill (Kline et al., 1987). Also, total hours of aerobic exercise in the past and present were separately calculated with a weighted average taking into account the weekly hours of aerobic exercise at each period, since frequency of sport is not constant and varies from time to time. The weights were the number of weeks that frequency of exercise had been kept for. Total hours of past exercise were added to total hours of present exercise. Total months along life were also calculated. The correlations between Rockport, total hours ($r = .47$, $p = .00$) and total months ($r = .41$, $p = .00$) were significant.

The characteristics of both groups are presented on Table 6. As in previous studies, the inclusion criteria for the active group were having practiced cardiovascular exercise for at least 10 years, following an exercise routine of at least 6 hours distributed in at least 3 days a week. The active group exercised an average of 10.44 hours per week (*SD* = 5.88). Passive participants should have done cardiovascular exercise for less than 1 hour a week in the last 4 years and they could not have exercised during their infancy at a high frequency or intensity routine (see Padilla et al., 2014). Their main exercise frequency was 1.29 hours per week (*SD* = 2.08). The groups differed significantly in terms of cardiovascular exercise frequency [t (42.87) = 8.81, $p = .00$, $d = 2.69$] and fitness level [t (67) = 5.73, $p = .00$, $d = 1.4$]. However, they did not differ in age [t (69) = .73, $p = .47$, $d = 0.18$] or education level [t (69) = 1.66, $p = .10$, $d = 0.40$]. Crystallized intelligence was measured using the Vocabulary Subtest of Wechsler Adult Intelligence Scale- III (WAIS-III; Wechsler, 1999) and did not reflect any significant difference between groups [t (67) = 1.09, $p = .28$, $d = 0.27$]. None of them had a history of mental disorder or physical illness incompatible with the study.

Table 6

Experiment's 4 sample demographic variables averages and standard deviations in brackets.

	Group	
Variables	Active	Passive
Age	22.14 (3.14)	22.71 (3.54)
Education	15.22 (3.63)	13.89 (3.12)
Rockport	56.94 (8.46)	45.60 (7.96)
Total Exercise Months along life	233.67 (217.96)	65.97 (45.87)
Total Exercise Hours along life	8072.48 (4937.98)	1534.88 (1611.83)
Wais	43.14 (6.49)	44.88 (6.83)

Procedure

Participants from previous studies (Padilla et al. 2013; 2014), were invited to take part in the current study. They gave their informed consent and received a monetary reward or course credits if they were University students. The experiment was performed in accordance with the ethical standards stated in the 1964 Declaration of Helsinki.

First, we used the results from the intrinsic motivation test (IMI, Ryan, Koestner & Deci, 1991) that was administered in Experiment 2 (Padilla et al., 2014) to assess the level of motivation during the performance of the Automatic Operation Span Task

(Unsworth, Heitz, Schrock, & Engle, 2005) and Stop Signal Task (Verbruggen, Logan, & Stevens, 2008). This inventory contains five dimensions: a) interest/enjoyment, b) perceived competence, c) value/usefulness, d) pressure/tension, and e) effort.

Participants were requested to complete several additional online personality and motivation questionnaires from home. Personality was evaluated using the “Big Five Questionnaire” (Caprara et al., 1993) described in the introduction. This questionnaire applies a Likert 5-point scale to assess the participant’s level of agreement or disagreement with a given statement. In addition to the dimensions previously described, it contains a response distortion scale (D) that measures the trend to lie in their responses. Direct scores were calculated for each subdimension subtracting reverse items scores from direct items scores. The result is added to the other subdimension conforming the dimension, for example, Dy + Do = E.

Achievement motivation was evaluated with the ML-1 and 2 scales (Morales-Vallejo, 2006) described in the introduction, which measure the person’s capacity to achieve a long-term goal.

Finally, effortful control was evaluated with a short version of the Adult Temperament Questionnaire (ATQ, Evans & Rothbart, 2007).

Results

The Big Five average scores are presented in Table 7. They were analyzed using independent t tests, showing that active participants significantly obtained higher scores in E [t (68) = 3.52, p = .00, d = 0.85], subdimensions of Dy [t (68) = 3.04, p = .00, d = 0.73] and Do [t (68) = 3.01, p = .00, d = 0.73]. More importantly, active participants obtained significantly higher scores in ES [t (68) = 2.89, p = .01, d = 0.70], Ce [t (68) = 2.81, p = .01, d = 0.68] and Ci [t (68) = 2.63, p = .01, d = 0.64]. In addition, they were more open to new experiences [t (68) = 3.29, p = .00, d = 0.79]. Active and passive participants did not differ in level of D in their responses [t (68) = 1.03, p = .31, d = 0.25].

Table 7

Averages (standard deviations in brackets) from Big Five Questionnaire dimensions and subdimensions in active and passive participants.

	Active	Passive	
Dimensions	*M*	*M*	*p*
Extraversion (E)	81.06 (9.95)	72.12 (11.26)	.00*
Dynamism (Dy)	42.17 (5.40)	37.59 (7.11)	.00*
Dominance (Do)	38.89 (5.95)	34.53 (6.13)	.00*
Affability (A)	87.50 (5.60)	84.03 (9.35)	.07
Cooperation (Cp)	45.78 (2.81)	44.29 (5.52)	.17
Cordialness (Co)	41.72 (4.25)	39.74 (5.65)	.10
Conscientiousness (Con)	83.72 (10.75)	86.88 (12.65)	.26
Scrupulousness (S)	38.75 (6.61)	42.24 (8.11)	.05
Perseverance (Pe)	44.97 (5.65)	44.65 (6.53)	.82
Openness (O)	88.86 (8.90)	85.35 (8.43)	.10
Openness Culture (Oc)	42.86 (5.79)	43.35 (5.43)	.72
Openness to Experience (Oe)	46.00 (4.85)	42.00 (5.33)	.00*
Emotional Stability (ES)	75.06 (15.60)	63.79 (16.95)	.01*
Control of Emotions (Ce)	38.39 (9.58)	32.15 (8.94)	.01*
Control of Impulses (Ci)	36.67 (7.00)	31.65 (8.89)	.01*
Distortion (D)	81.06 (9.95)	72.12 (11.26)	.31

Note. p values provided

None of the motivation scales revealed significant differences between active and passive participants (*p* > .09, see Table 8).

Table 8

Average, standard deviations per group and p values in tests measuring different aspects of motivation

	Active	Passive	
Test	*M*	*M*	*p*
ATQ:			
Activation Control	4.89 (0.76)	4.77 (0.84)	.55
Attentional Control	4.19 (0.89)	4.10 (1.11)	.71
Inhibitory Control	4.74 (0.87)	4.13 (1.04)	.01*
Total	4.65 (0.63)	4.36 (0.75)	.08
ML:			
ML-1	41.81 (4.64)	40.00 (4.47)	.10
ML-2	31.92 (5.31)	32.47 (4.19)	.63
IMI:			
Interest/Enjoyment	36.56 (7.68)	34.00 (7.37)	.17
Perceived Competence	26.67 (6.97)	23.82 (6.65)	.09
Effort	30.00 (2.98)	29.39 (3.83)	.47
Value/Usefulness	20.74 (4.81)	20.79 (4.17)	.96
Pressure/Tension	16.71 (5.35)	17.69 (6.19)	.49

Note. Adult Temperament Questionnaire (ATQ), Achievement Motivation Test (ML), and Intrinsic Motivation Inventory (IMI).

Importantly, groups differed significantly in the inhibitory control subscale [*t* (68) = 2.65, *p* = .01, *d* = 0.64], one of the components evaluated by the ATQ (see Table 8), showing that active participants had a higher inhibitory control than passive participants. Activation, attentional and total control did not differ significantly between groups (all p > .08).

Following Evans and Rothbart (2007), we studied correlations between Big Five personality traits, effortful control factors and cognitive control (SSRT and AOspan) and explored their relations with physical activity.

Correlations between physical exercise, cognitive control, self-regulation and personality.

As can be seen from Table 9, two types of SSRT were included in the correlation matrix, the one from the standard version of the SST and the one from the strategic version. From the 58 participants who performed the SST in previous studies 30 carried out the standard version and 28 the strategic version. Strategic SSRT correlated negatively with total months of exercise along life (*r* = -.45, *p* = .02). Total months of exercise explained 20% of the variance of strategic SSRT.

Regarding AOspan, physical exercise did not correlate with this measure (Table 9).

Finally, cardiovascular capacity measured with the Rockport test correlated with E (Dy, Do), A (Cp) and Oe (all *p* < .04; see Table 8) and total exercise hours with E (Dy) and Oe (all *p* < .02).

Correlations between self-regulation, personality and cognitive control.

The inhibitory control subcomponent of effortful control (see Table 9 for detailed information) correlated with Ce (*r* = .68, *p* < .001), Ci (*r* = .71, *p* < .001), and ES (*r* =

.73, p < .001) and AOSpan (r = .28, p = .04). The Ci personality subdimension also correlated with AOspan (r = .32, p = .01).

Regression analysis between AOSpan (see results in Padilla et al., 2014) and Ci was also calculated, since the resulting correlation index was higher than the one between AOSpan and Inhibitory control. Inhibition control was excluded from the regression analysis because it correlated with Ci and collinearity assumption was not met. A significant regression equation was found [F (1, 56) = 6.45, p = *.01*], with an R^2 = .10, indicating that Ci explains 10% of the variance of the AOSpan score. Participants' total letter recalled score (AOSpan) increased .45 points (B = .45) for each unit of the Ci score.

Finally, strategic SSRT did not correlate with self-regulation (see Table 9). Standard SSRT correlated negatively with total effortful control (r = -.38, p = .04).

Regression analysis between total effortful control and standard SSRT indicated that there was a significant regression equation [F (1, 28) = 4.65, p = .04], with an R^2 = .14. Thus, total effortful control explained 14.2% of the variance of the standard SSRT.

Table 9

Correlations between measures of frequency and level of exercise, ATQ subcomponents, Big Five subdimensions and dimensions, SSRT and AOSpan

	Total Months	Total Hours	Rockport	Activation Control	Attentional Control	Inhibitory Control	Total Control	Dy	Do	Cp	Co	S	Pe	Ce	Ci	Oc	Oe	E	A	C	ES	O	SSRT Standard	SSRT Strategic	AOspan
Total Months	--																								
Total Hours	.75**	--																							
Rockport	.41**	.47**	--																						
Activation Control	-0.08	-0.05	-0.07	--																					
Attentional Control	0.09	0.01	0.05	.46**	--																				
Inhibitory Control	0.23	0.17	0.19	.31*	.46**	--																			
Total Control	0.12	0.07	0.09	.74**	.79**	.79**	--																		
Dy	0.22	.33*	.46**	0.18	0.15	-0.03	0.12	--																	
Do	0.11	0.25	.47**	0.13	0.21	-0.08	0.10	.63**	--																
Cp	0.07	0.15	.34**	0.20	0.06	0.18	0.19	0.21	.28*	--															
Co	0.21	0.14	0.12	0.10	0.17	0.24	0.22	0.19	0.01	.43**	--														
S	-0.24	-0.17	-0.20	0.17	0.10	-0.04	0.09	-0.11	0.01	-0.00	-0.10	--													
Pe	-0.11	-0.07	-0.02	.49**	.32*	0.16	.39**	0.16	0.14	0.13	-0.00	.48**	--												
Ce	0.25	0.17	0.13	.34**	.51**	.68**	.67**	0.02	0.04	0.09	0.23	-0.14	0.16	--											
Ci	0.17	0.15	0.09	.27*	.52**	.72**	.66**	-0.01	-0.03	0.18	.330*	-0.05	0.13	.82**	--										
Oc	-0.08	-0.05	0.09	0.14	0.19	0.08	0.17	0.06	0.22	0.23	-0.05	0.21	0.26	0.24	0.25	--									
Oe	0.22	.31*	.32*	0.15	0.15	0.15	0.19	.47**	.33*	0.26	0.14	-0.15	0.14	0.25	.31*	.32*	--								
E	0.19	.32*	.51**	0.17	0.20	-0.06	0.12	.91**	.90**	.27*	0.12	-0.06	0.17	0.03	-0.02	0.15	.45**	--							
A	0.17	0.17	.27*	0.17	0.14	0.25	0.24	0.24	0.16	.83**	.86**	-0.06	0.07	0.19	.30*	0.10	0.23	0.22	--						
C	0.21	0.15	-0.14	.36**	0.23	0.06	.26*	0.01	0.08	0.06	-0.07	.90**	.82**	-0.02	0.03	.27*	-0.03	0.05	-0.00	--					
ES	0.22	0.17	0.12	.32*	.54**	.73**	.69**	0.00	0.01	0.14	.29*	-0.11	0.15	.96**	.95**	0.26	.29*	0.01	0.25	0.01	--				
O	0.08	0.16	0.25	0.18	0.21	0.14	0.22	.32*	.34**	.31*	0.05	0.04	0.25	.30*	.35**	.82**	.81**	.36**	0.20	0.15	.37**	--			
SSRT Standard	.27	.19	.09	-.31	-.35	-.27	-.38*	.02	-.02	-.23	-.11	-.18	-.28	-.01	-.17	-.30	-.06	.00	-.20	-.26	-.09	-.22	--		
SSRT Strategic	-.45*	-.19	-.20	.19	.02	-.12	.04	-.02	-.07	-.16	-.30	-.09	-.26	-.14	-.12	-.05	-.08	-.05	-.30	-.18	-.13	-.08		--	
AOspan	0.11	0.22	0.23	0.07	0.13	.28*	0.21	0.04	-0.03	0.01	-0.08	0.13	0.23	0.14	.32*	-0.01	0.17	0.01	-0.04	0.20	0.23	0.10	-0.21	-.26	--

Note. ATQ = Adult Temperament Questionnaire, SSRT = Stop Signal Reaction Time, AOSpan = Automatic Operation Span Task. Correlation is significant at the **.01 level or at the *.05 level.

Discussion

The aim of this study was to investigate the extent to which personality traits, motivation and self-regulation might mediate the relationship between chronic exercise and executive functions found in previous studies (Padilla et al., 2013; 2014). To this end, we compared scores in personality, motivation and self-regulation questionnaires in a group of active and passive participants. In addition, we studied how the long-term practice of exercise could modulate them. Finally, we explored the relationship between variables measuring different dimensions of personality, effortful control and cognitive control to corroborate Rothbart and colleague's predictions (Ahadi & Rothbart, 1994; Evans & Rothbart, 2007; Rothbart & Rueda, 2005).

Our results revealed that active participants were more extroverted or energetic than passive participants, suggesting that active participants tend to show a more positive mood state, are more dynamic and able to assert themselves in their personal relationships. Active participants also displayed higher scores on emotional stability and were more open to new experiences. However, groups did not differ in achievement motivation. Active and passive participants also differed in self-regulation, specifically in one of the factors included in effortful control, i.e., inhibitory control, where active participants presented with better control of positive and negative emotions and physiological reactions.

The fact that active participants controlled better their reactive emotions and showed a personality pattern characterized by low neuroticism and high positive emotions, accompanied also by new-experience seeking, characterizes active people as persons with high self-regulation levels according to Evans and Rothbart's (2007) predictions. Nevertheless, contrary to such predictions, active people although more self-regulated, were not characterized as more conscious than passive participants. This could be related to the fact that most participants were university students and good organization skills are required to reach that academic level. The absence of a difference between groups in consciousness suggests that this trait did not determine differences in the performance in cognitive tests. Thereby, the low degree of neuroticism of active participants accompanied by positive affect might result in more constructive strategies that motivate them positively to keep trying until achieving the task goal.

In order to explore this possibility, we investigated the relationship between physical exercise, cognitive control, self-regulation and personality, applying correlation and regression analysis. First, we explored the extent to which physical exercise is related to self-regulation and inhibitory control. Standard SSRT, in which active and passive showed similar performance in previous studies (Padilla et al., 2013; 2014), correlated negatively with total effortful control. This could mean that self-regulation is the variable influencing standard SSRT or the reverse. However, the measure in which active and passive groups differed in Padilla et al. (2013; 2014) was strategic SSRT and this measure did correlate negatively with total months of aerobic exercise. Therefore, the participants who practiced more aerobic exercise were those who showed lower strategic inhibition. On the contrary, strategic SSRT did not correlate with personality and self-regulation.

Second, we observed that working memory capacity (AOspan) was correlated with inhibitory control and control of impulses, variables in which active participants obtained higher scores. However, AOspan did not correlate with exercise frequency or fitness level. Control of impulses explained 10% of working memory variance.

Third, we explored the relationship between physical exercise and personality. The results showed that frequency of exercise and fitness level correlated with extraversion and openness to experience, being active participants the most extroverted and experience seekers.

In sum, different self-regulation factors were related to standard SSRT (total effortful control) and AOspan (inhibitory control), and the personality subdimension of Ci was associated with AOspan. Hence, between-group differences in self-regulation and Ci could have contributed to AOspan performance in Padilla et al. (2014). Nevertheless, differences in strategic SSRT were associated with frequency of exercise practice.

Rueda & Rothbart (2005; see also Rueda, 2012 or Rueda et al., 2011) suggested that better self-regulation contributed to better cognitive control. In our study, active participants showed greater self-regulation and better cognitive control than passive group. However, the study with correlations led us to think that practice of exercise was also contributing to strategic inhibition.

More studies will be necessary to corroborate whether self-regulatory capacity is one of the main factors contributing to better executive functions in studies about chronic exercise, or whether it is actually a combination of greater exercise practice and higher self-regulation which leads to higher cognitive control. As we mentioned before, aerobic exercise interventions on psychiatric disorders (Blumenthal et al., 2012) have suggested that exercise may be a way of improving emotional control and self-regulation (Allen, Frings, & Hunter, 2012).

In conclusion, our active participants showed higher inhibitory control, emotional stability and more positive mood than passive participants. Control of impulses predicted scores in working memory (AOspan; Padilla et al., 2014) and total months of exercise predicted strategic stop signal reaction times. Therefore, our findings suggest that personality and self-regulation contributed to the effect of exercise on working memory observed in Padilla et al.'s (2014) study, while months of exercise contributed to strategic inhibition. It will be necessary to further investigate the causality between self-regulation and exercise to better understand the direction of the effects between them.

Chapter 8.
Experiment 5: Improving memory inhibition: a study of RIF, executive control and fitness

Improving memory inhibition: a study of RIF, executive control and fitness

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Abstract

Aerobic exercise is being established as a way to enhance executive functions and prevent cognitive aging. Given that previous studies have shown that physically active participants usually show improved cognitive and interference control, we aimed at investigating whether aerobic exercise would also modulate interference control in retrieval processes using the Dual Retrieval Practice Task (Ortega, Román, Gómez-Ariza & Bajo, 2012). The results showed that while active participants were able to suppress the interference produced by competitive targets despite the working memory load, passive participants were not. These results are discussed in terms of the modulatory role of cardiovascular exercise on executive control and retrieval induced forgetting (Anderson, Björk, & Björk, 1994; Levy & Anderson, 2002).

Introduction

When we need to recall just certain elements from a set of items in our memory, forgetting the irrelevant ones can be a necessary and adaptive process. Under these circumstances, it has been shown that recalling memories intentionally may lead to forget competing elements that interfere with the retrieval of other items (Wimber, Alink, Charest, Kriegeskorte & Anderson, 2015). In other words, the very act of remembering some memories may be one of the major reasons why we forget others.

A paradigm that has been used to assess this type of forgetting is the Retrieval Practice paradigm (RP, Anderson et al., 1994). This paradigm consists of three phases. First, in the study phase, several lists of category-exemplars (FRUIT-Orange; REPTILE-Snake) are studied. Each category contains multiple exemplars. Second, in the retrieval practice phase, only half of the exemplars from half of the studied categories must be retrieved with the aid of a cue (FRUIT-Or____). Each exemplar is retrieved a number of times during this phase. Finally, in the recognition phase, all studied exemplars are presented one by one and participants must say if the exemplar was studied or not in the study phase (see Bajo, Gómez-Ariza, Fernández & Marful, 2006; Gómez-Ariza, Lechuga, Pelegrina, & Bajo, 2005; Hicks & Starns, 2004; for recognition based RIF).

The exemplars that were practiced during the retrieval practice phase are considered Rp+. The exemplars that were not retrieved but belonged to the categories practiced in the retrieval phase are called Rp-. Lastly, the exemplars that were not retrieved and did not belong to the categories practiced in the retrieval phase are named Nrp.

The typical key finding is that the non-practiced (Rp-) items are later less recognized than the control items (Nrp items). One of the most plausible explanations is that this retrieval induced forgetting or RIF effect is the consequence of an inhibitory mechanism that acts at the retrieval phase to reduce the activation of competitive nontarget items (Rp-) that interfere with the retrieval of target items (Rp+, Anderson et al., 1994). As a consequence, later in the recognition phase, Rp- items are harder to access than Nrp items even though both were equally non-practiced (see Murayama, Miyatsu, Buchli & Storm, 2014 for a review).

Recent neuroimaging studies (Wimber et al., 2015; also Kuhl, Dudukovic, Kahn, & Wagner, 2007) compared the neural activations associated with the retrieval and recognition patterns of Rp+, Rp- and Nrp items. At the beginning of the retrieval phase the results show that target (Rp+) and competing memory traces (Rp-) are co-activated. However, competing memory traces (Rp-) are suppressed progressively as retrieval of Rp+ is repeated, reaching below-baseline activation levels after retrieval. The mid-ventrolateral prefrontal cortex (VLPFC) is involved in this active suppression of competitor's traces in visual cortex, since there is a positive correlation between VLPFC activation, visual cortex suppression and forgetting rate in a subsequent recognition RIF test. In other words, the more the VLPFC is activated, the more suppression is exerted on the representations of Rp- items in the late processing visual areas, which is also associated with a greater RIF effect.

Within a larger context, inhibition control has been presented as one of the core executive functions (Miyake et al., 2000). Although defining inhibition has not been an easy task (see Harnishfeger, 1995; Nigg, 2000), some researchers have claimed the existence of a family of different types of inhibitory processes (e.g. Harnishfeger, 1995; Hasher, Zacks & May, 1999; Friedman & Miyake, 2004; Nigg, 2000). One of the features that have been argued as crucial to distinguish between different types of inhibitory tasks is the required level of executive control involved. According to several authors (Andrés, Guerrini, Phillips & Perfect, 2008; Friedman & Miyake, 2004; Harnishfeger, 1995; Nigg, 2000), inhibitory tasks can be classified into a continuum from very controlled to very automatic, and this also applies to RP.

Three studies have indeed contributed to explore the extent to which the RIF effect may be modulated by executive resources (Aslan & Bäuml, 2011; Ortega et al., 2012; Román, Soriano, Gómez-Ariza & Bajo, 2009). Román et al. (2009) created the "Dual-Retrieval Practice Task" (D-RP) by combining a working memory task (remembering 5 digits or updating a sequence of 3 numbers) with the retrieval of the previously studied exemplars. They showed that in the dual condition, the RIF effect was absent, since accuracy and response times were similar for Rp- and Nrp items in the recognition phase. This result suggested that some attentional resources are involved in the inhibition of memories at the retrieval phase, despite the lack of intentionality.

Later, Ortega et al. (2012) applied the simple and dual version of the RP task in a sample of young and older adults to investigate the effects of aging on the RIF effect. The results showed that there was a RIF effect in the young group under the dual condition for the 3, but not the 5 digits dual RP task, confirming that memory inhibition depended on executive control. Moreover, RIF was not observed in the older adults even for the 3 digits dual RP task, revealing that the reduction in executive resources typically observed in aging led to the disappearance of the RIF effect in the dual RP task. Finally, in line with the idea that RIF involved some executive control, Aslan and Bäuml (2011) showed a positive correlation between RIF and WM capacity in younger adults.

Up till now, several studies looking at individual differences in RIF have concentrated in populations or manipulations that were supposed to reduce the forgetting effect observed in the RP task, for example, depression (Storm & Jobe, 2012), posttraumatic stress disorder (Amir, Badour, & Freese, 2009), schizophrenia (Soriano, Jiménez, Román & Bajo, 2009) or anxiety (Law, Groome, Thorn, Potts, & Buchanan, 2012; Saunders, 2012). However, it would also be interesting to investigate the extent to which the RIF effect may be potentiated.

In that vein, cardiovascular fitness has been established as a factor leading to improvements in executive control (Bherer, Erickson, & Liu-Ambrose, 2013; Biddle & Asare 2011; Colcombe & Kramer, 2003; Cox et al., 2015; Guiney & Machado, 2013). More precisely, in a recent series of studies, we have shown that physically active participants with a history of regular cardiovascular exercise deal better than passive with demanding or executive inhibitory (Stop signal task; Padilla, Pérez, Parmentier, & Andrés, 2013), working memory (Padilla, Pérez, & Andrés, 2014) and flanker (Pérez, Padilla, Parmentier, & Andrés, 2013) tasks. Cardiovascular fitness has also been associated with greater prefrontal (Erickson, Leckie & Weinstein, 2014) and hippocampal (Leavitt et al., 2014) volumes, structures that are involved in the RIF effect (Wimber et al., 2015; Kuhl et al., 2007).

If the type of inhibition involved in the D-RP paradigm can be modulated by attentional resources, as has been shown in previous studies (Ortega et al., 2012; Román et al., 2009), then it should be sensitive to physical activity, a factor that has been shown to improve executive functions. The objective of the current study was to investigate this idea. The hypothesis is that active participants would present with additional executive resources compared to passive participants, and this would allow them to deal with the interference induced by the dual-working memory task whereas they suppress the RP- items. In other words, we predict that physically active participants would show a RIF effect despite being in a dual-task situation, whereas passive participants would not.

Method

Participants

Participants were from the city of Granada; none of them had a history of mental disorder or physical illness incompatible with the study. They gave their informed consent and were paid for their participation in the study. The experiment was performed in accordance with the ethical standards stated at the University of Granada and Helsinki.

Participants were 42 young adults divided in two groups according to their fitness level and frequency of exercise. To be included in the active group, participants had to have practiced cardiovascular exercise for at least the last 7 years, with a frequency of at least 4 hours distributed in at least three days a week. Passive participants could not have practiced cardiovascular exercise with a frequency higher than 6 h per week during their childhood and adolescence (0 - 14 years), taking into account that physical education is taught three days a week within the Spanish education system. In addition, they could not have exercised for more than three hours and a half per week in the last 4 years, being this exercise of low intensity.

Cardiovascular level was measured with the 20-m shuttle run test (Léger, Mercier, Gadoury, & Lambert, 1988). There were 21 participants in each group (see Table 10 for demographic details). As can be seen in Table 10, active and passive participants differed significantly in terms of cardiovascular level, and exercise frequency, but not in education or crystallized (WAIS) and fluid (RAVEN) intelligence, or age. They did not differ either in general CRIq or specific CRIq indexes (education, profession and leisure activities), number of languages spoken, depression or anxiety levels.

Procedure

Participants were recruited through different adverts at the University of Granada and were asked to fill two online questionnaires to quantify their cardiovascular exercise frequency and level, as well as their education and leisure activities through the Cognitive Reserve Index questionnaire (CRIq, Nucci, Mapelli, & Mondini, 2012). A fluent spoken languages question was included in the CRIq, since it has been shown that bilingualism enhances cognitive reserve and executive functions (Bialystok, Poarch, Luo, & Craik, 2014; Ljunberg, Hansson, Andrés, Josefsson, & Nilsson, 2013).

Participants were interviewed by phone by an experienced neuropsychologist to complete missing information. Subsequently, they were informed about the experiment and asked to complete several online questionnaires to assess anxiety (the State-Trait Anxiety Inventory; Spielberger, Gorssuch, & Lushene, 1970) and depression (Beck Depression Inventory; Beck, Steer, Ball, & Ranieri, 1996). Participants came then to the Brain, Mind and Behavior Research Center at the University of Granada to perform the cognitive tasks.

Cognitive Tasks

Participants carried out three cognitive tests in a quiet room during a two-hour session. The first 30 minutes were dedicated to explain and fill in the informed consent.

After that, participants began the cognitive-task session, in which they performed two tests of intelligence, and the Dual Retrieval Practice Task (D-RP; Ortega et al., 2011; Román et al., 2009). All tests except the vocabulary scale were administered using a computer. Raven's Advanced Progressive Matrices (Raven, Court, & Raven, 1996) and D-RP (Ortega et al., 2012) were designed and displayed using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA, Schneider, Eschman, & Zuccolotto, 2002).

Table 10

Demographic data of the active and passive participants.

		Actives Count/Mean	Passives Count/ Mean	Group differences p values
Participants		21	21	
Gender	Male	11	7	.21[b]
	Female	10	14	
Age		23.90 (2.61)	24.86 (3.41)	.32[c]
Cardiovascular Level (20-shuttle run test)		31.29 (11.33)	16.73 (7.63)	.00**[c]
Total hours of exercise		5775.97 (2393.47)	696.62 (850.78)	.00**[c]
Years of education		17.14 (2.92)	17.00 (4.16)	.89[c]
Education Level	Compulsory Education	0	2	.29[b]
	College	5	7	
	Graduate	12	7	
	Postgraduate	4	5	
Vocabulary (WAIS)		47.76 (4.97)	48.55 (5.29)	.63[c]
RAVEN Acc		9.38 (3.32)	9.67 (4.08)	.81[c]
Total CRIq		88.86 (15.91)	94.29 (9.66)	.19[c]
	CRIq Education	99.90 (10.25)	98.33 (12.38)	.66[c]
	CRIq Work	93.24 (3.92)	93.33 (4.66)	.92[a]
	CRIq Leisure	97.69 (7.49)	96.40 (6.98)	.60[c]
Spoken languages	Only L1	6	6	.89[b]
	L1 & L2 (co-official languages)	8	9	
	L1, L2, & L3 (including one co-official language)	4	6	
	More than 2 languages	0	0	
Depression Level	Normal mood fluctuations	20	18	.29[b]
	Mild mood disturbance	1	3	
	Intermittent depression states	0	0	
STAI Trait	PD < = 25	15	9	.10[b]
	PD 26 -50	5	5	
	PD 51 - 75	1	5	
	PD > 76	0	2	

First of all, participants carried out the D-RP task. After that, the Wechsler Adult Intelligence Scale Vocabulary subtest (Wechsler, 1999) was administered. Then, a computerized version of Raven's Advanced Progressive Matrices (Raven et al., 1996) was applied to obtain a measure of fluid intelligence. Only the 18 odd items were presented, so the time of the session could be shortened, with the time limit set to 20 minutes. Finally, participants performed the 20-m shuttle run test.

Dual Retrieval Practice Task (D-RP).

The D-RP task was the same as applied in the studies by Román et al. (2009) and Ortega et al. (2012) where a 5-digit updating task was concurrent with RP. We used this task instead of the standard RP task because previous research has shown that it is more sensitive to individual differences and variations in executive control (Ortega et al., 2012). There were four counterbalanced versions of the same task and participants were randomly assigned to one of them. The experiment had four phases: a) category-exemplar study, b) 5-digit-updating practice c) dual task: 5-digit updating and retrieval practice; and d) recognition (see Figure 7).

Materials. The materials were the same as the ones used by Román et al. (2009) and Ortega et al. (2012). Forty-eight category-exemplars pairs were drawn from Battig and Montague (1969) that in turn were divided into 8 semantic categories. Two of them were fillers. Each category was composed by 6 exemplars. One constrain was that none of the 6 exemplars within the category started with the same two first letters. Six blocks of six exemplars each were created; each exemplar was from a different category.

Study phase. Participants first read the instructions and then six blocks of 8 category-exemplar pairs were presented: 2 filler categories plus 6 experimental ones. The order of these blocks and the exemplars presented into each block were randomized among participants. Each category-exemplar pair was shown for 5 seconds at the center of the screen for encoding. Primacy and recency effects were controlled adding category-exemplar pairs from the two filler categories at the beginning and the end of the study phase. The study phase lasted 4 minutes plus the time taken to read and understand the instructions.

Five-digit-updating retrieval-practice task. After the study phase, 14 sequences of five digits were presented for 5 s each at the center of the screen: every 5-digits sequence was followed by another screen with a 100-ms high or low frequency tone. Participants had to keep the 5-digits sequence in mind, since after hearing the tone they had to say aloud the two smallest numbers if the tone was high, or the two biggest digits if the tone was low. They had 5 s to respond.

Retrieval Practice phase. Half of the six studied categories were presented in this phase. Of those categories, just half of the exemplars from each category were shown. These practiced items are considered Rp+. Exemplars from the practiced categories that did not appear in this phase were considered Rp-.

Before the task started there were 4 practice trials consisting of combining the 5-digit sequence task with the retrieval practice (see Figure 7). Participants were first presented with a 5-digit sequence for 5 seconds with the instructions to keep the numbers in mind since they would have to recall later some of them. Each sequence was followed by a screen presenting the category cue accompanied by a tone. The name of the category appeared in capital letters for 2 s after which the two first letters of the exemplar were shown in a subsequent screen until the participant responded, with a limit of 2 s. The two letters were written in lower case, followed by a black line (i.e. or_______). Participants had to complete the exemplar immediately by saying it aloud.

Next, another screen was presented for 5 s with an instruction requiring the participants to say the two smallest or biggest digits from the sequence, according to the tone they have heard before. After the 5 s, a white screen replaced it for 2 s; so participants had in total a maximum of 7 s to say aloud the digits. Responses to exemplars and digits were written and recorded by the experimenter. Every category-exemplar pair appeared randomly three times in the retrieval phase interleaved with other pairs. A category-exemplar pair from a filler category separated every repetition block; also filler items were included at the beginning and at the end of this phase. In total, 3 blocks of 9 Rp+ items plus 6 fillers each were presented. The total duration of this phase was 20 minutes approx.

Recognition task. In this phase, all the exemplars studied at the beginning of the study were presented, along with new ones. Participants were asked to say aloud as fast and precisely as possible whether the exemplar shown was new or old. As mentioned above, among the studied items there were Rp+, Rp -, but also those items from which neither the exemplar nor their category had been practiced in the retrieval practice phase (Nrp). Between the new items, there were items belonging to: a) the practiced categories, b) unpracticed categories, and c) new categories (see Figure 7). In this recognition task there were two blocks: Rp- and Nrp were presented first interleaved randomly with new items; and later in a second block, Rp+ interleaved with new items were shown. This order was aimed at preventing blocking of the critical Rp- items from Rp+ items. The task started with a fixation cross that lasted 500 ms, later an exemplar was presented in low case for 3 s, and finally a white screen appeared for 1 s. Participants had to respond ‘new’ or ‘old’ as soon as they saw the exemplar and had a maximum of 4 s. The total duration of this phase was 4 minutes approx.

Cardiorespiratory capacity test

The 20-m shuttle run test (Leger, Mercier, Gadoury, & Lambert, 1988) was applied to measure participant’s cardiovascular level. This test estimates the maximal oxygen uptake (VO_2 max) from the speed that the participants have reached during an effortful test. Participants have to run back and forth on a 20 meters course touching a line before a recorded signal sounds. The frequency of that signal increases as the test progresses, requiring the participants to increase their speed. As the participants run, they reach different speed stages. The number of the last achieved stage is used to estimate VO_2 max. This test showed a high validity when it was compared with the maximal multistage treadmill test as well as a high test-retest reliability (Leger, Mercier, Gadoury, & Lambert, 1988).

Results

Dual Retrieval practice

Accuracy for passive and active participants during the dual retrieval practice are presented on Table 11.

Accuracy. Word accuracy was calculated taking into account the Rp+ exemplars correctly recalled. T tests comparing proportions of word accuracy indicated that active (M = .66, SD = .17) and passive (M = .74, SD = .14) participants recalled similar proportions of words [t (40) = 1.76, p = .09, d = 0.56].

Finally, the proportion of digits recalled at the trials where Rp+ categories appeared at the same time was similar between groups [t (40) = .35, p = 73, d = 0.11].

Table 11

Mean proportions of correctly retrieved word and mean proportion of correctly recalled digits in the dual phase

	Active	Passive
Word Accuracy	.68 (.15)	.76 (.14)
Digit Accuracy	.89 (.10)	.90 (.09)

Recognition

Accuracy in the recognition phase was calculated by subtracting false alarms from hits in the corresponding conditions (see Table 12). Thus, hits in Rp- were subtracted from false alarms in new items that belonged to practiced categories (Rp false alarms), while Nrp were subtracted from false alarms in new items that belonged to studied, but not practiced categories (Nrp false alarms). Rp and Nrp false alarms did not differ significantly [t (41) = 1.45, p = .09, d = 0.55].

The RIF effect is measured as the difference between the Rp- and Nrp conditions (see Table 12 and Figure 8 for means and standard deviations). A 2 (group: active vs. passive) x 2 (condition: Rp- vs. Nrp) repeated measures ANOVA was calculated on the corrected hits, revealing a significant effect of condition [F (1, 40) = 5.78, MSE = .26, p = .02, η^2_p = .13], showing that Nrp items (M = 0.56, SD = 0.23) were better retrieved than Rp- items (M = 0.45, SD = 0.31). There was no significant group effect [F (1, 40) = 1.19, MSE = 0.12, p = .28, η^2_p = .03], but a significant condition x group interaction [F (1, 40) = 5.88, MSE = .26, p = .02, η^2_p = .13] was observed.

Table 12

Mean proportions of corrected hits (standard deviation in brackets)

			Type of item		
Group	Variable	Participants	Rp +	Rp -	Nrp
Active	Corrected Hits	21	.65 (.29)	.36 (.30)	.58 (.23)
	False Alarms		.19 (.20)		.08 (.13)
Passive	Corrected Hits	21	.81 (.21)	.54 (.29)	.54 (.24)
	False Alarms		.10 (.16)		.10 (.15)

To explore the condition x group interaction, we carried out pairwise comparisons, which apply Bonferroni correction for multiple comparisons. The results revealed that the active participants recognized significantly fewer Rp- (M = 0.36, SD = 0.3) items than the passive (M = 0.54, SD = 0.29) (p = .048). There was however no significant difference between active and passive participants for the Nrp exemplars (p = .62). T tests carried out to study forgetting effect in each group indicated that active participants showed RIF (t (20) = 3.81, p < .001, d = 1.70), while passive participants did not (t (20) = 0.01, p = .99, d = 0.00).

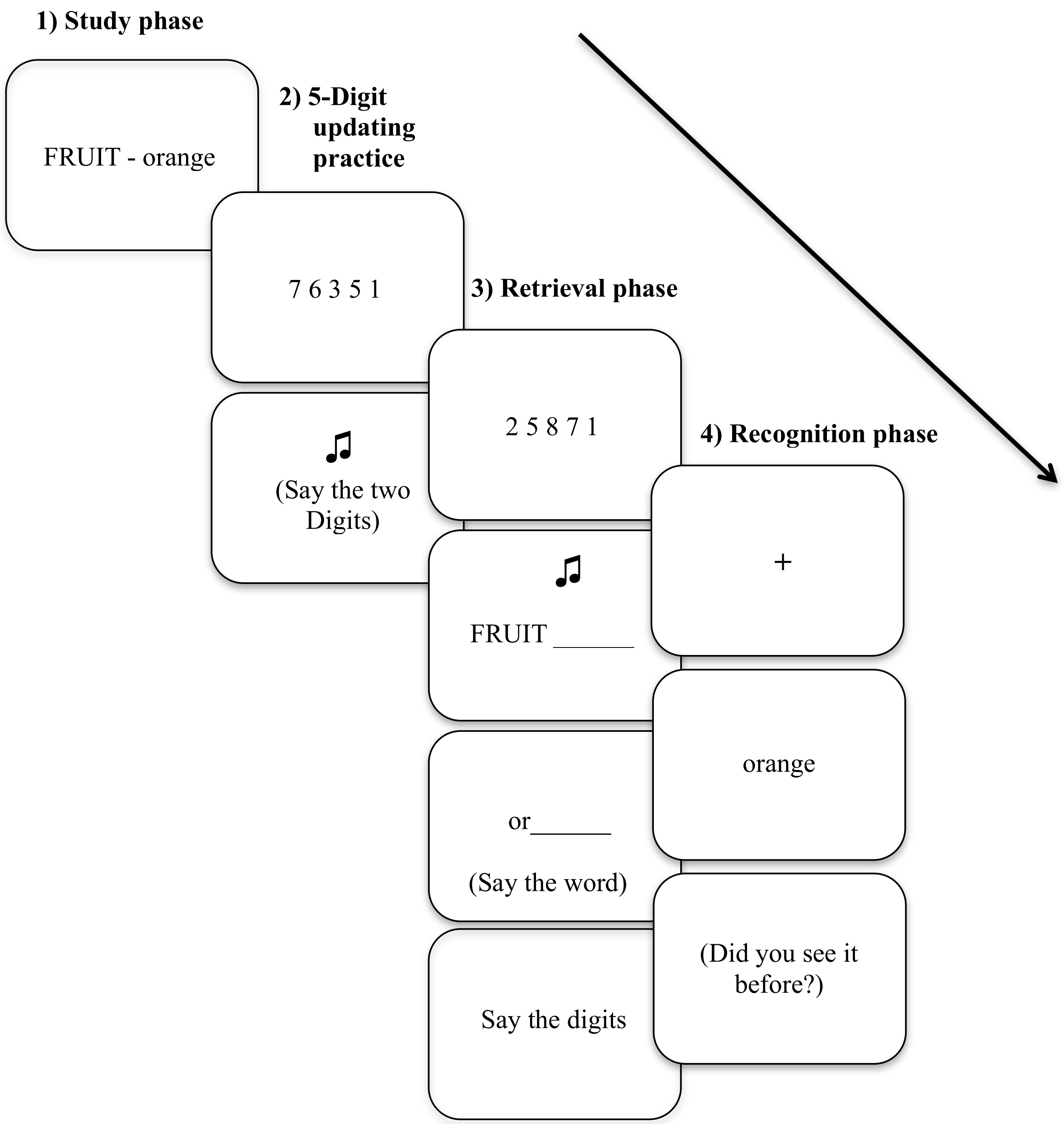

Figure 7. Dual retrieval practice task. 1) Study phase: category – exemplar pairs were shown to be studied, 2) Five-digit updating practice task: a digit sequence appeared on the screen, followed by a tone of high or low frequency indicating the numbers that had to be said aloud, 3) Retrieval phase: the updating and the retrieval of Rp+ tasks were combined. 4) Recognition phase: the exemplars from the study phase were presented interleaved with new exemplars. See text for detailed information.

Although Rp+ items were presented last and were therefore opened to the influence of previous items and to the possible strategies developed in the course of recognition, we analyzed facilitation effects by calculating the difference between Rp+ and Nrp items (see Table 12 and Figure 8 for means and standard deviations). A 2 (group: active vs passive) x 2 (condition: Nrp vs. Rp+) repeated measures ANOVA revealed a significant condition effect [F (1, 40) = 15.64, MSE = 1.22, p < .001, η^2_p = .28], showing that Rp+ items (*M* = 0.73, *SD* = 0.26) were better recognized than Nrp items (*M* = 0.56, *SD* = 0.23). The group effect was not significant [F (1, 40) = 1.09, *MSE* = 0.43, p = .30, η^2_p = .03]. The group x condition interaction was however significant [F (1, 40) = 5.49, *MSE* = 0.43, p = .02, η^2_p = .12]. Pairwise comparisons revealed that passive participants recognized more Rp+ items (*M* = 0.81, *SD* = 0.21) than the active participants (*M* = 0.65, *SD* = 0.29) (p = .039), whereas they did not differ in Nrp recognition (p = .62). As mentioned, the differences in the recognition of the Rp+ items for the passive and active group might be due to spurious factors related to the fact that they were presented in the final part of the recognition list and after Rp- and Nrp items had been presented.

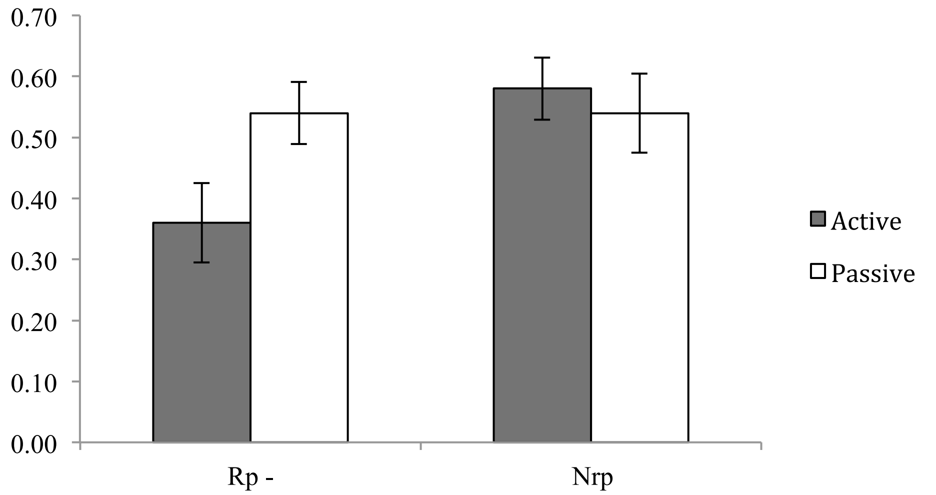

Figure 8. Mean corrected hits per group. Rp-: unpracticed exemplars from the same categories. Nrp: exemplars from different categories from the ones that were practiced. Error bars indicate standard deviations.

Discussion

The aim of this study was to investigate whether the inhibitory processes involved in the retrieval of competitive elements from memory might be positively modulated by aerobic exercise. The main prediction was that physically active participants would show RIF under high attentional or working memory load, whereas passive participants would not.

The results first indicated that active and passive participants did not differ in factors that could have improved executive control in active participants such as bilingualism, education, crystallized and fluid intelligence or age. This equivalence between passive and active participants on non-manipulated and potentially confounding variables makes possible group differences in D-RP statistically valid.

The results then revealed that active and passive groups showed different patterns of recognition. First, while active participants showed a significant D-RIF effect, passive did not. Active participants recognized significantly fewer Rp- items than Nrp. Also, active participants recognized fewer Rp- than passive participants. Since previous studies have revealed that physically active participants show improved attentional or executive resources (Guiney & Machado, 2013, Padilla et al., 2013, 2014; Pérez et al., 2014), it is likely that active participants were able to suppress Rp- memory traces at retrieval practice despite the concurrent working memory load (updating task). The absence of differences in the digit-recall task when performed by itself and the similar levels of recall of the Nrp items, suggests that physical activity specifically modulates the ability to inhibit competing information when executive control is taxed by dual tasking. Therefore, in line with previous studies (Padilla et al., 2013; 2014; Pérez et al., 2014) our results indicate that physical activity selectively affects executive control.

It is worth noting that the pattern of results revealed by our passive participants in forgetting is similar to the one observed in young participants when carrying the D-RP task with 5 digits by Ortega et al. (2012). In Ortega et al.'s study the absence of RIF effect in this condition was explained by the fact that divided attention caused such a reduction in attentional resources that active suppression of Rp- interference during retrieval could not be undertaken. In the same vein, the passive participants from our current study did not have enough attentional resources to suppress Rp- interference while dealing with the working memory task. It is argued that the chronic practice of physical activity has led to an increase in attentional or executive resources in the active participants, making it possible for them to suppress the interference from the Rp- at the retrieval phase.

Thus, our results suggest that greater attention/executive resources in active participants resulted in a greater ability to suppress interference when attentional resources are loaded in the dual-RP updating task. This leads us to think that inhibition during retrieval is susceptible to be modified by cardiovascular exercise, a factor that has been proven to tap on executive functions. We replicated previous results (Padilla et al., 2013; 2014; Pérez et al., 2014) and extended them by showing that a long-term routine of physical activity is associated with a better ability to deal with a demanding dual task such as the D-RP. It would be interesting to corroborate our results with an aerobic exercise intervention, since cross-sectional studies do not allow establishing causal relationships.

Chapter 9.
Experiments 6, 7, & 8: The effects of aerobic exercise on the brain in active and passive young adults

The effects of aerobic exercise on the brain in active and passive young adults

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Abstract

Previous studies exploring the effects of aerobic exercise have shown that brain areas related to executive functions and memory increased their volume after an exercise intervention (Chaddock et al., 2010; Colcombe et al., 2004; 2006; Holzschneider, Wolbers, Roder, & Hotting, 2012). Therefore, the pattern of results found in our previous studies in young adults (Padilla, Pérez, Andrés & Parmentier, 2013; Padilla, Pérez & Andrés, 2014; Pérez, Padilla, Parmentier & Andrés, 2014) might be an indicative that exercise may affect brain structures and function. We explored this hypothesis by applying structural, task-based functional and diffusion magnetic resonance. Results indicated that active and passive participants showed similar brain morphometry and myelin integrity. However, they differed significantly in their pattern of activation while performing the stop signal task (Verbruggen, Logan, & Stevens, 2008).

Introduction

Aerobic exercise has been highly related to brain changes in children (Chaddock, Pontifex, Hillman, & Kramer, 2011; Khan & Hillman, 2014), and older adults (Colcombe et al., 2004). This enhancement has been demonstrated applying different neuroimaging techniques as explained below.

Structural magnetic resonance imaging (sMRI) is a technique that measures the volume and concentration of the grey and white matter. sMRI studies have shown that the regular practice of exercise is related to increases in the volume of frontal and superior temporal cortices, cuneus (Colcombe et al., 2006; Holzschneider, Wolbers, Roder, & Hotting, 2012) and basal ganglia (Chaddock et al., 2010), accompanied by an improvement of executive functions (Colcombe et al., 2004; 2006).

Aerobic exercise also potentiates the functioning of some structures involved in memory processing (Maass et al., 2014; Pereira et al., 2007). Erickson et al. (2011) observed that after a one-year exercise intervention, the aerobic group showed a 2% greater hippocampus. The greater volume in temporal areas and hippocampus of old active people would help to prevent the development of cognitive impairment and brain density loss due to normal aging (Colcombe et al., 2006; Erickson et al., 2010). According to studies with animals (van Praag, Christie, Sejnowski, & Gage, 1999; van Praag, Kempermann, & Gage, 1999), exercise produces its effects through neurogenesis. In agreement with this, Erickson et al. (2009) found that changes in hippocampus volume correlated positively with brain derived neurotrophic factor (BDNF) level increment.

Concerning functional MRI (fMRI), this technique measures the blood oxygen level-dependent (BOLD) signal while participants are carrying out a task. The BOLD signal is the blood flow that is concentrated in a certain brain region in response to neuronal activity (Podrack, Mumford, & Nichols, 2012). In a first study, Colcombe et al. (2004) administered the flanker task to a group of fit and unfit participants who followed a 6-month exercise intervention program. The results revealed that the fitter participants dealt better with the incongruent condition and showed higher activation in the network associated, i.e., the bilateral superior parietal cortices and the right middle frontal gyrus. Curiously, unfit participants activated more the anterior cingulus (ACC), involved in conflict detection. In a second study, Voelcker-Rehage et al. (2011) carried out two types of intervention -cardiovascular and coordination exercises- in a sample of older adults. A flanker task and a visuospatial task were administered during the fMRI recordings at three different times: before the intervention, after 6 and after 12 months. The results showed that the participants from the cardiovascular and coordination groups improved their accuracy in the flanker task, but only the ones from the coordination group improved their performance in the visual search task. Contrary to Colcombe et al. (2004), participants from the cardiovascular group showed decreased activation in prefrontal and parietal areas when performing the flanker task. However, participants from the coordination group showed more activation in inferior frontal gyrus (IFG), superior parietal cortex, thalamus and caudate body. This study suggests that different types of exercise exert different effects on neural networks.

Diffusion tensor imaging (DTI) informs about white matter microstructural properties in vivo and is more sensitive to the brain deterioration caused by aging than the volumetric techniques. Research using DTI on exercise effects on cognition has been sparse and most published studies comparing participants with different cardiovascular levels are cross-sectional.

One of the main measures used in DTI is fractional anisotropy (FA). This technique informs about the in vivo microstructural properties of the white matter by quantifying the directionality and the water diffusion rate inside the tissue. This information is represented as a diffusion ellipsoid that is placed inside a voxel. Diffusion along the ellipsoid's longest or principal axis (first eigenvector, L1) is called "Axial Diffusivity", while the average of the second and third axes are called "Radial Diffusivity", reflecting perpendicular diffusivity with respect to the longest tensor. The most frequently used measures in DTI are FA and "Mean Diffusivity" (MD). FA represents the tensor fraction that is due to the anisotropic diffusion (directional movement). The values for FA range from 0 to 1, being 1 indicative of greater directionality, and is independent from the diffusion rate. The diffusion directionality depends on the density of the physical barriers, such as membranes and the water molecules distribution between different cellular compartments. Thus, FA is usually greater in white matter, where diffusion is restricted by the myelin sheath of the axon, mostly in compacted tracts with uniformly aligned fibers, as corpus callosum, while the diffusion in the gray matter is less delimited and more isotropic. MD is an average of the three axes of the diffusion ellipsis and indicates the water diffusion rate inside a voxel, independently of the directionality.

FA increases during child development (Giedd, 2004), reaches a peak during middle age and decreases with aging (Hasan et al., 2010). During aging, a loss of myelin is produced (mylodegeneration), which correlates with cognitive function deterioration (Bastin et al., 2010), so it is necessary to promote olligodendrocyte progenitor cells (OPC) proliferation to counteract this loss. Specifically, mylodegeneration affects the tracts that connect frontal and parietal lobes, because brain areas that myelinate later are those that are most affected by aging (Madden et al., 2009).

A moderated positive correlation has been found between fitness levels and FA in uncinate fasciculus, left middle cingulum (Marks, Katz, Styner, & Smith, 2010) and corpus callosum (Johnson, Kim, Clasey, Bailey, & Gold, 2012) in cross-sectional studies. Also, Voss et al. (2012) found a positive correlation between VO_2 increment and increases in prefrontal and temporal FA, although FA gains did not account for cognitive improvements. Finally, Burzynska et al. (2014) found that higher levels of activity were linked to lower white matter hyperintensities, probably due to exercise effects on structural vascularity. It was also observed that more sedentary hours were correlated to lower FA in the parahippocampal white matter.

Johnson et al. (2012) applied tractography - a technique scarcely used in this research field – and showed negative correlations between aerobic exercise and radial diffusivity (water diffusion in the transverse axis) in corpus callosum areas that connect frontal regions linked to high-level motor planning, but also to prefrontal regions. Finally, Wang et al. (2013) showed that world-class gymnasts exhibited a more connected sensorimotor, attentional and default mode networks, with a higher mean FA in the corticospinal tract. Areas related to movement obtained significant higher nodal degrees and greater regional efficiency in the anatomical network, which might be a product of long-term exercise practice, which requires fine viso-motor coordination, sustained attention and visual perception.

The aim of the current study was to investigate the effects of long-term regular physical activity on brain structure and function in active and passive young adults using different neuroimaging techniques. We hypothesized first that the active group would show greater brain volume and concentration in areas related to executive functions and memory. Second, we expected that the active group would have greater activation in areas related to inhibition and cognitive control. Finally, the active group would show greater connectivity in the cortex-basal ganglia loops related to motor control (Neubert et al., 2013) and the dorsal attention network, which is associated with allocation and maintenance of attention (Corbetta et al., 2008),

Materials and Methods

Participants

Forty-six young adults between 18 and 35 years old (M_{active} = 22.96, SD_{active} = 3.3; $M_{passive}$ = 25.3, $SD_{passive}$ = 4.34) were selected to participate in the study, although two participants were excluded from the sample because they presented a lesion. Participants were from the city of Granada and none presented a history of mental disorder or physical illness. They were paid for their participation in the study. The experiment was performed in accordance with the ethical standards stated by the 1964 Declaration of Helsinki and was approved by the Ethical Committee at the University of Granada.

Participants were divided in two groups according to their fitness levels and frequency of exercise. The active group (13 women, 11 men) was composed by participants who had done cardiovascular exercise for at least the last 7 years, with a frequency of at least 4 hours distributed in at least three days a week. Passive participants (13 women, 7 men) should not have done cardiovascular exercise with a frequency higher than 6 h per week during their childhood and adolescence (0 - 14 years), taking into account that physical education is taught three days a week in the Spanish education system. In addition, they could not have exercised for more than three hours and a half per week in the last 4 years, being this exercise of low intensity.

Procedure

Participants were recruited through advertisements in the city of Granada, University Campus, online University Newspaper, and Internet Social Networks. They were contacted by email, requiring to fill out a questionnaire where they had to describe the frequency and type of past and present aerobic exercise practiced (Annex I), and the Edinburgh Handedness Inventory (Oldfield, 1971), since all participants had to be right-handed. Total hours of exercise carried out during childhood and adulthood were calculated to have a pseudo-objective measure of frequency of exercise (see Table 13).

The selected candidates were contacted again to fulfill a safety questionnaire (Annex II) where they had to respond to several medical questions to know whether they were suitable to enter the magnetic resonance scanner, specifying whether they had any psychiatric or physical illness or whether they were taking any medication. In addition, information about magnetic resonance was provided (Annexes III and IV). Before coming to the scanning facilities, participants carried out the Big Five (Caprara, Barbaranelli & Borgogni, 1993), the Beck depression (Beck, Steer, Ball, & Ranieri, 1996), the Stai-Trait (Spielberger, Gorssuch, & Lushene, 1970) and the Cognitive Reserve Index (CRIq, Nucci, Mapelli, & Mondini, 2012), questionnaires to control for personality, depression, anxiety and lifestyle respectively that might affect the results (see Experiment 4 in Chapter 7). After that, only participants who were suitable for the MRI scanner and had normal scores in the questionnaires were selected to participate in the study.

Once they were accepted to the study, participants came to a session in which they performed several cognitive tests and the 20-shuttle run test (Leger, Mercier, Gadoury, & Lambert, 1988) to measure their cardiovascular level.

In a second session, they performed the magnetic resonance experiment, for which they came to the University's MRI unit. In the MRI session, a structural T1-weighted and a T2-weighted images were first acquired. Then, a functional T2*-weighted image was registered while participants performed the stop signal task (Verbruggen, Logan, & Stevens, 2008). Finally, a diffusion weighted image was registered. The session lasted for 1 hour in total, including the time to get the participant ready for the scanning. Not all participants were included in the three experiments. As mentioned before, two participants presented with a brain lesion when the scans were inspected by the radiologist, and were therefore removed from the sample. In Experiment 6, three participants had to be discarded because their images had artifacts. In Experiment 7, two participants did not carry out the stop signal task and 5 participants ignored the stop trials, just responding to the go trials, so all of them were removed from the sample. In Experiment 8, two participants had more than 3 volumes with movement artifacts, so they were also discarded from the analysis.

MRI acquisition

All recordings were run using a 3T Siemens Trio Tim scanner (Siemens, Erlangen, Germany). For Experiment 6, 176 spoiled magnetization-prepared (SP\MP) T1-weighted images with TR = 1.9, TE = 2.52, FOV = 256, matrix of 256 x 256, sagittal plane, and a slice thickness of 1 mm were acquired. It lasted 5 minutes approximately.

T2-weighted images were collected in order to know whether the participants had any lesion. We used a turbo spin echo (TSE) protocol with a TR = 3.91, TE = 76, FOV = 176 x 219, matrix of 384 x 247, a slice thickness of 3 mm, transversal plane, and 35 slices. T2 image collection lasted 5 minutes approximately.

For Experiment 7, functional T2*-weighted echoplanar images (EPIs) with TR = 2, TE = 30, field of view of 224, flip angle of 90º, matrix of 64 x 64, slice thickness of 3.5 mm, and 197 volumes with 32 slices each were collected. The slices were acquired in sequential descendent order. The voxel size was 3.3 x 3.5 x 4.2. The acquisition had a duration of 45 minutes approximately.

For Experiment 8, diffusion weighted images were collected in a session of ~10 minutes using a 3T Siemens Trio Tim scanner with a repetition time of 8,600 ms, an echo time of 96 ms, a flip angle of 90º, and a gradient strength of 1,500 s/mm^2. Sixty-eight volumes - 60 directions plus 8 no diffusion-weighted volumes (b0)- were obtained. Each volume was conformed of 65 slices, forming a matrix of 100 x 100 x 65 voxels, with a voxel size of 2.4 x 2.4 x 2.4 mm and a space between slices of 2.4 mm.

Experiment 6: Structural MRI

Participants

A total of 41 young adults were divided in two groups according to their fitness level and frequency of exercise. There were 22 active participants and 19 passive participants (see Table 13 for demographic details). Active and passive adults differed significantly in terms of cardiovascular level (t (39) = 4.86, $p < .001$, d = 1.55), and exercise frequency (t (26.56) = 7.52, $p < .001$, d = 2.92), but not in education (t (39) =

0.45, p = .66, d = 0.14), crystallized (t (39) = 0.47, p = .64, d = 0.15) and fluid intelligence (t (39) = .096, p = .92, d = 0.03), or age (t (39) = 1.52, p = .14, d = 0.49).

Table 13

Structural MRI demographic variables: averages for active and passive participants (standard deviations in brackets)

		Active	Passive
		Count/Mean	Count/ Mean
Participants		22	19
Gender	Male	10	7
	Female	12	12
Age		23.09 (3.25)	24.68 (3.45)
Cardiovascular Level (Course-Navette)		31.55 (10.96)	16.88 (7.80)
Total Hours of Exercise along Life		5,355.93 (2,550.38)	731.14 (876.50)
Total Hours of Exercise in Childhood		1,815.89 (1,248.28)	274.74 (485.28)
Total Hours of Exercise in Adulthood		3,540.04 (1,751.89)	456.40 (763.41)
Years of education		16.68 (3.30)	17.21 (4.21)
Vocabulary (WAIS)		47.77 (4.94)	48.53 (5.43)
RAVEN Acc		9.91 (3.70)	9.79 (4.28)

VBM analysis

The results obtained in the two sample t-tests carried out in the second-level analyses are only reported when significance is reached at a cluster level threshold of $p < .05$, applying familywise error (FWE) correction for multiple comparisons.

VBM Preprocessing

VBM8-Toolbox 8 (http://dbm.neuro.unijena.de/vbm8/) was used to analyze voxel-based morphometry (VBM) in structural data (T1-weighted images), which is a tool implemented in SPM8. T1 DICOM images were converted to Analyze 7.5 format using SPM8. Images were reoriented to change the radiological origin from the scanner to the one established by the Montreal Neurological Institute atlas (MNI), which has its origin point (0, 0, 0) placed in the anterior commissure, passing the axis through the posterior commissure. Images were also checked for artifacts and excessive head movement. They were segmented in grey and white matter, choosing the modulated and normalized (non-linear) option in order to compare group's volume. After that, images were smoothed with a Gaussian kernel of 8 mm at full width at half maximum (FWHM) using the SPM8 smoothing tool.

A second preprocessing step was carried out to obtain unmodulated but normalized images in order to compare grey and white matter concentration. Smoothing was also performed in these images (8-mm FWHM).

Results

Volume. T tests revealed no significant differences between active and passive participants in grey matter volume. Both comparisons: active – passive and passive – active, were non-significant. T test comparisons also revealed non-significant differences in white matter volume, either in the active – passive contrast as in the passive – active contrast. Multiple regressions were calculated between grey and white volumes, and measures of level of fitness (Course Navette scores) and speed of the inhibition process (stop signal reaction time, SSRT). None of them were significant.

Concentration. Non-significant differences were found between groups ($p > .05$) in grey and white matter concentration. Multiple regressions between grey and white matter concentrations, level of fitness and the SSRT –the most reliably inhibitory measure from the stop signal task (Verbruggen et al., 2008)- did not reveal any significant correlation ($p > .05$).

Experiment 7: fMRI

Participants

Participants were 37 young adults divided in two groups according to their fitness level and frequency of exercise. There were 20 participants in the active group and 17 participants in the passive group (see Table 14 for demographic details). Active and passive adults differed significantly in terms of cardiovascular level (t (35) = 4.69, $p < .001$, d = 1.59), and exercise frequency (t (35) = 6.83, $p < .001$, d = 2.31), but not in education (t (35) = 1.22, $p = .23$, d = 0.41), crystallized (t (35) = 1.04, $p = .31$, d = .35) and fluid intelligence (t (35) = 0.12, $p = .90$, d = 0.04), or age (t (35) = 1.64, p = .11, d = 0.55).

Table 14

Functional MRI demographic variables: average for active and passive participants (standard deviation in brackets)

		Active	Passive
		Count/Mean	Count/ Mean
Participants		20	17
Gender	Male	10	6
	Female	10	11
Age		22.9 (3.42)	24.76 (3.49)
Cardiovascular Level (Course-Navette)		32.79 (11.59)	17.28 (7.75)
Total Hours of Exercise along Life		5505.24 (2815)	672.84 (801.17)
Total Hours of Exercise in Childhood		2104.49 (1655.04)	199.59 (321.91)
Total Hours of Exercise in Adulthood		3400.75 (1790.66)	473.25 (800.33)
Years of education		16.15 (3.25)	17.65 (4.21)
Vocabulary (WAIS)		47.20 (4.38)	48.82 (5.11)
RAVEN Acc		10.20 (3.53)	10.35 (4.15)

Furthermore, as can be seen in Table 15, active and passive participants did not differ significantly either in lifestyle (CRq scale), languages spoken, anxiety traits or depression levels. They scored similarly in most personality dimensions, except for extraversion (see Table 15). [3]

[3] We did not take into account differences in extraversion, because in Experiment 4 extraversion did not correlated with AOspan or SST. In addition, we carried out an additional analysis at study completion comparing the participants with extreme extroversion scores, selecting those participants scoring above or below the 90% of the cases, that is, 12 participants in the lower extreme and 11 in the upper extreme. T test indicated no differences between the extreme groups in SSRT (calculated with integration or quantile method) or the remaining SST measures (all $p > .21$).

Behavioral Test Design

The strategic version of the stop signal task described in Padilla et al. (2013; 2014) was used, although it was adapted to the MRI environment as follows.
Two tracking ladders were applied, in order to make even more difficult to predict when the stop signal would appear (Aron & Poldrack, 2006; Congdon et al., 2012). Ladder 1 started 250 ms later than the visual stimuli onset, and ladder 2 started 350 ms later. Ladders were alternatively presented following a random order. The first stop signal always appeared 250 ms after the visual stimuli onset. Later, the stop signal delay (SSD) was calculated according to the participant's performance, adding or subtracting 50 ms to the following stop signal trial. On the other hand, the tracking procedure was designed to decrease the onset of the auditory signal until the very beginning of the trial (0 ms), so if the participant had many errors and the tracking procedure decreased much, the auditory signal could appear before or during the visual stimulus. Even so, it still indicated not to respond. Five participants did not understand this rule and responded when the sound appeared before the stimulus, so the SSD was shorter in the following stop trial, making again and again the same error.

Table 15

Mean scores and t tests in lifestyle, Beck, anxiety and BFQ dimensions and subdimensions per group

Scales	Group	Mean (SD)	t	df	p value
General CRIq	Active	87.5 (16.06)	-1.65	33	.11
	Passive	94.76 (10.51)			
CRIq - Education	Active	96.2 (11.95)	-0.95	35	.35
	Passive	100.06 (12.78)			
CRIq - Work	Active	93 (3.33)	-0.39	35	.7
	Passive	93.53 (4.91)			
CRIq - Leisure Time	Active	98.07 (8.25)	0.52	29	.61
	Passive	96.63 (7.2)			
Languages spoken	Active	1.88 (0.7)	-0.46	32	.65
	Passive	2 (0.79)			
Beck scale	Active	3.7 (3.83)	-1.45	35	16
	Passive	5.76 (4.86)			
Stai - Anxiety Trait	Active	13.79 (7.12)	-1.39	34	.17
	Passive	17.06 (6.96)			
BFQ - Extraversion	Active	81.2 (20.7)	4.42	34	.00*
	Passive	74.24 (6.96)			
BFQ - Affability	Active	81.55 (21.59)	0.06	34	.95
	Passive	85.65 (7.95)			
BFQ - Consciousness	Active	83.1 (21.8)	1.07	34	.29
	Passive	83.59 (11.92)			
BFQ - Emotional Stability	Active	73.4 (20.28)	0.76	34	.45
	Passive	74.35 (12.03)			
BFQ - Openness	Active	83.9 (21.48)	-0.51	34	0.61
	Passive	89.82 (8.97)			

The maximum duration of a trial was 2000 ms, the fixation-cross remained on the screen 500 ms and the visual stimulus was presented subsequently for 1500 ms (see Figure 9). However, if the participant responded before the 2000 ms, the trial finished, either if it was a stop or go trial. Hence, the trial duration was not fixed.

Jittering was applied between events (trials), establishing a range that went from 500 to 12000 ms. Jittering was included in the fixation cross at the beginning of each trial. Different inter-stimulus intervals were presented semi-randomly according to the sequences obtained with the tool "Opseqt" (Dale, 1999; see output in the Annex V).

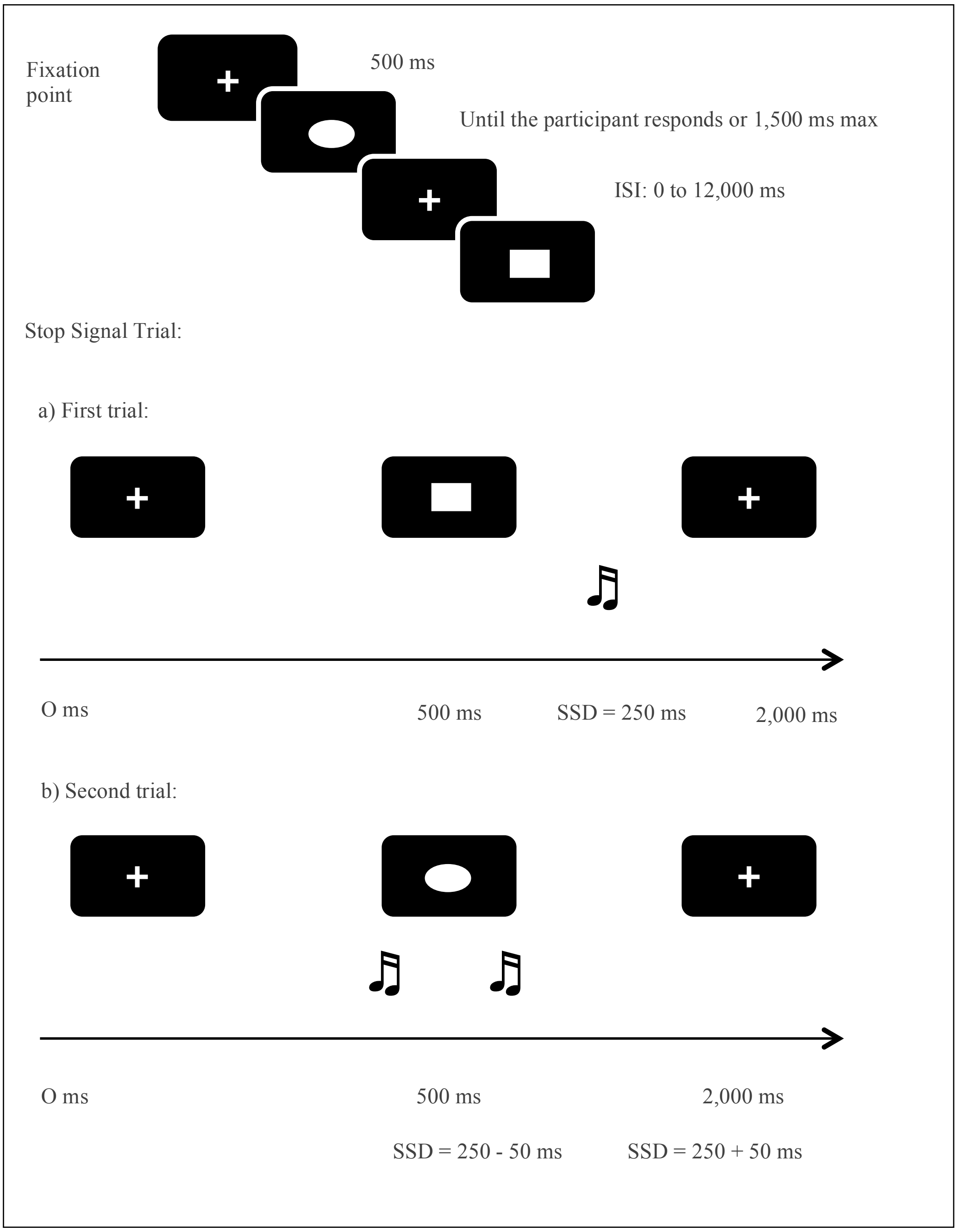

Figure 9. Stop Signal Task. In the go trials, participants respond whether the visual stimulus is a square or a circle. a) In the first stop trial, a sound is presented 250 ms after the visual stimulus appearance. b) In the following stop signal trials, the sound is presented 50 ms sooner or later depending on the participant's performance in the previous stop trial. If the response was correct, 50 ms are added to the stop signal delay (SSD). Otherwise, 50 ms are subtracted.

The stop signal task was programed with E-Prime 2.0. (Psychology Software Tools, Pittsburgh, PA, Schneider, Eschman, & Zuccolotto, 2002, the script may be seen in the final annex VI). The scanner was synchronized with the beginning and end of every run and the whole behavioral task, excluding instructions and practice blocks from the scanner time. Ten seconds were allowed between runs for the participants to rest or move, given the long duration of the scanning session. A localizer was applied at the beginning of each run to correct for movement.

Two versions of the same task were programed using two different random sequences obtained with Opseqt (see Table 16 and Annex V). The task consisted of four runs, one practice run and three experimental runs. The practice run served to make sure that the participant understood the instructions and was able to listen to the auditory stimulus correctly. Only when the participant performed the practice run correctly, the first block started.

Each of the three experimental runs had 128 trials: 32 stop signal trials (25%) and 96 go trials (75%). In total, there were 96 stop signal trials and 288 go trials. The theoretical model (Logan & Cowan, 1984) in which the stop signal is based requires that 50% of the stop signal trials are inhibited, and the other half responded to (stop response or error), in order to estimate correctly the SSD and subsequently calculate the stop signal reaction time (SSRT). The tracking procedure is meant to ensure these accuracy levels, making more difficult for the participant to predict when the auditory signal will appear.

The instructions used in this experiment were the "strategic instructions" described in Padilla et al., (2013), where participants were told that they should try to respond to the go trials as fast and precisely as possible, and this while stopping their responses in the stop signal trials. Previous research has shown that participants apply slowing strategies when they are provided with this type of instruction (Leotti & Wager, 2010; Liddle et al., 2009; Padilla et al., 2013; Sella, Bonato, Cutini & Umiltà, 2013). This means that participants slow their response in the go trials to make sure that the stop signal is not going to appear, so they do not commit an error in the stop trials.

Different procedures have been proposed to improve estimation of the covert process reflected by SSRT. First, as mentioned before, the tracking procedure was implemented to ensure that participants only were able to withdraw their response in 50% of the stop signal trials. Second, several interleaved ladders have been used (see for example, Aron & Poldrack, 2006; or Congdon et al., 2012) to make it difficult for participants to predict when the stop signal will appear.

Verbruggen, Chambers and Logan (2013) have concluded that the integration method is the most accurate to estimate SSRT. The integration method takes into account the fact that not all participants inhibit their response in 50% of the stop signal trials, since some of them apply strategies to respond deviating from that random pattern. Under this method, SSRT is calculated subtracting SSD from the finishing time of the stop process. The finishing time is obtained rank-ordering the go RTs and selecting the n position, which is determined multiplying the number of corrected go trials by the probability of responding in a stop signal trial.

We also calculated SSRT through the quantile method to have a control measure (Band, Van Der Molen, & Logan, 2003; Congdon et al., 2012). This method consists of rank ordering go RTs and choosing the response rate percentile. This percentile is the proportion of signal trials responded multiplied by 100. Mean stop signal delay is subtracted from the selected go RT.

The integration and quantile methods were preferred to the mean method, the one used in Padilla et al. (2013; 2014), because they do not require removing participants not responding to 50% of the stop signal trials. In fMRI experiments it is not so easy to remove outliers as in behavioral experiments due to the high costs of the scanner.

Furthermore, the stop signal task has 6 experimental dependent variables (see Experiment 1 for details): a) Go accuracy, b) Go RT, c) Stop accuracy, d) Stop signal reaction time (SSRT) e) Stop signal delay (SSD), f) P (R/S), and g) Stop response reaction time (SRRT). In the fMRI analysis we were interested in measuring the brain activity produced in the go, stop, and stop response trials (conditions) and comparing each with the resting activity (baseline) detected during ISI. Hence, there were four experimental conditions: a) Go events in which the participant responded correctly, b) Stop events in which participant inhibited their response, c) Stop responded events in which participants responded to the signal, and d) null events, which represent the brain activity during ISIs reflecting basal brain activation, while participants did not perform any task. Null event condition was used to extract the activity due to the go, stop or stop response condition in all contrasts.

Table 16

Jittering calculated to each version of the stop signal task

Optseq2 Jittering Version 1
optseq2 --ntp 192 --tr 2 --psdwin 4 12 2 --tnullmin 0.5 --tnullmax 12 --ev Stop 1.5 32 --ev Go 1.5 96 --evc 1 -1 --nkeep 3 --o LongerStopSignal --nsearch 100000

Optseq2 Jittering Version 2:
optseq2 --ntp 192 --tr 2 --psdwin 4 12 2 --tnullmin 0.5 --tnullmax 12 --ev Stop 1.5 32 --ev Go 1.5 96 --evc 1 -1 --nkeep 3 --o StopSignalV2 --nsearch 100000

Behavioral Results

Results are presented in Table 17. Independent sample t tests revealed that active and passive participants did not differ in go accuracy (t (35) = 0.51, p = .61, d = 0.17), go RT (t (35) = 1.46, p = .15, d = 0.49), stop signal accuracy (t (35) = 1.42, p = .16, d = 0.48), P (R/S) (t (35) = 1.42, p = .16, d = 0.48), nor SSD (t (35) = 1.65, p = .11, d = 0.56). However, they differed significantly in SRRT (t (35) = 2.15, p = .04, d = 0.73).

Table 17

Mean scores and reaction times per group (standard deviations in brackets).

	Active	Passive
Stop Signal Acc	0.65 (0.12)	0.70 (0.09)
Go RT	826.84 (157.25)	897.35 (132.87)
Go Acc	93.12 (3.25)	92.55 (3.51)
SSRT (Quantile)	323.18 (40.82)	337.86 (42.76)
SSRT (Integration)	335.37 (41.68)	337.91 (41.03)
P (R/S)	0.36 (0.12)	0.30 (0.09)
SRRT	700.25 (124.69)	786 (116.28)
SSD	406.67 (102.41)	457.41 (80.91)

Note. Acc: accuracy; RT: reaction time; SSRT: Stop signal reaction time calculated with the quantile or the integration method; P (R/S): probability of respond in a stop signal trial; SRRT: stop signal response time; SSD: stop signal delay; *: significant difference with a $p < .05$. Standard deviations are provided between brackets.

Active and passive participants did not differ in SSRT estimated with the integration method (*t* (35) = 0.19, *p* = .85, *d* = 0.06), nor SSRT estimated with the quantile method (*t* (35) = 1.07, *p* = .29, *d* = 0.36). Results did not change when lenient and conservative outlier requirements (see Congdon et al., 2012) were applied.
In addition, when we applied the mean method requirements (see Verbruggen et al., 2008), there were only 13 participants left (9 active and 4 passive participants). Among these participants, active and passive groups did not differ in SSRT.

Preprocessing

fMRI analyses were performed using Statistical Parametric Mapping (SPM8, Wellcome Department of Cognitive Neurology, London, UK: www.fil.ion.ucl.ac.uk/spm/). Functional images were reoriented to the MNI space's origin point. They were spatially and temporally realigned, co-registered, segmented in white and grey matter, normalized to a MNI T1 template and smoothed with a Gaussian kernel of 8 mm at FWHM.

First level analysis

First level analyses were performed. Three runs were specified in the design matrix, specifying the four experimental conditions go, stop, stop response and null event. Units for design were set to seconds, since the experiment was an event-related design, and durations were set to 0. The three first volumes (the first six seconds) of each run were not taken into account in the analysis in order to stabilize the signal. To this aim, events from each condition previous to those 6 seconds were not included in the model. Movement regressors were entered as multiple regressors. Movement displacement was visually checked in all participants, checking that displacement was inferior to one voxel size. None of the participants included in the sample had extreme movement displacement. Canonical hemodynamic response function (HRF), time and dispersion derivatives were chosen as basis functions.

Since there were four independent variables, factorial design was not possible. Thus, t contrasts were set manually. Three t contrasts were calculated using the canonical HRF basis function: a) Go – Null Event; b) Stop – Null Event; and c) Stop Response – Null Event. Contrasts were corrected applying FWE.

Second Level Analysis

The three conditions calculated in the first level: a) Go – Null Event, b) Stop – Null Event, and c) Stop Response – Null Event, were used to carry out the second level analysis.

Two sample t tests were performed for each of these conditions comparing active and passive groups. They were performed applying the subtraction method, according to which the activity from one group is subtracted from the other. Thus, in each condition activation from passive participants was subtracted from active participants' first (active - passive), and activation from active participants was then subtracted from passive participants' (passive –active).

The results (see Table 18) revealed significant differences between active and passive participants in the go condition ($p < .05$). The active group (see Figure 10A) showed greater activity in the right postcentral gyrus, precuneus, frontal inferior triangularis and supplementary motor area. There was also greater activation in an area placed in the white matter, between the right postcentral and superior parietal.

The reversed contrast did not indicate that passive showed a greater activation than active participants in the go condition ($p > .05$).

In the stop condition, a t contrast between active and passive participants revealed a significant effect ($p < .05$), indicating that active participants showed increased activity than passive ($p > .05$), while the reverse contrast did not show significant differences in any brain area ($p > .05$). The areas most activated in the active participants were located in the right hemisphere (see Figure 10B): postcentral, precuneus and the same area in the white matter, placed between superior parietal and postcentral cortex, that appeared in the go condition.

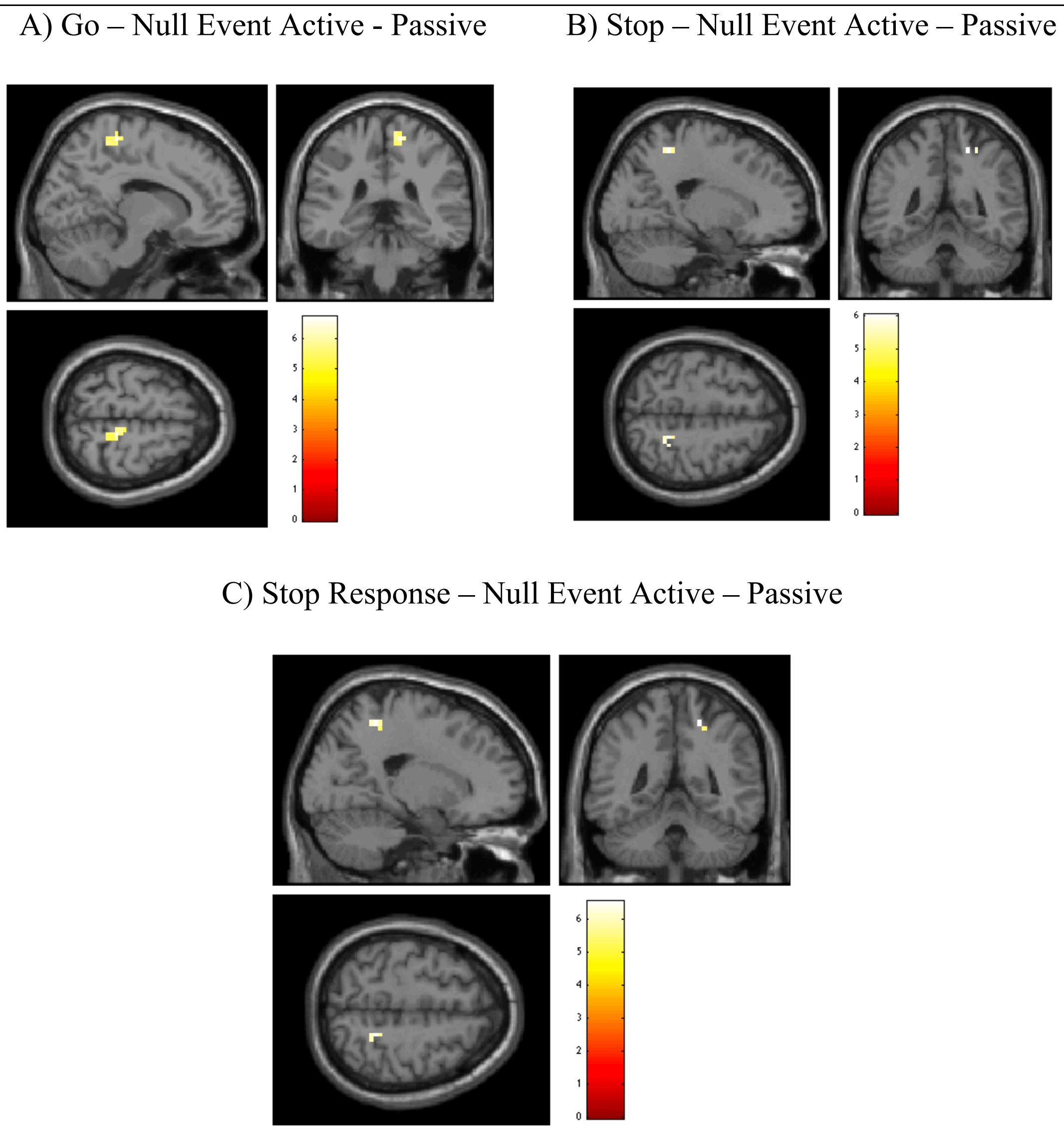

Figure 10. MIP showing significant differences between active and passive participants

In the stop response condition (Figure 10C), the t contrast between active and passive participants was also significant ($p < .05$), with greater activity in active participants in right postcentral and frontal inferior triangularis. In addition, there was greater activity in two areas placed in the white matter, one between the right superior parietal and the right postcentral gyrus, and the other, between the left precentral area and the postcentral gyrus. Furthermore, regressions were carried out to ascertain whether stop signal reaction time (SSRT), go RT, go accuracy or cardiovascular level (Course Navette) predicted brain activity during go, stop and stop response events.

Stop signal reaction times (SSRT) calculated with the integration method (Verbruggen et al., 2013) were regressed to activation in the stop signal events. No area was found to correlate significantly with SSRT ($p > .05$).

Table 18

a. Areas showing increased activation in the active group

Go	Stop	Stop Response
Right Postcentral Superior Parietal (WhM)	Right Postcentral Superior Parietal (WhM)	Right Postcentral Superior Parietal (WhM)
Right Precuneus	Right Precuneus	
Right Frontal Inferior Triangular		Right Frontal Inferior Triangular
Right Supplementary Motor Area		
		Precentral-Postcentral (WhM)

b. Areas, coordinates and number of voxels per condition

Go	Coordinates	Number of Voxels
Cluster:		
• Right Postcentral	13, -35, 63	
• Right Superior Parietal (WhM)	20, -46, 55	30
• Right Precuneus	13, -42, 59	
Right Frontal Inferior Triangular	48, 32, 9	1
Right Supplementary Motor Area	10, -24, 51	1
Stop	**Coordinates**	**Number of Voxels**
Superior Parietal (WhM)	20, -46, 55	5
Right Postcentral	13, -35, 63	1
Right Precuneus	13, -42, 59	1
Stop Response	**Coordinates**	**Number of Voxels**
Right Superior Parietal (WhM)	20, -46, 55	6
Right Postcentral	13, -35, 63	8
Right Frontal Inferior Triangular	52 28 17	1
Precentral-Postcentral (WhM)	-26 -24 47	1

Note. Table a compares the activated areas in the three conditions. Table b shows areas, coordinates and number of voxels per condition. WhM: white matter

SSRT calculated with the quantile method (Congdon et al., 2012) was also regressed on stop signal activation. We followed the recommendations stated by Congdon et al. (2012) and only participants that met the lenient outlier criteria were included in the analysis. No significant correlations were found either between stop signal activation and SSRT ($p > .05$).

Go RT and Go accuracy were regressed each on go and stop response conditions. None of these regressions reached significance ($p > .05$).

Finally, fitness level measured with the Course-Navette test was regressed to activation in the go, stop and stop response conditions. The results showed no correlation between fitness level and activation in any of the conditions tested ($p > .05$).

Experiment 8: DTI

Participants

Participants were 42 young adults divided in two groups according to their fitness levels and frequency of exercise. There were 23 participants in the active group and 19 participants in the passive group (see Table 19 for demographic details). Active and passive adults differed significantly in terms of cardiovascular level (t (40) = 4.70, p < .001*,* d = 1.49), and exercise frequency (t (40) = 7.71, p < .001, d = 2.44), but not in education (t (40) = .56, p = *.58*, d = 0.18), crystallized (t (40) = 1.01, p = *.32*, d = 0.32) or fluid intelligence (t (40) = 0.31, p = *.76*, d = 0.09), or age (t (40) = 1.69, p = .09, d = 0.53).

Materials

Procedure

DICOM images were converted to compressed-4D NIFTI format using MRICron. Images were checked for artifacts in all 42 participants, removing the slices that were affected. Two participants were removed from the initial sample because they had more than 3 volumes corrupted.

Just one volume was removed in two participants, since they had two corrupted slices in that volume. After that, DICOM images were converted again to 4D NIFTI format, so bvec (direction vectors) and bval (strength values) text files represented the corrected gradient directions and slices respectively.

There are several ways to analyze the DTI data; in this case, the mean white matter (WhM) skeleton and the WhM fibers tracking (tractography) were analyzed.

Table 19.

Diffusion MRI demographic variables: averages for active and passive participants (standard deviations in brackets)

		Actives	Passives
		Count/Mean	Count/ Mean
Participants		23	19
Gender	Male	10	7
Gender	Female	13	12
Age		23.17 (3.20)	25.16 (4.41)
Cardiovascular Level (Course-Navette)		31.15 (10.89)	15.89 (9.94)
Total Hours of Exercise along Life		5291.01 (2511.12)	751.97 (863.30)
Total Hours of Exercise in Childhood		1805.02 (1220.69)	274.74 (485.28)
Total Hours of Exercise in Adulthood		3485.98 (1731.13)	477.24 (756.26)
Years of education		16.61 (3.24)	17.26 (4.31)
Vocabulary (WAIS)		47.39 (5.16)	49.05 (5.45)
RAVEN Acc		9.78 (3.67)	10.16 (4.23)

Experiment 8a: TBSS

Analysis

Diffusion weighted images were preprocessed using FMRIB's Diffusion Toolbox (FDT), which is part of the FMRIB's Software Library (FSL). First, eddy current distortions correction was performed with the “eddy correct” tool; second, a binary brain mask was made from a no diffusion-weighted image with the BET (Smith, 2002) option, applying a fractional intensity threshold equal to 0.3. Diffusion tensor for each voxel in the mask was calculated using DTIFIT. This process estimates different indexes, among them, FA, MD or first eigenvalue (L1). Then, Tract-Based Spatial Statistic (TBSS, Smith et al., 2006) was applied to perform voxelwise statistical analysis of the FA and L1 data. TBSS projects the FA/L1 data (native space) from all participants to an averaged and normalized (1 x 1 x 1 MNI space) FA tract skeleton for later calculating the mean FA/L1 across participants. Subsequent contrasts between active and passive groups were calculated in order to know if the mean FA/L1 significantly differed between them.

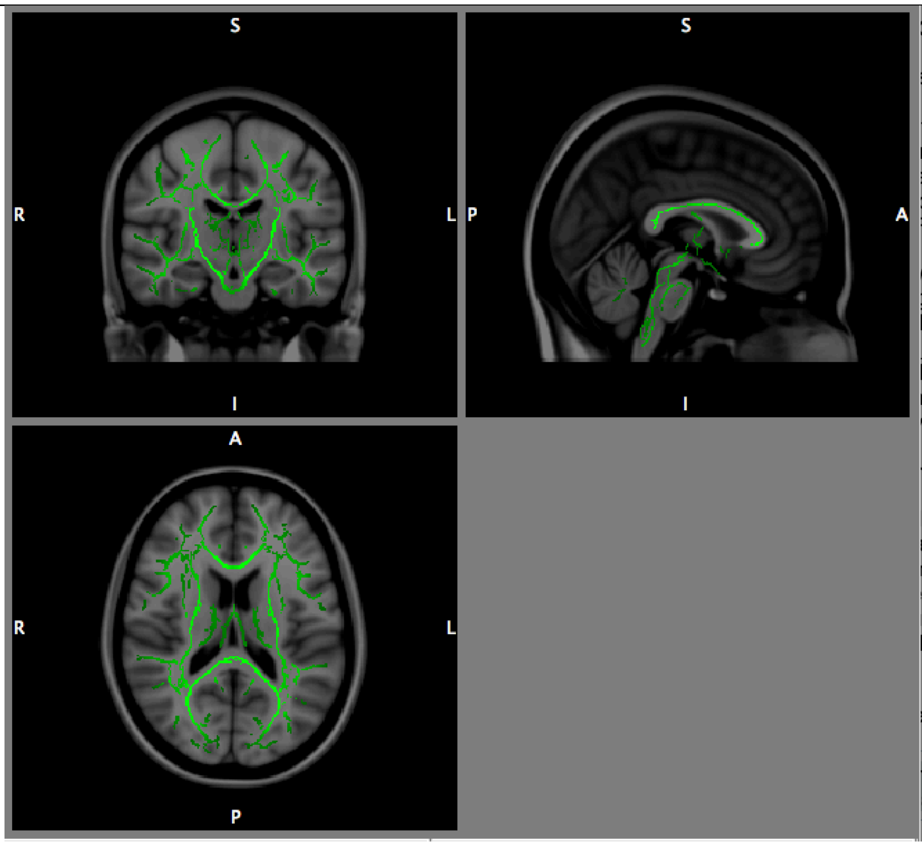

Figure 11. Tract-based spatial statistics (TBSS). Results: MNI152 T1 template + mean FA + tbss_tfce_corrp_tstat1/2. No differences between groups at $p = .05$. The mean skeleton is represented in green color.

Results

T independent tests indicated that active and passive groups did not differ significantly in FA nor L1 indexes (Figure 11); revealing that cardiovascular level was not associated with greater axonal integrity as we hypothesized.

Experiment 8b: Tractography

Analysis

Tractography was analyzed using ExploreDTI. NIFTI data was converted to a .mat file. The sign of the x gradient was flipped, setting it to negative (-x y z), and the gradient components permuted, changing them to y x z. Subject motion and eddy current distortions were corrected. After that, tracts were calculated for each participant and normalized to a standardized space (MNI space) using a FA template provided by ExploreDTI. Regions of interest (ROI) were extracted using the AAL template (Tzourio-Mazoyer et al., 2002) adapted to ExploreDTI. ROIs selected were all in the right hemisphere and belonged to the direct, indirect, and hyperdirect pathways (Aron & Poldrack, 2006): precentral, frontal inferior opercular, frontal inferior triangularis, frontal inferior orbicular, supplementary motor area, putamen, caudate, pallidum, thalamus, and subthalamic nucleus (see Figure 12). Subthalamic nucleus was a 3 mm^3-diameter circle centered at voxel 99 116 66 (x, y, z; MNI coordinates) following the study by Aron and Poldrack (2006).

In addition, areas from the dorsal attentional network (Corbetta, Patel, & Shulman, 2008) were included. All of them belonged to the right hemisphere: frontal superior, postcentral, parietal superior, and precuneus.

The entire process was carried out with the ExploreDTI's tool "Network Analysis Tool". All tracts that ended between two regions of interest (ROI) were entered into the analysis. FA indexes were provided and included in SPSS to explore group differences in the FA index of each tract (Figure 12).

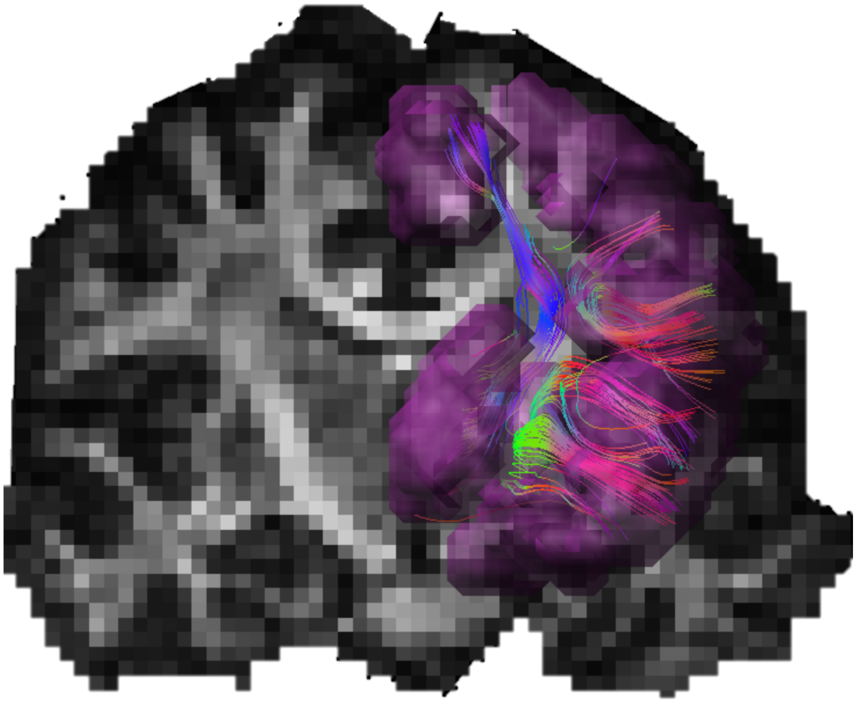

Figure 12. Regions of interest and tracts from the cortex-basal ganglia loops. ROIs are represented in purple. Color of tracts represent coordinate axis: blue = vertical, green = horizontal, and red = transversal.

Tractography Results

ExploreDTI calculated tracts connecting the 14 ROIs areas. Ninety-eight tracts were obtained in total, although not all participants had them (see Annex VII). Mean FA index from each tract was analyzed using t tests for independent samples (active and passive), which revealed significant differences between active and passive groups two of them: thalamus – frontal inferior triangularis (t (4) = 5.44, p = .01, d = 5.44), and thalamus - pallidum (t (7) = 3.49, p = .01, d = 2.64). However, these two tracts cannot be considered representative of the whole sample, since only 6 and 9 people respectively had them.

General Discussion

Our purpose in this final study was to investigate whether the practice of regular exercise along life would result in brain morphometry differences between active and passive participants. We were also interested in exploring whether these participants would show different patterns of brain activity when facing an executive/inhibitory control task. We finally aimed at investigating whether they would show different integrity levels in networks related to inhibition and attention control.

Our results revealed similar whole brain volume and concentration in grey and white matter in active and passive participants. Moreover, these variables did not correlate with levels of fitness measured by the Course-Navette, or the inhibition latency measured by stop signal task.

Furthermore, white matter tracts of active participants did not show higher myelin integrity than those of passive participants. A more detailed tractography study of the direct, indirect, and hyperdirect pathways (cortico-basal ganglia loops) and dorsal attention tract indicated that active participants did not show greater myelin integrity either.

Thus, we must conclude that unlike the studies carried out with children (Chaddock-Heyman et al., 2015; Chaddock et al., 2011; Chaddock-Heyman et al., 2014) and older adults (Colcombe et al., 2006; Holzschneider et al., 2012), we found no differences between our active and passive young participants in brain morphometry. Neither active or passive participants differed in the myelin integrity of the cortico-basal ganglia loops or the dorsal attention network. It might be the case that such differences disappear during youth, since it is a period in which brain and cognitive functioning is at its maximum peak. Besides, it is important to note that active and passive participants in our study carried a very similar lifestyle, that is, they did not differ significantly in demographic variables, personality (excepting extraversion) and lifestyle questionnaires, or anxiety and depression scales. Extraversion was not considered a variable that could influence behavioral results, since Experiment 4 showed that this personality trait was not correlated with executive control measures. Additionally, further analysis indicated that groups with extreme extraversion scores did not obtained significant differences in SST's measures.

Additionally, in the fMRI experiment active and passive participants did not differ in the behavioral measures of the executive/inhibition task (the stop signal task, Verbruggen et al., 2008). They showed the same go RT, revealing that the different levels of fitness did not affect motor processing speed. Both groups also showed similar accuracy levels in the stop and go conditions. Their stop signal delay and probability to respond when a stop trial was presented were similar as well. This probability, along with the long go RTs (see the average Go RTs in the standard version from Padilla et al., 2013; 2014 to have a reference measure), indicated that both groups applied the strategy to slow their responses in order to make sure that the sound did not appear. Passive participants significantly obtained a longer stop response RT, which reflected that they only responded to stop trials when the SSD was very long. Regarding the SSRT, groups did not differ in the speed of the inhibition process, whichever the method and the outlier requirements applied to estimate it.

We could not replicate Padilla et al.'s (2013; 2014) behavioral results, i.e., our active participants did not present with shorter SSRTs compared to passive participants. The no replication could be due to several reasons. The fMRI environment could give rise to a different way to facing the task, limiting the use of good strategies because the participants did not feel comfortable in such new environment. In addition, we could not replicate strategic stop signal outlier requirements in this experiment. In Padilla et al.'s (2013; 2014) study, the participants who responded significantly more or less than the 50% of the stop trials were discarded from the sample following the mean method outlier requirement (Verbruggen et al., 2008). However, in our fMRI experiment, we could not apply this outlier requirement due to the high costs of the scanning sessions. This was the reason why we applied the integration and the quantile SSRT estimation methods, since they allow calculating SSRTs in those participants who apply extreme strategies. The fact that most participants from the present study applied extreme strategies, since only 13 met the outlier requirements from the mean method (Verbruggen et al., 2008), made this sample difficult to compare with the ones from Padilla et al. (2013; 2014). Finally, similar behavioral results may be due to the participants were not so extreme in their frequency of fitness practice as our participants from Padilla et al. (2013; 2014). The active participants from our first studies have practiced exercise for at least 10 years, with a minimum frequency of 6 hours per week, while the active participants from the present study have exercised for at least 7 years, with a minimum frequency of 4 hours per week. Moreover, passive participants from our first studies have practiced non-cardiovascular exercise no more than 1 hour per week, while the passive participants from this experiment have practiced low intensity exercise (walking) with a frequency of no more than 3.5 hours per week.

Nevertheless, the key point here is that despite not showing significant differences in SSRTs, active and passive participants differed significantly in brain activity. Our results showed that active participants had more activity compared to passive participants in the right postcentral and superior parietal areas in all conditions. This difference in activation cannot be due to greater vascularization in the active group, since in both groups the baseline activation was subtracted from the activation showed in each stop signal condition. It is difficult to interpret this different activation, since no significant regressions between SSRT/go RT/go accuracy and brain activity were found in any stop signal condition. Therefore, the greater activation showed in the active group might not be directly related to the variables measured by the stop signal task, but with other cognitive processes involved in task performance such as perception, attention, or motor planning.

It is likely that the active participants' long-term practice of exercise has led to brain plasticity changes. Kelly and Garavan (2005) distinguished between three types of activation patterns that can be observed after long-term repetitive training: a) greater signal or more extended activation, which can be interpreted as an additional recruitment of cortical networks (Karni et al., 1995); b) lower signal or less extended activation, which might be related to higher processing efficiency (Kelly & Garavan, 2005); and finally, c) different patterns of activation, giving rise to redistribution or reorganization of neural networks. However, it is difficult to conclude that any of these patterns is associated with better cognitive functioning unless connectivity analyses are carried out (Kelly & Garavan, 2005). Therefore, further connectivity and time series analyses would need to be considered in our study to interpret the greater activity observed in active participants.

However, Kelly and Garavan (2005) suggested that long-term motor training usually results in increased activity in highly specialized motor and non-visual sensorial areas. Thus, a possible explanation of the active participants' greater activation comes from research on motor skill expertise in sports. Expert athletes show extended quiet eye duration (Vickers, 1996), greater readiness potential (Jahanshashi & Hallett, 2003) and greater right superior parietal activation (Milton, Solodkin, Hluštík, & Small, 2007). Quiet eye is the final fixation to a target before initiating a programmed movement

(Vickers, 1996). Expert athletes exert fewer fixations of longer durations (Mann, Coombes, Mousseau & Janelle, 2011). A longer final fixation serves to perceive better relevant visuospatial information needed to execute a subsequent precise movement (Mann et al., 2011). Moreover, readiness potential is a negative event potential observed 1000 to 1500 ms before movement execution, reflecting anticipatory attention and movement preparation (Mann et al., 2011). Readiness potential is comprised of the early, late and peak components. Early component begins 1500 ms before movement, reflecting the activation of the supplementary motor area when retrieves the required motor program from memory (Mann et al., 2011). Conversely, late component occurs 400 ms before movement initiation and indicates the primary motor area activity. Finally, peak component takes place 50 ms before movement initiation and reflects the coordinated activation of the supplementary motor area and the primary motor cortex (Mann et al., 2011). Di Russo et al. (2005) found that expert shooters showed longer readiness potential than non-expert shooters while performing a simple finger flexion task. Mann, Coombes, Mousseau and Janelle (2011) showed that the quiet eye duration and the readiness potential amplitude placed in central cortical areas were positively correlated. Expert athletes had a longer quiet eye period and a greater activation in the right central and parietal areas. Milton et al. (2007) supported these results showing that expert athletes had less whole-brain activation, except in the right superior parietal lobe. They interpreted these results as experts having a motor network more specialized in motor planning that allow them to integrate visual and motor information more efficiently (Milton et al., 2007).

Further investigation would be necessary to assure that our active group showed more activation in right superior parietal lobe due to more allocation of attentional resources to obtain more visuospatial information to prepare the subsequent motor program. The fact is that in the three stop signal task conditions they showed greater activation in the right postcentral area, which processes somatosensorial information, and a white matter area close to the right superior parietal, which is responsible of visuospatial information processing and attention allocation (Milton et al., 2007). Active group also showed greater activation in the supplementary motor area in the go condition, which supports the motor preparation hypothesis mentioned above.

In addition, the areas showing greater activation in the active group might belong to the dorsal attention network (Corbetta, Patel, & Shulman, 2008), which might indicate that they maintained attention better and were more ready to respond to the subsequent stimuli than passive participants. Colcombe et al. (2004) observed the same pattern of activation in their fit older adults when performing the flanker task.

The dorsal attention network consists of the intraparietal sulcus, superior parietal lobule, and frontal eye field. This network is activated while the individual is concentrated on a task, selecting stimuli relevant for the task demands, and linking them to their corresponding response (Corbetta, et al., 2008; Petersen & Posner, 2012). It also reflects anticipatory activity when the participant is waiting for performing a response. To achieve these goals, the dorsal network suppresses the ventral network through the middle frontal gyrus to filter irrelevant stimuli and avoid reorienting of attention (Corbetta et al., 2008). Ventral network includes right temporoparietal junction, right middle and right inferior frontal gyrus. These areas get deactivated while a task is being performed to filter irrelevant stimuli. It is suggested (Corbetta et al., 2008) that a cognitive control network -ACC and anterior insula- deactivate them (Dosenbach et al., 2006; Shulman et al., 2003). The greater activation that active group showed in pars triangularis - an area belonging to the ventral attention network - in go and stop-response conditions might reflect that passive participants suppressed more intensely the ventral attention network while the main task (go) was performed in order to avoid the interference of irrelevant stimuli.

Active participants also showed more activity in the precuneus in the go and stop conditions. This area belongs to the frontoparietal network (Dosenbach et al., 2007), which contains areas overlapping with the dorsal attention network, but in this case related to executive control. Frontoparietal network is responsible for action initiation, task switching and inter-trial stabilization (Petersen & Posner, 2012). Hence, active participants' greater activation would be related to inter-trial adjustment and reprograming of action.

It is important to note that active participants showed activation in areas close to the right superior parietal and between the precentral and postcentral cortex that were localized in the white matter. Theoretically, bold signal reflects the postynaptic activity originated in the neuron bodies placed in the gray matter (Logothetis et al., 2001). Moreover, the cerebral blood volume and flow is seven times higher in the grey matter than the white matter (Rostrup et al., 2000). However, a recent review (Gawryluk, Mazerolle, & D'Arcy, 2014) has claimed that bold signal can also be detected in the white matter, given that scanners with higher field strength have shown that white matter contains enough vasculature and perfusion to support hemodynamic changes detectable with fMRI. The venous vessels in white matter are the same size than the one found in the grey matter, however, the vasculature density in the white matter is half of the grey matter's one (Jochimsen et al., 2010). Therefore, it is plausible that active participants showed higher activity in those white matter areas. Gawryluk et al. (2014) support that diffusion fMRI is the technique most sensitive to collate white matter functional activity. However, we applied diffusion MRI, which is not sensitive to activity-dependent changes in white matter. Conversely, other alternative explanation to white matter activation is that smoothing produced spatial displacement of the BOLD signal.

Finally, our study was limited regarding our volumetric and functional analyses, since they were performed in the whole brain, not limiting the explored areas to the ones where previous studies have found specific effects of sport. Whole-brain analyses correct for multiple comparisons applying family wise correction, being less sensitive to significant differences produced in specific areas of interest. However, we chose whole-brain analyses because we did not want to limit our research to previous findings with children and older adults. As not many neuroimaging studies have been carried out with young adults, it is not well understood whether the neural correlates of sport in this population would be different from the ones found in older adults and children. In addition, this general analysis will allow us exploring further and more specific hypotheses in the future.

In conclusion, active and passive groups showed similar whole brain morphometry and similar myelin integrity in the tracts related to attention and motor programming. However, they presented with different strengths of brain activation, with the active group exhibiting greater activity in areas related to attention and somatosensorial processing in all stop signal task conditions. The active group also showed increased activity in premotor areas when responding to the go trials. This might indicate that active participants maintained their selective attention better, being less affected by interference, and they integrated visuospatial information with motor programming in a more efficient way as a consequence of exercise practice. In any case, both groups achieved the same behavioral results in terms of accuracy and speed of processing. Further connectivity analyses will be necessary to elucidate this hypothesis.

DISCUSSION

Chapter 10. General Discussion & Conclusion

Chapter 10. General discussion and conclusions

1. Experimental studies: discussion and conclusions

The aim of our study was to explore the effects of the long-term and regular practice of cardiovascular exercise on the cognitive functions and the brain. To this purpose we selected a group of young adults with high differences of cardiovascular level and frequency of exercise that we considered as active and passive participants to compare them in eight experiments.

In Experiment 1, active participants showed faster stop signal reaction times (SSRT) than passive participants only when the stop signal task (SST) was strategic. Differences in cognitive control were only seen in this version of the SST, but not in the standard version. We argued that the strategic version required more executive control than the standard version, since the former became a dual task where performance trade-offs were applied in order to carry out both tasks at the same level. Aerobic exercise effects would be associated with an improvement of cognitive control in high-demanding situations, requiring higher working memory resources.

In Experiment 2, the possibility of a higher working memory capacity (WMC) in the active group was assessed. As we expected, active participants showed higher WMC when performed the Automatic Operation span task (AOspan). Again, groups differed in SSRT only when they carried out the strategic version, replicating our previous study (Experiment 1, Padilla et al., 2013). When WMC was controlled for, differences in inhibition between groups disappeared. Higher WMC in active participants allowed them to deal better with the greater executive demands of the strategic SST. This confirmed our predictions, although left open the possibility of other variables affecting the results.

In Experiment 3, we evaluated the effect of aerobic exercise on long-term memory. We found that active and passive groups discriminated attended items at the same level in a recognition task. However, the active group discriminated unattended items worst, treating them as if they were new. We concluded that active participants suppressed better the few unattended memory traces that reached encoding, discriminating the unattended items from the new items worst than passive participants.

In Experiment 4, we investigated the influence of personality, achievement motivation, and self-regulation in the performance of cognitive control tasks (SST and AOspan). The results showed that active participants showed more emotional stability (control of impulses and emotions), positive mood and openness to new experiences. Regarding achievement motivation active and passive participants did not differ. On the other hand, active participants showed better self-regulation, specifically more inhibitory control, controlling positive and negative emotions and physiological reactivity more efficiently than passive participants. Regression analyses indicated that self-regulation and control of impulses contributed to AOspan performance, but frequency of exercise practice was the variable associated with strategic SSRT.

In Experiment 5, carried at the University of Granada, retrieval induced forgetting (RIF) was studied with a dual RIF task, where updating and retrieval were interleaved. In this sample, we controlled differences in personality, anxiety, depression and lifestyle through standardized questionnaires. The results showed that active participants were able to surpass the high attentional demands from the updating task, suppressing non-relevant items from memory, while passive participants were not. As a consequence, only the active participants showed the RIF effect, the measure that reflects the involvement of inhibitory mechanisms in memory.

In Experiments 6, volume and density of grey and white matter were compared between active and passive participants. No significant differences in brain morphometry were found between physically active and passive young adults.

In Experiment 7, brain activation was measured while active and passive participants were performing the strategic SST. Results indicated that groups showed similar SSRTs, but their brain activation was different. The lack of correlations between brain activity and SST measures did not allow us to interpret active participants' greater activation. These differences in activation could be reflecting other processes not directly measured in the SST, but involved in task performing. However, according to Kelly and Garavan (2005), a greater activation in motor and sensory areas is related to more efficient processing. In this way, the greater activity found in the right postcentral gyrus and in a white matter area close to the right superior parietal lobe in all stop signal conditions, along with the greater activity in the supplementary motor area in the go condition, led us to think that this pattern of activation could be the product of long-term exercise practice. Active participants, as the expert athletes observed in other studies (Jahanshashi & Hallett, 2003; Milton et al., 2007; Vickers, 1996), would allocate and maintain their attentional focus better than passive participants, extracting more visuospatial information from their environment, integrating it with the somatosensory information and using it to prepare a self-paced motor response. Therefore, they would be more ready and efficient when responding, suppressing more easily non-relevant information. Nevertheless, further research is necessary to confirm this hypothesis.

Finally in Experiment 8, active and passive participants did not show significant differences in white matter integrity in those tracts connecting areas that belong to the dorsal ventral network and the motor control loops.

Experiment 6 and 8 indicated that young adults, at least in this sample, do not show structural differences in their brains. Probably, the reason is that young adults are at their cognitive peak and it is difficult to find differences due to a ceiling effect. In addition, people from these Experiments were very similar between them, since they only differed in frequency of exercise and fitness level. Furthermore, as we pointed out in the Chapter 9's discussion, the active and passive participants from this sample were not as extreme as the ones from previous studies, so we had to deal with a greater ceiling effect in our MRI study.

On the other hand, we found that active and passive groups from the Experiment 7 did not differ significantly in the SSRT unlike the ones from the Experiments 1 and 2. We think that this was due to several causes. First, participants from the Experiment 7 carried out the task inside of the MRI scanner, so this could affect performance. Second, participants applied more extreme strategies than in Experiments 1 and 2, because we could not reject individuals who responded to more o less than 50% of the stop trials as we did in Padilla et al.'s (2013; 2014) study following the mean method requirements. This outlier condition could have caused high costs arising from the scanner. Second, the differences in exercise frequency and fitness levels between active and passive participants were less extreme in Experiment 7 than in Experiments 1 and 2. Other studies carried out with young adults not having such extreme fitness levels (see Hillman, Erickson, & Kramer, 2008) found similar patterns of results, that is, similar behavioral performance, but significant psychophysiological differences (Hillman, Kramer, Belopolsky, & Smith, 2006a; Polich & Lardon, 1997).

In sum, considering all our experiments, we conclude that the common factor in our results is that cardiovascular exercise is related to greater attentional resources and better executive control. The fact that active people showed more attentional resources is reflected in their ability to perform tasks where several cognitive operations are carried out at the same time, as in the case of AOspan, strategic stop signal task and dual RIF. However, executive control is also exerted in these tasks, as they demand strategic decision-making and cognitive operations.

Self-regulation and control of impulses were related to the results in AOspan, while frequency of exercise was related to the results in strategic SSRT. Nonetheless, when the differences in personality were controlled for in Experiments 5 to 8, active and passive participants still differed in dual-RIF performance.

Psychophysiological studies might shed light on the actual processing differences between active and passive participants. In our case, the neuroimaging studies carried out showed that active and passive participants did not show activation differences in areas related to cognitive control, but they did in areas related to attention and sensorimotor information, pointing to differences in attentional resources. The higher activation found in the white matter area close to the right superior parietal and in the sensorimotor cortex suggested that the long practice of exercise may be related to visuospatial attention, sensorimotor integration and motor programming, giving rise to a more focused and strategic processing when active people face a task and have to make decisions.

All in all, it seems that active participants tend to outperform passive participants only when they face highly demanding tasks implying the implementation of strategies. This could mean that active participants make decisions that give rise to a more efficient processing of information and thereby, to a better use of the available attentional resources. Conversely, it could mean that active participants carry out cognitive operations more easily because they have more attentional resources. Nonetheless, findings from neuroimaging suggested that the differences between active and passive participants resided on the amount of attentional resources available. Further analyses would be necessary to study the timing of each type of process.

As stated above, participants with a physical illness or under medication were excluded from the study. The participants from experiments 5, 6, 7, and 8 filled up an extensive medical questionnaire to know whether they were eligible for magnetic resonance scanning. At the same time, the radiologist checked that any of them was suffering from a neurological disorder. Finally, active and passive participants showed no differences in structural or myelin integrity measures. Thus, as far as we know, we can conclude that our young adults did not differ in biological terms, although other measurements such as cholesterol, body mass index, hormones, BDNF or brain blood flow should have been carried out to further support this point.

If we assume that there were no major biological differences between our groups, it may well be that the effects of exercise in young adults are only measurable in cognitive functioning. In that case, we should further investigate whether they differ in strategic thinking, planning, or inference/prediction, since these aspects might affect to other more basic executive functions such as inhibition or working memory, making them more efficient. If the results applying tasks measuring these variables did not show any group differences, we would conclude that exercise modulate attentional resources. We must acknowledge that our studies present some limitations regarding the experimental design, since cross-sectional studies may not lead to establish causal relationships between variables. In this way, our results suggest that cardiovascular exercise is related to better attentional resources and cognitive control. However, our objective with this project was to investigate the longitudinal effect of aerobic exercise along a period of at least seven years. It is difficult to reproduce this period of time applying an interventional design due to the high costs and the possible participant dropouts. In addition, it is important to note that frequently interventional studies do not control entirely for other variables that accompany the practice of exercise as possible changes in lifestyle, diet, level of socialization, cognitive demands that can be masked in the specific tasks carried out in the exercise intervention. As later it will be discussed, these variables might influence brain and cognitive enhancement. Thereby, the type of design used in our experiments is closer to epidemiological designs and have tried to control variables that might have affected cognitive enhancement such as daily activities, personality and self-regulation. Thus, groups were chosen trying to make them as similar as possible, and differing only in cardiovascular frequency and fitness level.

Our main conclusion, therefore, is that young adults with a history of chronic cardiovascular exercise show better cognitive control and greater attentional resources than passive participants.

2. Future directions in the exercise research field

The review carried out in the first chapter showed that chronic exercise enhance executive functions and prevents cognitive deterioration. Research in this field pointed to three main factors: a) the regulation of neurotrophines promoting neurogenesis and neuroplasticity, b) the greater brain oxygenation due to angiogenesis and blood flow increase, and c) the greater neurotransmissor release in the monoamine system improving cognitive processing (Gallota et al., 2015).

Regarding the neurogenesis/neuroplasticity factor, it is worth taking into account that other types of interventions implying new skills acquisition as musical practice (Chang, 2014; Gärtner et al., 2013), motor skill learning (Dayan & Cohen, 2011; Voelcker-Rehage & Niemann, 2013) or cognitive training (Lampit, Hallock, Suo, Naismith, & Valenzuela, 2015; Pressler et al., 2015) are also related to increases in brain volume, white matter integrity (Wang & Young, 2014) and BDNF levels (Angelucci et al., 2015; Dayab & Cohen, 2011; Pressler et al., 2015). Therefore, recent research shows that, far from being the only cause of neurogenesis, cardiovascular exercise has not the exclusivity to increase it. It rather seems that other factors where people are faced to novel demanding situations for which new skills would have to be applied would favor neurogenesis.

As Chang (2014) suggested, structural changes in the brain reflect the areas that have been involved in a specific intervention, whether it is musical practice or sport. These areas will increase their volume after intervention, but will decrease if such skills are no longer practiced. At the same time, there will lead to functional reorganization in the networks involved in the skill learned, becoming more efficient.

Other supportive findings come from research in non-cardiovascular exercise. More and more research is finding that other types of physical activity interventions such as coordination or toning exercise have an impact on brain (Cassilhas et al., 2007; Niemann, Godde, & Voelcker-Rehage, 2014; Voelcker-Rehage, Godde, & Staudinger, 2011; Voelcker-Rehage & Niemman, 2013; Voss et al., 2010a).

Hence, it is important to elucidate whether the type of activity carried out during the exercise intervention is what produces neural changes and not cardiovascular exercise by itself. In this vein, it will be more likely to observe more changes in executive functions when the intervention has more cognitive-engaging exercises.

We could for example imagine an interventional study in which different types of cardiovascular exercise would be compared, say, team sports, in which participants have to anticipate future movements from themselves or other players, versus sports in which participants just work out (static bicycle, treadmill or elliptical trainer).

Concerning the oxygenation hypothesis, cardiovascular exercise -and no other interventions- would be intimately related to the increase of vessels density and blood flow (Black et al., 1990). However, Isaacs et al.'s (1992) study suggests that it would be possible that synaptogenesis and neurogenesis produced by complex motor learning is accompanied by angiogenesis, supporting blood supply. It would be interesting to clarify whether other types of sport (i.e., yoga, coordination exercise) or cognitive interventions are also accompanied by angiogenesis.

Furthermore, research on how many exercise doses are the most recommended to improve cognitive functions or prevent deterioration, and follow-up studies to know whether effects of exercise remain after intervention would be beneficial in order to come up with practical advice for the general public.

Finally, as we concluded from Experiment 4, it would be necessary to control personality and self-regulation, since they may affect the performance in tasks that measure executive control.

To conclude, our results show that cardiovascular exercise may be applied as an intervention to enhance cognitive performance in young adults that also may help to prevent cognitive decline during aging.

ABBREVIATIONS

Abbreviations

A

A: Affability
ACC: anterior cingulate cortex
AMPA: α-Amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid receptor
AOSPAN: automatic operation span
ATQ: Adult Temperament Questionnaire

B

b0: no diffusion-weighted volumes
BDNF: brain derived neurotrophic factor
BOLD: Blood-oxygen-level dependent

C

C: Consciousness
CBF: cerebral blood-flow
Ce: control of emotions
Ci: control of impulses
Co: cordiality/kindness
Cp: cooperation/empathy
CREB: cAMP response element-binding protein
CRIq: Cognitive Reserve Index questionnaire

D

D-RIF: Dual-Retrieval Induced Forgetting Task
D: distortion scale
DLPFC: dorsolateral prefrontal cortex
DMN: default mode network
Do: dominance
DTI: diffusion tensor imaging
Dy: dynamism

E

E: Extraversion
EPI: echoplanar images
ERN: error-related negativity
ERP: event-related potential
ES: Emotional Stability

F

FA: fractional anisotropy

FDT: FMRIB's Diffusion Toolbox
fMRI: functional magnetic resonance
FP: fronto-parietal network
FSL: FMRIB's Software Library
FWE: Family Wise Error
FWHM: Full width at half maximum

G

Gpe: external globus pallidus
GPi: interior globus pallidus

H

HRF: Hemodynamic response function

I

IFG-1: insulin-like growth factor 1
IFJ: inferior frontal junction
IMI: Intrinsic Motivation Inventory
ISI: inter stimuli interval

L

L1: first eigenvector or axial diffusivity
LPFC: lateral prefrontal cortex
LTM: long-term memory

M

M1: primary motor area
MD: mean diffusivity
MEP: motor evoked potential
ML: Achievement motivation questionnaire
MNI: Montreal Neurological Institute atlas
MPFC: Medial prefrontal cortex
MRI: magnetic resonance imaging

N

NAA: N-Acetylaspartate
NMDA: N-methyl-d-aspartate receptor
Nrp: Exemplars from the non-practiced categories

O

O: Openness

Oc: Openness to culture
Oe: Openness to experience
OPC: Olligodendrocyte progenitor cells

P

PA: Perception/action
PAL: Paired associate learning task
Pe: Perseverance
Pe: Positivity error
PFC: Prefrontal cortex
PI: Proactive interference
PM: Primary memory
Pre-SMA: Pre-supplementary motor area
PRI: Prepotent response inhibition

R

RDI: Resistance to distractor interference
RIF: Retrieval induced forgetting
rIFG: Right inferior frontal gyrus
ROI: Regions of interest
Rp-: Exemplars from the practiced categories no included in the practice phase
Rp+: Repeated practiced exemplars
RPI: Resistance to proactive interference
RT: Reaction time

S

S: Scrupulosity
SAS: Supervisory attentional system
SM: Secondary memory
sMRI: Structural magnetic resonance imaging
SNr: Substantia nigra reticulata
SP\MP: Spoiled magnetization-prepared
SPM: Statistical Parametric Mapping
SSD: Stop signal delay
SSRT: Stop signal response time
SST: Stop signal task
STM: Verbal short-term memory
STN: Subtalamic nucleus
Str: Striatum (putamen and caudate)

T

TBSS: Tract-based spatial statistic

TE: Echo time
Th: Thalamus
TMS: Transcranial magnetic stimulation
TNT: Think/no think paradigm
TR: Repetition time
TSE: Turbo spin echo

V

VBM: Voxel-based morphometry
VEGF: Vascular endothelial growth factor
VLPFC: Mid-ventrolateral prefrontal cortex
VMPFC: Ventromedial cortex
VO_2 max: Maximum volume of oxygen consumption

W

WAIS-III: Wechsler Adult Intelligence Scale- III
WhM: White matter
WM: Working memory
WMC: Working memory capacity

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ANNEXES

Annex I: Physical Activity Questionnaire

Por favor, responda a las siguientes preguntas intentando especificar lo máximo posible el número de años, meses y horas que ha realizado ejercicio, así como el tipo de actividad que ha llevado a cabo a lo largo de su vida. * Required

Nombre *

Fecha de Nacimiento *

Apellido *

Teléfono de contacto *

¿Qué disponibilidad tiene? *

¿Tiene o ha tenido en el pasado algún problema de salud? * Si es así, especifique cuál.

¿Toma o ha tomado alguna medicación? * Si es así, especifique cuál.

¿Sufre o ha sufrido algún trastorno psicológico? * Si es así, especifique cuál.

¿Realiza ejercicio actualmente? *
o Sí
o No

Especifique el/los tipo/s de actividad/es que realiza. *

Especifique cuánto tiempo lleva realizando cada una de las actividades deportivas que realiza.*

Trate de concretar cuántos días y horas dedica a la semana a cada una de las actividades. *

¿Ha realizado deporte en el pasado? *
Describa todas las actividades físico-deportivas que ha realizado desde la infancia hasta la actualidad. Detalle los años que realizó cada actividad, los días y horas que dedicaba a cada una.

¿Cómo suele desplazarse por la ciudad? *
Andando, en coche, en transporte público, bicicleta,...

¿Se considera una persona activa o sedentaria? *

¿Ha sido así siempre? *

Protección de datos *
Protección de datos En cumplimiento de lo dispuesto en la Ley Orgánica 15/1999, de 13 de diciembre, de Protección de Datos de Carácter Personal, le informamos que los datos recabados serán incluidos en un fichero del Laboratorio de Psicología Cognitiva gestionado por la UIB, cuya finalidad es gestionar los participantes en las investigaciones de dicho laboratorio. Los datos solicitados son necesarios para cumplir con dicha finalidad y, por lo tanto, la no obtención de los mismos impide su consecución. Asimismo, para participar en cualquier estudio llevado a cabo por miembros de este laboratorio, deberá otorgar su consentimiento para tratar datos especialmente protegidos para la finalidad mencionada anteriormente, consentimiento que podrá revocar en cualquier momento. La UIB es el responsable del tratamiento de los datos y como tal le garantiza el ejercicio de los derechos de acceso, rectificación, cancelación y oposición de los datos facilitados, para lo cual deberá dirigirse por escrito a: Universitat de les Illes Balears, Secretaría General, a la atención del Responsable de seguridad, Ctra. de Valldemossa, km 7,5, 07122 Palma (Illes Balears). De igual modo, la UIB se compromete a respetar la confidencialidad de sus datos y a utilizarlos de acuerdo con la finalidad de los ficheros.
o Confirmo que he leído y comprendido la información proporcionada, y doy mi consentimiento para formar parte de este estudio de investigación.
o Doy mi consentimiento para que, de cumplir los requisitos necesarios, los miembros del laboratorio de Psicología Cognitiva contacten conmigo en futuros estudios remunerados.

Annex II: Safety Questionnaire

Centro de Investigación de Mente, Cerebro y Comportamiento CUESTIONARIO DE SEGURIDAD PARA LOS PARTICIPANTES RM 3T

La información de este cuestionario es confidencial. Es importante que lo complete con cuidado y aportando toda la información que se le solicita. Por favor, escriba de forma legible y en mayúsculas, y conteste marcando con una X en las casillas. Consulte al técnico de RM si tiene alguna duda al realizar este cuestionario o antes de entrar en la habitación del sistema RM.

Fecha de nacimiento _______/ _______/ ____________ día mes año
Edad _______ años
Altura _________ metros
Peso _______ kg Hombre Mujer

1. ¿Ha sufrido previamente una operación? Si ha contestado afirmativamente, por favor, indique el tipo de operación:
Fecha _______/ _______/ ______________ Fecha _______/ _______/ ______________ Fecha _______/ _______/ ______________
2. ¿Tiene un marcapasos?

3. ¿Ha tenido algún problema relacionado con la aplicación de la técnica RM?
En caso afirmativo, describa el problema: ____

4. ¿Ha sufrido algún daño en el ojo debido a algún objeto metálico (astilla, cuerpo extraño en el ojo, etc.)?
En caso afirmativo, descríbalo: ____

5. ¿Tiene algún objeto metálico en su cuerpo (p.e. prótesis)? En caso afirmativo, descríbalo: ____

6. ¿Está tomando alguna medicación?
¿Cuál?____

7. ¿Sufre alguna enfermedad actualmente o ha tenido problemas de salud en el pasado? ¿Cuál? ____

Para mujeres participantes:
8. ¿Está embarazada o existe la posibilidad de que pueda estarlo?
Tipo de operación ____
Tipo de operación ____
Tipo de operación ____

AVISO: Ciertos implantes y objetos pueden ser peligrosos para usted o interferir con el procedimiento RM. No entre en la habitación del sistema RM si tiene alguna duda sobre un implante, o algún objeto que lleve encima. Consulte al Técnico de la RM antes de entrar la habitación. El sistema RM está siempre encendido.

Por favor, indique si tiene:
Un tatuaje o maquillaje permanente No Si
Un piercing en alguna parte de su cuerpo No Si
Parches de Nicotina o nitroglicerina No Si
Algún objeto metálico o cuerpo extraño No Si
Puntos quirúrgicos, tornillos, suturas metálicas No Si
Prótesis (rodilla, cadera, etc.) No Si
Implantes magnéticos o electrónicos No Si
Implantes radiactivos No Si
Electrodos internos No Si
Parches transdérmicos de medicación con soporte metálico No Si
Cualquier tipo de prótesis (mama, pene, ojos) No Si
Equipos de inyección de medicinas No Si

Pierna artificial No Si
Implantes de cualquier tipo No Si
DIU o diafragmas o espirales metálicas contraceptivas No Si
Dentaduras o aparatos dentales No Si
Aparatos auditivos No Si
Esquirlas de metal en ojos o ha sido trabajador del metal No Si
Pinzas o clips de aneurismas No Si
Sistemas de neuroestimulación No Si
Estimulador de la Espina dorsal No Si
Cualquier tipo de estimulador No Si
Dispensador de insulina u otra medicación No Si
Bomba de insulina No Si
Válvula cardiaca artificial No Si
Muelle o alambre en los párpados No Si
Marcapasos metálicos, filtros No Si
Anus praeter (ano artificial) con cierre magnético No Si
Cateter o puertos de acceso vascular No Si
Implate de defibrilador cardíaco (IDC) No Si
Cateterismo cardiaco Swan-Ganz o catéter de termodilución No Si
Implantes cocleares, otológicos u otros implantes de oído No Si
Shunt espinal o intraventricular No Si
Problema de respiración o de movimiento No Si
Claustrofobia (miedo a espacios cerrados) No Si

Antes de entrar a la habitación de la RM debe quitarse TODOS los objetos metálicos incluidos los pendientes, dentaduras, llaves, teléfonos móviles, gafas, horquillas y pinzas del pelo, sortijas, pulseras, colgantes del cuello, collares, clips, tarjetas magnéticas, tarjetas de crédito, bolígrafos, herramientas, navajas, ropa con cremalleras metálicas, etc.

Algunas fajas, sostenes y sujetadores pueden contener piezas metálicas. Consulte con el técnico de RM para evitarle heridas y quemaduras.

Por favor, PREGUNTE al técnico ANTES de entrar en la habitación de la RM si tiene alguna pregunta o duda.

Aviso: Es posible que se le pida que se ponga unos auriculares o tapones de los oidos para amortiguar el ruido que produce la RM.

Para su comodidad pida ir al aseo antes de entrar a la resonancia y si cree tener fiebre o una temperatura no habitual comuníqueselo inmediatamente al técnico de RM.

Declaro que la información que he escrito en contestación al cuestionario es correcta. He leído y entendido toda la información de este documento y he tenido la oportunidad de preguntar al operador de la RM mis dudas sobre la información en este documento y sobre el procedimiento de RM
Nombre: ______________________________________ Firma: ______________ Fecha ______/ ______ /________

PARA USO INTERNO DE LA UNIDAD DE RM (CIMCYC)
Nombre del responsable:
____
Referencia del proyecto:
____

Este documento lo han revisado el responsable y el técnico de la RM y está actualizado en el momento de escanear.

El participante ha mencionado información que hace necesario comprobar si es seguro realizar una RM en este momento: No Si

Es seguro realizar la RM al participante en este momento: No Si

Nombre del técnico: ________________________________
Firma: ____
Fecha ________/ _______________________/___________

Annex III: fMRI Study Information Document

HOJA DE NFORMACIÓN ESTUDIO fMRI
CENTRO DE INSTRUMENTACIÓN CIENTIFICA
Universidad de Granada

Información fRMI:

Hasta la fecha, más de 150 millones de estudios de resonancia magnética se han realizado en todo el mundo. La fRMI ha demostrado ser extremadamente segura mientras se toman precauciones de seguridad adecuadas. La fRMI utiliza campos magnéticos y ondas de radio para obtener imágenes del cerebro. En este estudio se utilizará un escáner de resonancia magnética 3.0
Tesla. No hay exposición a los rayos X o radiactividad durante una resonancia magnética. Todas las exploraciones que se realizan no representan más que un riesgo mínimo ya que los niveles de energía instantánea y acumulada están dentro de los límites de seguridad establecidos.
Se le pedirá que deje objetos metálicos y objetos personales en los casilleros proporcionados. También se le pedirá que se quite las prendas de vestir con insertos metálicos o broches antes de entrar en la sala de resonancia magnética. Se le solicitará información sobre prótesis, implantes, tatuajes, etc. Por favor, pregunte al experimentador si no está seguro acerca de cualquier artículo. Se le pedirá que se acueste en una cama que se desliza en el tubo largo del escáner. Se le dará auriculares y / o tapones para los oídos para la protección auditiva. El escáner de resonancia magnética hace ruidos fuertes durante el funcionamiento normal. Se le pedirá que permanezca muy quieto en esos momentos. En las exploraciones de la cabeza, podemos poner cojines alrededor de la cabeza. Usted será capaz de hablar con el técnico de fMRI por un intercomunicador, y él / ella será capaz de ver y escuchar en todo momento. También se le dará un dispositivo de señalización. Si en algún momento desea interrumpir el estudio, puede llamar los investigadores a través del intercomunicador o presionar el dispositivo de señalización y se le retirará inmediatamente del escáner.
Molestias y riesgos de la fRMI: El riesgo de lesiones es muy bajo durante una resonancia magnética. Sin embargo, la fRMI no es seguro para todos. Puede que no sea seguro, si tiene cualquier metal que contenga hierro en o sobre el cuerpo. Esto es porque el hierro puede representar un riesgo de seguridad cuando está en presencia de campos magnéticos fuertes. Las ondas de radio también pueden calentar el cuerpo y los objetos metálicos dentro o sobre el cuerpo, resultando posiblemente en quemaduras. Antes de entrar en la sala del escáner, se le harán una serie de preguntas para determinar si es seguro para que usted haga una resonancia magnética en este momento. Por ejemplo, puede no ser seguro hacer una resonancia magnética si tiene un marcapasos cardíaco, clips de aneurisma, un dispositivo intrauterino (DIU), etc. Para su seguridad, es muy importante que conteste todas las preguntas con la verdad. Es posible que usted pueda sentirse incómodo o confinado una vez dentro del escáner. Este sentimiento suele pasar en pocos minutos ya que los experimentadores hablar con usted y comienza el estudio. Puede experimentar mareos, náusea leve, o pequeños destellos de luz en su campo de visión. Estas sensaciones son principalmente debido al movimiento y se detendrá poco después de salir del imán.
No hay riesgos conocidos aparte de los descritos anteriormente. Sin embargo, siempre existe la posibilidad de que existan riesgos desconocidos asociados con este procedimiento. Debido a que la RM no se ha demostrado ser seguro durante el

embarazo, es importante que un feto en el útero no se exponga a riesgos innecesarios. Por lo tanto, con el fin de participar en este estudio, no debe estar embarazada en el momento de la exploración.
Hallazgos adicionales: Los investigadores de este proyecto no están capacitados para realizar el diagnóstico médico y los análisis que deben realizarse en el estudio no se han optimizado para encontrar anormalidades. Sin embargo el protocolo de ética incluye la revisión por parte de un neurólogo de todas las resonancias. En caso de que el neurólogo detecte algún hallazgo que sea de relevancia el investigador se comunicará con usted y le pondrá en contacto con el neurólogo para que le facilite información si así lo desea.
Por favor, proporcione la información de contacto para que se le pueda localizar en caso de un hallazgo incidental y/o resultados de relevancia de las pruebas.
Correo electrónico:...
Dirección postal:...
Teléfono:.................................
Es importante que sepa que su participación es voluntaria y en cualquier caso y en cualquier momento puedes abandonar el experimento sin que por ello se penalice. Si quiere abandonar el estudio, notifíqueselo al experimentador.
Aseguramos la total confidencialidad de los datos que nos suministra y que registraremos utilizando las tarea experimentales.
Si tiene alguna duda sobre las tareas experimentales o sobre el proyecto pregunte al experimentador o al investigador principal.

Acepto participar en el estudio que se lleva a cabo bajo la supervisión del CENTRO DE INVESTIGACIÓN MENTE CEREBRO Y COMPORTAMIENTO de la Universidad de Granada. He tomado esta decisión basándome en la información que he se me ha proporcionado por escrito y he tenido la oportunidad de recibir información adicional que he solicita. Manifiesto decir la verdad en mis respuestas para garantizar los datos reales que solicito. Entiendo que puedo retirar este consentimiento en cualquier momento sin recibir una penalización por ello.

Nombre: Nombre del Testigo:

DNI, firma, y fecha DNI y firma del testigo y fecha

Si quieres acceder a los resultados de la investigación deja tu correo electrónico y te enviaremos los artículos científicos que se publicaran gracias a este estudio.

Correo electrónico...

Firma del responsable del proyecto

Annex IV: Responsability Report

D./Da.. como Investigador Principal responsable del Experimento.. a realizar en la Unidad de RMF entre las fechas .... y ....

DECLARO
Que la utilización de la RM para este experimento tiene una finalidad exclusivamente investigadora y en ningún caso asistencial.

Que se compromete a enviar la información proporcionada por el neurólogo que revisa la RM para la unidad en caso que este detecte una anomalía en la RM de participante.

Que se compromete a seguir todos los protocolos de seguridad y ética correspondientes al uso de la RM.

Que el proyecto del que forma parte el experimento ha sido aprobado por un comité de ética de investigación humana con número de referencia................

Que acepta las normas de funcionamiento de la Unidad de Resonancia Magnética Funcional del CIC de las que ha sido informado.

En Granada a.......de....................de 20......

Fdo. ....

Annex V: Experimental Design and Jittering

Stop Signal Task Version 1

Block 1:

Block	Trial	Number of Trial	Type of Trial	Stimulus	Correct R	Incorrect R	ISI	Ladder	Sound
1	GoTrial	1	Go	square.jpg	a	cbd	500	0	
1	GoTrial	2	Go	square.jpg	a	cbd	2500	0	
1	StopTrial	3	Stop	square.jpg		abcd	2500	1	StopSignal.wav
1	GoTrial	4	Go	circle.jpg	d	abc	500	0	
1	StopTrial	5	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	StopTrial	6	Stop	square.jpg		abcd	2500	1	StopSignal.wav
1	GoTrial	7	Go	square.jpg	a	cbd	2500	0	
1	GoTrial	8	Go	square.jpg	a	cbd	500	0	
1	GoTrial	9	Go	circle.jpg	d	abc	500	0	
1	StopTrial	10	Stop	circle.jpg		abcd	2500	2	StopSignal.wav
1	GoTrial	11	Go	square.jpg	a	cbd	500	0	
1	GoTrial	12	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	13	Go	square.jpg	a	cbd	500	0	
1	GoTrial	14	Go	circle.jpg	d	abc	4500	0	
1	GoTrial	15	Go	circle.jpg	d	abc	2500	0	
1	StopTrial	16	Stop	square.jpg		abcd	4500	2	StopSignal.wav
1	StopTrial	17	Stop	square.jpg		abcd	2500	2	StopSignal.wav
1	GoTrial	18	Go	circle.jpg	d	abc	500	0	
1	StopTrial	19	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	20	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	21	Go	square.jpg	a	cbd	500	0	
1	GoTrial	22	Go	square.jpg	a	cbd	500	0	
1	GoTrial	23	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	24	Go	circle.jpg	d	abc	500	0	
1	StopTrial	25	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	26	Go	circle.jpg	d	abc	500	0	
1	GoTrial	27	Go	square.jpg	a	cbd	500	0	
1	StopTrial	28	Stop	square.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	29	Go	circle.jpg	d	abc	500	0	
1	GoTrial	30	Go	square.jpg	a	cbd	6500	0	
1	StopTrial	31	Stop	square.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	32	Go	square.jpg	a	cbd	500	0	
1	StopTrial	33	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	StopTrial	34	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	StopTrial	35	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	36	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	37	Go	square.jpg	a	cbd	500	0	
1	GoTrial	38	Go	circle.jpg	d	abc	500	0	
1	GoTrial	39	Go	square.jpg	a	cbd	500	0	
1	StopTrial	40	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	41	Go	square.jpg	a	cbd	2500	0	
1	GoTrial	42	Go	circle.jpg	d	abc	500	0	
1	GoTrial	43	Go	circle.jpg	d	abc	500	0	
1	GoTrial	44	Go	square.jpg	a	cbd	4500	0	
1	GoTrial	45	Go	square.jpg	a	cbd	500	0	
1	GoTrial	46	Go	circle.jpg	d	abc	500	0	
1	StopTrial	47	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
1	StopTrial	48	Stop	square.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	49	Go	circle.jpg	d	abc	500	0	
1	GoTrial	50	Go	square.jpg	a	cbd	500	0	
1	GoTrial	51	Go	circle.jpg	d	abc	500	0	
1	GoTrial	52	Go	circle.jpg	d	abc	500	0	
1	GoTrial	53	Go	square.jpg	a	cbd	2500	0	
1	GoTrial	54	Go	square.jpg	a	cbd	500	0	
1	GoTrial	55	Go	square.jpg	a	cbd	500	0	
1	GoTrial	56	Go	square.jpg	a	cbd	2500	0	
1	GoTrial	57	Go	circle.jpg	d	abc	500	0	
1	GoTrial	58	Go	square.jpg	a	cbd	500	0	
1	GoTrial	59	Go	square.jpg	a	cbd	500	0	
1	GoTrial	60	Go	circle.jpg	d	abc	6500	0	
1	GoTrial	61	Go	square.jpg	a	cbd	500	0	
1	GoTrial	62	Go	square.jpg	a	cbd	500	0	
1	GoTrial	63	Go	circle.jpg	d	abc	4500	0	
1	GoTrial	64	Go	square.jpg	a	cbd	500	0	
1	StopTrial	65	Stop	square.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	66	Go	circle.jpg	d	abc	500	0	
1	StopTrial	67	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	68	Go	circle.jpg	d	abc	500	0	
1	StopTrial	69	Stop	square.jpg		abcd	4500	2	StopSignal.wav
1	GoTrial	70	Go	square.jpg	a	cbd	2500	0	
1	GoTrial	71	Go	circle.jpg	d	abc	500	0	
1	GoTrial	72	Go	square.jpg	a	cbd	500	0	
1	GoTrial	73	Go	square.jpg	a	cbd	500	0	
1	GoTrial	74	Go	circle.jpg	d	abc	500	0	
1	StopTrial	75	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	76	Go	circle.jpg	d	abc	500	0	
1	GoTrial	77	Go	square.jpg	a	cbd	500	0	
1	StopTrial	78	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
1	GoTrial	79	Go	circle.jpg	d	abc	500	0	
1	GoTrial	80	Go	circle.jpg	d	abc	500	0	
1	GoTrial	81	Go	square.jpg	a	cbd	500	0	
1	GoTrial	82	Go	circle.jpg	d	abc	500	0	
1	GoTrial	83	Go	circle.jpg	d	abc	4500	0	
1	GoTrial	84	Go	square.jpg	a	cbd	6500	0	
1	StopTrial	85	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	StopTrial	86	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	87	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	88	Go	square.jpg	a	cbd	500	0	
1	GoTrial	89	Go	circle.jpg	d	abc	2500	0	

1	GoTrial	90	Go	circle.jpg	d	abc	500	0	
1	GoTrial	91	Go	circle.jpg	d	abc	6500	0	
1	GoTrial	92	Go	circle.jpg	d	abc	500	0	
1	GoTrial	93	Go	square.jpg	a	cbd	2500	0	
1	StopTrial	94	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	StopTrial	95	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	96	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	97	Go	square.jpg	a	cbd	2500	0	
1	GoTrial	98	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	99	Go	square.jpg	a	cbd	500	0	
1	GoTrial	100	Go	square.jpg	a	cbd	2500	0	
1	StopTrial	101	Stop	square.jpg		abcd	2500	1	StopSignal.wav
1	GoTrial	102	Go	square.jpg	a	cbd	2500	0	
1	GoTrial	103	Go	circle.jpg	d	abc	500	0	
1	StopTrial	104	Stop	square.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	105	Go	square.jpg	a	cbd	500	0	
1	StopTrial	106	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	107	Go	square.jpg	a	cbd	500	0	
1	GoTrial	108	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	109	Go	circle.jpg	d	abc	500	0	
1	GoTrial	110	Go	square.jpg	a	cbd	500	0	
1	GoTrial	111	Go	square.jpg	a	cbd	500	0	
1	StopTrial	112	Stop	square.jpg		abcd	500	2	StopSignal.wav
1	StopTrial	113	Stop	square.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	114	Go	circle.jpg	d	abc	500	0	
1	GoTrial	115	Go	circle.jpg	d	abc	500	0	
1	GoTrial	116	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	117	Go	square.jpg	a	cbd	500	0	
1	GoTrial	118	Go	square.jpg	a	cbd	500	0	
1	GoTrial	119	Go	square.jpg	a	cbd	4500	0	
1	StopTrial	120	Stop	square.jpg		abcd	4500	2	StopSignal.wav
1	GoTrial	121	Go	square.jpg	a	cbd	2500	0	
1	GoTrial	122	Go	square.jpg	a	cbd	2500	0	
1	GoTrial	123	Go	circle.jpg	d	abc	500	0	
1	GoTrial	124	Go	square.jpg	a	cbd	2500	0	
1	GoTrial	125	Go	circle.jpg	d	abc	500	0	
1	GoTrial	126	Go	square.jpg	a	cbd	2500	0	
1	StopTrial	127	Stop	square.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	128	Go	circle.jpg	d	abc	8500	0	

Block 2:

Block	Trial	Number of Trial	Type of Trial	Stimulus	Correct R	Incorrect R	ISI	Ladder	Sound
2	GoTrial	129	Go	circle.jpg	d	abc	500	0	
2	GoTrial	130	Go	square.jpg	a	cbd	2500	0	
2	GoTrial	131	Go	square.jpg	a	cbd	500	0	
2	GoTrial	132	Go	square.jpg	a	cbd	2500	0	
2	GoTrial	133	Go	circle.jpg	d	abc	500	0	
2	GoTrial	134	Go	circle.jpg	d	abc	500	0	
2	GoTrial	135	Go	square.jpg	a	cbd	500	0	
2	GoTrial	136	Go	square.jpg	a	cbd	500	0	
2	GoTrial	137	Go	circle.jpg	d	abc	6500	0	
2	StopTrial	138	Stop	circle.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	139	Go	circle.jpg	d	abc	2500	0	
2	GoTrial	140	Go	square.jpg	a	cbd	500	0	
2	GoTrial	141	Go	circle.jpg	d	abc	500	0	
2	StopTrial	142	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	143	Go	square.jpg	a	cbd	500	0	
2	GoTrial	144	Go	circle.jpg	d	abc	500	0	
2	StopTrial	145	Stop	circle.jpg		abcd	500	1	StopSignal.wav
2	StopTrial	146	Stop	square.jpg		abdc	4500	1	StopSignal.wav
2	GoTrial	147	Go	circle.jpg	d	abc	500	0	
2	GoTrial	148	Go	square.jpg	a	cbd	500	0	
2	GoTrial	149	Go	circle.jpg	d	abc	2500	0	
2	StopTrial	150	Stop	square.jpg		abcd	2500	1	StopSignal.wav
2	GoTrial	151	Go	square.jpg	a	cbd	500	0	
2	StopTrial	152	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	153	Go	square.jpg	a	cbd	500	0	
2	GoTrial	154	Go	square.jpg	a	cbd	500	0	
2	GoTrial	155	Go	square.jpg	a	cbd	2500	0	
2	GoTrial	156	Go	square.jpg	a	cbd	500	0	
2	GoTrial	157	Go	circle.jpg	d	abc	500	0	
2	StopTrial	158	Stop	circle.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	159	Go	circle.jpg	d	abc	500	0	
2	StopTrial	160	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	161	Go	circle.jpg	d	abc	500	0	
2	GoTrial	162	Go	circle.jpg	d	abc	4500	0	
2	GoTrial	163	Go	square.jpg	a	cbd	500	0	
2	GoTrial	164	Go	square.jpg	a	cbd	500	0	
2	GoTrial	165	Go	square.jpg	a	cbd	500	0	
2	GoTrial	166	Go	square.jpg	a	cbd	500	0	
2	StopTrial	167	Stop	circle.jpg		abcd	4500	1	StopSignal.wav
2	GoTrial	168	Go	square.jpg	a	cbd	2500	0	
2	GoTrial	169	Go	square.jpg	a	cbd	500	0	
2	GoTrial	170	Go	circle.jpg	d	abc	500	0	
2	GoTrial	171	Go	circle.jpg	d	abc	500	0	
2	StopTrial	172	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	173	Go	square.jpg	a	cbd	500	0	
2	GoTrial	174	Go	circle.jpg	d	abc	500	0	
2	GoTrial	175	Go	square.jpg	a	cbd	500	0	
2	GoTrial	176	Go	circle.jpg	d	abc	500	0	
2	GoTrial	177	Go	circle.jpg	d	abc	2500	0	
2	GoTrial	178	Go	circle.jpg	d	abc	500	0	
2	StopTrial	179	Stop	circle.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	180	Go	square.jpg	a	cbd	500	0	
2	GoTrial	181	Go	circle.jpg	d	abc	500	0	
2	GoTrial	182	Go	square.jpg	a	cbd	4500	0	
2	StopTrial	183	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	184	Go	circle.jpg	d	abc	4500	0	
2	GoTrial	185	Go	circle.jpg	d	abc	500	0	

2	GoTrial	186	Go	circle.jpg	d	abc	500	0	
2	GoTrial	187	Go	square.jpg	a	cbd	2500	0	
2	GoTrial	188	Go	square.jpg	a	cbd	500	0	
2	GoTrial	189	Go	square.jpg	a	cbd	500	0	
2	GoTrial	190	Go	square.jpg	a	cbd	500	0	
2	GoTrial	191	Go	square.jpg	a	cbd	500	0	
2	GoTrial	192	Go	circle.jpg	d	abc	500	0	
2	GoTrial	193	Go	circle.jpg	d	abc	500	0	
2	GoTrial	194	Go	square.jpg	a	cbd	2500	0	
2	GoTrial	195	Go	circle.jpg	d	abc	500	0	
2	GoTrial	196	Go	circle.jpg	d	abc	500	0	
2	StopTrial	197	Stop	square.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	198	Go	square.jpg	a	cbd	2500	0	
2	GoTrial	199	Go	square.jpg	a	cbd	4500	0	
2	GoTrial	200	Go	square.jpg	a	cbd	500	0	
2	GoTrial	201	Go	square.jpg	a	cbd	500	0	
2	GoTrial	202	Go	square.jpg	a	cbd	2500	0	
2	StopTrial	203	Stop	square.jpg		abcd	4500	2	StopSignal.wav
2	GoTrial	204	Go	circle.jpg	d	abc	500	0	
2	StopTrial	205	Stop	square.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	206	Go	circle.jpg	d	abc	500	0	
2	GoTrial	207	Go	circle.jpg	d	abc	500	0	
2	GoTrial	208	Go	circle.jpg	d	abc	2500	0	
2	StopTrial	209	Stop	square.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	210	Go	circle.jpg	d	abc	500	0	
2	GoTrial	211	Go	circle.jpg	d	abc	6500	0	
2	GoTrial	212	Go	circle.jpg	d	abc	500	0	
2	StopTrial	213	Stop	circle.jpg		abcd	500	1	StopSignal.wav
2	StopTrial	214	Stop	circle.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	215	Go	square.jpg	a	cbd	2500	0	
2	StopTrial	216	Stop	circle.jpg		abcd	500	1	StopSignal.wav
2	StopTrial	217	Stop	circle.jpg		abcd	500	1	StopSignal.wav
2	StopTrial	218	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	219	Go	square.jpg	a	cbd	500	0	
2	StopTrial	220	Stop	circle.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	221	Go	circle.jpg	d	abc	500	0	
2	GoTrial	222	Go	square.jpg	a	cbd	2500	0	
2	StopTrial	223	Stop	circle.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	224	Go	circle.jpg	d	abc	500	0	
2	StopTrial	225	Stop	circle.jpg		abcd	4500	2	StopSignal.wav
2	GoTrial	226	Go	square.jpg	a	cbd	500	0	
2	GoTrial	227	Go	square.jpg	a	cbd	2500	0	
2	GoTrial	228	Go	circle.jpg	d	abc	500	0	
2	GoTrial	229	Go	circle.jpg	d	abc	500	0	
2	StopTrial	230	Stop	square.jpg		abcd	4500	2	StopSignal.wav
2	GoTrial	231	Go	circle.jpg	d	abc	2500	0	
2	GoTrial	232	Go	square.jpg	a	cbd	500	0	
2	StopTrial	233	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
2	StopTrial	234	Stop	circle.jpg		abcd	6500	2	StopSignal.wav
2	StopTrial	235	Stop	circle.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	236	Go	circle.jpg	d	abc	4500	0	
2	GoTrial	237	Go	square.jpg	a	cbd	500	0	
2	GoTrial	238	Go	square.jpg	a	cbd	500	0	
2	GoTrial	239	Go	square.jpg	a	cbd	2500	0	
2	GoTrial	240	Go	square.jpg	a	cbd	4500	0	
2	GoTrial	241	Go	square.jpg	a	cbd	500	0	
2	GoTrial	242	Go	square.jpg	a	cbd	4500	0	
2	GoTrial	243	Go	circle.jpg	d	abc	500	0	
2	GoTrial	244	Go	square.jpg	a	cbd	500	0	
2	GoTrial	245	Go	circle.jpg	d	abc	500	0	
2	StopTrial	246	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	247	Go	circle.jpg	d	abc	500	0	
2	GoTrial	248	Go	circle.jpg	d	abc	2500	0	
2	StopTrial	249	Stop	circle.jpg		abcd	500	2	StopSignal.wav
2	StopTrial	250	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	251	Go	circle.jpg	d	abc	500	0	
2	GoTrial	252	Go	square.jpg	a	cbd	500	0	
2	StopTrial	253	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
2	GoTrial	254	Go	circle.jpg	d	abc	6500	0	
2	GoTrial	255	Go	square.jpg	a	cbd	4500	0	
2	GoTrial	256	Go	circle.jpg	d	abc	10500	0	

Block 3:

Block	Trial	Number of Trial	Type of Trial	Stimulus	Correct R	Incorrect R	ISI	Ladder	Sound
3	GoTrial	257	Go	circle.jpg	d	abc	4500	0	
3	GoTrial	258	Go	circle.jpg	d	abc	500	0	
3	StopTrial	259	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	260	Go	square.jpg	a	bcd	500	0	
3	GoTrial	261	Go	square.jpg	a	bcd	500	0	
3	GoTrial	262	Go	circle.jpg	d	abc	2500	0	
3	StopTrial	263	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	StopTrial	264	Stop	circle.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	265	Go	square.jpg	a	bcd	500	0	
3	GoTrial	266	Go	circle.jpg	d	abc	500	0	
3	GoTrial	267	Go	square.jpg	a	bcd	500	0	
3	GoTrial	268	Go	square.jpg	a	bcd	500	0	
3	GoTrial	269	Go	circle.jpg	d	abc	500	0	
3	GoTrial	270	Go	circle.jpg	d	abc	500	0	
3	GoTrial	271	Go	square.jpg	a	bcd	2500	0	
3	StopTrial	272	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	273	Go	square.jpg	a	bcd	4500	0	
3	StopTrial	274	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	275	Go	circle.jpg	d	abc	500	0	
3	StopTrial	276	Stop	circle.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	277	Go	square.jpg	a	bcd	500	0	
3	GoTrial	278	Go	square.jpg	a	bcd	500	0	
3	GoTrial	279	Go	square.jpg	a	bcd	500	0	
3	GoTrial	280	Go	square.jpg	a	bcd	500	0	
3	GoTrial	281	Go	circle.jpg	d	abc	2500	0	

3	GoTrial	282	Go	circle.jpg	d	abc	4500	0	
3	GoTrial	283	Go	square.jpg	a	bcd	500	0	
3	GoTrial	284	Go	square.jpg	a	bcd	500	0	
3	GoTrial	285	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	286	Go	square.jpg	a	bcd	4500	0	
3	GoTrial	287	Go	circle.jpg	d	abc	500	0	
3	GoTrial	288	Go	circle.jpg	d	abc	500	0	
3	StopTrial	289	Stop	circle.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	290	Go	square.jpg	a	bcd	500	0	
3	GoTrial	291	Go	circle.jpg	d	abc	500	0	
3	GoTrial	292	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	293	Go	circle.jpg	d	abc	4500	0	
3	StopTrial	294	Stop	circle.jpg		abcd	4500	2	StopSignal.wav
3	GoTrial	295	Go	square.jpg	a	bcd	500	0	
3	GoTrial	296	Go	circle.jpg	d	abc	500	0	
3	GoTrial	297	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	298	Go	square.jpg	a	bcd	500	0	
3	GoTrial	299	Go	circle.jpg	d	abc	500	0	
3	GoTrial	300	Go	square.jpg	a	bcd	2500	0	
3	StopTrial	301	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	302	Go	circle.jpg	d	abc	4500	0	
3	GoTrial	303	Go	square.jpg	a	bcd	500	0	
3	StopTrial	304	Stop	circle.jpg		abcd	500	2	StopSignal.wav
3	StopTrial	305	Stop	circle.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	306	Go	circle.jpg	d	abc	500	0	
3	GoTrial	307	Go	square.jpg	a	bcd	500	0	
3	GoTrial	308	Go	square.jpg	a	bcd	500	0	
3	GoTrial	309	Go	square.jpg	a	bcd	500	0	
3	GoTrial	310	Go	circle.jpg	d	abc	500	0	
3	GoTrial	311	Go	circle.jpg	d	abc	500	0	
3	GoTrial	312	Go	square.jpg	a	bcd	500	0	
3	GoTrial	313	Go	circle.jpg	d	abc	500	0	
3	GoTrial	314	Go	square.jpg	a	bcd	500	0	
3	StopTrial	315	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	316	Go	circle.jpg	d	abc	500	0	
3	StopTrial	317	Stop	square.jpg		abcd	4500	2	StopSignal.wav
3	GoTrial	318	Go	circle.jpg	d	abc	500	0	
3	StopTrial	319	Stop	circle.jpg		abcd	500	2	StopSignal.wav
3	StopTrial	320	Stop	circle.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	321	Go	circle.jpg	d	abc	500	0	
3	GoTrial	322	Go	square.jpg	a	bcd	500	0	
3	GoTrial	323	Go	circle.jpg	d	abc	500	0	
3	GoTrial	324	Go	circle.jpg	d	abc	4500	0	
3	GoTrial	325	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	326	Go	circle.jpg	d	abc	500	0	
3	GoTrial	327	Go	square.jpg	a	bcd	500	0	
3	StopTrial	328	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	329	Go	square.jpg	a	bcd	500	0	
3	GoTrial	330	Go	circle.jpg	d	abc	500	0	
3	StopTrial	331	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
3	GoTrial	332	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	333	Go	square.jpg	a	bcd	500	0	
3	StopTrial	334	Stop	square.jpg		abcd	4500	2	StopSignal.wav
3	GoTrial	335	Go	circle.jpg	d	abc	500	0	
3	GoTrial	336	Go	circle.jpg	d	abc	500	0	
3	GoTrial	337	Go	circle.jpg	d	abc	500	0	
3	StopTrial	338	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	StopTrial	339	Stop	square.jpg		abcd	2500	1	StopSignal.wav
3	GoTrial	340	Go	circle.jpg	d	abc	4500	0	
3	GoTrial	341	Go	square.jpg	a	bcd	4500	0	
3	StopTrial	342	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	343	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	344	Go	square.jpg	a	bcd	500	0	
3	StopTrial	345	Stop	circle.jpg		abcd	4500	2	StopSignal.wav
3	StopTrial	346	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	347	Go	square.jpg	a	bcd	500	0	
3	StopTrial	348	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	StopTrial	349	Stop	circle.jpg		abcd	500	1	StopSignal.wav
3	StopTrial	350	Stop	circle.jpg		abcd	2500	2	StopSignal.wav
3	GoTrial	351	Go	circle.jpg	d	abc	500	0	
3	GoTrial	352	Go	square.jpg	a	bcd	4500	0	
3	GoTrial	353	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	354	Go	square.jpg	a	bcd	500	0	
3	GoTrial	355	Go	circle.jpg	d	abc	2500	0	
3	StopTrial	356	Stop	circle.jpg		abcd	2500	2	StopSignal.wav
3	GoTrial	357	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	358	Go	square.jpg	a	bcd	500	0	
3	GoTrial	359	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	360	Go	square.jpg	a	bcd	500	0	
3	GoTrial	361	Go	square.jpg	a	bcd	500	0	
3	GoTrial	362	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	363	Go	circle.jpg	d	abc	4500	0	
3	StopTrial	364	Stop	circle.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	365	Go	square.jpg	a	bcd	500	0	
3	StopTrial	366	Stop	square.jpg		abcd	2500	2	StopSignal.wav
3	GoTrial	367	Go	circle.jpg	d	abc	500	0	
3	GoTrial	368	Go	circle.jpg	d	abc	500	0	
3	GoTrial	369	Go	circle.jpg	d	abc	4500	0	
3	GoTrial	370	Go	square.jpg	a	bcd	500	0	
3	GoTrial	371	Go	circle.jpg	d	abc	500	0	
3	GoTrial	372	Go	circle.jpg	d	abc	6500	0	
3	GoTrial	373	Go	square.jpg	a	bcd	2500	0	
3	StopTrial	374	Stop	circle.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	375	Go	circle.jpg	d	abc	4500	0	
3	GoTrial	376	Go	circle.jpg	d	abc	500	0	
3	GoTrial	377	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	378	Go	square.jpg	a	bcd	500	0	
3	StopTrial	379	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	380	Go	circle.jpg	d	abc	500	0	
3	GoTrial	381	Go	circle.jpg	d	abc	500	0	
3	StopTrial	382	Stop	circle.jpg		abcd	500	1	StopSignal.wav

3	GoTrial	383	Go	square.jpg	a	bcd	4500	0
3	GoTrial	384	Go	square.jpg	a	bcd	6500	0

Stop Signal Task Version 2

Block 1:

Block	Trial	Number of Trial	Type of Trial	Stimulus	Correct R	Incorrect R	ISI	Ladder	Sound
1	GoTrial	1	Go	square.jpg	a	bcd	500	0	
1	GoTrial	2	Go	square.jpg	a	bcd	4500	0	
1	GoTrial	3	Go	square.jpg	a	bcd	500	0	
1	GoTrial	4	Go	circle.jpg	d	abc	500	0	
1	GoTrial	5	Go	square.jpg	a	bcd	500	0	
1	StopTrial	6	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	7	Go	circle.jpg	d	abc	500	0	
1	GoTrial	8	Go	circle.jpg	d	abc	500	0	
1	GoTrial	9	Go	circle.jpg	d	abc	500	0	
1	StopTrial	10	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
1	GoTrial	11	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	12	Go	square.jpg	a	bcd	500	0	
1	GoTrial	13	Go	circle.jpg	d	abc	500	0	
1	StopTrial	14	Stop	square.jpg		abcd	500	2	StopSignal.wav
1	StopTrial	15	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	16	Go	square.jpg	a	bcd	500	0	
1	GoTrial	17	Go	circle.jpg	d	abc	2500	0	
1	StopTrial	18	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	19	Go	circle.jpg	d	abc	500	0	
1	GoTrial	20	Go	circle.jpg	d	abc	500	0	
1	GoTrial	21	Go	circle.jpg	d	abc	2500	0	
1	StopTrial	22	Stop	circle.jpg		abcd	4500	2	StopSignal.wav
1	GoTrial	23	Go	circle.jpg	d	abc	500	0	
1	GoTrial	24	Go	circle.jpg	d	abc	500	0	
1	StopTrial	25	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	26	Go	square.jpg	a	bcd	8500	0	
1	GoTrial	27	Go	circle.jpg	d	abc	500	0	
1	StopTrial	28	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	29	Go	circle.jpg	d	abc	500	0	
1	StopTrial	30	Stop	square.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	31	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	32	Go	square.jpg	a	bcd	500	0	
1	GoTrial	33	Go	square.jpg	a	bcd	500	0	
1	GoTrial	34	Go	square.jpg	a	bcd	2500	0	
1	StopTrial	35	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	36	Go	circle.jpg	d	abc	500	0	
1	StopTrial	37	Stop	circle.jpg		abcd	8500	2	StopSignal.wav
1	GoTrial	38	Go	square.jpg	a	bcd	500	0	
1	GoTrial	39	Go	circle.jpg	d	abc	500	0	
1	StopTrial	40	Stop	square.jpg		abcd	2500	1	StopSignal.wav
1	GoTrial	41	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	42	Go	square.jpg	a	bcd	500	0	
1	GoTrial	43	Go	square.jpg	a	bcd	2500	0	
1	GoTrial	44	Go	square.jpg	a	bcd	500	0	
1	GoTrial	45	Go	square.jpg	a	bcd	2500	0	
1	GoTrial	46	Go	circle.jpg	d	abc	500	0	
1	GoTrial	47	Go	circle.jpg	d	abc	500	0	
1	GoTrial	48	Go	square.jpg	a	bcd	500	0	
1	GoTrial	49	Go	circle.jpg	d	abc	500	0	
1	GoTrial	50	Go	square.jpg	a	bcd	4500	0	
1	StopTrial	51	Stop	square.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	52	Go	circle.jpg	d	abc	500	0	
1	GoTrial	53	Go	square.jpg	a	bcd	2500	0	
1	StopTrial	54	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	55	Go	square.jpg	a	bcd	500	0	
1	StopTrial	56	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	StopTrial	57	Stop	square.jpg		abcd	2500	2	StopSignal.wav
1	GoTrial	58	Go	circle.jpg	d	abc	500	0	
1	GoTrial	59	Go	square.jpg	a	bcd	500	0	
1	GoTrial	60	Go	square.jpg	a	bcd	500	0	
1	GoTrial	61	Go	square.jpg	a	bcd	2500	0	
1	GoTrial	62	Go	circle.jpg	d	abc	500	0	
1	GoTrial	63	Go	square.jpg	a	bcd	500	0	
1	StopTrial	64	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	65	Go	circle.jpg	d	abc	500	0	
1	GoTrial	66	Go	circle.jpg	d	abc	500	0	
1	StopTrial	67	Stop	square.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	68	Go	square.jpg	a	bcd	4500	0	
1	StopTrial	69	Stop	square.jpg		abcd	500	2	StopSignal.wav
1	StopTrial	70	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	71	Go	square.jpg	a	bcd	2500	0	
1	GoTrial	72	Go	square.jpg	a	bcd	500	0	
1	StopTrial	73	Stop	circle.jpg		abcd	4500	2	StopSignal.wav
1	StopTrial	74	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	75	Go	square.jpg	a	bcd	500	0	
1	StopTrial	76	Stop	square.jpg		abcd	2500	2	StopSignal.wav
1	StopTrial	77	Stop	square.jpg		abcd	500	1	StopSignal.wav
1	StopTrial	78	Stop	circle.jpg		abcd	4500	2	StopSignal.wav
1	GoTrial	79	Go	square.jpg	a	bcd	500	0	
1	GoTrial	80	Go	square.jpg	a	bcd	500	0	
1	GoTrial	81	Go	square.jpg	a	bcd	2500	0	
1	GoTrial	82	Go	circle.jpg	d	abc	500	0	
1	GoTrial	83	Go	circle.jpg	d	abc	500	0	
1	GoTrial	84	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	85	Go	square.jpg	a	bcd	500	0	
1	GoTrial	86	Go	circle.jpg	d	abc	2500	0	
1	GoTrial	87	Go	circle.jpg	d	abc	500	0	
1	GoTrial	88	Go	square.jpg	a	bcd	500	0	
1	GoTrial	89	Go	circle.jpg	d	abc	2500	0	

1	GoTrial	90	Go	square.jpg	a	bcd	500	0	
1	GoTrial	91	Go	square.jpg	a	bcd	2500	0	
1	StopTrial	92	Stop	square.jpg		abcd	500	2	StopSignal.wav
1	StopTrial	93	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	94	Go	square.jpg	a	bcd	2500	0	
1	GoTrial	95	Go	square.jpg	a	bcd	2500	0	
1	GoTrial	96	Go	square.jpg	a	bcd	500	0	
1	GoTrial	97	Go	square.jpg	a	bcd	500	0	
1	GoTrial	98	Go	square.jpg	a	bcd	500	0	
1	GoTrial	99	Go	square.jpg	a	bcd	2500	0	
1	GoTrial	100	Go	square.jpg	a	bcd	500	0	
1	GoTrial	101	Go	circle.jpg	d	abc	500	0	
1	GoTrial	102	Go	circle.jpg	d	abc	500	0	
1	GoTrial	103	Go	square.jpg	a	bcd	500	0	
1	GoTrial	104	Go	circle.jpg	d	abc	500	0	
1	GoTrial	105	Go	circle.jpg	d	abc	8500	0	
1	StopTrial	106	Stop	square.jpg		abcd	500	1	StopSignal.wav
1	StopTrial	107	Stop	circle.jpg		abcd	2500	2	StopSignal.wav
1	GoTrial	108	Go	circle.jpg	d	abc	500	0	
1	GoTrial	109	Go	circle.jpg	d	abc	2500	0	
1	StopTrial	110	Stop	circle.jpg		abcd	500	2	StopSignal.wav
1	GoTrial	111	Go	square.jpg	a	bcd	500	0	
1	GoTrial	112	Go	circle.jpg	d	abc	500	0	
1	GoTrial	113	Go	square.jpg	a	bcd	4500	0	
1	GoTrial	114	Go	circle.jpg	d	abc	500	0	
1	StopTrial	115	Stop	square.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	116	Go	square.jpg	a	bcd	500	0	
1	GoTrial	117	Go	square.jpg	a	bcd	500	0	
1	GoTrial	118	Go	circle.jpg	d	abc	500	0	
1	StopTrial	119	Stop	circle.jpg		abcd	500	1	StopSignal.wav
1	GoTrial	120	Go	circle.jpg	d	abc	500	0	
1	GoTrial	121	Go	square.jpg	a	bcd	4500	0	
1	GoTrial	122	Go	square.jpg	a	bcd	500	0	
1	GoTrial	123	Go	circle.jpg	d	abc	500	0	
1	GoTrial	124	Go	circle.jpg	d	abc	500	0	
1	GoTrial	125	Go	square.jpg	a	bcd	500	0	
1	GoTrial	126	Go	square.jpg	a	bcd	2500	0	
1	GoTrial	127	Go	square.jpg	a	bcd	8500	0	
1	GoTrial	128	Go	square.jpg	a	bcd	12500	0	

Block 2:

Block	Trial	Number of Trial	Type of Trial	Stimulus	Correct R	Incorrect R	ISI	Ladder	Sound
2	GoTrial	129	Go	square.jpg	a	bcd	500	0	
2	GoTrial	130	Go	square.jpg	a	bcd	2500	0	
2	GoTrial	131	Go	circle.jpg	d	abc	500	0	
2	GoTrial	132	Go	square.jpg	a	bcd	500	0	
2	GoTrial	133	Go	circle.jpg	d	abc	6500	0	
2	GoTrial	134	Go	square.jpg	a	bcd	500	0	
2	GoTrial	135	Go	circle.jpg	d	abc	500	0	
2	GoTrial	136	Go	square.jpg	a	bcd	500	0	
2	GoTrial	137	Go	square.jpg	a	bcd	500	0	
2	GoTrial	138	Go	square.jpg	a	bcd	500	0	
2	GoTrial	139	Go	circle.jpg	d	abc	500	0	
2	GoTrial	140	Go	circle.jpg	d	abc	500	0	
2	GoTrial	141	Go	square.jpg	a	bcd	500	0	
2	StopTrial	142	Stop	square.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	143	Go	circle.jpg	d	abc	500	0	
2	StopTrial	144	Stop	circle.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	145	Go	square.jpg	a	bcd	500	0	
2	GoTrial	146	Go	circle.jpg	d	abc	500	0	
2	GoTrial	147	Go	circle.jpg	d	abc	2500	0	
2	GoTrial	148	Go	circle.jpg	d	abc	500	0	
2	GoTrial	149	Go	square.jpg	a	bcd	500	0	
2	GoTrial	150	Go	square.jpg	a	bcd	500	0	
2	StopTrial	151	Stop	circle.jpg		abcd	4500	2	StopSignal.wav
2	GoTrial	152	Go	square.jpg	a	bcd	2500	0	
2	GoTrial	153	Go	square.jpg	a	bcd	4500	0	
2	GoTrial	154	Go	square.jpg	a	bcd	500	0	
2	StopTrial	155	Stop	circle.jpg		abcd	500	2	StopSignal.wav
2	StopTrial	156	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	157	Go	square.jpg	a	bcd	500	0	
2	StopTrial	158	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	159	Go	square.jpg	a	bcd	500	0	
2	GoTrial	160	Go	square.jpg	a	bcd	2500	0	
2	GoTrial	161	Go	circle.jpg	d	abc	500	0	
2	GoTrial	162	Go	circle.jpg	d	abc	500	0	
2	StopTrial	163	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
2	GoTrial	164	Go	circle.jpg	d	abc	500	0	
2	GoTrial	165	Go	square.jpg	a	bcd	2500	0	
2	GoTrial	166	Go	circle.jpg	d	abc	500	0	
2	StopTrial	167	Stop	square.jpg		abcd	6500	2	StopSignal.wav
2	GoTrial	168	Go	circle.jpg	d	abc	500	0	
2	StopTrial	169	Stop	circle.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	170	Go	square.jpg	a	bcd	2500	0	
2	StopTrial	171	Stop	circle.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	172	Go	square.jpg	a	bcd	500	0	
2	GoTrial	173	Go	circle.jpg	d	abc	500	0	
2	GoTrial	174	Go	circle.jpg	d	abc	500	0	
2	GoTrial	175	Go	circle.jpg	d	abc	500	0	
2	GoTrial	176	Go	square.jpg	a	bcd	4500	0	
2	GoTrial	177	Go	circle.jpg	d	abc	500	0	
2	StopTrial	178	Stop	square.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	179	Go	square.jpg	a	bcd	500	0	
2	GoTrial	180	Go	square.jpg	a	bcd	500	0	
2	StopTrial	181	Stop	circle.jpg		abcd	500	2	StopSignal.wav
2	StopTrial	182	Stop	square.jpg		abcd	4500	2	StopSignal.wav
2	StopTrial	183	Stop	square.jpg		abcd	2500	2	StopSignal.wav
2	GoTrial	184	Go	square.jpg	a	bcd	500	0	
2	StopTrial	185	Stop	circle.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	186	Go	circle.jpg	d	abc	2500	0	

2	GoTrial	187	Go	square.jpg	a	bcd	500	0	
2	GoTrial	188	Go	square.jpg	a	bcd	2500	0	
2	StopTrial	189	Stop	square.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	190	Go	square.jpg	a	bcd	500	0	
2	GoTrial	191	Go	square.jpg	a	bcd	4500	0	
2	GoTrial	192	Go	circle.jpg	d	abc	500	0	
2	StopTrial	193	Stop	square.jpg		abcd	2500	2	StopSignal.wav
2	GoTrial	194	Go	square.jpg	a	bcd	500	0	
2	GoTrial	195	Go	square.jpg	a	bcd	500	0	
2	GoTrial	196	Go	square.jpg	a	bcd	500	0	
2	GoTrial	197	Go	square.jpg	a	bcd	500	0	
2	GoTrial	198	Go	square.jpg	a	bcd	4500	0	
2	GoTrial	199	Go	square.jpg	a	bcd	500	0	
2	GoTrial	200	Go	square.jpg	a	bcd	500	0	
2	GoTrial	201	Go	circle.jpg	d	abc	500	0	
2	GoTrial	202	Go	circle.jpg	d	abc	500	0	
2	GoTrial	203	Go	circle.jpg	d	abc	2500	0	
2	GoTrial	204	Go	circle.jpg	d	abc	500	0	
2	StopTrial	205	Stop	square.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	206	Go	square.jpg	a	bcd	500	0	
2	GoTrial	207	Go	square.jpg	a	bcd	500	0	
2	GoTrial	208	Go	square.jpg	a	bcd	2500	0	
2	GoTrial	209	Go	circle.jpg	d	abc	500	0	
2	GoTrial	210	Go	circle.jpg	d	abc	2500	0	
2	StopTrial	211	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
2	GoTrial	212	Go	circle.jpg	d	abc	500	0	
2	GoTrial	213	Go	circle.jpg	d	abc	2500	0	
2	GoTrial	214	Go	circle.jpg	d	abc	500	0	
2	GoTrial	215	Go	square.jpg	a	bcd	10500	0	
2	GoTrial	216	Go	circle.jpg	d	abc	2500	0	
2	StopTrial	217	Stop	circle.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	218	Go	circle.jpg	d	abc	2500	0	
2	GoTrial	219	Go	circle.jpg	d	abc	500	0	
2	GoTrial	220	Go	square.jpg	a	bcd	2500	0	
2	StopTrial	221	Stop	square.jpg		abcd	500	1	StopSignal.wav
2	StopTrial	222	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
2	StopTrial	223	Stop	circle.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	224	Go	circle.jpg	d	abc	500	0	
2	GoTrial	225	Go	circle.jpg	d	abc	500	0	
2	GoTrial	226	Go	circle.jpg	d	abc	500	0	
2	GoTrial	227	Go	circle.jpg	d	abc	500	0	
2	StopTrial	228	Stop	square.jpg		abcd	500	1	StopSignal.wav
2	StopTrial	229	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
2	GoTrial	230	Go	circle.jpg	d	abc	500	0	
2	GoTrial	231	Go	circle.jpg	d	abc	2500	0	
2	StopTrial	232	Stop	square.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	233	Go	circle.jpg	d	abc	500	0	
2	GoTrial	234	Go	circle.jpg	d	abc	500	0	
2	GoTrial	235	Go	square.jpg	a	bcd	500	0	
2	GoTrial	236	Go	circle.jpg	d	abc	500	0	
2	GoTrial	237	Go	circle.jpg	d	abc	6500	0	
2	GoTrial	238	Go	square.jpg	a	bcd	2500	0	
2	StopTrial	239	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	StopTrial	240	Stop	circle.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	241	Go	circle.jpg	d	abc	500	0	
2	StopTrial	242	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
2	GoTrial	243	Go	circle.jpg	d	abc	6500	0	
2	GoTrial	244	Go	circle.jpg	d	abc	2500	0	
2	StopTrial	245	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	246	Go	circle.jpg	d	abc	500	0	
2	GoTrial	247	Go	square.jpg	a	bcd	2500	0	
2	GoTrial	248	Go	circle.jpg	d	abc	2500	0	
2	GoTrial	249	Go	circle.jpg	d	abc	4500	0	
2	GoTrial	250	Go	square.jpg	a	bcd	500	0	
2	GoTrial	251	Go	square.jpg	a	bcd	500	0	
2	GoTrial	252	Go	circle.jpg	d	abc	4500	0	
2	StopTrial	253	Stop	square.jpg		abcd	500	1	StopSignal.wav
2	GoTrial	254	Go	square.jpg	a	bcd	500	0	
2	StopTrial	255	Stop	square.jpg		abcd	500	2	StopSignal.wav
2	GoTrial	256	Go	square.jpg	a	bcd	8500	0	

Block 3:

3	StopTrial	257	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	258	Go	circle.jpg	d	abc	500	0	
3	StopTrial	259	Stop	circle.jpg		abcd	2500	2	StopSignal.wav
3	GoTrial	260	Go	circle.jpg	d	abc	500	0	
3	GoTrial	261	Go	circle.jpg	d	abc	500	0	
3	GoTrial	262	Go	circle.jpg	d	abc	500	0	
3	GoTrial	263	Go	square.jpg	a	bcd	500	0	
3	GoTrial	264	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	265	Go	square.jpg	a	bcd	500	0	
3	GoTrial	266	Go	square.jpg	a	bcd	2500	0	
3	StopTrial	267	Stop	circle.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	268	Go	circle.jpg	d	abc	500	0	
3	GoTrial	269	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	270	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	271	Go	circle.jpg	d	abc	500	0	
3	GoTrial	272	Go	circle.jpg	d	abc	500	0	
3	GoTrial	273	Go	square.jpg	a	bcd	500	0	
3	GoTrial	274	Go	square.jpg	a	bcd	500	0	
3	GoTrial	275	Go	circle.jpg	d	abc	500	0	
3	GoTrial	276	Go	square.jpg	a	bcd	500	0	
3	GoTrial	277	Go	circle.jpg	d	abc	500	0	
3	GoTrial	278	Go	square.jpg	a	bcd	500	0	
3	GoTrial	279	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	280	Go	circle.jpg	d	abc	500	0	
3	GoTrial	281	Go	circle.jpg	d	abc	500	0	
3	StopTrial	282	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	283	Go	circle.jpg	d	abc	500	0	
3	GoTrial	284	Go	square.jpg	a	bcd	500	0	
3	GoTrial	285	Go	square.jpg	a	bcd	500	0	

3	StopTrial	286	Stop	circle.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	287	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	288	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	289	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	290	Go	circle.jpg	d	abc	500	0	
3	StopTrial	291	Stop	circle.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	292	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	293	Go	square.jpg	a	bcd	500	0	
3	StopTrial	294	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	StopTrial	295	Stop	circle.jpg		abcd	4500	2	StopSignal.wav
3	StopTrial	296	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	StopTrial	297	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	298	Go	square.jpg	a	bcd	500	0	
3	StopTrial	299	Stop	circle.jpg		abcd	6500	2	StopSignal.wav
3	GoTrial	300	Go	circle.jpg	d	abc	500	0	
3	GoTrial	301	Go	square.jpg	a	bcd	500	0	
3	GoTrial	302	Go	circle.jpg	d	abc	500	0	
3	StopTrial	303	Stop	circle.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	304	Go	circle.jpg	d	abc	2500	0	
3	StopTrial	305	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	StopTrial	306	Stop	circle.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	307	Go	circle.jpg	d	abc	500	0	
3	GoTrial	308	Go	square.jpg	a	bcd	2500	0	
3	StopTrial	309	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	StopTrial	310	Stop	circle.jpg		abcd	2500	2	StopSignal.wav
3	StopTrial	311	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	312	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	313	Go	square.jpg	a	bcd	500	0	
3	GoTrial	314	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	315	Go	square.jpg	a	bcd	500	0	
3	GoTrial	316	Go	square.jpg	a	bcd	500	0	
3	GoTrial	317	Go	square.jpg	a	bcd	500	0	
3	GoTrial	318	Go	square.jpg	a	bcd	500	0	
3	GoTrial	319	Go	circle.jpg	d	abc	500	0	
3	GoTrial	320	Go	circle.jpg	d	abc	500	0	
3	StopTrial	321	Stop	circle.jpg		abcd	4500	2	StopSignal.wav
3	GoTrial	322	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	323	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	324	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	325	Go	circle.jpg	d	abc	6500	0	
3	StopTrial	326	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	327	Go	circle.jpg	d	abc	500	0	
3	GoTrial	328	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	329	Go	square.jpg	a	bcd	500	0	
3	GoTrial	330	Go	square.jpg	a	bcd	6500	0	
3	GoTrial	331	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	332	Go	square.jpg	a	bcd	500	0	
3	GoTrial	333	Go	square.jpg	a	bcd	500	0	
3	GoTrial	334	Go	circle.jpg	d	abc	500	0	
3	GoTrial	335	Go	square.jpg	a	bcd	500	0	
3	GoTrial	336	Go	circle.jpg	d	abc	500	0	
3	StopTrial	337	Stop	circle.jpg		abcd	2500	2	StopSignal.wav
3	GoTrial	338	Go	square.jpg	a	bcd	500	0	
3	GoTrial	339	Go	square.jpg	a	bcd	4500	0	
3	GoTrial	340	Go	circle.jpg	d	abc	500	0	
3	GoTrial	341	Go	square.jpg	a	bcd	500	0	
3	GoTrial	342	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	343	Go	square.jpg	a	bcd	4500	0	
3	GoTrial	344	Go	square.jpg	a	bcd	500	0	
3	StopTrial	345	Stop	square.jpg		abcd	2500	1	StopSignal.wav
3	StopTrial	346	Stop	circle.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	347	Go	square.jpg	a	bcd	500	0	
3	GoTrial	348	Go	circle.jpg	d	abc	2500	0	
3	StopTrial	349	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	350	Go	circle.jpg	d	abc	500	0	
3	StopTrial	351	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	352	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	353	Go	circle.jpg	d	abc	6500	0	
3	GoTrial	354	Go	circle.jpg	d	abc	500	0	
3	StopTrial	355	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
3	GoTrial	356	Go	circle.jpg	d	abc	8500	0	
3	GoTrial	357	Go	square.jpg	a	bcd	500	0	
3	StopTrial	358	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	359	Go	circle.jpg	d	abc	4500	0	
3	GoTrial	360	Go	square.jpg	a	bcd	500	0	
3	GoTrial	361	Go	square.jpg	a	bcd	2500	0	
3	GoTrial	362	Go	circle.jpg	d	abc	2500	0	
3	StopTrial	363	Stop	square.jpg		abcd	500	2	StopSignal.wav
3	GoTrial	364	Go	circle.jpg	d	abc	500	0	
3	GoTrial	365	Go	square.jpg	a	bcd	500	0	
3	StopTrial	366	Stop	circle.jpg		abcd	500	2	StopSignal.wav
3	StopTrial	367	Stop	circle.jpg		abcd	500	1	StopSignal.wav
3	StopTrial	368	Stop	square.jpg		abcd	500	1	StopSignal.wav
3	GoTrial	369	Go	square.jpg	a	bcd	500	0	
3	GoTrial	370	Go	square.jpg	a	bcd	500	0	
3	GoTrial	371	Go	square.jpg	a	bcd	500	0	
3	GoTrial	372	Go	circle.jpg	d	abc	500	0	
3	StopTrial	373	Stop	circle.jpg		abcd	2500	1	StopSignal.wav
3	GoTrial	374	Go	square.jpg	a	bcd	500	0	
3	GoTrial	375	Go	square.jpg	a	bcd	500	0	
3	GoTrial	376	Go	circle.jpg	d	abc	500	0	
3	GoTrial	377	Go	circle.jpg	d	abc	2500	0	
3	StopTrial	378	Stop	square.jpg		abcd	2500	1	StopSignal.wav
3	GoTrial	379	Go	circle.jpg	d	abc	500	0	
3	GoTrial	380	Go	circle.jpg	d	abc	500	0	
3	GoTrial	381	Go	square.jpg	a	bcd	4500	0	
3	GoTrial	382	Go	square.jpg	a	bcd	500	0	
3	GoTrial	383	Go	circle.jpg	d	abc	2500	0	
3	GoTrial	384	Go	circle.jpg	d	abc	8500	0	

Annex VI: E-prime Script of the Stop Signal Task

```
'
'
'
'      C:\Users\Conchy\Desktop\Experimento_Verbruggen_3_runs_V1.ebs2
'      Generated on: 12/19/2015     19:02:09
'
'
'      This experiment has been generated with E-Prime version: 2.0.10.242
'
'      This file generated with E-Studio interface.
'      E-Prime Copyright © 1996-2012 Psychology Software Tools.
'      ALL RIGHTS RESERVED
'
'      Legal use of this experiment script requires a full E-Prime or Runtime License.
'
'
'      Author:
'             Usuario (UGR)
'
'
'
'

Option CStrings On
Dim ebContext As Context


'-----------------------------------------------------------------------------
' Class Declarations
'-----------------------------------------------------------------------------


'-----------------------------------------------------------------------------
' Instance Declarations
'-----------------------------------------------------------------------------
Dim Display As DisplayDevice
Dim Sound As SoundDevice
Dim Keyboard As KeyboardDevice
Dim Mouse As MouseDevice
' List Attribute Constants
Const attrib_weight = ebUCase_W & ebLCase_e & ebLCase_i & ebLCase_g & ebLCase_h & ebLCase_t
Const attrib_nested = ebUCase_N & ebLCase_e & ebLCase_s & ebLCase_t & ebLCase_e & ebLCase_d
Const attrib_procedure = ebUCase_P & ebLCase_r & ebLCase_o & ebLCase_c & ebLCase_e & ebLCase_d & ebLCase_u & ebLCase_r & ebLCase_e
Const attrib_practicemode = ebUCase_P & ebLCase_r & ebLCase_a & ebLCase_c & ebLCase_t & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_M &
ebLCase_o & ebLCase_d & ebLCase_e
Const attrib_trial_number = ebUCase_T & ebLCase_r & ebLCase_i & ebLCase_a & ebLCase_l & ebUnderscore & ebUCase_N & ebLCase_u & ebLCase_m &
ebLCase_b & ebLCase_e & ebLCase_r
Const attrib_gostop = ebUCase_G & ebLCase_o & ebUCase_S & ebLCase_t & ebLCase_o & ebLCase_p
Const attrib_figure = ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e
Const attrib_correctresponse = ebUCase_C & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e
Const attrib_incorrectresponse = ebUCase_I & ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t &
ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e
Const attrib_isi = ebUCase_I & ebUCase_S & ebUCase_I
Const attrib_ladder = ebUCase_L & ebLCase_a & ebLCase_d & ebLCase_d & ebLCase_e & ebLCase_r
Const attrib_sound = ebUCase_S & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d

Dim Blocklist As List

Dim SessionProc As Procedure

Dim GoTrial As Procedure

Dim Instructions1 As TextDisplay
Dim Instructions1EchoClients As EchoClientCollection

Dim Goodbye As TextDisplay
Dim GoodbyeEchoClients As EchoClientCollection

Dim FixationGo As TextDisplay
Dim FixationGoEchoClients As EchoClientCollection

Dim BlockProc As List

Dim Figure As ImageDisplay
Dim FigureEchoClients As EchoClientCollection

Dim GetReady As TextDisplay
Dim GetReadyEchoClients As EchoClientCollection

Dim SoundOut3 As SoundOut
Dim SoundOut3EchoClients As EchoClientCollection
Dim SoundOut3SoundBuffer As SoundBuffer
Dim StopTrial As Procedure
Dim StopTrial_nObject As Long
Dim StopTrial_bCanExit As Boolean
Dim StopTrial_theCollection As RteCollection
Dim StopTrial_theInputObject As RteRunnableInputObject

Dim PostSig1 As Slide
Dim PostSig1EchoClients As EchoClientCollection
Dim PostSig1_State As SlideState
Dim PostSig1_SlideImage As SlideImage

Dim FixationStop As TextDisplay
Dim FixationStopEchoClients As EchoClientCollection

Dim PreSig As ImageDisplay
Dim PreSigEchoClients As EchoClientCollection

Dim SSD As TextDisplay
Dim SSDEchoClients As EchoClientCollection

Dim Figure3 As ImageDisplay
Dim Figure3EchoClients As EchoClientCollection

Dim SoundOut4 As SoundOut
Dim SoundOut4EchoClients As EchoClientCollection
Dim SoundOut4SoundBuffer As SoundBuffer
Dim FixationStop1 As TextDisplay
Dim FixationStop1EchoClients As EchoClientCollection

Dim Practice As List

Dim BlockProc2 As List

Dim Pract As Procedure
Dim Pract_nObject As Long
Dim Pract_bCanExit As Boolean
```

```
Dim Pract_theCollection As RteCollection
Dim Pract_theInputObject As RteRunnableInputObject

Dim Run1 As Procedure
Dim Run1_nObject As Long
Dim Run1_bCanExit As Boolean
Dim Run1_theCollection As RteCollection
Dim Run1_theInputObject As RteRunnableInputObject

Dim Run2 As Procedure
Dim Run2_nObject As Long
Dim Run2_bCanExit As Boolean
Dim Run2_theCollection As RteCollection
Dim Run2_theInputObject As RteRunnableInputObject

Dim GoTrial8 As Procedure

Dim StopTrial8 As Procedure
Dim StopTrial8_nObject As Long
Dim StopTrial8_bCanExit As Boolean
Dim StopTrial8_theCollection As RteCollection
Dim StopTrial8_theInputObject As RteRunnableInputObject

Dim FixationGo1 As TextDisplay
Dim FixationGo1EchoClients As EchoClientCollection

Dim Figure1 As ImageDisplay
Dim Figure1EchoClients As EchoClientCollection

Dim FeedbackDisplay3 As FeedbackDisplay
Dim FeedbackDisplay3_State As SlideState
Dim FeedbackDisplay3_SlideText As SlideText
Dim FeedbackDisplay3_Child As RteRunnableInputObject
Dim FeedbackDisplay3_ChildIterator As Long
Dim FeedbackDisplay3_MaskIterator As Long
Dim FeedbackDisplay3_Mask As InputMask

Dim FixationStop2 As TextDisplay
Dim FixationStop2EchoClients As EchoClientCollection

Dim PreSig1 As ImageDisplay
Dim PreSig1EchoClients As EchoClientCollection

Dim SoundOut5 As SoundOut
Dim SoundOut5EchoClients As EchoClientCollection
Dim SoundOut5SoundBuffer As SoundBuffer
Dim PostSig2 As Slide
Dim PostSig2EchoClients As EchoClientCollection
Dim PostSig2_State As SlideState
Dim PostSig2_SlideImage As SlideImage

Dim FeedbackDisplay5 As FeedbackDisplay
Dim FeedbackDisplay5_State As SlideState
Dim FeedbackDisplay5_SlideText As SlideText
Dim FeedbackDisplay5_Child As RteRunnableInputObject
Dim FeedbackDisplay5_ChildIterator As Long
Dim FeedbackDisplay5_MaskIterator As Long
Dim FeedbackDisplay5_Mask As InputMask

Dim FixationStop3 As TextDisplay
Dim FixationStop3EchoClients As EchoClientCollection

Dim SoundOut6 As SoundOut
Dim SoundOut6EchoClients As EchoClientCollection
Dim SoundOut6SoundBuffer As SoundBuffer
Dim SSD1 As TextDisplay
Dim SSD1EchoClients As EchoClientCollection

Dim Figure4 As ImageDisplay
Dim Figure4EchoClients As EchoClientCollection

Dim FeedbackDisplay6 As FeedbackDisplay
Dim FeedbackDisplay6_State As SlideState
Dim FeedbackDisplay6_SlideText As SlideText
Dim FeedbackDisplay6_Child As RteRunnableInputObject
Dim FeedbackDisplay6_ChildIterator As Long
Dim FeedbackDisplay6_MaskIterator As Long
Dim FeedbackDisplay6_Mask As InputMask

Dim Bienvenida As Slide
Dim BienvenidaEchoClients As EchoClientCollection
Dim Bienvenida_State As SlideState
Dim Bienvenida_SlideText As SlideText
Dim Bienvenida_SlideImage As SlideImage

Dim GetReady1 As TextDisplay
Dim GetReady1EchoClients As EchoClientCollection

Dim Descanso As TextDisplay
Dim DescansoEchoClients As EchoClientCollection

Dim Run3 As Procedure
Dim Run3_nObject As Long
Dim Run3_bCanExit As Boolean
Dim Run3_theCollection As RteCollection
Dim Run3_theInputObject As RteRunnableInputObject

Dim BlockProc3 As List

Dim GetReady2 As TextDisplay
Dim GetReady2EchoClients As EchoClientCollection


'--------------------------------------------------------------------------
' Package Declare Script
'--------------------------------------------------------------------------



'--------------------------------------------------------------------------
' User Script - BEGIN
'--------------------------------------------------------------------------
'Declare Summation object
Dim StopAcc As Summation
Dim StopSignalTrial As Summation
Dim StopDelay As Summation


'Declare global variables
Dim intStopAcc As Integer
Dim intStopSignalTrial As Integer
Dim intStopDelay_A As Integer
```

```
Dim intStopDelay_B As Integer
Dim nDuration As Long



'--------------------------------------------------------------------------
' User Script - END
'--------------------------------------------------------------------------



'--------------------------------------------------------------------------
' Package Global Script
'--------------------------------------------------------------------------



'--------------------------------------------------------------------------
' Implementation
'--------------------------------------------------------------------------
Sub SessionProc_Run(c As Context)

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Start BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Start:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_StartResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_StartResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Start END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

		Bienvenida.ResetLoggingProperties

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Start BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Start:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_Timeline_StartResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_Timeline_StartResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Start END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''



	Bienvenida.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		BienvenidaEchoClients.RemoveAll
		Bienvenida.InputMasks.Add Keyboard.CreateInputMask(ebBraceOpen & ebUCase_A & ebUCase_N & ebUCase_Y & ebBraceClose, ebEmptyText, 
CLng(Bienvenida.Duration), CLng(ebDigit_1), ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, 
ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	If Mouse.GetState() = ebStateOpen Then
		BienvenidaEchoClients.RemoveAll
		Bienvenida.InputMasks.Add Mouse.CreateInputMask(ebBraceOpen & ebUCase_A & ebUCase_N & ebUCase_Y & ebBraceClose, ebEmptyText, 
CLng(Bienvenida.Duration), CLng(ebDigit_1), ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, 
ebEmptyText, "")


	End If

	Bienvenida.Run

	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameOnsetDelay, Bienvenida.OnsetDelay
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameOnsetTime, Bienvenida.OnsetTime
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameDurationError, Bienvenida.DurationError
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameRTTime, Bienvenida.RTTime
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameACC, Bienvenida.ACC
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameRT, Bienvenida.RT
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameRESP, Bienvenida.RESP
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameCRESP, Bienvenida.CRESP
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameOnsetToOnsetTime, Bienvenida.OnsetToOnsetTime




	Instructions1.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		Instructions1EchoClients.RemoveAll
		Instructions1.InputMasks.Add Keyboard.CreateInputMask(ebBraceOpen & ebUCase_A & ebUCase_N & ebUCase_Y & ebBraceClose, 
ebEmptyText, CLng(Instructions1.Duration), CLng(ebDigit_1), ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), 
ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")
```

```
	End If

	If Mouse.GetState() = ebStateOpen Then
		Instructions1EchoClients.RemoveAll
		Instructions1.InputMasks.Add Mouse.CreateInputMask(ebBraceOpen & ebUCase_A & ebUCase_N & ebUCase_Y & ebBraceClose, ebEmptyText, CLng(Instructions1.Duration), CLng(ebDigit_1), ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "")


	End If

	Instructions1.Run
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameOnsetDelay, Instructions1.OnsetDelay
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameOnsetTime, Instructions1.OnsetTime
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameDurationError, Instructions1.DurationError
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameRTTime, Instructions1.RTTime
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameACC, Instructions1.ACC
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameRT, Instructions1.RT
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameRESP, Instructions1.RESP
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameCRESP, Instructions1.CRESP
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameOnsetToOnsetTime, Instructions1.OnsetToOnsetTime

		Blocklist.Run c



	Goodbye.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		GoodbyeEchoClients.RemoveAll
		Goodbye.InputMasks.Add Keyboard.CreateInputMask(ebBraceOpen & ebUCase_A & ebUCase_N & ebUCase_Y & ebBraceClose, ebEmptyText, CLng(Goodbye.Duration), CLng(ebDigit_1), ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	If Mouse.GetState() = ebStateOpen Then
		GoodbyeEchoClients.RemoveAll
		Goodbye.InputMasks.Add Mouse.CreateInputMask(ebBraceOpen & ebUCase_A & ebUCase_N & ebUCase_Y & ebBraceClose, ebEmptyText, CLng(Goodbye.Duration), CLng(ebDigit_1), ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "")


	End If

	Goodbye.Run
	''''''''''''''''''''''''''''''''''''''''''''
	'End Of Procedure Clean-Up
	''''''''''''''''''''''''''''''''''''''''''''

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Finish BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Finish:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_Timeline_FinishResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_Timeline_FinishResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Finish END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

	Bienvenida.EndOfProcedure

	Instructions1.EndOfProcedure

	Goodbye.EndOfProcedure

	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameOnsetDelay, Bienvenida.OnsetDelay
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameOnsetTime, Bienvenida.OnsetTime
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameDurationError, Bienvenida.DurationError
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameRTTime, Bienvenida.RTTime
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameACC, Bienvenida.ACC
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameRT, Bienvenida.RT
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameRESP, Bienvenida.RESP
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameCRESP, Bienvenida.CRESP
	c.SetAttrib Bienvenida.Name & ebDot & ebLogNameOnsetToOnsetTime, Bienvenida.OnsetToOnsetTime

	c.SetAttrib Instructions1.Name & ebDot & ebLogNameOnsetDelay, Instructions1.OnsetDelay
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameOnsetTime, Instructions1.OnsetTime
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameDurationError, Instructions1.DurationError
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameRTTime, Instructions1.RTTime
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameACC, Instructions1.ACC
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameRT, Instructions1.RT
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameRESP, Instructions1.RESP
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameCRESP, Instructions1.CRESP
	c.SetAttrib Instructions1.Name & ebDot & ebLogNameOnsetToOnsetTime, Instructions1.OnsetToOnsetTime


	c.Log

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Finish BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Finish:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_FinishResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
```

```
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_FinishResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Finish END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

End Sub

Sub GoTrial_Run(c As Context)

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Start BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Start:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_StartResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_StartResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Start END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

		FixationGo.ResetLoggingProperties
		Figure.ResetLoggingProperties

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Start BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Start:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_Timeline_StartResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_Timeline_StartResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Start END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''


	FixationGo.Duration = CLng(c.GetAttrib(ebUCase_I & ebUCase_S & ebUCase_I))

	FixationGo.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		FixationGoEchoClients.RemoveAll
		FixationGo.InputMasks.Add Keyboard.CreateInputMask(ebLCase_s, ebLCase_s, CLng(ebDigit_5 & ebDigit_5 & ebDigit_0 & ebDigit_0), 
CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes 
ResponseMode:All ProcessBackspace:Yes")


	End If

	FixationGo.Run
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameOnsetDelay, FixationGo.OnsetDelay
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameOnsetTime, FixationGo.OnsetTime
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameDurationError, FixationGo.DurationError
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameRTTime, FixationGo.RTTime
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameACC, FixationGo.ACC
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameRT, FixationGo.RT
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameRESP, FixationGo.RESP
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameCRESP, FixationGo.CRESP
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationGo.OnsetToOnsetTime


	Figure.Filename = c.GetAttrib(ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e)
	Figure.Load

	On Error GoTo Feedback7

	Figure.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		FigureEchoClients.RemoveAll
		Figure.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I & ebLCase_n 
& ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & 
ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(ebDigit_1 & ebDigit_5 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), 
ebEndResponseActionJump, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All 
ProcessBackspace:Yes")


	End If

	If Keyboard.GetState() = ebStateOpen Then
		FigureEchoClients.RemoveAll
		Figure.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C & ebLCase_o 
& ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & 
```

```
ebLCase_s & ebLCase_e), CLng(ebDigit_1 & ebDigit_5 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), ebEndResponseActionTerminate,
CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")

	End If

	Figure.Run
	c.SetAttrib Figure.Name & ebDot & ebLogNameOnsetDelay, Figure.OnsetDelay
	c.SetAttrib Figure.Name & ebDot & ebLogNameOnsetTime, Figure.OnsetTime
	c.SetAttrib Figure.Name & ebDot & ebLogNameDurationError, Figure.DurationError
	c.SetAttrib Figure.Name & ebDot & ebLogNameRTTime, Figure.RTTime
	c.SetAttrib Figure.Name & ebDot & ebLogNameACC, Figure.ACC
	c.SetAttrib Figure.Name & ebDot & ebLogNameRT, Figure.RT
	c.SetAttrib Figure.Name & ebDot & ebLogNameRESP, Figure.RESP
	c.SetAttrib Figure.Name & ebDot & ebLogNameCRESP, Figure.CRESP
	c.SetAttrib Figure.Name & ebDot & ebLogNameOnsetToOnsetTime, Figure.OnsetToOnsetTime

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Feedback7 BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Feedback7:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Feedback7Resume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Feedback7Resume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Feedback7 END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

	''''''''''''''''''''''''''''''''''''''''''''
	'End Of Procedure Clean-Up
	''''''''''''''''''''''''''''''''''''''''''''

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Finish BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Finish:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_Timeline_FinishResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_Timeline_FinishResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Finish END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	' We are processing any pending input masks.
	' To prevent this code from being generated, set the Procedure object's
	'.ProcessPendingInputMasks property to None.
	'
	' Loop until a condition allows us to complete this Procedure
	Do
		'Any requests for termination?
		If GetTerminateMode() = ebTerminate Then
			SetTerminateMode ebTerminateNone
			SetNextTargetOnsetTime Clock.Read
			Exit Do
		ElseIf GetTerminateMode() = ebTerminateJump Then
			SetTerminateMode ebTerminateNone
			SetNextTargetOnsetTime Clock.Read
			Err.Raise ebInputAccepted
		End If

		'NOTE: The last object on the Procedure is not a
		'  RteRunnableInputObject, therefore there is no
		'  script generated here for Object.InputMasks.IsPending()

		'Ready for the next object?
		If Clock.Read >= (GetNextTargetOnsetTime() - 1) Then
			Exit Do
		End If

		'Conditional Exit?
		If GetConditionalExitState() <> 0 Then
			Exit Do
		End If

		If GetNextTargetOnsetTime() - Clock.Read > 4 Then Sleep 4
		DoEvents
	Loop
	'
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

	FixationGo.EndOfProcedure

	Figure.EndOfProcedure

	c.SetAttrib FixationGo.Name & ebDot & ebLogNameOnsetDelay, FixationGo.OnsetDelay
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameOnsetTime, FixationGo.OnsetTime
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameDurationError, FixationGo.DurationError
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameRTTime, FixationGo.RTTime
	c.SetAttrib FixationGo.Name & ebDot & ebLogNameACC, FixationGo.ACC
```

```
		c.SetAttrib FixationGo.Name & ebDot & ebLogNameRT, FixationGo.RT
		c.SetAttrib FixationGo.Name & ebDot & ebLogNameRESP, FixationGo.RESP
		c.SetAttrib FixationGo.Name & ebDot & ebLogNameCRESP, FixationGo.CRESP
		c.SetAttrib FixationGo.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationGo.OnsetToOnsetTime

		c.SetAttrib Figure.Name & ebDot & ebLogNameOnsetDelay, Figure.OnsetDelay
		c.SetAttrib Figure.Name & ebDot & ebLogNameOnsetTime, Figure.OnsetTime
		c.SetAttrib Figure.Name & ebDot & ebLogNameDurationError, Figure.DurationError
		c.SetAttrib Figure.Name & ebDot & ebLogNameRTTime, Figure.RTTime
		c.SetAttrib Figure.Name & ebDot & ebLogNameACC, Figure.ACC
		c.SetAttrib Figure.Name & ebDot & ebLogNameRT, Figure.RT
		c.SetAttrib Figure.Name & ebDot & ebLogNameRESP, Figure.RESP
		c.SetAttrib Figure.Name & ebDot & ebLogNameCRESP, Figure.CRESP
		c.SetAttrib Figure.Name & ebDot & ebLogNameOnsetToOnsetTime, Figure.OnsetToOnsetTime


		c.Log

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Finish BEGIN
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Finish:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume Procedure_FinishResume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
			' into account for any input masks that jump.
			'
			'Raise the error so the default error handler will show the message
			Err.Raise Err.Number, Err.Source, Err.Description
		End If

Procedure_FinishResume:

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Finish END
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

End Sub

Sub StopTrial_Run(c As Context)

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Start BEGIN
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Start:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume Procedure_StartResume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
			' into account for any input masks that jump.
			'
			'Raise the error so the default error handler will show the message
			Err.Raise Err.Number, Err.Source, Err.Description
		End If

Procedure_StartResume:

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Start END
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

			FixationStop.ResetLoggingProperties
			PreSig.ResetLoggingProperties
			SoundOut4.ResetLoggingProperties
			PostSig1.ResetLoggingProperties
			FixationStop1.ResetLoggingProperties
			SoundOut3.ResetLoggingProperties
			SSD.ResetLoggingProperties
			Figure3.ResetLoggingProperties

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Timeline_Start BEGIN
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Start:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume Procedure_Timeline_StartResume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
			' into account for any input masks that jump.
			'
			'Raise the error so the default error handler will show the message
			Err.Raise Err.Number, Err.Source, Err.Description
		End If

Procedure_Timeline_StartResume:

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Timeline_Start END
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''


		''''''''''''''''''''''''''''''''''''''''''''''
		' InLine - StopVbles BEGIN <StopVbles>
		''''''''''''''''''''''''''''''''''''''''''''''
		'Ladder 1 (set the stimuli's screens)

If c.GetAttrib ("Ladder") = 1 Then
c.SetAttrib "PreSignal", intStopDelay_A
c.SetAttrib "PostSignal1", 1400 - intStopDelay_A
'c.SetAttrib "FixStop1", intStopDelay_A + 450
c.SetAttrib "FixStop2", - intStopDelay_A - 100
```

```
c.SetAttrib "StopDelay", intStopDelay_A


'Ladder 2 (set the stimuli's screens)
Else If c.GetAttrib ("Ladder") = 2 Then

c.SetAttrib "PreSignal", intStopDelay_B
c.SetAttrib "PostSignal1", 1400 - intStopDelay_B
'c.SetAttrib "FixStop1", intStopDelay_B + 450
c.SetAttrib "FixStop2", - intStopDelay_B - 100
c.SetAttrib "StopDelay", intStopDelay_B


End If
End If


c.SetAttrib "StopAcc", intStopAcc


c.SetAttrib "StopSignalTrial", intStopSignalTrial


If c.GetAttrib ("GoStop") = "Stop" Then
        intStopSignalTrial = intStopSignalTrial + 1
End If

        ''''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - StopVbles END
        ''''''''''''''''''''''''''''''''''''''''''''''


        ''''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - WhereToGo BEGIN <WhereToGo>
        ''''''''''''''''''''''''''''''''''''''''''''''

'If (intStopDelay_A Or intStopDelay_B   >= 0 And _
        'intStopDelay_A Or intStopDelay_B  <= 1000) Then
                'GoTo StopTrial1
                'Else
                        'If intStopDelay < 0 Then
                                'GoTo StopTrial3
                        'End If
'End If

If c.GetAttrib ("StopDelay") >= 0 And _
        c.GetAttrib ("StopDelay") <= 1500 Then
                GoTo StopTrial1
        Else
                If c.GetAttrib ("StopDelay") < 0 Then
                        GoTo StopTrial3
                End If
End If

        ''''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - WhereToGo END
        ''''''''''''''''''''''''''''''''''''''''''''''


        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - StopTrial1 BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

StopTrial1:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume StopTrial1Resume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

StopTrial1Resume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - StopTrial1 END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''



        FixationStop.Duration = CLng(c.GetAttrib(ebUCase_I & ebUCase_S & ebUCase_I))

        FixationStop.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
                FixationStopEchoClients.RemoveAll
                FixationStop.InputMasks.Add Keyboard.CreateInputMask(ebLCase_s, ebLCase_s, CLng(ebDigit_5 & ebDigit_5 & ebDigit_0 & ebDigit_0), 
CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes 
ResponseMode:All ProcessBackspace:Yes")


        End If

        FixationStop.Run
        c.SetAttrib FixationStop.Name & ebDot & ebLogNameOnsetDelay, FixationStop.OnsetDelay
        c.SetAttrib FixationStop.Name & ebDot & ebLogNameOnsetTime, FixationStop.OnsetTime
        c.SetAttrib FixationStop.Name & ebDot & ebLogNameDurationError, FixationStop.DurationError
        c.SetAttrib FixationStop.Name & ebDot & ebLogNameRTTime, FixationStop.RTTime
        c.SetAttrib FixationStop.Name & ebDot & ebLogNameACC, FixationStop.ACC
        c.SetAttrib FixationStop.Name & ebDot & ebLogNameRT, FixationStop.RT
        c.SetAttrib FixationStop.Name & ebDot & ebLogNameRESP, FixationStop.RESP
        c.SetAttrib FixationStop.Name & ebDot & ebLogNameCRESP, FixationStop.CRESP
        c.SetAttrib FixationStop.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationStop.OnsetToOnsetTime


        PreSig.Filename = c.GetAttrib(ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e)
        PreSig.Load

        PreSig.Duration = CLng(c.GetAttrib(ebUCase_P & ebLCase_r & ebLCase_e & ebUCase_S & ebLCase_i & ebLCase_g & ebLCase_n & ebLCase_a & 
ebLCase_l))
        On Error GoTo Feedback2

        PreSig.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
```

```
		PreSigEchoClients.RemoveAll
		PreSig.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I & ebLCase_n
& ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p &
ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(PreSig.Duration), CLng(ebDigit_1), ebEndResponseActionJump, CLogical(ebUCase_Y &
ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:No")


	End If

	If Keyboard.GetState() = ebStateOpen Then
		PreSigEchoClients.RemoveAll
		PreSig.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C & ebLCase_o
& ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n &
ebLCase_s & ebLCase_e), CLng(PreSig.Duration), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s),
ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	PreSig.Run
	c.SetAttrib PreSig.Name & ebDot & ebLogNameOnsetDelay, PreSig.OnsetDelay
	c.SetAttrib PreSig.Name & ebDot & ebLogNameOnsetTime, PreSig.OnsetTime
	c.SetAttrib PreSig.Name & ebDot & ebLogNameDurationError, PreSig.DurationError
	c.SetAttrib PreSig.Name & ebDot & ebLogNameRTTime, PreSig.RTTime
	c.SetAttrib PreSig.Name & ebDot & ebLogNameACC, PreSig.ACC
	c.SetAttrib PreSig.Name & ebDot & ebLogNameRT, PreSig.RT
	c.SetAttrib PreSig.Name & ebDot & ebLogNameRESP, PreSig.RESP
	c.SetAttrib PreSig.Name & ebDot & ebLogNameCRESP, PreSig.CRESP
	c.SetAttrib PreSig.Name & ebDot & ebLogNameOnsetToOnsetTime, PreSig.OnsetToOnsetTime


	''''''''''''''''''''''''''''''''''''''''''''
	' InLine - InLine3 BEGIN <InLine3>
	''''''''''''''''''''''''''''''''''''''''''''
	If PreSig.RESP = "" And PreSig.RT = 0 Then
PreSig.ACC = 1
End If


	''''''''''''''''''''''''''''''''''''''''''''
	' InLine - InLine3 END
	''''''''''''''''''''''''''''''''''''''''''''


	Set SoundOut4SoundBuffer = SoundOut4.Buffers(1)
	SoundOut4SoundBuffer.Filename = c.GetAttrib(ebUCase_S & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d)
	SoundOut4SoundBuffer.Load

	On Error GoTo Feedback2

	SoundOut4.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		SoundOut4EchoClients.RemoveAll
		SoundOut4.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I &
ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p
& ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(ebDigit_1 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), ebEndResponseActionJump,
CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	If Keyboard.GetState() = ebStateOpen Then
		SoundOut4EchoClients.RemoveAll
		SoundOut4.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C &
ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n
& ebLCase_s & ebLCase_e), CLng(ebDigit_1 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e &
ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	SoundOut4.Run
	c.SetAttrib SoundOut4.Name & ebDot & ebLogNameOnsetDelay, SoundOut4.OnsetDelay
	c.SetAttrib SoundOut4.Name & ebDot & ebLogNameOnsetTime, SoundOut4.OnsetTime
	c.SetAttrib SoundOut4.Name & ebDot & ebLogNameDurationError, SoundOut4.DurationError
	c.SetAttrib SoundOut4.Name & ebDot & ebLogNameRTTime, SoundOut4.RTTime
	c.SetAttrib SoundOut4.Name & ebDot & ebLogNameACC, SoundOut4.ACC
	c.SetAttrib SoundOut4.Name & ebDot & ebLogNameRT, SoundOut4.RT
	c.SetAttrib SoundOut4.Name & ebDot & ebLogNameRESP, SoundOut4.RESP
	c.SetAttrib SoundOut4.Name & ebDot & ebLogNameCRESP, SoundOut4.CRESP

		Select Case PostSig1.ActiveState
		Case ebUCase_D & ebLCase_e & ebLCase_f & ebLCase_a & ebLCase_u & ebLCase_l & ebLCase_t

			'Image1
			Set PostSig1_SlideImage = CSlideImage(PostSig1.ActiveSlideState.Objects(ebUCase_I & ebLCase_m & ebLCase_a & ebLCase_g &
ebLCase_e & ebDigit_1))
			PostSig1_SlideImage.Filename = c.GetAttrib(ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e)
			PostSig1_SlideImage.Load
			Set PostSig1_SlideImage = Nothing

	End Select


	PostSig1.Duration = CLng(c.GetAttrib(ebUCase_P & ebLCase_o & ebLCase_s & ebLCase_t & ebUCase_S & ebLCase_i & ebLCase_g & ebLCase_n &
ebLCase_a & ebLCase_l & ebDigit_1))
	On Error GoTo Feedback2

	PostSig1.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		PostSig1EchoClients.RemoveAll
		PostSig1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I &
ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p
& ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(PostSig1.Duration), CLng(ebDigit_1), ebEndResponseActionJump, CLogical(ebUCase_Y &
ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	If Keyboard.GetState() = ebStateOpen Then
		PostSig1EchoClients.RemoveAll
		PostSig1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C &
ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n
& ebLCase_s & ebLCase_e), CLng(PostSig1.Duration), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s),
ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	PostSig1.Run
```

```
        c.SetAttrib PostSig1.Name & ebDot & ebLogNameOnsetDelay, PostSig1.OnsetDelay
        c.SetAttrib PostSig1.Name & ebDot & ebLogNameOnsetTime, PostSig1.OnsetTime
        c.SetAttrib PostSig1.Name & ebDot & ebLogNameDurationError, PostSig1.DurationError
        c.SetAttrib PostSig1.Name & ebDot & ebLogNameRTTime, PostSig1.RTTime
        c.SetAttrib PostSig1.Name & ebDot & ebLogNameACC, PostSig1.ACC
        c.SetAttrib PostSig1.Name & ebDot & ebLogNameRT, PostSig1.RT
        c.SetAttrib PostSig1.Name & ebDot & ebLogNameRESP, PostSig1.RESP
        c.SetAttrib PostSig1.Name & ebDot & ebLogNameCRESP, PostSig1.CRESP
        c.SetAttrib PostSig1.Name & ebDot & ebLogNameOnsetToOnsetTime, PostSig1.OnsetToOnsetTime


        '''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - InLine2 BEGIN <InLine2>
        '''''''''''''''''''''''''''''''''''''''''''''
        If PostSig1.RT = 0 And PostSig1.RESP = "" Then
PostSig1.ACC = 1
End If
        '''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - InLine2 END
        '''''''''''''''''''''''''''''''''''''''''''''


        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Feedback2 BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Feedback2:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Feedback2Resume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Feedback2Resume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Feedback2 END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''


        '''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - CalcStopDelay1 BEGIN <CalcStopDelay1>
        '''''''''''''''''''''''''''''''''''''''''''''
        'If PreSig.RESP = c.GetAttrib ("CorrectResponse") Then
        'intStopAcc = intStopAcc + 1
        'Else
        'intStopAcc = intStopAcc + 0
'End If

        'If c.GetAttrib ("Ladder") = 1 Then
                'If intStopDelay_A < 1000 Then
                        'intStopDelay_A = intStopDelay_A + 50
                        'Else
                                'intStopDelay_A = 1000
                'End If
        'End If

        'Else
        'If intStopDelay > (- 500) Then
                'intStopDelay = - 50 + intStopDelay
                'Else
                        'intStopDelay = - 500
        'End If
'End If

'SIMPLIFIED

If PreSig.ACC = 1 And PostSig1.ACC = 1 Then
        intStopAcc = intStopAcc + 1
        If c.GetAttrib ("Ladder") = 1 Then
        If intStopDelay_A < 1400 Then
                intStopDelay_A = intStopDelay_A + 50
                Else
                intStopDelay_A = 1400
        End If
        End If

        If c.GetAttrib ("Ladder") = 2 Then
        If intStopDelay_B < 1400 Then
                intStopDelay_B = intStopDelay_B + 50
                Else
                intStopDelay_B = 1400
        End If
        End If
Else
        If c.GetAttrib ("Ladder") = 1 Then
        If intStopDelay_A > (- 500) Then
                intStopDelay_A = - 50 + intStopDelay_A
                Else
                        intStopDelay_A = - 500
        End If
        End If

        If c.GetAttrib ("Ladder") = 2 Then
        If intStopDelay_B > (- 500) Then
                intStopDelay_B = - 50 + intStopDelay_B
                Else
                        intStopDelay_B = - 500
        End If
        End If

End If

'MODIFIED TASK BASED ON JESSICA COHEN'S ARTICLE:
'Fixation cross: 500 ms
'Stimulus: 1000 ms. When the subject responds, the stimulus ends and a variable ISI comes up
'Two ladders: a) 250 ms after the visual stimulus, b) 350 ms after the stimulus
'The ladders go from 0 To 1000 ms In the StopTrial1, And from - 500 To 0 In the StopTrial3


'FIRST TASK BASED ON VERBRUGGEN:
'Taking into account that the total trial duration Is 3500 ms, And the input collection lasts 1250
'(Figure duration) + 2000 (Verbruggen's default ISI)= 3250 ms of input collection.
```

```
'Stop Signal Delay may go from the beging of the trial (0 ms) to 1500 ms
'However Stop Trial 2 is designed to carry out SSD from 1250 to 1500 ms
'Stop Trial 3 from 0 to 1250 ms
'Stop Trial 1 from 1250 to 500 ms

'Fixation point lasts 250 ms
'Stimulus lasts 1250 ms

'The firs component of each type of stop trial is the one set to collect the participant's response

'The actual SSD goes from -250 ms to 1500 ms
	''''''''''''''''''''''''''''''''''''''''''''
	' InLine - CalcStopDelay1 END
	''''''''''''''''''''''''''''''''''''''''''''


	''''''''''''''''''''''''''''''''''''''''''''
	' InLine - GoToEnd1 BEGIN <GoToEnd1>
	''''''''''''''''''''''''''''''''''''''''''''
	GoTo End0
	''''''''''''''''''''''''''''''''''''''''''''
	' InLine - GoToEnd1 END
	''''''''''''''''''''''''''''''''''''''''''''


	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - StopTrial3 BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

StopTrial3:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume StopTrial3Resume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

StopTrial3Resume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - StopTrial3 END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''



	FixationStop1.Duration = CLng(c.GetAttrib(ebUCase_I & ebUCase_S & ebUCase_I))
	On Error GoTo Feedback4

	FixationStop1.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		FixationStop1EchoClients.RemoveAll
		FixationStop1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I & 
ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p 
& ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(ebDigit_5 & ebDigit_5 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), 
ebEndResponseActionJump, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All 
ProcessBackspace:Yes")


	End If

	If Keyboard.GetState() = ebStateOpen Then
		FixationStop1EchoClients.RemoveAll
		FixationStop1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C & 
ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n 
& ebLCase_s & ebLCase_e), CLng(ebDigit_5 & ebDigit_5 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & 
ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	FixationStop1.Run
	c.SetAttrib FixationStop1.Name & ebDot & ebLogNameOnsetDelay, FixationStop1.OnsetDelay
	c.SetAttrib FixationStop1.Name & ebDot & ebLogNameOnsetTime, FixationStop1.OnsetTime
	c.SetAttrib FixationStop1.Name & ebDot & ebLogNameDurationError, FixationStop1.DurationError
	c.SetAttrib FixationStop1.Name & ebDot & ebLogNameRTTime, FixationStop1.RTTime
	c.SetAttrib FixationStop1.Name & ebDot & ebLogNameACC, FixationStop1.ACC
	c.SetAttrib FixationStop1.Name & ebDot & ebLogNameRT, FixationStop1.RT
	c.SetAttrib FixationStop1.Name & ebDot & ebLogNameRESP, FixationStop1.RESP
	c.SetAttrib FixationStop1.Name & ebDot & ebLogNameCRESP, FixationStop1.CRESP
	c.SetAttrib FixationStop1.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationStop1.OnsetToOnsetTime


	Set SoundOut3SoundBuffer = SoundOut3.Buffers(1)
	SoundOut3SoundBuffer.Filename = c.GetAttrib(ebUCase_S & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d)
	SoundOut3SoundBuffer.Load

	On Error GoTo Feedback4

	SoundOut3.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		SoundOut3EchoClients.RemoveAll
		SoundOut3.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I & 
ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p 
& ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(SoundOut3.Duration), CLng(ebDigit_1), ebEndResponseActionJump, CLogical(ebUCase_Y & 
ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	If Keyboard.GetState() = ebStateOpen Then
		SoundOut3EchoClients.RemoveAll
		SoundOut3.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C & 
ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n 
& ebLCase_s & ebLCase_e), CLng(SoundOut3.Duration), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), 
ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	SoundOut3.Run
	c.SetAttrib SoundOut3.Name & ebDot & ebLogNameOnsetDelay, SoundOut3.OnsetDelay
	c.SetAttrib SoundOut3.Name & ebDot & ebLogNameOnsetTime, SoundOut3.OnsetTime
```

```
	c.SetAttrib SoundOut3.Name & ebDot & ebLogNameDurationError, SoundOut3.DurationError
	c.SetAttrib SoundOut3.Name & ebDot & ebLogNameRTTime, SoundOut3.RTTime
	c.SetAttrib SoundOut3.Name & ebDot & ebLogNameACC, SoundOut3.ACC
	c.SetAttrib SoundOut3.Name & ebDot & ebLogNameRT, SoundOut3.RT
	c.SetAttrib SoundOut3.Name & ebDot & ebLogNameRESP, SoundOut3.RESP
	c.SetAttrib SoundOut3.Name & ebDot & ebLogNameCRESP, SoundOut3.CRESP


	SSD.Duration = CLng(c.GetAttrib(ebUCase_F & ebLCase_i & ebLCase_x & ebUCase_S & ebLCase_t & ebLCase_o & ebLCase_p & ebDigit_2))
	On Error GoTo Feedback4

	SSD.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		SSDEchoClients.RemoveAll
		SSD.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I & ebLCase_n & 
ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o 
& ebLCase_n & ebLCase_s & ebLCase_e), CLng(SSD.Duration), CLng(ebDigit_1), ebEndResponseActionJump, CLogical(ebUCase_Y & ebLCase_e & 
ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	If Keyboard.GetState() = ebStateOpen Then
		SSDEchoClients.RemoveAll
		SSD.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C & ebLCase_o & 
ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s 
& ebLCase_e), CLng(SSD.Duration), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, 
ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	SSD.Run
	c.SetAttrib SSD.Name & ebDot & ebLogNameOnsetDelay, SSD.OnsetDelay
	c.SetAttrib SSD.Name & ebDot & ebLogNameOnsetTime, SSD.OnsetTime
	c.SetAttrib SSD.Name & ebDot & ebLogNameDurationError, SSD.DurationError
	c.SetAttrib SSD.Name & ebDot & ebLogNameRTTime, SSD.RTTime
	c.SetAttrib SSD.Name & ebDot & ebLogNameACC, SSD.ACC
	c.SetAttrib SSD.Name & ebDot & ebLogNameRT, SSD.RT
	c.SetAttrib SSD.Name & ebDot & ebLogNameRESP, SSD.RESP
	c.SetAttrib SSD.Name & ebDot & ebLogNameCRESP, SSD.CRESP
	c.SetAttrib SSD.Name & ebDot & ebLogNameOnsetToOnsetTime, SSD.OnsetToOnsetTime


	Figure3.Filename = c.GetAttrib(ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e)
	Figure3.Load

	On Error GoTo Feedback4

	Figure3.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		Figure3EchoClients.RemoveAll
		Figure3.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I & 
ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p 
& ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(ebDigit_5 & ebDigit_0 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), 
ebEndResponseActionJump, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All 
ProcessBackspace:Yes")


	End If

	If Keyboard.GetState() = ebStateOpen Then
		Figure3EchoClients.RemoveAll
		Figure3.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C & 
ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n 
& ebLCase_s & ebLCase_e), CLng(ebDigit_5 & ebDigit_0 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & 
ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	Figure3.Run
	c.SetAttrib Figure3.Name & ebDot & ebLogNameOnsetDelay, Figure3.OnsetDelay
	c.SetAttrib Figure3.Name & ebDot & ebLogNameOnsetTime, Figure3.OnsetTime
	c.SetAttrib Figure3.Name & ebDot & ebLogNameDurationError, Figure3.DurationError
	c.SetAttrib Figure3.Name & ebDot & ebLogNameRTTime, Figure3.RTTime
	c.SetAttrib Figure3.Name & ebDot & ebLogNameACC, Figure3.ACC
	c.SetAttrib Figure3.Name & ebDot & ebLogNameRT, Figure3.RT
	c.SetAttrib Figure3.Name & ebDot & ebLogNameRESP, Figure3.RESP
	c.SetAttrib Figure3.Name & ebDot & ebLogNameCRESP, Figure3.CRESP
	c.SetAttrib Figure3.Name & ebDot & ebLogNameOnsetToOnsetTime, Figure3.OnsetToOnsetTime


	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Feedback4 BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Feedback4:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Feedback4Resume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Feedback4Resume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Feedback4 END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''


	''''''''''''''''''''''''''''''''''''''''''''''
	' InLine - CalcStopDelay3 BEGIN <CalcStopDelay3>
	''''''''''''''''''''''''''''''''''''''''''''''
	'If SoundOut3.RESP = c.GetAttrib ("CorrectResponse") Then
	'intStopAcc = intStopAcc + 1
	'If intStopDelay < 1500 Then
		'intStopDelay = intStopDelay + 50
		'Else
		'intStopDelay = 1500
```

```
		'End If
'Else
		'If intStopDelay > (- 250) Then
			'intStopDelay = - 50 + intStopDelay
			'Else
				'intStopDelay = - 250
		'End If
'End If

'NEW ONE WITH THE TWO LADDERS
If FixationStop1.RESP = c.GetAttrib ("CorrectResponse") And Figure3.RT = 0 Then
		intStopAcc = intStopAcc + 1

		If c.GetAttrib ("Ladder") = 1 Then
		If intStopDelay_A < 1400 Then
			intStopDelay_A = intStopDelay_A + 50
			Else
			intStopDelay_A = 1400
		End If
		End If

		If c.GetAttrib ("Ladder") = 2 Then
		If intStopDelay_B < 1400 Then
			intStopDelay_B = intStopDelay_B + 50
			Else
			intStopDelay_B = 1400
		End If
		End If
Else
		If c.GetAttrib ("Ladder") = 1 Then
		If intStopDelay_A > (- 500) Then
			intStopDelay_A = - 50 + intStopDelay_A
			Else
				intStopDelay_A = - 500
		End If
		End If

		If c.GetAttrib ("Ladder") = 2 Then
		If intStopDelay_B > (- 500) Then
			intStopDelay_B = - 50 + intStopDelay_B
			Else
				intStopDelay_B = - 500
		End If
		End If

End If
'End If

		''''''''''''''''''''''''''''''''''''''''''''
		' InLine - CalcStopDelay3 END
		''''''''''''''''''''''''''''''''''''''''''''


		''''''''''''''''''''''''''''''''''''''''''''
		' InLine - GoToEnd2 BEGIN <GoToEnd2>
		''''''''''''''''''''''''''''''''''''''''''''
		GoTo End0
		''''''''''''''''''''''''''''''''''''''''''''
		' InLine - GoToEnd2 END
		''''''''''''''''''''''''''''''''''''''''''''


		'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - End0 BEGIN
		'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

End0:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume End0Resume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
			' into account for any input masks that jump.
			'
			'Raise the error so the default error handler will show the message
			Err.Raise Err.Number, Err.Source, Err.Description
		End If

End0Resume:

		'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - End0 END
		'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

		''''''''''''''''''''''''''''''''''''''''''''
		'End Of Procedure Clean-Up
		''''''''''''''''''''''''''''''''''''''''''''

		'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Timeline_Finish BEGIN
		'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Finish:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume Procedure_Timeline_FinishResume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
			' into account for any input masks that jump.
			'
			'Raise the error so the default error handler will show the message
			Err.Raise Err.Number, Err.Source, Err.Description
		End If

Procedure_Timeline_FinishResume:

		'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Timeline_Finish END
		'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

		'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		' We are processing any pending input masks.
		' To prevent this code from being generated, set the Procedure object's
```

```
'.ProcessPendingInputMasks property to None.
'

' Enum through the items on the Procedure and
'  and determine if they are RteRunnableInputObject
StopTrial_theCollection.RemoveAll
For StopTrial_nObject = 1 To StopTrial.ChildObjectCount
	Set StopTrial_theInputObject = CRteRunnableInputObject(Rte.GetObject(StopTrial.GetChildObjectName(StopTrial_nObject)))
	If Not StopTrial_theInputObject Is Nothing Then StopTrial_theCollection.Add StopTrial_theInputObject
Next

' Loop until a condition allows us to complete this Procedure
Do
	'Any requests for termination?
	If GetTerminateMode() = ebTerminate Then
		SetTerminateMode ebTerminateNone
		SetNextTargetOnsetTime Clock.Read
		Exit Do
	ElseIf GetTerminateMode() = ebTerminateJump Then
		SetTerminateMode ebTerminateNone
		SetNextTargetOnsetTime Clock.Read
		Err.Raise ebInputAccepted
	End If

	' Any input mask on this procedure have pending input masks?
	StopTrial_bCanExit = True
	For StopTrial_nObject = 1 To StopTrial_theCollection.Count
		Set StopTrial_theInputObject = CRteRunnableInputObject(StopTrial_theCollection(StopTrial_nObject))
		If Not StopTrial_theInputObject Is Nothing Then
			If StopTrial_theInputObject.InputMasks.IsPending() Then
				StopTrial_bCanExit = False
				Exit For
			End If
		End If
	Next

	' No input masks
	If StopTrial_bCanExit Then Exit Do

	'Ready for the next object?
	If Clock.Read >= (GetNextTargetOnsetTime() - 1) Then
		Exit Do
	End If

	'Conditional Exit?
	If GetConditionalExitState() <> 0 Then
		Exit Do
	End If

	If GetNextTargetOnsetTime() - Clock.Read > 4 Then Sleep 4
	DoEvents
Loop

' Cleanup
StopTrial_theCollection.RemoveAll

'
''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

FixationStop.EndOfProcedure

PreSig.EndOfProcedure

SoundOut4.EndOfProcedure

PostSig1.EndOfProcedure

FixationStop1.EndOfProcedure

SoundOut3.EndOfProcedure

SSD.EndOfProcedure

Figure3.EndOfProcedure

c.SetAttrib FixationStop.Name & ebDot & ebLogNameOnsetDelay, FixationStop.OnsetDelay
c.SetAttrib FixationStop.Name & ebDot & ebLogNameOnsetTime, FixationStop.OnsetTime
c.SetAttrib FixationStop.Name & ebDot & ebLogNameDurationError, FixationStop.DurationError
c.SetAttrib FixationStop.Name & ebDot & ebLogNameRTTime, FixationStop.RTTime
c.SetAttrib FixationStop.Name & ebDot & ebLogNameACC, FixationStop.ACC
c.SetAttrib FixationStop.Name & ebDot & ebLogNameRT, FixationStop.RT
c.SetAttrib FixationStop.Name & ebDot & ebLogNameRESP, FixationStop.RESP
c.SetAttrib FixationStop.Name & ebDot & ebLogNameCRESP, FixationStop.CRESP
c.SetAttrib FixationStop.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationStop.OnsetToOnsetTime

c.SetAttrib PreSig.Name & ebDot & ebLogNameOnsetDelay, PreSig.OnsetDelay
c.SetAttrib PreSig.Name & ebDot & ebLogNameOnsetTime, PreSig.OnsetTime
c.SetAttrib PreSig.Name & ebDot & ebLogNameDurationError, PreSig.DurationError
c.SetAttrib PreSig.Name & ebDot & ebLogNameRTTime, PreSig.RTTime
c.SetAttrib PreSig.Name & ebDot & ebLogNameACC, PreSig.ACC
c.SetAttrib PreSig.Name & ebDot & ebLogNameRT, PreSig.RT
c.SetAttrib PreSig.Name & ebDot & ebLogNameRESP, PreSig.RESP
c.SetAttrib PreSig.Name & ebDot & ebLogNameCRESP, PreSig.CRESP
c.SetAttrib PreSig.Name & ebDot & ebLogNameOnsetToOnsetTime, PreSig.OnsetToOnsetTime

c.SetAttrib SoundOut4.Name & ebDot & ebLogNameOnsetDelay, SoundOut4.OnsetDelay
c.SetAttrib SoundOut4.Name & ebDot & ebLogNameOnsetTime, SoundOut4.OnsetTime
c.SetAttrib SoundOut4.Name & ebDot & ebLogNameDurationError, SoundOut4.DurationError
c.SetAttrib SoundOut4.Name & ebDot & ebLogNameRTTime, SoundOut4.RTTime
c.SetAttrib SoundOut4.Name & ebDot & ebLogNameACC, SoundOut4.ACC
c.SetAttrib SoundOut4.Name & ebDot & ebLogNameRT, SoundOut4.RT
c.SetAttrib SoundOut4.Name & ebDot & ebLogNameRESP, SoundOut4.RESP
c.SetAttrib SoundOut4.Name & ebDot & ebLogNameCRESP, SoundOut4.CRESP

c.SetAttrib PostSig1.Name & ebDot & ebLogNameOnsetDelay, PostSig1.OnsetDelay
c.SetAttrib PostSig1.Name & ebDot & ebLogNameOnsetTime, PostSig1.OnsetTime
c.SetAttrib PostSig1.Name & ebDot & ebLogNameDurationError, PostSig1.DurationError
c.SetAttrib PostSig1.Name & ebDot & ebLogNameRTTime, PostSig1.RTTime
c.SetAttrib PostSig1.Name & ebDot & ebLogNameACC, PostSig1.ACC
c.SetAttrib PostSig1.Name & ebDot & ebLogNameRT, PostSig1.RT
c.SetAttrib PostSig1.Name & ebDot & ebLogNameRESP, PostSig1.RESP
c.SetAttrib PostSig1.Name & ebDot & ebLogNameCRESP, PostSig1.CRESP
c.SetAttrib PostSig1.Name & ebDot & ebLogNameOnsetToOnsetTime, PostSig1.OnsetToOnsetTime

c.SetAttrib FixationStop1.Name & ebDot & ebLogNameOnsetDelay, FixationStop1.OnsetDelay
c.SetAttrib FixationStop1.Name & ebDot & ebLogNameOnsetTime, FixationStop1.OnsetTime
c.SetAttrib FixationStop1.Name & ebDot & ebLogNameDurationError, FixationStop1.DurationError
c.SetAttrib FixationStop1.Name & ebDot & ebLogNameRTTime, FixationStop1.RTTime
c.SetAttrib FixationStop1.Name & ebDot & ebLogNameACC, FixationStop1.ACC
c.SetAttrib FixationStop1.Name & ebDot & ebLogNameRT, FixationStop1.RT
c.SetAttrib FixationStop1.Name & ebDot & ebLogNameRESP, FixationStop1.RESP
c.SetAttrib FixationStop1.Name & ebDot & ebLogNameCRESP, FixationStop1.CRESP
c.SetAttrib FixationStop1.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationStop1.OnsetToOnsetTime
```

```
        c.SetAttrib SoundOut3.Name & ebDot & ebLogNameOnsetDelay, SoundOut3.OnsetDelay
        c.SetAttrib SoundOut3.Name & ebDot & ebLogNameOnsetTime, SoundOut3.OnsetTime
        c.SetAttrib SoundOut3.Name & ebDot & ebLogNameDurationError, SoundOut3.DurationError
        c.SetAttrib SoundOut3.Name & ebDot & ebLogNameRTTime, SoundOut3.RTTime
        c.SetAttrib SoundOut3.Name & ebDot & ebLogNameACC, SoundOut3.ACC
        c.SetAttrib SoundOut3.Name & ebDot & ebLogNameRT, SoundOut3.RT
        c.SetAttrib SoundOut3.Name & ebDot & ebLogNameRESP, SoundOut3.RESP
        c.SetAttrib SoundOut3.Name & ebDot & ebLogNameCRESP, SoundOut3.CRESP

        c.SetAttrib SSD.Name & ebDot & ebLogNameOnsetDelay, SSD.OnsetDelay
        c.SetAttrib SSD.Name & ebDot & ebLogNameOnsetTime, SSD.OnsetTime
        c.SetAttrib SSD.Name & ebDot & ebLogNameDurationError, SSD.DurationError
        c.SetAttrib SSD.Name & ebDot & ebLogNameRTTime, SSD.RTTime
        c.SetAttrib SSD.Name & ebDot & ebLogNameACC, SSD.ACC
        c.SetAttrib SSD.Name & ebDot & ebLogNameRT, SSD.RT
        c.SetAttrib SSD.Name & ebDot & ebLogNameRESP, SSD.RESP
        c.SetAttrib SSD.Name & ebDot & ebLogNameCRESP, SSD.CRESP
        c.SetAttrib SSD.Name & ebDot & ebLogNameOnsetToOnsetTime, SSD.OnsetToOnsetTime

        c.SetAttrib Figure3.Name & ebDot & ebLogNameOnsetDelay, Figure3.OnsetDelay
        c.SetAttrib Figure3.Name & ebDot & ebLogNameOnsetTime, Figure3.OnsetTime
        c.SetAttrib Figure3.Name & ebDot & ebLogNameDurationError, Figure3.DurationError
        c.SetAttrib Figure3.Name & ebDot & ebLogNameRTTime, Figure3.RTTime
        c.SetAttrib Figure3.Name & ebDot & ebLogNameACC, Figure3.ACC
        c.SetAttrib Figure3.Name & ebDot & ebLogNameRT, Figure3.RT
        c.SetAttrib Figure3.Name & ebDot & ebLogNameRESP, Figure3.RESP
        c.SetAttrib Figure3.Name & ebDot & ebLogNameCRESP, Figure3.CRESP
        c.SetAttrib Figure3.Name & ebDot & ebLogNameOnsetToOnsetTime, Figure3.OnsetToOnsetTime


        c.Log
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Finish BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Finish:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_FinishResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_FinishResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Finish END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

End Sub



Sub Pract_Run(c As Context)

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Start BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Start:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_StartResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_StartResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Start END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

                GetReady1.ResetLoggingProperties


        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Timeline_Start BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Start:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_Timeline_StartResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_Timeline_StartResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Timeline_Start END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
```

```
        GetReady1.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
                GetReady1EchoClients.RemoveAll
                GetReady1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, ebEmptyText,
CLng(GetReady1.Duration), CLng(ebDigit_1), ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText,
ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        GetReady1.Run

        '''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - IntVariables BEGIN <IntVariables>
        '''''''''''''''''''''''''''''''''''''''''''''
        'Initialize variables
Set StopSignalTrial = New Summation
Set StopDelay = New Summation
Set StopAcc = New Summation


'c.SetAttrib "StopAcc", intStopAcc
'c.SetAttrib "StopDelay", intStopDelay

'Initialize Variables
intStopDelay_A = 250
intStopDelay_B = 350
intStopAcc = 1
intStopSignalTrial = 1

        '''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - IntVariables END
        '''''''''''''''''''''''''''''''''''''''''''''

                Practice.Run c
        '''''''''''''''''''''''''''''''''''''''''''''
        'End Of Procedure Clean-Up
        '''''''''''''''''''''''''''''''''''''''''''''

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Timeline_Finish BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Finish:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_Timeline_FinishResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_Timeline_FinishResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Timeline_Finish END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        ' We are processing any pending input masks.
        ' To prevent this code from being generated, set the Procedure object's
        '.ProcessPendingInputMasks property to None.
        '

        ' Enum through the items on the Procedure and
        '  and determine if they are RteRunnableInputObject
        Pract_theCollection.RemoveAll
        For Pract_nObject = 1 To Pract.ChildObjectCount
                Set Pract_theInputObject = CRteRunnableInputObject(Rte.GetObject(Pract.GetChildObjectName(Pract_nObject)))
                If Not Pract_theInputObject Is Nothing Then Pract_theCollection.Add Pract_theInputObject
        Next

        ' Loop until a condition allows us to complete this Procedure
        Do
                'Any requests for termination?
                If GetTerminateMode() = ebTerminate Then
                        SetTerminateMode ebTerminateNone
                        SetNextTargetOnsetTime Clock.Read
                        Exit Do
                ElseIf GetTerminateMode() = ebTerminateJump Then
                        SetTerminateMode ebTerminateNone
                        SetNextTargetOnsetTime Clock.Read
                        Err.Raise ebInputAccepted
                End If

                ' Any input mask on this procedure have pending input masks?
                Pract_bCanExit = True
                For Pract_nObject = 1 To Pract_theCollection.Count
                        Set Pract_theInputObject = CRteRunnableInputObject(Pract_theCollection(Pract_nObject))
                        If Not Pract_theInputObject Is Nothing Then
                                If Pract_theInputObject.InputMasks.IsPending() Then
                                        Pract_bCanExit = False
                                        Exit For
                                End If
                        End If
                Next

                ' No input masks
                If Pract_bCanExit Then Exit Do

                'Ready for the next object?
                If Clock.Read >= (GetNextTargetOnsetTime() - 1) Then
                        Exit Do
                End If

                'Conditional Exit?
                If GetConditionalExitState() <> 0 Then
                        Exit Do
                End If

                If GetNextTargetOnsetTime() - Clock.Read > 4 Then Sleep 4
                DoEvents
```

```
	Loop

	' Cleanup
	Pract_theCollection.RemoveAll

	'
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

	GetReady1.EndOfProcedure


	c.Log

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Finish BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Finish:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_FinishResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_FinishResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Finish END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

End Sub

Sub Run1_Run(c As Context)

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Start BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Start:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_StartResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_StartResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Start END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

		GetReady.ResetLoggingProperties


	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Start BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Start:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_Timeline_StartResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_Timeline_StartResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Start END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''



	GetReady.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		GetReadyEchoClients.RemoveAll
		GetReady.InputMasks.Add Keyboard.CreateInputMask(ebLCase_s, ebEmptyText, CLng(GetReady.Duration), CLng(ebDigit_1), 
ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes 
ResponseMode:All ProcessBackspace:Yes")


	End If

	GetReady.Run
	c.SetAttrib GetReady.Name & ebDot & ebLogNameOnsetDelay, GetReady.OnsetDelay
	c.SetAttrib GetReady.Name & ebDot & ebLogNameOnsetTime, GetReady.OnsetTime
	c.SetAttrib GetReady.Name & ebDot & ebLogNameDurationError, GetReady.DurationError
	c.SetAttrib GetReady.Name & ebDot & ebLogNameRTTime, GetReady.RTTime
	c.SetAttrib GetReady.Name & ebDot & ebLogNameACC, GetReady.ACC
	c.SetAttrib GetReady.Name & ebDot & ebLogNameRT, GetReady.RT
	c.SetAttrib GetReady.Name & ebDot & ebLogNameRESP, GetReady.RESP
	c.SetAttrib GetReady.Name & ebDot & ebLogNameCRESP, GetReady.CRESP
```

```
        c.SetAttrib GetReady.Name & ebDot & ebLogNameOnsetToOnsetTime, GetReady.OnsetToOnsetTime

        '''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - IntVariables BEGIN <IntVariables>
        '''''''''''''''''''''''''''''''''''''''''''''
        'Initialize variables
Set StopSignalTrial = New Summation
Set StopDelay = New Summation
Set StopAcc = New Summation


'c.SetAttrib "StopAcc", intStopAcc
'c.SetAttrib "StopDelay", intStopDelay

'Initialize Variables
intStopDelay_A = 250
intStopDelay_B = 350
intStopAcc = 1
intStopSignalTrial = 1

        '''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - IntVariables END
        '''''''''''''''''''''''''''''''''''''''''''''

                BlockProc.Run c
        '''''''''''''''''''''''''''''''''''''''''''''
        'End Of Procedure Clean-Up
        '''''''''''''''''''''''''''''''''''''''''''''

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Timeline_Finish BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Finish:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_Timeline_FinishResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_Timeline_FinishResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Timeline_Finish END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        ' We are processing any pending input masks.
        ' To prevent this code from being generated, set the Procedure object's
        '.ProcessPendingInputMasks property to None.
        '

        ' Enum through the items on the Procedure and
        '  and determine if they are RteRunnableInputObject
        Run1_theCollection.RemoveAll
        For Run1_nObject = 1 To Run1.ChildObjectCount
                Set Run1_theInputObject = CRteRunnableInputObject(Rte.GetObject(Run1.GetChildObjectName(Run1_nObject)))
                If Not Run1_theInputObject Is Nothing Then Run1_theCollection.Add Run1_theInputObject
        Next

        ' Loop until a condition allows us to complete this Procedure
        Do
                'Any requests for termination?
                If GetTerminateMode() = ebTerminate Then
                        SetTerminateMode ebTerminateNone
                        SetNextTargetOnsetTime Clock.Read
                        Exit Do
                ElseIf GetTerminateMode() = ebTerminateJump Then
                        SetTerminateMode ebTerminateNone
                        SetNextTargetOnsetTime Clock.Read
                        Err.Raise ebInputAccepted
                End If

                ' Any input mask on this procedure have pending input masks?
                Run1_bCanExit = True
                For Run1_nObject = 1 To Run1_theCollection.Count
                        Set Run1_theInputObject = CRteRunnableInputObject(Run1_theCollection(Run1_nObject))
                        If Not Run1_theInputObject Is Nothing Then
                                If Run1_theInputObject.InputMasks.IsPending() Then
                                        Run1_bCanExit = False
                                        Exit For
                                End If
                        End If
                Next

                ' No input masks
                If Run1_bCanExit Then Exit Do

                'Ready for the next object?
                If Clock.Read >= (GetNextTargetOnsetTime() - 1) Then
                        Exit Do
                End If

                'Conditional Exit?
                If GetConditionalExitState() <> 0 Then
                        Exit Do
                End If

                If GetNextTargetOnsetTime() - Clock.Read > 4 Then Sleep 4
                DoEvents
        Loop

        ' Cleanup
        Run1_theCollection.RemoveAll

        '
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

        GetReady.EndOfProcedure

        c.SetAttrib GetReady.Name & ebDot & ebLogNameOnsetDelay, GetReady.OnsetDelay
        c.SetAttrib GetReady.Name & ebDot & ebLogNameOnsetTime, GetReady.OnsetTime
```

```
        c.SetAttrib GetReady.Name & ebDot & ebLogNameDurationError, GetReady.DurationError
        c.SetAttrib GetReady.Name & ebDot & ebLogNameRTTime, GetReady.RTTime
        c.SetAttrib GetReady.Name & ebDot & ebLogNameACC, GetReady.ACC
        c.SetAttrib GetReady.Name & ebDot & ebLogNameRT, GetReady.RT
        c.SetAttrib GetReady.Name & ebDot & ebLogNameRESP, GetReady.RESP
        c.SetAttrib GetReady.Name & ebDot & ebLogNameCRESP, GetReady.CRESP
        c.SetAttrib GetReady.Name & ebDot & ebLogNameOnsetToOnsetTime, GetReady.OnsetToOnsetTime


        c.Log
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Finish BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Finish:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_FinishResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_FinishResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Finish END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

End Sub

Sub Run2_Run(c As Context)

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Start BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Start:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_StartResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_StartResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Start END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

                Descanso.ResetLoggingProperties
                GetReady2.ResetLoggingProperties



        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Timeline_Start BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Start:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_Timeline_StartResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_Timeline_StartResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Timeline_Start END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''



        Descanso.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
                DescansoEchoClients.RemoveAll
                Descanso.InputMasks.Add Keyboard.CreateInputMask(ebLCase_m, ebEmptyText, CLng(Descanso.Duration), CLng(ebDigit_1),
ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes
ResponseMode:All ProcessBackspace:Yes")


        End If

        Descanso.Run
        c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetDelay, Descanso.OnsetDelay
        c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetTime, Descanso.OnsetTime
        c.SetAttrib Descanso.Name & ebDot & ebLogNameDurationError, Descanso.DurationError
        c.SetAttrib Descanso.Name & ebDot & ebLogNameRTTime, Descanso.RTTime
        c.SetAttrib Descanso.Name & ebDot & ebLogNameACC, Descanso.ACC
        c.SetAttrib Descanso.Name & ebDot & ebLogNameRT, Descanso.RT
        c.SetAttrib Descanso.Name & ebDot & ebLogNameRESP, Descanso.RESP
        c.SetAttrib Descanso.Name & ebDot & ebLogNameCRESP, Descanso.CRESP
```

```
        c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetToOnsetTime, Descanso.OnsetToOnsetTime


        GetReady2.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
                GetReady2EchoClients.RemoveAll
                GetReady2.InputMasks.Add Keyboard.CreateInputMask(ebLCase_s, ebEmptyText, CLng(GetReady2.Duration), CLng(ebDigit_1),
ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes
ResponseMode:All ProcessBackspace:Yes")


        End If

        GetReady2.Run
        c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetDelay, GetReady2.OnsetDelay
        c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetTime, GetReady2.OnsetTime
        c.SetAttrib GetReady2.Name & ebDot & ebLogNameDurationError, GetReady2.DurationError
        c.SetAttrib GetReady2.Name & ebDot & ebLogNameRTTime, GetReady2.RTTime
        c.SetAttrib GetReady2.Name & ebDot & ebLogNameACC, GetReady2.ACC
        c.SetAttrib GetReady2.Name & ebDot & ebLogNameRT, GetReady2.RT
        c.SetAttrib GetReady2.Name & ebDot & ebLogNameRESP, GetReady2.RESP
        c.SetAttrib GetReady2.Name & ebDot & ebLogNameCRESP, GetReady2.CRESP
        c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetToOnsetTime, GetReady2.OnsetToOnsetTime


        ''''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - IntVariables BEGIN <IntVariables>
        ''''''''''''''''''''''''''''''''''''''''''''''
        'Initialize variables
Set StopSignalTrial = New Summation
Set StopDelay = New Summation
Set StopAcc = New Summation


'c.SetAttrib "StopAcc", intStopAcc
'c.SetAttrib "StopDelay", intStopDelay

'Initialize Variables
intStopDelay_A = 250
intStopDelay_B = 350
intStopAcc = 1
intStopSignalTrial = 1

        ''''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - IntVariables END
        ''''''''''''''''''''''''''''''''''''''''''''''

                BlockProc2.Run c
        ''''''''''''''''''''''''''''''''''''''''''''''
        'End Of Procedure Clean-Up
        ''''''''''''''''''''''''''''''''''''''''''''''

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Timeline_Finish BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Finish:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_Timeline_FinishResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_Timeline_FinishResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Timeline_Finish END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        ' We are processing any pending input masks.
        ' To prevent this code from being generated, set the Procedure object's
        '.ProcessPendingInputMasks property to None.
        '

        ' Enum through the items on the Procedure and
        '  and determine if they are RteRunnableInputObject
        Run2_theCollection.RemoveAll
        For Run2_nObject = 1 To Run2.ChildObjectCount
                Set Run2_theInputObject = CRteRunnableInputObject(Rte.GetObject(Run2.GetChildObjectName(Run2_nObject)))
                If Not Run2_theInputObject Is Nothing Then Run2_theCollection.Add Run2_theInputObject
        Next

        ' Loop until a condition allows us to complete this Procedure
        Do
                'Any requests for termination?
                If GetTerminateMode() = ebTerminate Then
                        SetTerminateMode ebTerminateNone
                        SetNextTargetOnsetTime Clock.Read
                        Exit Do
                ElseIf GetTerminateMode() = ebTerminateJump Then
                        SetTerminateMode ebTerminateNone
                        SetNextTargetOnsetTime Clock.Read
                        Err.Raise ebInputAccepted
                End If

                ' Any input mask on this procedure have pending input masks?
                Run2_bCanExit = True
                For Run2_nObject = 1 To Run2_theCollection.Count
                        Set Run2_theInputObject = CRteRunnableInputObject(Run2_theCollection(Run2_nObject))
                        If Not Run2_theInputObject Is Nothing Then
                                If Run2_theInputObject.InputMasks.IsPending() Then
                                        Run2_bCanExit = False
                                        Exit For
                                End If
                        End If
                Next

                ' No input masks
                If Run2_bCanExit Then Exit Do
```

```
			'Ready for the next object?
			If Clock.Read >= (GetNextTargetOnsetTime() - 1) Then
				Exit Do
			End If

			'Conditional Exit?
			If GetConditionalExitState() <> 0 Then
				Exit Do
			End If

			If GetNextTargetOnsetTime() - Clock.Read > 4 Then Sleep 4
			DoEvents
		Loop

		' Cleanup
		Run2_theCollection.RemoveAll

		'
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

		Descanso.EndOfProcedure

		GetReady2.EndOfProcedure

		c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetDelay, Descanso.OnsetDelay
		c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetTime, Descanso.OnsetTime
		c.SetAttrib Descanso.Name & ebDot & ebLogNameDurationError, Descanso.DurationError
		c.SetAttrib Descanso.Name & ebDot & ebLogNameRTTime, Descanso.RTTime
		c.SetAttrib Descanso.Name & ebDot & ebLogNameACC, Descanso.ACC
		c.SetAttrib Descanso.Name & ebDot & ebLogNameRT, Descanso.RT
		c.SetAttrib Descanso.Name & ebDot & ebLogNameRESP, Descanso.RESP
		c.SetAttrib Descanso.Name & ebDot & ebLogNameCRESP, Descanso.CRESP
		c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetToOnsetTime, Descanso.OnsetToOnsetTime

		c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetDelay, GetReady2.OnsetDelay
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetTime, GetReady2.OnsetTime
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameDurationError, GetReady2.DurationError
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameRTTime, GetReady2.RTTime
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameACC, GetReady2.ACC
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameRT, GetReady2.RT
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameRESP, GetReady2.RESP
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameCRESP, GetReady2.CRESP
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetToOnsetTime, GetReady2.OnsetToOnsetTime


		c.Log

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Finish BEGIN
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Finish:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume Procedure_FinishResume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
			' into account for any input masks that jump.
			'
			'Raise the error so the default error handler will show the message
			Err.Raise Err.Number, Err.Source, Err.Description
		End If

Procedure_FinishResume:

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Finish END
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

End Sub

Sub GoTrial8_Run(c As Context)

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Start BEGIN
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Start:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume Procedure_StartResume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
			' into account for any input masks that jump.
			'
			'Raise the error so the default error handler will show the message
			Err.Raise Err.Number, Err.Source, Err.Description
		End If

Procedure_StartResume:

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Start END
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

			FixationGo1.ResetLoggingProperties
			Figure1.ResetLoggingProperties

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Timeline_Start BEGIN
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Start:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume Procedure_Timeline_StartResume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
```

```
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_Timeline_StartResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Start END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''



	FixationGo1.Duration = CLng(c.GetAttrib(ebUCase_I & ebUCase_S & ebUCase_I))

	FixationGo1.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		FixationGo1EchoClients.RemoveAll
		FixationGo1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_s, ebLCase_s, CLng(ebDigit_5 & ebDigit_5 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	FixationGo1.Run
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameOnsetDelay, FixationGo1.OnsetDelay
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameOnsetTime, FixationGo1.OnsetTime
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameDurationError, FixationGo1.DurationError
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameRTTime, FixationGo1.RTTime
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameACC, FixationGo1.ACC
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameRT, FixationGo1.RT
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameRESP, FixationGo1.RESP
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameCRESP, FixationGo1.CRESP
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationGo1.OnsetToOnsetTime


	Figure1.Filename = c.GetAttrib(ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e)
	Figure1.Load

	On Error GoTo Feedback

	Figure1.InputMasks.Reset

	If Keyboard.GetState() = ebStateOpen Then
		Figure1EchoClients.RemoveAll
		Figure1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I & ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(ebDigit_1 & ebDigit_5 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), ebEndResponseActionJump, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	If Keyboard.GetState() = ebStateOpen Then
		Figure1EchoClients.RemoveAll
		Figure1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(ebDigit_1 & ebDigit_5 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


	End If

	Figure1.Run
	c.SetAttrib Figure1.Name & ebDot & ebLogNameOnsetDelay, Figure1.OnsetDelay
	c.SetAttrib Figure1.Name & ebDot & ebLogNameOnsetTime, Figure1.OnsetTime
	c.SetAttrib Figure1.Name & ebDot & ebLogNameDurationError, Figure1.DurationError
	c.SetAttrib Figure1.Name & ebDot & ebLogNameRTTime, Figure1.RTTime
	c.SetAttrib Figure1.Name & ebDot & ebLogNameACC, Figure1.ACC
	c.SetAttrib Figure1.Name & ebDot & ebLogNameRT, Figure1.RT
	c.SetAttrib Figure1.Name & ebDot & ebLogNameRESP, Figure1.RESP
	c.SetAttrib Figure1.Name & ebDot & ebLogNameCRESP, Figure1.CRESP
	c.SetAttrib Figure1.Name & ebDot & ebLogNameOnsetToOnsetTime, Figure1.OnsetToOnsetTime


	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Feedback BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Feedback:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume FeedbackResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

FeedbackResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Feedback END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''


	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Feedback_Start BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Feedback_Start:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_Feedback_StartResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
```

```
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_Feedback_StartResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Feedback_Start END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''


	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	' We are processing the input object pending any input masks.
	' To prevent this code from being generated, set the Feedback object's
	'.ProcessInputObjectPendingInputMasks property to No/False.
	'
	Do
		'Any requests for termination?
		If GetTerminateMode() = ebTerminate Then
			SetTerminateMode ebTerminateNone
			SetNextTargetOnsetTime Clock.Read
			Exit Do
		ElseIf GetTerminateMode() = ebTerminateJump Then
			SetTerminateMode ebTerminateNone
			SetNextTargetOnsetTime Clock.Read
			Err.Raise ebInputAccepted
		End If

		'Input Masks still pending?
		If Not Figure1.InputMasks.IsPending() Then
			Exit Do
		End If

		'Ready for the next object?
		If Clock.Read >= (GetNextTargetOnsetTime() - 1) Then
			Exit Do
		End If

		'Conditional Exit?
		If GetConditionalExitState() <> 0 Then
			Exit Do
		End If

		If GetNextTargetOnsetTime() - Clock.Read > 4 Then Sleep 4
		DoEvents
	Loop
	'
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

	If Figure1.ACC = 1 Then
		'Set the ActiveState to Correct
		FeedbackDisplay3.ActiveState = "Correct"

		'Add an observation to the accuracy stats
		FeedbackDisplay3.AccStats.AddObservation Figure1.Acc

		'Add an observation to the response time stats
		' unless the user did not respond and the author
		' does not want us to add the no response RT
		If Len(Figure1.RESP) > 0 Then
			FeedbackDisplay3.RTStats.AddObservation Figure1.RT
			FeedbackDisplay3.CorrectRTStats.AddObservation Figure1.RT
		End If
	Else
		'Is it incorrect or no response?
		If Len(Figure1.RESP) > 0 Then
			'Set the ActiveState to Incorrect
			FeedbackDisplay3.ActiveState = "Incorrect"

			'Set the accuracy stats
			FeedbackDisplay3.AccStats.AddObservation Figure1.Acc

			'Set the RT stats
			FeedbackDisplay3.RTStats.AddObservation Figure1.RT
			FeedbackDisplay3.IncorrectRTStats.AddObservation Figure1.RT
		Else
			'Set the ActiveState to NoResponse
			FeedbackDisplay3.ActiveState = "NoResponse"

			'Does the author want to consider a NoResponse
			' to sum as an incorrect response in the ACC stats?
			If FeedbackDisplay3.CollectNoRespACCStats = True Then
				FeedbackDisplay3.AccStats.AddObservation Figure1.Acc
			End If
		End If
	End If

	'Deterimine if there are any InputMask with a ebTimeLimitUntilFeedback set
	For FeedbackDisplay3_ChildIterator = 1 To GoTrial8.ChildObjectCount
		Set FeedbackDisplay3_Child = 
CRteRunnableInputObject(Rte.GetObject(GoTrial8.GetChildObjectName(FeedbackDisplay3_ChildIterator)))
		If Not FeedbackDisplay3_Child Is Nothing Then

			'Have we reached this FeedbackDisplay?
			'(we do not terminate InputMask with ebTimeLimitUntilFeedback
			'  that occur after our FeedbackDisplay)
			If FeedbackDisplay3_Child.Name = FeedbackDisplay3.Name Then Exit For

			'Enumerate through each object and then through each InputMask
			'terminate any input masks that have ebTimeLimitUntilFeeback set
			For FeedbackDisplay3_MaskIterator = 1 To FeedbackDisplay3_Child.InputMasks.Count
				Set FeedbackDisplay3_Mask = FeedbackDisplay3_Child.InputMasks(FeedbackDisplay3_MaskIterator)
				If Not FeedbackDisplay3_Mask Is Nothing Then
					If FeedbackDisplay3_Mask.Status = ebStatusArmed Then
						If FeedbackDisplay3_Mask.TimeLimit = ebTimeLimitUntilFeedback Then
							FeedbackDisplay3_Mask.Terminate
						End If
					End If
				End If
			Next
		End If
	Next

	Select Case FeedbackDisplay3.ActiveState
		Case ebUCase_C & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t


			'Text2
			Set FeedbackDisplay3_SlideText = CSlideText(FeedbackDisplay3.ActiveSlideState.Objects(ebUCase_T & ebLCase_e & ebLCase_x
& ebLCase_t & ebDigit_2))
			FeedbackDisplay3_SlideText.Text = "" & _
```

```
		Format$((Figure1.RT / FeedbackDisplay3.RTDivisor), FeedbackDisplay3.RTFormat) & _
		" segundos tardados en responder"
			Set FeedbackDisplay3_SlideText = Nothing

		Case ebUCase_I & ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t


			'Text2
			Set FeedbackDisplay3_SlideText = CSlideText(FeedbackDisplay3.ActiveSlideState.Objects(ebUCase_T & ebLCase_e & ebLCase_x
& ebLCase_t & ebDigit_2))
			FeedbackDisplay3_SlideText.Text = "" & _
		Format$((Figure1.RT / FeedbackDisplay3.RTDivisor), FeedbackDisplay3.RTFormat) & _
		" segundos tardados en responder"
			Set FeedbackDisplay3_SlideText = Nothing

	End Select



	FeedbackDisplay3.Run


	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Feedback_Finish BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Feedback_Finish:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_Feedback_FinishResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_Feedback_FinishResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Feedback_Finish END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

	'''''''''''''''''''''''''''''''''''''''''''''
	'End Of Procedure Clean-Up
	'''''''''''''''''''''''''''''''''''''''''''''

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Finish BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Finish:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_Timeline_FinishResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_Timeline_FinishResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Finish END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	' We are processing any pending input masks.
	' To prevent this code from being generated, set the Procedure object's
	'.ProcessPendingInputMasks property to None.
	'
	' Loop until a condition allows us to complete this Procedure
	Do
		'Any requests for termination?
		If GetTerminateMode() = ebTerminate Then
			SetTerminateMode ebTerminateNone
			SetNextTargetOnsetTime Clock.Read
			Exit Do
		ElseIf GetTerminateMode() = ebTerminateJump Then
			SetTerminateMode ebTerminateNone
			SetNextTargetOnsetTime Clock.Read
			Err.Raise ebInputAccepted
		End If

		'Input Masks still pending?
		If Not FeedbackDisplay3.InputMasks.IsPending() Then
			Exit Do
		End If

		'Ready for the next object?
		If Clock.Read >= (GetNextTargetOnsetTime() - 1) Then
			Exit Do
		End If

		'Conditional Exit?
		If GetConditionalExitState() <> 0 Then
			Exit Do
		End If

		If GetNextTargetOnsetTime() - Clock.Read > 4 Then Sleep 4
		DoEvents
	Loop
	'
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

	FixationGo1.EndOfProcedure

	Figure1.EndOfProcedure
```

```
	FeedbackDisplay3.EndOfProcedure

	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameOnsetDelay, FixationGo1.OnsetDelay
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameOnsetTime, FixationGo1.OnsetTime
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameDurationError, FixationGo1.DurationError
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameRTTime, FixationGo1.RTTime
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameACC, FixationGo1.ACC
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameRT, FixationGo1.RT
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameRESP, FixationGo1.RESP
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameCRESP, FixationGo1.CRESP
	c.SetAttrib FixationGo1.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationGo1.OnsetToOnsetTime

	c.SetAttrib Figure1.Name & ebDot & ebLogNameOnsetDelay, Figure1.OnsetDelay
	c.SetAttrib Figure1.Name & ebDot & ebLogNameOnsetTime, Figure1.OnsetTime
	c.SetAttrib Figure1.Name & ebDot & ebLogNameDurationError, Figure1.DurationError
	c.SetAttrib Figure1.Name & ebDot & ebLogNameRTTime, Figure1.RTTime
	c.SetAttrib Figure1.Name & ebDot & ebLogNameACC, Figure1.ACC
	c.SetAttrib Figure1.Name & ebDot & ebLogNameRT, Figure1.RT
	c.SetAttrib Figure1.Name & ebDot & ebLogNameRESP, Figure1.RESP
	c.SetAttrib Figure1.Name & ebDot & ebLogNameCRESP, Figure1.CRESP
	c.SetAttrib Figure1.Name & ebDot & ebLogNameOnsetToOnsetTime, Figure1.OnsetToOnsetTime


	c.Log
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Finish BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Finish:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_FinishResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_FinishResume:
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Finish END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

End Sub

Sub StopTrial8_Run(c As Context)

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Start BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Start:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_StartResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_StartResume:
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Start END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

		FixationStop2.ResetLoggingProperties
		PreSig1.ResetLoggingProperties
		SoundOut5.ResetLoggingProperties
		PostSig2.ResetLoggingProperties
		FixationStop3.ResetLoggingProperties
		SoundOut6.ResetLoggingProperties
		SSD1.ResetLoggingProperties
		Figure4.ResetLoggingProperties

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Start BEGIN
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Start:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_Timeline_StartResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_Timeline_StartResume:
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Timeline_Start END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''


	''''''''''''''''''''''''''''''''''''''''''''''
	' InLine - StopVbles1 BEGIN <StopVbles1>
```

```
        ''''''''''''''''''''''''''''''''''''''''''''''
        'Ladder 1 (set the stimuli's screens)

If c.GetAttrib ("Ladder") = 1 Then
c.SetAttrib "PreSignal", intStopDelay_A
c.SetAttrib "PostSignal1", 1400 - intStopDelay_A
'c.SetAttrib "FixStop1", intStopDelay_A + 500
c.SetAttrib "FixStop2", - intStopDelay_A - 100
'Antes tenÌa - 50
c.SetAttrib "StopDelay", intStopDelay_A

'Ladder 2 (set the stimuli's screens)
Else If c.GetAttrib ("Ladder") = 2 Then

c.SetAttrib "PreSignal", intStopDelay_B
c.SetAttrib "PostSignal1", 1400 - intStopDelay_B
'c.SetAttrib "FixStop1", intStopDelay_B + 450
c.SetAttrib "FixStop2", - intStopDelay_B - 100
'Antes tenÌa - 50
c.SetAttrib "StopDelay", intStopDelay_B

End If
End If

c.SetAttrib "StopAcc", intStopAcc


c.SetAttrib "StopSignalTrial", intStopSignalTrial


If c.GetAttrib ("GoStop") = "Stop" Then
        intStopSignalTrial = intStopSignalTrial + 1
End If

        ''''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - StopVbles1 END
        ''''''''''''''''''''''''''''''''''''''''''''''


        ''''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - WhereToGo1 BEGIN <WhereToGo1>
        ''''''''''''''''''''''''''''''''''''''''''''''

'If (intStopDelay_A Or intStopDelay_B   >= 0 And _
        'intStopDelay_A Or intStopDelay_B  <= 1000) Then
                'GoTo StopTrial1
                'Else
                        'If intStopDelay < 0 Then
                                'GoTo StopTrial3
                        'End If
'End If

If c.GetAttrib ("StopDelay") >= 0 And _
        c.GetAttrib ("StopDelay") <= 1500 Then
                GoTo StopTrial2
        Else
                If c.GetAttrib ("StopDelay") < 0 Then
                        GoTo StopTrial4
                End If
End If

        ''''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - WhereToGo1 END
        ''''''''''''''''''''''''''''''''''''''''''''''


        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - StopTrial2 BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

StopTrial2:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume StopTrial2Resume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

StopTrial2Resume:
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - StopTrial2 END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''



        FixationStop2.Duration = CLng(c.GetAttrib(ebUCase_I & ebUCase_S & ebUCase_I))

        FixationStop2.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
                FixationStop2EchoClients.RemoveAll
                FixationStop2.InputMasks.Add Keyboard.CreateInputMask(ebLCase_s, ebLCase_s, CLng(ebDigit_5 & ebDigit_5 & ebDigit_0 &
ebDigit_0), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText,
"AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        FixationStop2.Run
        c.SetAttrib FixationStop2.Name & ebDot & ebLogNameOnsetDelay, FixationStop2.OnsetDelay
        c.SetAttrib FixationStop2.Name & ebDot & ebLogNameOnsetTime, FixationStop2.OnsetTime
        c.SetAttrib FixationStop2.Name & ebDot & ebLogNameDurationError, FixationStop2.DurationError
        c.SetAttrib FixationStop2.Name & ebDot & ebLogNameRTTime, FixationStop2.RTTime
        c.SetAttrib FixationStop2.Name & ebDot & ebLogNameACC, FixationStop2.ACC
        c.SetAttrib FixationStop2.Name & ebDot & ebLogNameRT, FixationStop2.RT
        c.SetAttrib FixationStop2.Name & ebDot & ebLogNameRESP, FixationStop2.RESP
        c.SetAttrib FixationStop2.Name & ebDot & ebLogNameCRESP, FixationStop2.CRESP
        c.SetAttrib FixationStop2.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationStop2.OnsetToOnsetTime


        PreSig1.Filename = c.GetAttrib(ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e)
        PreSig1.Load
```

```
        PreSig1.Duration = CLng(c.GetAttrib(ebUCase_P & ebLCase_r & ebLCase_e & ebUCase_S & ebLCase_i & ebLCase_g & ebLCase_n & ebLCase_a & 
ebLCase_l))
        On Error GoTo Feedback3

        PreSig1.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
                PreSig1EchoClients.RemoveAll
                PreSig1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I & 
ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p 
& ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(ebDigit_5 & ebDigit_0 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), 
ebEndResponseActionJump, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All 
ProcessBackspace:No")


        End If

        If Keyboard.GetState() = ebStateOpen Then
                PreSig1EchoClients.RemoveAll
                PreSig1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C & 
ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n 
& ebLCase_s & ebLCase_e), CLng(ebDigit_5 & ebDigit_0 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & 
ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        PreSig1.Run
        c.SetAttrib PreSig1.Name & ebDot & ebLogNameOnsetDelay, PreSig1.OnsetDelay
        c.SetAttrib PreSig1.Name & ebDot & ebLogNameOnsetTime, PreSig1.OnsetTime
        c.SetAttrib PreSig1.Name & ebDot & ebLogNameDurationError, PreSig1.DurationError
        c.SetAttrib PreSig1.Name & ebDot & ebLogNameRTTime, PreSig1.RTTime
        c.SetAttrib PreSig1.Name & ebDot & ebLogNameACC, PreSig1.ACC
        c.SetAttrib PreSig1.Name & ebDot & ebLogNameRT, PreSig1.RT
        c.SetAttrib PreSig1.Name & ebDot & ebLogNameRESP, PreSig1.RESP
        c.SetAttrib PreSig1.Name & ebDot & ebLogNameCRESP, PreSig1.CRESP
        c.SetAttrib PreSig1.Name & ebDot & ebLogNameOnsetToOnsetTime, PreSig1.OnsetToOnsetTime


        Set SoundOut5SoundBuffer = SoundOut5.Buffers(1)
        SoundOut5SoundBuffer.Filename = c.GetAttrib(ebUCase_S & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d)
        SoundOut5SoundBuffer.Load

        On Error GoTo Feedback3

        SoundOut5.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
                SoundOut5EchoClients.RemoveAll
                SoundOut5.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I & 
ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p 
& ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(SoundOut5.Duration), CLng(ebDigit_1), ebEndResponseActionJump, CLogical(ebUCase_Y & 
ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        If Keyboard.GetState() = ebStateOpen Then
                SoundOut5EchoClients.RemoveAll
                SoundOut5.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C & 
ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n 
& ebLCase_s & ebLCase_e), CLng(SoundOut5.Duration), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), 
ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        SoundOut5.Run
        c.SetAttrib SoundOut5.Name & ebDot & ebLogNameOnsetDelay, SoundOut5.OnsetDelay
        c.SetAttrib SoundOut5.Name & ebDot & ebLogNameOnsetTime, SoundOut5.OnsetTime
        c.SetAttrib SoundOut5.Name & ebDot & ebLogNameDurationError, SoundOut5.DurationError
        c.SetAttrib SoundOut5.Name & ebDot & ebLogNameRTTime, SoundOut5.RTTime
        c.SetAttrib SoundOut5.Name & ebDot & ebLogNameACC, SoundOut5.ACC
        c.SetAttrib SoundOut5.Name & ebDot & ebLogNameRT, SoundOut5.RT
        c.SetAttrib SoundOut5.Name & ebDot & ebLogNameRESP, SoundOut5.RESP
        c.SetAttrib SoundOut5.Name & ebDot & ebLogNameCRESP, SoundOut5.CRESP

                Select Case PostSig2.ActiveState
                Case ebUCase_D & ebLCase_e & ebLCase_f & ebLCase_a & ebLCase_u & ebLCase_l & ebLCase_t

                        'Image1
                        Set PostSig2_SlideImage = CSlideImage(PostSig2.ActiveSlideState.Objects(ebUCase_I & ebLCase_m & ebLCase_a & ebLCase_g & 
ebLCase_e & ebDigit_1))
                        PostSig2_SlideImage.Filename = c.GetAttrib(ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e)
                        PostSig2_SlideImage.Load
                        Set PostSig2_SlideImage = Nothing

        End Select


        PostSig2.Duration = CLng(c.GetAttrib(ebUCase_P & ebLCase_o & ebLCase_s & ebLCase_t & ebUCase_S & ebLCase_i & ebLCase_g & ebLCase_n & 
ebLCase_a & ebLCase_l & ebDigit_1))
        On Error GoTo Feedback3

        PostSig2.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
                PostSig2EchoClients.RemoveAll
                PostSig2.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I & 
ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p 
& ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(PostSig2.Duration), CLng(ebDigit_1), ebEndResponseActionJump, CLogical(ebUCase_Y & 
ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        If Keyboard.GetState() = ebStateOpen Then
                PostSig2EchoClients.RemoveAll
                PostSig2.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C & 
ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n 
& ebLCase_s & ebLCase_e), CLng(PostSig2.Duration), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), 
ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        PostSig2.Run

        c.SetAttrib PostSig2.Name & ebDot & ebLogNameOnsetDelay, PostSig2.OnsetDelay
        c.SetAttrib PostSig2.Name & ebDot & ebLogNameOnsetTime, PostSig2.OnsetTime
        c.SetAttrib PostSig2.Name & ebDot & ebLogNameDurationError, PostSig2.DurationError
        c.SetAttrib PostSig2.Name & ebDot & ebLogNameRTTime, PostSig2.RTTime
        c.SetAttrib PostSig2.Name & ebDot & ebLogNameACC, PostSig2.ACC
```

```
        c.SetAttrib PostSig2.Name & ebDot & ebLogNameRT, PostSig2.RT
        c.SetAttrib PostSig2.Name & ebDot & ebLogNameRESP, PostSig2.RESP
        c.SetAttrib PostSig2.Name & ebDot & ebLogNameCRESP, PostSig2.CRESP
        c.SetAttrib PostSig2.Name & ebDot & ebLogNameOnsetToOnsetTime, PostSig2.OnsetToOnsetTime

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Feedback3 BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Feedback3:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Feedback3Resume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Feedback3Resume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Feedback3 END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''


        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Feedback_Start BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Feedback_Start:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_Feedback_StartResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_Feedback_StartResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Feedback_Start END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''


        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        ' We are processing the input object pending any input masks.
        ' To prevent this code from being generated, set the Feedback object's
        '.ProcessInputObjectPendingInputMasks property to No/False.
        '
        Do
                'Any requests for termination?
                If GetTerminateMode() = ebTerminate Then
                        SetTerminateMode ebTerminateNone
                        SetNextTargetOnsetTime Clock.Read
                        Exit Do
                ElseIf GetTerminateMode() = ebTerminateJump Then
                        SetTerminateMode ebTerminateNone
                        SetNextTargetOnsetTime Clock.Read
                        Err.Raise ebInputAccepted
                End If

                'Input Masks still pending?
                If Not PreSig1.InputMasks.IsPending() Then
                        Exit Do
                End If

                'Ready for the next object?
                If Clock.Read >= (GetNextTargetOnsetTime() - 1) Then
                        Exit Do
                End If

                'Conditional Exit?
                If GetConditionalExitState() <> 0 Then
                        Exit Do
                End If

                If GetNextTargetOnsetTime() - Clock.Read > 4 Then Sleep 4
                DoEvents
        Loop
        '
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

        If PreSig1.ACC = 1 Then
                'Set the ActiveState to Correct
                FeedbackDisplay5.ActiveState = "Correct"

                'Add an observation to the accuracy stats
                FeedbackDisplay5.AccStats.AddObservation PreSig1.Acc

                'Add an observation to the response time stats
                ' unless the user did not respond and the author
                ' does not want us to add the no response RT
                If Len(PreSig1.RESP) > 0 Then
                        FeedbackDisplay5.RTStats.AddObservation PreSig1.RT
                        FeedbackDisplay5.CorrectRTStats.AddObservation PreSig1.RT
                End If
        Else
                'Is it incorrect or no response?
                If Len(PreSig1.RESP) > 0 Then
                        'Set the ActiveState to Incorrect
                        FeedbackDisplay5.ActiveState = "Incorrect"

                        'Set the accuracy stats
                        FeedbackDisplay5.AccStats.AddObservation PreSig1.Acc
```

```
                    'Set the RT stats
                    FeedbackDisplay5.RTStats.AddObservation PreSig1.RT
                    FeedbackDisplay5.IncorrectRTStats.AddObservation PreSig1.RT
            Else
                    'Set the ActiveState to NoResponse
                    FeedbackDisplay5.ActiveState = "NoResponse"

                    'Does the author want to consider a NoResponse
                    ' to sum as an incorrect response in the ACC stats?
                    If FeedbackDisplay5.CollectNoRespACCStats = True Then
                            FeedbackDisplay5.AccStats.AddObservation PreSig1.Acc
                    End If
            End If
        End If

        'Deterimine if there are any InputMask with a ebTimeLimitUntilFeedback set
        For FeedbackDisplay5_ChildIterator = 1 To StopTrial8.ChildObjectCount
                Set FeedbackDisplay5_Child =
CRteRunnableInputObject(Rte.GetObject(StopTrial8.GetChildObjectName(FeedbackDisplay5_ChildIterator)))
                If Not FeedbackDisplay5_Child Is Nothing Then

                        'Have we reached this FeedbackDisplay?
                        '(we do not terminate InputMask with ebTimeLimitUntilFeedback
                        '  that occur after our FeedbackDisplay)
                        If FeedbackDisplay5_Child.Name = FeedbackDisplay5.Name Then Exit For

                        'Enumerate through each object and then through each InputMask
                        'terminate any input masks that have ebTimeLimitUntilFeeback set
                        For FeedbackDisplay5_MaskIterator = 1 To FeedbackDisplay5_Child.InputMasks.Count
                                Set FeedbackDisplay5_Mask = FeedbackDisplay5_Child.InputMasks(FeedbackDisplay5_MaskIterator)
                                If Not FeedbackDisplay5_Mask Is Nothing Then
                                        If FeedbackDisplay5_Mask.Status = ebStatusArmed Then
                                                If FeedbackDisplay5_Mask.TimeLimit = ebTimeLimitUntilFeedback Then
                                                        FeedbackDisplay5_Mask.Terminate
                                                End If
                                        End If
                                End If
                        Next
                End If
        Next



        FeedbackDisplay5.Run



        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Feedback_Finish BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Feedback_Finish:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_Feedback_FinishResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_Feedback_FinishResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Feedback_Finish END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''


        ''''''''''''''''''''''''''''''''''''''''''''''
        ' InLine - CalcStopDelay2 BEGIN <CalcStopDelay2>
        ''''''''''''''''''''''''''''''''''''''''''''''
        'If PreSig.RESP = c.GetAttrib ("CorrectResponse") Then
        'intStopAcc = intStopAcc + 1
        'Else
        'intStopAcc = intStopAcc + 0
'End If

        'If c.GetAttrib ("Ladder") = 1 Then
                'If intStopDelay_A < 1000 Then
                        'intStopDelay_A = intStopDelay_A + 50
                        'Else
                                'intStopDelay_A = 1000
                'End If
        'End If

        'Else
        'If intStopDelay > (- 500) Then
                'intStopDelay = - 50 + intStopDelay
                'Else
                        'intStopDelay = - 500
        'End If
'End If

'SIMPLIFIED

If PreSig1.RESP = c.GetAttrib ("CorrectResponse") And PostSig2.RT = 0 Then
        intStopAcc = intStopAcc + 1
        If c.GetAttrib ("Ladder") = 1 Then
        If intStopDelay_A < 1400 Then
                intStopDelay_A = intStopDelay_A + 50
                Else
                intStopDelay_A = 1400
        End If
        End If

        If c.GetAttrib ("Ladder") = 2 Then
        If intStopDelay_B < 1400 Then
                intStopDelay_B = intStopDelay_B + 50
                Else
                intStopDelay_B = 1400
        End If
        End If
Else
        If c.GetAttrib ("Ladder") = 1 Then
        If intStopDelay_A > (- 500) Then
```

```
				intStopDelay_A = - 50 + intStopDelay_A
			Else
				intStopDelay_A = - 500
		End If
		End If

		If c.GetAttrib ("Ladder") = 2 Then
		If intStopDelay_B > (- 500) Then
			intStopDelay_B = - 50 + intStopDelay_B
			Else
				intStopDelay_B = - 500
		End If
		End If

End If

'MODIFIED TASK BASED ON JESSICA COHEN'S ARTICLE:
'Fixation cross: 500 ms
'Stimulus: 1000 ms. When the subject responds, the stimulus ends and a variable ISI comes up
'Two ladders: a) 250 ms after the visual stimulus, b) 350 ms after the stimulus
'The ladders go from 0 To 1000 ms In the StopTrial1, And from - 500 To 0 In the StopTrial3


'FIRST TASK BASED ON VERBRUGGEN:
'Taking into account that the total trial duration Is 3500 ms, And the input collection lasts 1250
'(Figure duration) + 2000 (Verbruggen's default ISI)= 3250 ms of input collection.
'Stop Signal Delay may go from the beging of the trial (0 ms) to 1500 ms
'However Stop Trial 2 is designed to carry out SSD from 1250 to 1500 ms
'Stop Trial 3 from 0 to 1250 ms
'Stop Trial 1 from 1250 to 500 ms

'Fixation point lasts 250 ms
'Stimulus lasts 1250 ms

'The firs component of each type of stop trial is the one set to collect the participant's response

'The actual SSD goes from -250 ms to 1500 ms
		''''''''''''''''''''''''''''''''''''''''''''''
		' InLine - CalcStopDelay2 END
		''''''''''''''''''''''''''''''''''''''''''''''


		''''''''''''''''''''''''''''''''''''''''''''''
		' InLine - GoToEnd3 BEGIN <GoToEnd3>
		''''''''''''''''''''''''''''''''''''''''''''''
		GoTo End1
		''''''''''''''''''''''''''''''''''''''''''''''
		' InLine - GoToEnd3 END
		''''''''''''''''''''''''''''''''''''''''''''''


		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - StopTrial4 BEGIN
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

StopTrial4:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume StopTrial4Resume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
			' into account for any input masks that jump.
			'
			'Raise the error so the default error handler will show the message
			Err.Raise Err.Number, Err.Source, Err.Description
		End If

StopTrial4Resume:

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - StopTrial4 END
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''



		FixationStop3.Duration = CLng(c.GetAttrib(ebUCase_I & ebUCase_S & ebUCase_I))
		On Error GoTo Feedback5

		FixationStop3.InputMasks.Reset

		If Keyboard.GetState() = ebStateOpen Then
			FixationStop3EchoClients.RemoveAll
			FixationStop3.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I &
ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p
& ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(ebDigit_5 & ebDigit_5 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1),
ebEndResponseActionJump, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All
ProcessBackspace:Yes")


		End If

		If Keyboard.GetState() = ebStateOpen Then
			FixationStop3EchoClients.RemoveAll
			FixationStop3.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C &
ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n
& ebLCase_s & ebLCase_e), CLng(ebDigit_5 & ebDigit_5 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y &
ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


		End If

		FixationStop3.Run
		c.SetAttrib FixationStop3.Name & ebDot & ebLogNameOnsetDelay, FixationStop3.OnsetDelay
		c.SetAttrib FixationStop3.Name & ebDot & ebLogNameOnsetTime, FixationStop3.OnsetTime
		c.SetAttrib FixationStop3.Name & ebDot & ebLogNameDurationError, FixationStop3.DurationError
		c.SetAttrib FixationStop3.Name & ebDot & ebLogNameRTTime, FixationStop3.RTTime
		c.SetAttrib FixationStop3.Name & ebDot & ebLogNameACC, FixationStop3.ACC
		c.SetAttrib FixationStop3.Name & ebDot & ebLogNameRT, FixationStop3.RT
		c.SetAttrib FixationStop3.Name & ebDot & ebLogNameRESP, FixationStop3.RESP
		c.SetAttrib FixationStop3.Name & ebDot & ebLogNameCRESP, FixationStop3.CRESP
		c.SetAttrib FixationStop3.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationStop3.OnsetToOnsetTime


		Set SoundOut6SoundBuffer = SoundOut6.Buffers(1)
		SoundOut6SoundBuffer.Filename = c.GetAttrib(ebUCase_S & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d)
		SoundOut6SoundBuffer.Load

		On Error GoTo Feedback5
```

```
        SoundOut6.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
                SoundOut6EchoClients.RemoveAll
                SoundOut6.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I &
ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p
& ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(SoundOut6.Duration), CLng(ebDigit_1), ebEndResponseActionJump, CLogical(ebUCase_Y &
ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        If Keyboard.GetState() = ebStateOpen Then
                SoundOut6EchoClients.RemoveAll
                SoundOut6.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C &
ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n
& ebLCase_s & ebLCase_e), CLng(SoundOut6.Duration), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s),
ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        SoundOut6.Run
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameOnsetDelay, SoundOut6.OnsetDelay
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameOnsetTime, SoundOut6.OnsetTime
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameDurationError, SoundOut6.DurationError
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameRTTime, SoundOut6.RTTime
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameACC, SoundOut6.ACC
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameRT, SoundOut6.RT
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameRESP, SoundOut6.RESP
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameCRESP, SoundOut6.CRESP



        SSD1.Duration = CLng(c.GetAttrib(ebUCase_F & ebLCase_i & ebLCase_x & ebUCase_S & ebLCase_t & ebLCase_o & ebLCase_p & ebDigit_2))
        On Error GoTo Feedback5

        SSD1.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
                SSD1EchoClients.RemoveAll
                SSD1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I & ebLCase_n &
ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o
& ebLCase_n & ebLCase_s & ebLCase_e), CLng(SSD1.Duration), CLng(ebDigit_1), ebEndResponseActionJump, CLogical(ebUCase_Y & ebLCase_e &
ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        If Keyboard.GetState() = ebStateOpen Then
                SSD1EchoClients.RemoveAll
                SSD1.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C & ebLCase_o &
ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s
& ebLCase_e), CLng(SSD1.Duration), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText,
ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        SSD1.Run
        c.SetAttrib SSD1.Name & ebDot & ebLogNameOnsetDelay, SSD1.OnsetDelay
        c.SetAttrib SSD1.Name & ebDot & ebLogNameOnsetTime, SSD1.OnsetTime
        c.SetAttrib SSD1.Name & ebDot & ebLogNameDurationError, SSD1.DurationError
        c.SetAttrib SSD1.Name & ebDot & ebLogNameRTTime, SSD1.RTTime
        c.SetAttrib SSD1.Name & ebDot & ebLogNameACC, SSD1.ACC
        c.SetAttrib SSD1.Name & ebDot & ebLogNameRT, SSD1.RT
        c.SetAttrib SSD1.Name & ebDot & ebLogNameRESP, SSD1.RESP
        c.SetAttrib SSD1.Name & ebDot & ebLogNameCRESP, SSD1.CRESP
        c.SetAttrib SSD1.Name & ebDot & ebLogNameOnsetToOnsetTime, SSD1.OnsetToOnsetTime


        Figure4.Filename = c.GetAttrib(ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e)
        Figure4.Load

        On Error GoTo Feedback5

        Figure4.InputMasks.Reset

        If Keyboard.GetState() = ebStateOpen Then
                Figure4EchoClients.RemoveAll
                Figure4.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_I &
ebLCase_n & ebLCase_c & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p
& ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e), CLng(ebDigit_1 & ebDigit_5 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1),
ebEndResponseActionJump, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All
ProcessBackspace:Yes")


        End If

        If Keyboard.GetState() = ebStateOpen Then
                Figure4EchoClients.RemoveAll
                Figure4.InputMasks.Add Keyboard.CreateInputMask(ebLCase_a & ebLCase_b & ebLCase_c & ebLCase_d, c.GetAttrib(ebUCase_C &
ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n
& ebLCase_s & ebLCase_e), CLng(ebDigit_1 & ebDigit_5 & ebDigit_0 & ebDigit_0), CLng(ebDigit_1), ebEndResponseActionNone, CLogical(ebUCase_Y &
ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes ResponseMode:All ProcessBackspace:Yes")


        End If

        Figure4.Run
        c.SetAttrib Figure4.Name & ebDot & ebLogNameOnsetDelay, Figure4.OnsetDelay
        c.SetAttrib Figure4.Name & ebDot & ebLogNameOnsetTime, Figure4.OnsetTime
        c.SetAttrib Figure4.Name & ebDot & ebLogNameDurationError, Figure4.DurationError
        c.SetAttrib Figure4.Name & ebDot & ebLogNameRTTime, Figure4.RTTime
        c.SetAttrib Figure4.Name & ebDot & ebLogNameACC, Figure4.ACC
        c.SetAttrib Figure4.Name & ebDot & ebLogNameRT, Figure4.RT
        c.SetAttrib Figure4.Name & ebDot & ebLogNameRESP, Figure4.RESP
        c.SetAttrib Figure4.Name & ebDot & ebLogNameCRESP, Figure4.CRESP
        c.SetAttrib Figure4.Name & ebDot & ebLogNameOnsetToOnsetTime, Figure4.OnsetToOnsetTime


        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Feedback5 BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Feedback5:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Feedback5Resume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
```

```
        ' was thrown (ebInputAccepted for catching input masks that jump).
        'You are encouraged to either handle the error so that
        ' it is not thrown in the future or will have to set up
        ' your own error handler, which will also need to take
        ' into account for any input masks that jump.
        '
        'Raise the error so the default error handler will show the message
        Err.Raise Err.Number, Err.Source, Err.Description
    End If

Feedback5Resume:

    ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
    '       Label - Feedback5 END
    ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''


    ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
    ' We are processing the input object pending any input masks.
    ' To prevent this code from being generated, set the Feedback object's
    '.ProcessInputObjectPendingInputMasks property to No/False.
    '
    Do
        'Any requests for termination?
        If GetTerminateMode() = ebTerminate Then
            SetTerminateMode ebTerminateNone
            SetNextTargetOnsetTime Clock.Read
            Exit Do
        ElseIf GetTerminateMode() = ebTerminateJump Then
            SetTerminateMode ebTerminateNone
            SetNextTargetOnsetTime Clock.Read
            Err.Raise ebInputAccepted
        End If

        'Input Masks still pending?
        If Not FixationStop3.InputMasks.IsPending() Then
            Exit Do
        End If

        'Ready for the next object?
        If Clock.Read >= (GetNextTargetOnsetTime() - 1) Then
            Exit Do
        End If

        'Conditional Exit?
        If GetConditionalExitState() <> 0 Then
            Exit Do
        End If

        If GetNextTargetOnsetTime() - Clock.Read > 4 Then Sleep 4
        DoEvents
    Loop
    '
    ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

    If FixationStop3.ACC = 1 Then
        'Set the ActiveState to Correct
        FeedbackDisplay6.ActiveState = "Correct"

        'Add an observation to the accuracy stats
        FeedbackDisplay6.AccStats.AddObservation FixationStop3.Acc
    Else
        'Is it incorrect or no response?
        If Len(FixationStop3.RESP) > 0 Then
            'Set the ActiveState to Incorrect
            FeedbackDisplay6.ActiveState = "Incorrect"

            'Set the accuracy stats
            FeedbackDisplay6.AccStats.AddObservation FixationStop3.Acc
        Else
            'Set the ActiveState to NoResponse
            FeedbackDisplay6.ActiveState = "NoResponse"

            'Does the author want to consider a NoResponse
            ' to sum as an incorrect response in the ACC stats?
            If FeedbackDisplay6.CollectNoRespACCStats = True Then
                FeedbackDisplay6.AccStats.AddObservation FixationStop3.Acc
            End If
        End If
    End If

    'Deterimine if there are any InputMask with a ebTimeLimitUntilFeedback set
    For FeedbackDisplay6_ChildIterator = 1 To StopTrial8.ChildObjectCount
        Set FeedbackDisplay6_Child =
CRteRunnableInputObject(Rte.GetObject(StopTrial8.GetChildObjectName(FeedbackDisplay6_ChildIterator)))
        If Not FeedbackDisplay6_Child Is Nothing Then

            'Have we reached this FeedbackDisplay?
            '(we do not terminate InputMask with ebTimeLimitUntilFeedback
            '  that occur after our FeedbackDisplay)
            If FeedbackDisplay6_Child.Name = FeedbackDisplay6.Name Then Exit For

            'Enumerate through each object and then through each InputMask
            'terminate any input masks that have ebTimeLimitUntilFeeback set
            For FeedbackDisplay6_MaskIterator = 1 To FeedbackDisplay6_Child.InputMasks.Count
                Set FeedbackDisplay6_Mask = FeedbackDisplay6_Child.InputMasks(FeedbackDisplay6_MaskIterator)
                If Not FeedbackDisplay6_Mask Is Nothing Then
                    If FeedbackDisplay6_Mask.Status = ebStatusArmed Then
                        If FeedbackDisplay6_Mask.TimeLimit = ebTimeLimitUntilFeedback Then
                            FeedbackDisplay6_Mask.Terminate
                        End If
                    End If
                End If
            Next
        End If
    Next



    FeedbackDisplay6.Run


    ''''''''''''''''''''''''''''''''''''''''''''
    ' InLine - CalcStopDelay4 BEGIN <CalcStopDelay4>
    ''''''''''''''''''''''''''''''''''''''''''''
    'If SoundOut3.RESP = c.GetAttrib ("CorrectResponse") Then
    'intStopAcc = intStopAcc + 1
    'If intStopDelay < 1500 Then
        'intStopDelay = intStopDelay + 50
        'Else
        'intStopDelay = 1500
```

```
		'End If
'Else
		'If intStopDelay > (- 250) Then
			'intStopDelay = - 50 + intStopDelay
			'Else
				'intStopDelay = - 250
		'End If
'End If

'NEW ONE WITH THE TWO LADDERS
If FixationStop3.RESP = c.GetAttrib ("CorrectResponse") And Figure4.RT = 0 Then
		intStopAcc = intStopAcc + 1

		If c.GetAttrib ("Ladder") = 1 Then
		If intStopDelay_A < 1400 Then
			intStopDelay_A = intStopDelay_A + 50
			Else
			intStopDelay_A = 1400
		End If
		End If

		If c.GetAttrib ("Ladder") = 2 Then
		If intStopDelay_B < 1400 Then
			intStopDelay_B = intStopDelay_B + 50
			Else
			intStopDelay_B = 1400
		End If
		End If
Else
		If c.GetAttrib ("Ladder") = 1 Then
		If intStopDelay_A > (- 500) Then
			intStopDelay_A = - 50 + intStopDelay_A
			Else
				intStopDelay_A = - 500
		End If
		End If

		If c.GetAttrib ("Ladder") = 2 Then
		If intStopDelay_B > (- 500) Then
			intStopDelay_B = - 50 + intStopDelay_B
			Else
				intStopDelay_B = - 500
		End If
		End If

End If
'End If

		''''''''''''''''''''''''''''''''''''''''''''''
		' InLine - CalcStopDelay4 END
		''''''''''''''''''''''''''''''''''''''''''''''


		''''''''''''''''''''''''''''''''''''''''''''''
		' InLine - GoToEnd4 BEGIN <GoToEnd4>
		''''''''''''''''''''''''''''''''''''''''''''''
		GoTo End1
		''''''''''''''''''''''''''''''''''''''''''''''
		' InLine - GoToEnd4 END
		''''''''''''''''''''''''''''''''''''''''''''''


		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - End1 BEGIN
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

End1:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume End1Resume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
			' into account for any input masks that jump.
			'
			'Raise the error so the default error handler will show the message
			Err.Raise Err.Number, Err.Source, Err.Description
		End If

End1Resume:

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - End1 END
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

		''''''''''''''''''''''''''''''''''''''''''''''
		'End Of Procedure Clean-Up
		''''''''''''''''''''''''''''''''''''''''''''''

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Timeline_Finish BEGIN
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Finish:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume Procedure_Timeline_FinishResume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
			' into account for any input masks that jump.
			'
			'Raise the error so the default error handler will show the message
			Err.Raise Err.Number, Err.Source, Err.Description
		End If

Procedure_Timeline_FinishResume:

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Timeline_Finish END
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		' We are processing any pending input masks.
		' To prevent this code from being generated, set the Procedure object's
```

```
'.ProcessPendingInputMasks property to None.
'
' Enum through the items on the Procedure and
'  and determine if they are RteRunnableInputObject
StopTrial8_theCollection.RemoveAll
For StopTrial8_nObject = 1 To StopTrial8.ChildObjectCount
	Set StopTrial8_theInputObject = CRteRunnableInputObject(Rte.GetObject(StopTrial8.GetChildObjectName(StopTrial8_nObject)))
	If Not StopTrial8_theInputObject Is Nothing Then StopTrial8_theCollection.Add StopTrial8_theInputObject
Next

' Loop until a condition allows us to complete this Procedure
Do
	'Any requests for termination?
	If GetTerminateMode() = ebTerminate Then
		SetTerminateMode ebTerminateNone
		SetNextTargetOnsetTime Clock.Read
		Exit Do
	ElseIf GetTerminateMode() = ebTerminateJump Then
		SetTerminateMode ebTerminateNone
		SetNextTargetOnsetTime Clock.Read
		Err.Raise ebInputAccepted
	End If

	' Any input mask on this procedure have pending input masks?
	StopTrial8_bCanExit = True
	For StopTrial8_nObject = 1 To StopTrial8_theCollection.Count
		Set StopTrial8_theInputObject = CRteRunnableInputObject(StopTrial8_theCollection(StopTrial8_nObject))
		If Not StopTrial8_theInputObject Is Nothing Then
			If StopTrial8_theInputObject.InputMasks.IsPending() Then
				StopTrial8_bCanExit = False
				Exit For
			End If
		End If
	Next

	' No input masks
	If StopTrial8_bCanExit Then Exit Do

	'Ready for the next object?
	If Clock.Read >= (GetNextTargetOnsetTime() - 1) Then
		Exit Do
	End If

	'Conditional Exit?
	If GetConditionalExitState() <> 0 Then
		Exit Do
	End If

	If GetNextTargetOnsetTime() - Clock.Read > 4 Then Sleep 4
	DoEvents
Loop

' Cleanup
StopTrial8_theCollection.RemoveAll

'
''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

FixationStop2.EndOfProcedure

PreSig1.EndOfProcedure

SoundOut5.EndOfProcedure

PostSig2.EndOfProcedure

FeedbackDisplay5.EndOfProcedure

FixationStop3.EndOfProcedure

SoundOut6.EndOfProcedure

SSD1.EndOfProcedure

Figure4.EndOfProcedure

FeedbackDisplay6.EndOfProcedure

c.SetAttrib FixationStop2.Name & ebDot & ebLogNameOnsetDelay, FixationStop2.OnsetDelay
c.SetAttrib FixationStop2.Name & ebDot & ebLogNameOnsetTime, FixationStop2.OnsetTime
c.SetAttrib FixationStop2.Name & ebDot & ebLogNameDurationError, FixationStop2.DurationError
c.SetAttrib FixationStop2.Name & ebDot & ebLogNameRTTime, FixationStop2.RTTime
c.SetAttrib FixationStop2.Name & ebDot & ebLogNameACC, FixationStop2.ACC
c.SetAttrib FixationStop2.Name & ebDot & ebLogNameRT, FixationStop2.RT
c.SetAttrib FixationStop2.Name & ebDot & ebLogNameRESP, FixationStop2.RESP
c.SetAttrib FixationStop2.Name & ebDot & ebLogNameCRESP, FixationStop2.CRESP
c.SetAttrib FixationStop2.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationStop2.OnsetToOnsetTime

c.SetAttrib PreSig1.Name & ebDot & ebLogNameOnsetDelay, PreSig1.OnsetDelay
c.SetAttrib PreSig1.Name & ebDot & ebLogNameOnsetTime, PreSig1.OnsetTime
c.SetAttrib PreSig1.Name & ebDot & ebLogNameDurationError, PreSig1.DurationError
c.SetAttrib PreSig1.Name & ebDot & ebLogNameRTTime, PreSig1.RTTime
c.SetAttrib PreSig1.Name & ebDot & ebLogNameACC, PreSig1.ACC
c.SetAttrib PreSig1.Name & ebDot & ebLogNameRT, PreSig1.RT
c.SetAttrib PreSig1.Name & ebDot & ebLogNameRESP, PreSig1.RESP
c.SetAttrib PreSig1.Name & ebDot & ebLogNameCRESP, PreSig1.CRESP
c.SetAttrib PreSig1.Name & ebDot & ebLogNameOnsetToOnsetTime, PreSig1.OnsetToOnsetTime

c.SetAttrib SoundOut5.Name & ebDot & ebLogNameOnsetDelay, SoundOut5.OnsetDelay
c.SetAttrib SoundOut5.Name & ebDot & ebLogNameOnsetTime, SoundOut5.OnsetTime
c.SetAttrib SoundOut5.Name & ebDot & ebLogNameDurationError, SoundOut5.DurationError
c.SetAttrib SoundOut5.Name & ebDot & ebLogNameRTTime, SoundOut5.RTTime
c.SetAttrib SoundOut5.Name & ebDot & ebLogNameACC, SoundOut5.ACC
c.SetAttrib SoundOut5.Name & ebDot & ebLogNameRT, SoundOut5.RT
c.SetAttrib SoundOut5.Name & ebDot & ebLogNameRESP, SoundOut5.RESP
c.SetAttrib SoundOut5.Name & ebDot & ebLogNameCRESP, SoundOut5.CRESP

c.SetAttrib PostSig2.Name & ebDot & ebLogNameOnsetDelay, PostSig2.OnsetDelay
c.SetAttrib PostSig2.Name & ebDot & ebLogNameOnsetTime, PostSig2.OnsetTime
c.SetAttrib PostSig2.Name & ebDot & ebLogNameDurationError, PostSig2.DurationError
c.SetAttrib PostSig2.Name & ebDot & ebLogNameRTTime, PostSig2.RTTime
c.SetAttrib PostSig2.Name & ebDot & ebLogNameACC, PostSig2.ACC
c.SetAttrib PostSig2.Name & ebDot & ebLogNameRT, PostSig2.RT
c.SetAttrib PostSig2.Name & ebDot & ebLogNameRESP, PostSig2.RESP
c.SetAttrib PostSig2.Name & ebDot & ebLogNameCRESP, PostSig2.CRESP
c.SetAttrib PostSig2.Name & ebDot & ebLogNameOnsetToOnsetTime, PostSig2.OnsetToOnsetTime

c.SetAttrib FixationStop3.Name & ebDot & ebLogNameOnsetDelay, FixationStop3.OnsetDelay
c.SetAttrib FixationStop3.Name & ebDot & ebLogNameOnsetTime, FixationStop3.OnsetTime
c.SetAttrib FixationStop3.Name & ebDot & ebLogNameDurationError, FixationStop3.DurationError
c.SetAttrib FixationStop3.Name & ebDot & ebLogNameRTTime, FixationStop3.RTTime
c.SetAttrib FixationStop3.Name & ebDot & ebLogNameACC, FixationStop3.ACC
```

```
        c.SetAttrib FixationStop3.Name & ebDot & ebLogNameRT, FixationStop3.RT
        c.SetAttrib FixationStop3.Name & ebDot & ebLogNameRESP, FixationStop3.RESP
        c.SetAttrib FixationStop3.Name & ebDot & ebLogNameCRESP, FixationStop3.CRESP
        c.SetAttrib FixationStop3.Name & ebDot & ebLogNameOnsetToOnsetTime, FixationStop3.OnsetToOnsetTime

        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameOnsetDelay, SoundOut6.OnsetDelay
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameOnsetTime, SoundOut6.OnsetTime
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameDurationError, SoundOut6.DurationError
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameRTTime, SoundOut6.RTTime
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameACC, SoundOut6.ACC
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameRT, SoundOut6.RT
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameRESP, SoundOut6.RESP
        c.SetAttrib SoundOut6.Name & ebDot & ebLogNameCRESP, SoundOut6.CRESP

        c.SetAttrib SSD1.Name & ebDot & ebLogNameOnsetDelay, SSD1.OnsetDelay
        c.SetAttrib SSD1.Name & ebDot & ebLogNameOnsetTime, SSD1.OnsetTime
        c.SetAttrib SSD1.Name & ebDot & ebLogNameDurationError, SSD1.DurationError
        c.SetAttrib SSD1.Name & ebDot & ebLogNameRTTime, SSD1.RTTime
        c.SetAttrib SSD1.Name & ebDot & ebLogNameACC, SSD1.ACC
        c.SetAttrib SSD1.Name & ebDot & ebLogNameRT, SSD1.RT
        c.SetAttrib SSD1.Name & ebDot & ebLogNameRESP, SSD1.RESP
        c.SetAttrib SSD1.Name & ebDot & ebLogNameCRESP, SSD1.CRESP
        c.SetAttrib SSD1.Name & ebDot & ebLogNameOnsetToOnsetTime, SSD1.OnsetToOnsetTime

        c.SetAttrib Figure4.Name & ebDot & ebLogNameOnsetDelay, Figure4.OnsetDelay
        c.SetAttrib Figure4.Name & ebDot & ebLogNameOnsetTime, Figure4.OnsetTime
        c.SetAttrib Figure4.Name & ebDot & ebLogNameDurationError, Figure4.DurationError
        c.SetAttrib Figure4.Name & ebDot & ebLogNameRTTime, Figure4.RTTime
        c.SetAttrib Figure4.Name & ebDot & ebLogNameACC, Figure4.ACC
        c.SetAttrib Figure4.Name & ebDot & ebLogNameRT, Figure4.RT
        c.SetAttrib Figure4.Name & ebDot & ebLogNameRESP, Figure4.RESP
        c.SetAttrib Figure4.Name & ebDot & ebLogNameCRESP, Figure4.CRESP
        c.SetAttrib Figure4.Name & ebDot & ebLogNameOnsetToOnsetTime, Figure4.OnsetToOnsetTime


        c.Log

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Finish BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Finish:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_FinishResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_FinishResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Finish END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

End Sub


Sub Run3_Run(c As Context)

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Start BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Start:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_StartResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_StartResume:

        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Start END
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

                Descanso.ResetLoggingProperties
                GetReady2.ResetLoggingProperties



        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
        '       Label - Procedure_Timeline_Start BEGIN
        ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Start:
        If Err.Number = ebInputAccepted Then
                Err.Clear
                Resume Procedure_Timeline_StartResume
        ElseIf Err.Number <> 0 Then
                'NOTE: If you receive a runtime error here, it
                ' is because a runtime error other than ebInputAccepted
                ' was thrown (ebInputAccepted for catching input masks that jump).
                'You are encouraged to either handle the error so that
                ' it is not thrown in the future or will have to set up
                ' your own error handler, which will also need to take
                ' into account for any input masks that jump.
                '
                'Raise the error so the default error handler will show the message
                Err.Raise Err.Number, Err.Source, Err.Description
        End If

Procedure_Timeline_StartResume:
```

```
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Timeline_Start END
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''



		Descanso.InputMasks.Reset

		If Keyboard.GetState() = ebStateOpen Then
			DescansoEchoClients.RemoveAll
			Descanso.InputMasks.Add Keyboard.CreateInputMask(ebLCase_m, ebEmptyText, CLng(Descanso.Duration), CLng(ebDigit_1), 
ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes 
ResponseMode:All ProcessBackspace:Yes")


		End If

		Descanso.Run
		c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetDelay, Descanso.OnsetDelay
		c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetTime, Descanso.OnsetTime
		c.SetAttrib Descanso.Name & ebDot & ebLogNameDurationError, Descanso.DurationError
		c.SetAttrib Descanso.Name & ebDot & ebLogNameRTTime, Descanso.RTTime
		c.SetAttrib Descanso.Name & ebDot & ebLogNameACC, Descanso.ACC
		c.SetAttrib Descanso.Name & ebDot & ebLogNameRT, Descanso.RT
		c.SetAttrib Descanso.Name & ebDot & ebLogNameRESP, Descanso.RESP
		c.SetAttrib Descanso.Name & ebDot & ebLogNameCRESP, Descanso.CRESP
		c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetToOnsetTime, Descanso.OnsetToOnsetTime



		GetReady2.InputMasks.Reset

		If Keyboard.GetState() = ebStateOpen Then
			GetReady2EchoClients.RemoveAll
			GetReady2.InputMasks.Add Keyboard.CreateInputMask(ebLCase_s, ebEmptyText, CLng(GetReady2.Duration), CLng(ebDigit_1), 
ebEndResponseActionTerminate, CLogical(ebUCase_Y & ebLCase_e & ebLCase_s), ebEmptyText, ebEmptyText, "AutoResponseEnabled:Yes 
ResponseMode:All ProcessBackspace:Yes")


		End If

		GetReady2.Run
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetDelay, GetReady2.OnsetDelay
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetTime, GetReady2.OnsetTime
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameDurationError, GetReady2.DurationError
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameRTTime, GetReady2.RTTime
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameACC, GetReady2.ACC
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameRT, GetReady2.RT
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameRESP, GetReady2.RESP
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameCRESP, GetReady2.CRESP
		c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetToOnsetTime, GetReady2.OnsetToOnsetTime


		''''''''''''''''''''''''''''''''''''''''''''
		' InLine - IntVariables BEGIN <IntVariables>
		''''''''''''''''''''''''''''''''''''''''''''
		'Initialize variables
Set StopSignalTrial = New Summation
Set StopDelay = New Summation
Set StopAcc = New Summation


'c.SetAttrib "StopAcc", intStopAcc
'c.SetAttrib "StopDelay", intStopDelay

'Initialize Variables
intStopDelay_A = 250
intStopDelay_B = 350
intStopAcc = 1
intStopSignalTrial = 1

		''''''''''''''''''''''''''''''''''''''''''''
		' InLine - IntVariables END
		''''''''''''''''''''''''''''''''''''''''''''

			BlockProc3.Run c
		''''''''''''''''''''''''''''''''''''''''''''
		'End Of Procedure Clean-Up
		''''''''''''''''''''''''''''''''''''''''''''

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Timeline_Finish BEGIN
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Timeline_Finish:
		If Err.Number = ebInputAccepted Then
			Err.Clear
			Resume Procedure_Timeline_FinishResume
		ElseIf Err.Number <> 0 Then
			'NOTE: If you receive a runtime error here, it
			' is because a runtime error other than ebInputAccepted
			' was thrown (ebInputAccepted for catching input masks that jump).
			'You are encouraged to either handle the error so that
			' it is not thrown in the future or will have to set up
			' your own error handler, which will also need to take
			' into account for any input masks that jump.
			'
			'Raise the error so the default error handler will show the message
			Err.Raise Err.Number, Err.Source, Err.Description
		End If

Procedure_Timeline_FinishResume:

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		'	Label - Procedure_Timeline_Finish END
		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

		''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
		' We are processing any pending input masks.
		' To prevent this code from being generated, set the Procedure object's
		'.ProcessPendingInputMasks property to None.
		'

		' Enum through the items on the Procedure and
		'  and determine if they are RteRunnableInputObject
		Run3_theCollection.RemoveAll
		For Run3_nObject = 1 To Run3.ChildObjectCount
			Set Run3_theInputObject = CRteRunnableInputObject(Rte.GetObject(Run3.GetChildObjectName(Run3_nObject)))
			If Not Run3_theInputObject Is Nothing Then Run3_theCollection.Add Run3_theInputObject
		Next

		' Loop until a condition allows us to complete this Procedure
```

```
Do
	'Any requests for termination?
	If GetTerminateMode() = ebTerminate Then
		SetTerminateMode ebTerminateNone
		SetNextTargetOnsetTime Clock.Read
		Exit Do
	ElseIf GetTerminateMode() = ebTerminateJump Then
		SetTerminateMode ebTerminateNone
		SetNextTargetOnsetTime Clock.Read
		Err.Raise ebInputAccepted
	End If

	' Any input mask on this procedure have pending input masks?
	Run3_bCanExit = True
	For Run3_nObject = 1 To Run3_theCollection.Count
		Set Run3_theInputObject = CRteRunnableInputObject(Run3_theCollection(Run3_nObject))
		If Not Run3_theInputObject Is Nothing Then
			If Run3_theInputObject.InputMasks.IsPending() Then
				Run3_bCanExit = False
				Exit For
			End If
		End If
	Next

	' No input masks
	If Run3_bCanExit Then Exit Do

	'Ready for the next object?
	If Clock.Read >= (GetNextTargetOnsetTime() - 1) Then
		Exit Do
	End If

	'Conditional Exit?
	If GetConditionalExitState() <> 0 Then
		Exit Do
	End If

	If GetNextTargetOnsetTime() - Clock.Read > 4 Then Sleep 4
	DoEvents
Loop

' Cleanup
Run3_theCollection.RemoveAll

'
''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Descanso.EndOfProcedure

GetReady2.EndOfProcedure

c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetDelay, Descanso.OnsetDelay
c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetTime, Descanso.OnsetTime
c.SetAttrib Descanso.Name & ebDot & ebLogNameDurationError, Descanso.DurationError
c.SetAttrib Descanso.Name & ebDot & ebLogNameRTTime, Descanso.RTTime
c.SetAttrib Descanso.Name & ebDot & ebLogNameACC, Descanso.ACC
c.SetAttrib Descanso.Name & ebDot & ebLogNameRT, Descanso.RT
c.SetAttrib Descanso.Name & ebDot & ebLogNameRESP, Descanso.RESP
c.SetAttrib Descanso.Name & ebDot & ebLogNameCRESP, Descanso.CRESP
c.SetAttrib Descanso.Name & ebDot & ebLogNameOnsetToOnsetTime, Descanso.OnsetToOnsetTime

c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetDelay, GetReady2.OnsetDelay
c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetTime, GetReady2.OnsetTime
c.SetAttrib GetReady2.Name & ebDot & ebLogNameDurationError, GetReady2.DurationError
c.SetAttrib GetReady2.Name & ebDot & ebLogNameRTTime, GetReady2.RTTime
c.SetAttrib GetReady2.Name & ebDot & ebLogNameACC, GetReady2.ACC
c.SetAttrib GetReady2.Name & ebDot & ebLogNameRT, GetReady2.RT
c.SetAttrib GetReady2.Name & ebDot & ebLogNameRESP, GetReady2.RESP
c.SetAttrib GetReady2.Name & ebDot & ebLogNameCRESP, GetReady2.CRESP
c.SetAttrib GetReady2.Name & ebDot & ebLogNameOnsetToOnsetTime, GetReady2.OnsetToOnsetTime


c.Log

''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
'	Label - Procedure_Finish BEGIN
''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Procedure_Finish:
	If Err.Number = ebInputAccepted Then
		Err.Clear
		Resume Procedure_FinishResume
	ElseIf Err.Number <> 0 Then
		'NOTE: If you receive a runtime error here, it
		' is because a runtime error other than ebInputAccepted
		' was thrown (ebInputAccepted for catching input masks that jump).
		'You are encouraged to either handle the error so that
		' it is not thrown in the future or will have to set up
		' your own error handler, which will also need to take
		' into account for any input masks that jump.
		'
		'Raise the error so the default error handler will show the message
		Err.Raise Err.Number, Err.Source, Err.Description
	End If

Procedure_FinishResume:

	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
	'	Label - Procedure_Finish END
	''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

End Sub


'--------------------------------------------------------------------------
' InitDevices
'
'--------------------------------------------------------------------------
Sub InitDevices(c As Context)


	Set Display = New DisplayDevice
	Display.Name = ebUCase_D & ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y

	Dim DisplayDisplayDeviceInfo As DisplayDeviceInfo
	DisplayDisplayDeviceInfo.XRes = 1920
	DisplayDisplayDeviceInfo.YRes = 1080
	DisplayDisplayDeviceInfo.ColorDepth = 32
	DisplayDisplayDeviceInfo.DisplayIndex = 1
	DisplayDisplayDeviceInfo.UseDesktopSettings = True
	DisplayDisplayDeviceInfo.DefaultColor = Color.White
	DisplayDisplayDeviceInfo.RefreshRateRequested = 0
```

```
        DisplayDisplayDeviceInfo.NumPages = 0

        'Load values from context if they exist
        If c.AttribExists(Display.Name & ebDot & ebUCase_X & ebUCase_R & ebLCase_e & ebLCase_s) Then DisplayDisplayDeviceInfo.XRes =
CLng(c.GetAttrib(Display.Name & ebDot & ebUCase_X & ebUCase_R & ebLCase_e & ebLCase_s))
        If c.AttribExists(Display.Name & ebDot & ebUCase_Y & ebUCase_R & ebLCase_e & ebLCase_s) Then DisplayDisplayDeviceInfo.YRes =
CLng(c.GetAttrib(Display.Name & ebDot & ebUCase_Y & ebUCase_R & ebLCase_e & ebLCase_s))
        If c.AttribExists(Display.Name & ebDot & ebUCase_C & ebLCase_o & ebLCase_l & ebLCase_o & ebLCase_r & ebUCase_D & ebLCase_e & ebLCase_p
& ebLCase_t & ebLCase_h) Then DisplayDisplayDeviceInfo.ColorDepth = CLng(c.GetAttrib(Display.Name & ebDot & ebUCase_C & ebLCase_o & ebLCase_l
& ebLCase_o & ebLCase_r & ebUCase_D & ebLCase_e & ebLCase_p & ebLCase_t & ebLCase_h))
        If c.AttribExists(Display.Name & ebDot & ebUCase_D & ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebUCase_I
& ebLCase_n & ebLCase_d & ebLCase_e & ebLCase_x) Then DisplayDisplayDeviceInfo.DisplayIndex = CLng(c.GetAttrib(Display.Name & ebDot &
ebUCase_D & ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebUCase_I & ebLCase_n & ebLCase_d & ebLCase_e &
ebLCase_x))
        If c.AttribExists(Display.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_f & ebLCase_a & ebLCase_u & ebLCase_l & ebLCase_t & ebUCase_C
& ebLCase_o & ebLCase_l & ebLCase_o & ebLCase_r) Then DisplayDisplayDeviceInfo.DefaultColor = CColor(c.GetAttrib(Display.Name & ebDot &
ebUCase_D & ebLCase_e & ebLCase_f & ebLCase_a & ebLCase_u & ebLCase_l & ebLCase_t & ebUCase_C & ebLCase_o & ebLCase_l & ebLCase_o &
ebLCase_r))
        If c.AttribExists(Display.Name & ebDot & ebUCase_R & ebLCase_e & ebLCase_f & ebLCase_r & ebLCase_e & ebLCase_s & ebLCase_h & ebUCase_R
& ebLCase_a & ebLCase_t & ebLCase_e & ebUCase_R & ebLCase_e & ebLCase_q & ebLCase_u & ebLCase_e & ebLCase_s & ebLCase_t & ebLCase_e &
ebLCase_d) Then DisplayDisplayDeviceInfo.RefreshRateRequested = CLng(c.GetAttrib(Display.Name & ebDot & ebUCase_R & ebLCase_e & ebLCase_f &
ebLCase_r & ebLCase_e & ebLCase_s & ebLCase_h & ebUCase_R & ebLCase_a & ebLCase_t & ebLCase_e & ebUCase_R & ebLCase_e & ebLCase_q & ebLCase_u
& ebLCase_e & ebLCase_s & ebLCase_t & ebLCase_e & ebLCase_d))
        If c.AttribExists(Display.Name & ebDot & ebUCase_N & ebLCase_u & ebLCase_m & ebUCase_P & ebLCase_a & ebLCase_g & ebLCase_e &
ebLCase_s) Then DisplayDisplayDeviceInfo.NumPages = CLng(c.GetAttrib(Display.Name & ebDot & ebUCase_N & ebLCase_u & ebLCase_m & ebUCase_P &
ebLCase_a & ebLCase_g & ebLCase_e & ebLCase_s))
        If c.AttribExists(Display.Name & ebDot & ebUCase_U & ebLCase_s & ebLCase_e & ebUCase_D & ebLCase_e & ebLCase_s & ebLCase_k & ebLCase_t
& ebLCase_o & ebLCase_p & ebUCase_S & ebLCase_e & ebLCase_t & ebLCase_t & ebLCase_i & ebLCase_n & ebLCase_g & ebLCase_s) Then
DisplayDisplayDeviceInfo.UseDesktopSettings = CLogical(c.GetAttrib(Display.Name & ebDot & ebUCase_U & ebLCase_s & ebLCase_e & ebUCase_D &
ebLCase_e & ebLCase_s & ebLCase_k & ebLCase_t & ebLCase_o & ebLCase_p & ebUCase_S & ebLCase_e & ebLCase_t & ebLCase_t & ebLCase_i & ebLCase_n
& ebLCase_g & ebLCase_s))

        'Open the device, unless the context values indicate otherwise
        Dim DisplayOpen As Boolean
        DisplayOpen = True
        If c.AttribExists(Display.Name & ebDot & ebUCase_O & ebLCase_p & ebLCase_e & ebLCase_n) Then DisplayOpen =
CLogical(c.GetAttrib(Display.Name & ebDot & ebUCase_O & ebLCase_p & ebLCase_e & ebLCase_n))
        If DisplayOpen = True Then
                Display.Open DisplayDisplayDeviceInfo
                Display.RefreshAlignment = ebDigit_0 & ebPercent
                If c.AttribExists(Display.Name & ebDot & ebUCase_R & ebLCase_e & ebLCase_f & ebLCase_r & ebLCase_e & ebLCase_s & ebLCase_h &
ebUCase_A & ebLCase_l & ebLCase_i & ebLCase_g & ebLCase_n & ebLCase_m & ebLCase_e & ebLCase_n & ebLCase_t) Then Display.RefreshAlignment =
c.GetAttrib(Display.Name & ebDot & ebUCase_R & ebLCase_e & ebLCase_f & ebLCase_r & ebLCase_e & ebLCase_s & ebLCase_h & ebUCase_A & ebLCase_l
& ebLCase_i & ebLCase_g & ebLCase_n & ebLCase_m & ebLCase_e & ebLCase_n & ebLCase_t)
        End If

        'Enable flipping, if requested
        If c.AttribExists(Display.Name & ebDot & ebUCase_F & ebLCase_l & ebLCase_i & ebLCase_p & ebLCase_p & ebLCase_i & ebLCase_n & ebLCase_g
& ebUCase_E & ebLCase_n & ebLCase_a & ebLCase_b & ebLCase_l & ebLCase_e & ebLCase_d) Then
                Display.FlippingEnabled = CLogical(c.GetAttrib(Display.Name & ebDot & ebUCase_F & ebLCase_l & ebLCase_i & ebLCase_p & ebLCase_p
& ebLCase_i & ebLCase_n & ebLCase_g & ebUCase_E & ebLCase_n & ebLCase_a & ebLCase_b & ebLCase_l & ebLCase_e & ebLCase_d))
        Else
                Display.FlippingEnabled = False
        End If

        Set Sound = New SoundDevice
        Sound.Name = ebUCase_S & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d

        Dim SoundSoundDeviceInfo As SoundDeviceInfo
        SoundSoundDeviceInfo.API = ebSoundApiDirectSound
        SoundSoundDeviceInfo.DeviceIndex = 1
        SoundSoundDeviceInfo.Channels = 0
        SoundSoundDeviceInfo.SamplesPerSecond = 0
        SoundSoundDeviceInfo.BitsPerSample = 0
        SoundSoundDeviceInfo.DeviceReserved1 = 0
        SoundSoundDeviceInfo.DeviceReserved2 = 0
        SoundSoundDeviceInfo.DeviceReserved3 = 0
        SoundSoundDeviceInfo.DeviceReserved4 = 0
        SoundSoundDeviceInfo.DeviceReservedA = ebEmptyText
        SoundSoundDeviceInfo.DeviceReservedB = ebEmptyText
        SoundSoundDeviceInfo.DeviceReservedC = ebEmptyText
        SoundSoundDeviceInfo.DeviceReservedD = ebEmptyText

        'Load values from context if they exist
        If c.AttribExists(Sound.Name & ebDot & ebUCase_A & ebUCase_P & ebUCase_I) Then SoundSoundDeviceInfo.API = c.GetAttrib(Sound.Name &
ebDot & ebUCase_A & ebUCase_P & ebUCase_I)
        If c.AttribExists(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_I & ebLCase_n &
ebLCase_d & ebLCase_e & ebLCase_x) Then SoundSoundDeviceInfo.DeviceIndex = CLng(c.GetAttrib(Sound.Name & ebDot & ebUCase_D & ebLCase_e &
ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_I & ebLCase_n & ebLCase_d & ebLCase_e & ebLCase_x))
        If c.AttribExists(Sound.Name & ebDot & ebUCase_C & ebLCase_h & ebLCase_a & ebLCase_n & ebLCase_n & ebLCase_e & ebLCase_l & ebLCase_s)
Then SoundSoundDeviceInfo.Channels = CLng(c.GetAttrib(Sound.Name & ebDot & ebUCase_C & ebLCase_h & ebLCase_a & ebLCase_n & ebLCase_n &
ebLCase_e & ebLCase_l & ebLCase_s))
        If c.AttribExists(Sound.Name & ebDot & ebUCase_S & ebLCase_a & ebLCase_m & ebLCase_p & ebLCase_l & ebLCase_e & ebLCase_s & ebUCase_P &
ebLCase_e & ebLCase_r & ebUCase_S & ebLCase_e & ebLCase_c & ebLCase_o & ebLCase_n & ebLCase_d) Then SoundSoundDeviceInfo.SamplesPerSecond =
CLng(c.GetAttrib(Sound.Name & ebDot & ebUCase_S & ebLCase_a & ebLCase_m & ebLCase_p & ebLCase_l & ebLCase_e & ebLCase_s & ebUCase_P &
ebLCase_e & ebLCase_r & ebUCase_S & ebLCase_e & ebLCase_c & ebLCase_o & ebLCase_n & ebLCase_d))
        If c.AttribExists(Sound.Name & ebDot & ebUCase_B & ebLCase_i & ebLCase_t & ebLCase_s & ebUCase_P & ebLCase_e & ebLCase_r & ebUCase_S &
ebLCase_a & ebLCase_m & ebLCase_p & ebLCase_l & ebLCase_e) Then SoundSoundDeviceInfo.BitsPerSample = CLng(c.GetAttrib(Sound.Name & ebDot &
ebUCase_B & ebLCase_i & ebLCase_t & ebLCase_s & ebUCase_P & ebLCase_e & ebLCase_r & ebUCase_S & ebLCase_a & ebLCase_m & ebLCase_p & ebLCase_l
& ebLCase_e))
        If c.AttribExists(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebDigit_1) Then SoundSoundDeviceInfo.DeviceReserved1 =
CLng(c.GetAttrib(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebDigit_1))
        If c.AttribExists(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebDigit_2) Then SoundSoundDeviceInfo.DeviceReserved2 =
CLng(c.GetAttrib(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebDigit_2))
        If c.AttribExists(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebDigit_3) Then SoundSoundDeviceInfo.DeviceReserved3 =
CLng(c.GetAttrib(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebDigit_3))
        If c.AttribExists(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebDigit_4) Then SoundSoundDeviceInfo.DeviceReserved4 =
CLng(c.GetAttrib(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebDigit_4))
        If c.AttribExists(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebUCase_A) Then SoundSoundDeviceInfo.DeviceReservedA =
c.GetAttrib(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebUCase_A)
        If c.AttribExists(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebUCase_B) Then SoundSoundDeviceInfo.DeviceReservedB =
c.GetAttrib(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebUCase_B)
        If c.AttribExists(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebUCase_C) Then SoundSoundDeviceInfo.DeviceReservedC =
c.GetAttrib(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebUCase_C)
        If c.AttribExists(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e &
ebLCase_s & ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebUCase_D) Then SoundSoundDeviceInfo.DeviceReservedD =
c.GetAttrib(Sound.Name & ebDot & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_e & ebLCase_r & ebLCase_v & ebLCase_e & ebLCase_d & ebUCase_D)
```

```
        'Open the device, unless the context values indicate otherwise
        Dim SoundOpen As Boolean
        SoundOpen = True
        If c.AttribExists(Sound.Name & ebDot & ebUCase_O & ebLCase_p & ebLCase_e & ebLCase_n) Then SoundOpen = CLogical(c.GetAttrib(Sound.Name
& ebDot & ebUCase_O & ebLCase_p & ebLCase_e & ebLCase_n))
        If SoundOpen = True Then
                Sound.Open SoundSoundDeviceInfo
        End If

        Set Keyboard = New KeyboardDevice
        Keyboard.Name = ebUCase_K & ebLCase_e & ebLCase_y & ebLCase_b & ebLCase_o & ebLCase_a & ebLCase_r & ebLCase_d


        Dim KeyboardKeyboardDeviceInfo As KeyboardDeviceInfo
        KeyboardKeyboardDeviceInfo.CollectionMode = ebPressesOnly
        KeyboardKeyboardDeviceInfo.CapsLock = ebCapsLockOff
        KeyboardKeyboardDeviceInfo.NumLock = ebNumLockOn
        'Load values from context if they exist
        If c.AttribExists(Keyboard.Name & ebDot & ebUCase_C & ebLCase_o & ebLCase_l & ebLCase_l & ebLCase_e & ebLCase_c & ebLCase_t &
ebLCase_i & ebLCase_o & ebLCase_n & ebUCase_M & ebLCase_o & ebLCase_d & ebLCase_e) Then KeyboardKeyboardDeviceInfo.CollectionMode =
CLng(c.GetAttrib(Keyboard.Name & ebDot & ebUCase_C & ebLCase_o & ebLCase_l & ebLCase_l & ebLCase_e & ebLCase_c & ebLCase_t & ebLCase_i &
ebLCase_o & ebLCase_n & ebUCase_M & ebLCase_o & ebLCase_d & ebLCase_e))
        If c.AttribExists(Keyboard.Name & ebDot & ebUCase_C & ebLCase_a & ebLCase_p & ebLCase_s & ebUCase_L & ebLCase_o & ebLCase_c &
ebLCase_k) Then KeyboardKeyboardDeviceInfo.CapsLock = CLng(c.GetAttrib(Keyboard.Name & ebDot & ebUCase_C & ebLCase_a & ebLCase_p & ebLCase_s
& ebUCase_L & ebLCase_o & ebLCase_c & ebLCase_k))
        If c.AttribExists(Keyboard.Name & ebDot & ebUCase_N & ebLCase_u & ebLCase_m & ebUCase_L & ebLCase_o & ebLCase_c & ebLCase_k) Then
KeyboardKeyboardDeviceInfo.NumLock = CLng(c.GetAttrib(Keyboard.Name & ebDot & ebUCase_N & ebLCase_u & ebLCase_m & ebUCase_L & ebLCase_o &
ebLCase_c & ebLCase_k))
        If c.AttribExists(Keyboard.Name & ebDot & ebUCase_E & ebLCase_m & ebLCase_u & ebLCase_l & ebLCase_a & ebLCase_t & ebLCase_e &
ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_N & ebLCase_a & ebLCase_m & ebLCase_e) Then
KeyboardKeyboardDeviceInfo.EmulateDeviceName = c.GetAttrib(Keyboard.Name & ebDot & ebUCase_E & ebLCase_m & ebLCase_u & ebLCase_l & ebLCase_a
& ebLCase_t & ebLCase_e & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_N & ebLCase_a & ebLCase_m &
ebLCase_e)

        'Open the device, unless the context values indicate otherwise
        Dim KeyboardOpen As Boolean
        KeyboardOpen = True
        If c.AttribExists(Keyboard.Name & ebDot & ebUCase_O & ebLCase_p & ebLCase_e & ebLCase_n) Then KeyboardOpen =
CLogical(c.GetAttrib(Keyboard.Name & ebDot & ebUCase_O & ebLCase_p & ebLCase_e & ebLCase_n))
        If KeyboardOpen = True Then
                Keyboard.Open KeyboardKeyboardDeviceInfo

                Keyboard.AutoResponseEnabled = True
                Keyboard.AutoResponseTimeLimitLowerBound = ebDigit_2 & ebDigit_5 & ebPercent
                Keyboard.AutoResponseTimeLimitUpperBound = ebDigit_7 & ebDigit_5 & ebPercent
                Keyboard.AutoResponseTimeLimitWhenInfinite = 1000
                Keyboard.AutoResponseCorrectProbability = ebDigit_8 & ebDigit_0 & ebPercent
                Keyboard.AutoResponseAllowableOverride = ebEmptyText
                Keyboard.AutoResponseMaxCountLowerBound = ebDigit_2 & ebDigit_5 & ebPercent
                Keyboard.AutoResponseMaxCountUpperBound = ebDigit_7 & ebDigit_5 & ebPercent
                Keyboard.AutoResponseDelayBetweenResponses = 30
                If c.AttribExists(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_E & ebLCase_n & ebLCase_a & ebLCase_b & ebLCase_l & ebLCase_e &
ebLCase_d) Then Keyboard.AutoResponseEnabled = CLogical(c.GetAttrib(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o &
ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_E & ebLCase_n & ebLCase_a & ebLCase_b
& ebLCase_l & ebLCase_e & ebLCase_d))
                If c.AttribExists(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_T & ebLCase_i & ebLCase_m & ebLCase_e & ebUCase_L & ebLCase_i & ebLCase_m
& ebLCase_i & ebLCase_t & ebUCase_L & ebLCase_o & ebLCase_w & ebLCase_e & ebLCase_r & ebUCase_B & ebLCase_o & ebLCase_u & ebLCase_n &
ebLCase_d) Then Keyboard.AutoResponseTimeLimitLowerBound = c.GetAttrib(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o
& ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_T & ebLCase_i & ebLCase_m &
ebLCase_e & ebUCase_L & ebLCase_i & ebLCase_m & ebLCase_i & ebLCase_t & ebUCase_L & ebLCase_o & ebLCase_w & ebLCase_e & ebLCase_r & ebUCase_B
& ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d)
                If c.AttribExists(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_T & ebLCase_i & ebLCase_m & ebLCase_e & ebUCase_L & ebLCase_i & ebLCase_m
& ebLCase_i & ebLCase_t & ebUCase_U & ebLCase_p & ebLCase_p & ebLCase_e & ebLCase_r & ebUCase_B & ebLCase_o & ebLCase_u & ebLCase_n &
ebLCase_d) Then Keyboard.AutoResponseTimeLimitUpperBound = c.GetAttrib(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o
& ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_T & ebLCase_i & ebLCase_m &
ebLCase_e & ebUCase_L & ebLCase_i & ebLCase_m & ebLCase_i & ebLCase_t & ebUCase_U & ebLCase_p & ebLCase_p & ebLCase_e & ebLCase_r & ebUCase_B
& ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d)
                If c.AttribExists(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_T & ebLCase_i & ebLCase_m & ebLCase_e & ebUCase_L & ebLCase_i & ebLCase_m
& ebLCase_i & ebLCase_t & ebUCase_W & ebLCase_h & ebLCase_e & ebLCase_n & ebUCase_I & ebLCase_n & ebLCase_f & ebLCase_i & ebLCase_n &
ebLCase_i & ebLCase_t & ebLCase_e) Then Keyboard.AutoResponseTimeLimitWhenInfinite = CLng(c.GetAttrib(Keyboard.Name & ebDot & ebUCase_A &
ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_T
& ebLCase_i & ebLCase_m & ebLCase_e & ebUCase_L & ebLCase_i & ebLCase_m & ebLCase_i & ebLCase_t & ebUCase_W & ebLCase_h & ebLCase_e &
ebLCase_n & ebUCase_I & ebLCase_n & ebLCase_f & ebLCase_i & ebLCase_n & ebLCase_i & ebLCase_t & ebLCase_e))
                If c.AttribExists(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_C & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_t
& ebUCase_P & ebLCase_r & ebLCase_o & ebLCase_b & ebLCase_a & ebLCase_b & ebLCase_i & ebLCase_l & ebLCase_i & ebLCase_t & ebLCase_y) Then
Keyboard.AutoResponseCorrectProbability = c.GetAttrib(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R &
ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_C & ebLCase_o & ebLCase_r & ebLCase_r & ebLCase_e
& ebLCase_c & ebLCase_t & ebUCase_P & ebLCase_r & ebLCase_o & ebLCase_b & ebLCase_a & ebLCase_b & ebLCase_i & ebLCase_l & ebLCase_i &
ebLCase_t & ebLCase_y)
                If c.AttribExists(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_A & ebLCase_l & ebLCase_l & ebLCase_o & ebLCase_w & ebLCase_a & ebLCase_b
& ebLCase_l & ebLCase_e & ebUCase_O & ebLCase_v & ebLCase_e & ebLCase_r & ebLCase_r & ebLCase_i & ebLCase_d & ebLCase_e) Then
Keyboard.AutoResponseAllowableOverride = c.GetAttrib(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R &
ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_A & ebLCase_l & ebLCase_l & ebLCase_o & ebLCase_w
& ebLCase_a & ebLCase_b & ebLCase_l & ebLCase_e & ebUCase_O & ebLCase_v & ebLCase_e & ebLCase_r & ebLCase_r & ebLCase_i & ebLCase_d &
ebLCase_e)
                If c.AttribExists(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_M & ebLCase_a & ebLCase_x & ebUCase_C & ebLCase_o & ebLCase_u & ebLCase_n
& ebLCase_t & ebUCase_L & ebLCase_o & ebLCase_w & ebLCase_e & ebLCase_r & ebUCase_B & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d) Then
Keyboard.AutoResponseMaxCountLowerBound = c.GetAttrib(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R &
ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_M & ebLCase_a & ebLCase_x & ebUCase_C & ebLCase_o
& ebLCase_u & ebLCase_n & ebLCase_t & ebUCase_L & ebLCase_o & ebLCase_w & ebLCase_e & ebLCase_r & ebUCase_B & ebLCase_o & ebLCase_u &
ebLCase_n & ebLCase_d)
                If c.AttribExists(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_M & ebLCase_a & ebLCase_x & ebUCase_C & ebLCase_o & ebLCase_u & ebLCase_n
& ebLCase_t & ebUCase_U & ebLCase_p & ebLCase_p & ebLCase_e & ebLCase_r & ebUCase_B & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d) Then
Keyboard.AutoResponseMaxCountUpperBound = c.GetAttrib(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R &
ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_M & ebLCase_a & ebLCase_x & ebUCase_C & ebLCase_o
& ebLCase_u & ebLCase_n & ebLCase_t & ebUCase_U & ebLCase_p & ebLCase_p & ebLCase_e & ebLCase_r & ebUCase_B & ebLCase_o & ebLCase_u &
ebLCase_n & ebLCase_d)
                If c.AttribExists(Keyboard.Name & ebDot & ebUCase_A & ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R & ebLCase_e & ebLCase_s &
ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_D & ebLCase_e & ebLCase_l & ebLCase_a & ebLCase_y & ebUCase_B & ebLCase_e
& ebLCase_t & ebLCase_w & ebLCase_e & ebLCase_e & ebLCase_n & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n &
ebLCase_s & ebLCase_e & ebLCase_s) Then Keyboard.AutoResponseDelayBetweenResponses = CLng(c.GetAttrib(Keyboard.Name & ebDot & ebUCase_A &
ebLCase_u & ebLCase_t & ebLCase_o & ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebUCase_D
& ebLCase_e & ebLCase_l & ebLCase_a & ebLCase_y & ebUCase_B & ebLCase_e & ebLCase_t & ebLCase_w & ebLCase_e & ebLCase_e & ebLCase_n &
ebUCase_R & ebLCase_e & ebLCase_s & ebLCase_p & ebLCase_o & ebLCase_n & ebLCase_s & ebLCase_e & ebLCase_s))

        End If

        Set Mouse = New MouseDevice
        Mouse.Name = ebUCase_M & ebLCase_o & ebLCase_u & ebLCase_s & ebLCase_e


        Dim MouseMouseDeviceInfo As MouseDeviceInfo
        MouseMouseDeviceInfo.OpenMode = ebMouseOpenModeDirect
        MouseMouseDeviceInfo.CollectionMode = ebPressesOnly
        MouseMouseDeviceInfo.ShowCursor = False
```

```
        'Load values from context if they exist
        If c.AttribExists(Mouse.Name & ebDot & ebUCase_O & ebLCase_p & ebLCase_e & ebLCase_n & ebUCase_M & ebLCase_o & ebLCase_d & ebLCase_e)
Then MouseMouseDeviceInfo.OpenMode = CLng(c.GetAttrib(Mouse.Name & ebDot & ebUCase_O & ebLCase_p & ebLCase_e & ebLCase_n & ebUCase_M &
ebLCase_o & ebLCase_d & ebLCase_e))
        If c.AttribExists(Mouse.Name & ebDot & ebUCase_C & ebLCase_o & ebLCase_l & ebLCase_l & ebLCase_e & ebLCase_c & ebLCase_t & ebLCase_i &
ebLCase_o & ebLCase_n & ebUCase_M & ebLCase_o & ebLCase_d & ebLCase_e) Then MouseMouseDeviceInfo.CollectionMode = CLng(c.GetAttrib(Mouse.Name
& ebDot & ebUCase_C & ebLCase_o & ebLCase_l & ebLCase_l & ebLCase_e & ebLCase_c & ebLCase_t & ebLCase_i & ebLCase_o & ebLCase_n & ebUCase_M &
ebLCase_o & ebLCase_d & ebLCase_e))
        If c.AttribExists(Mouse.Name & ebDot & ebUCase_S & ebLCase_h & ebLCase_o & ebLCase_w & ebUCase_C & ebLCase_u & ebLCase_r & ebLCase_s &
ebLCase_o & ebLCase_r) Then MouseMouseDeviceInfo.ShowCursor = CLng(c.GetAttrib(Mouse.Name & ebDot & ebUCase_S & ebLCase_h & ebLCase_o &
ebLCase_w & ebUCase_C & ebLCase_u & ebLCase_r & ebLCase_s & ebLCase_o & ebLCase_r))
        If c.AttribExists(Mouse.Name & ebDot & ebUCase_E & ebLCase_m & ebLCase_u & ebLCase_l & ebLCase_a & ebLCase_t & ebLCase_e & ebUCase_D &
ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_N & ebLCase_a & ebLCase_m & ebLCase_e) Then
MouseMouseDeviceInfo.EmulateDeviceName = c.GetAttrib(Mouse.Name & ebDot & ebUCase_E & ebLCase_m & ebLCase_u & ebLCase_l & ebLCase_a &
ebLCase_t & ebLCase_e & ebUCase_D & ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebUCase_N & ebLCase_a & ebLCase_m &
ebLCase_e)

        'Open the device, unless the context values indicate otherwise
        Dim MouseOpen As Boolean
        MouseOpen = True
        If c.AttribExists(Mouse.Name & ebDot & ebUCase_O & ebLCase_p & ebLCase_e & ebLCase_n) Then MouseOpen = CLogical(c.GetAttrib(Mouse.Name
& ebDot & ebUCase_O & ebLCase_p & ebLCase_e & ebLCase_n))
        If MouseOpen = True Then
                Mouse.Open MouseMouseDeviceInfo
        End If

        'Init All Devices
        Rte.DeviceManager.Init

        ' Log DisplayDevice(s) Refresh Rates
        If DisplayOpen = True Then
                c.SetAttrib Display.Name & ebDot & ebUCase_R & ebLCase_e & ebLCase_f & ebLCase_r & ebLCase_e & ebLCase_s & ebLCase_h &
ebUCase_R & ebLCase_a & ebLCase_t & ebLCase_e, Format$(Display.CalculatedRefreshRate, ebDigit_0 & ebDot & ebDigit_0 & ebDigit_0 & ebDigit_0)

                'Ensure that the refresh rate is acceptable
                If CLng(Display.CalculatedRefreshRate) = 0 Then
                        'WARNING: RefreshRate of 0 (Zero) Detected.  Experiment will assume 60hz to continue. Data collection should NOT be used
for time critical analysis.  Please ensure your display adapter is configured with the most recent and device specific driver.\n(Standard
Display Adapter under Windows Vista or later is not compatible)
                        Dim strDisplayError As String
                        strDisplayError = ebUCase_W & ebUCase_A & ebUCase_R & ebUCase_N & ebUCase_I & ebUCase_N & ebUCase_G & ebColon & ebSpace
& ebUCase_R & ebLCase_e & ebLCase_f & ebLCase_r & ebLCase_e & ebLCase_s & ebLCase_h & ebUCase_R & ebLCase_a & ebLCase_t & ebLCase_e & ebSpace
& ebLCase_o & ebLCase_f & ebSpace & ebDigit_0 & ebSpace & ebParenOpen & ebUCase_Z & ebLCase_e & ebLCase_r & ebLCase_o & ebParenClose &
ebSpace & ebUCase_D & ebLCase_e & ebLCase_t & ebLCase_e & ebLCase_c & ebLCase_t & ebLCase_e & ebLCase_d & ebDot & ebSpace & ebSpace &
ebUCase_E & ebLCase_x & ebLCase_p & ebLCase_e & ebLCase_r & ebLCase_i & ebLCase_m & ebLCase_e & ebLCase_n & ebLCase_t & ebSpace & ebLCase_w &
ebLCase_i & ebLCase_l & ebLCase_l & ebSpace & ebLCase_a & ebLCase_s & ebLCase_s & ebLCase_u & ebLCase_m & ebLCase_e & ebSpace & ebDigit_6 &
ebDigit_0 & ebLCase_h & ebLCase_z & ebSpace & ebLCase_t & ebLCase_o & ebSpace & ebLCase_c & ebLCase_o & ebLCase_n & ebLCase_t & ebLCase_i &
ebLCase_n & ebLCase_u & ebLCase_e & ebDot & ebSpace & ebUCase_D & ebLCase_a & ebLCase_t & ebLCase_a & ebSpace & ebLCase_c & ebLCase_o &
ebLCase_l & ebLCase_l & ebLCase_e & ebLCase_c & ebLCase_t & ebLCase_i & ebLCase_o & ebLCase_n & ebSpace & ebLCase_s & ebLCase_h & ebLCase_o &
ebLCase_u & ebLCase_l & ebLCase_d & ebSpace & ebUCase_N & ebUCase_O & ebUCase_T & ebSpace & ebLCase_b & ebLCase_e & ebSpace & ebLCase_u &
ebLCase_s & ebLCase_e & ebLCase_d & ebSpace & ebLCase_f & ebLCase_o & ebLCase_r & ebSpace & ebLCase_t & ebLCase_i & ebLCase_m & ebLCase_e &
ebSpace & ebLCase_c & ebLCase_r & ebLCase_i & ebLCase_t & ebLCase_i & ebLCase_c & ebLCase_a & ebLCase_l & ebSpace & ebLCase_a & ebLCase_n &
ebLCase_a & ebLCase_l & ebLCase_y & ebLCase_s & ebLCase_i & ebLCase_s & ebDot & ebSpace & ebSpace & ebUCase_P & ebLCase_l & ebLCase_e &
ebLCase_a & ebLCase_s & ebLCase_e & ebSpace & ebLCase_e & ebLCase_n & ebLCase_s & ebLCase_u & ebLCase_r & ebLCase_e & ebSpace & ebLCase_y &
ebLCase_o & ebLCase_u & ebLCase_r & ebSpace & ebLCase_d & ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebSpace &
ebLCase_a & ebLCase_d & ebLCase_a & ebLCase_p & ebLCase_t & ebLCase_e & ebLCase_r & ebSpace & ebLCase_i & ebLCase_s & ebSpace & ebLCase_c &
ebLCase_o & ebLCase_n & ebLCase_f & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e & ebLCase_d & ebSpace & ebLCase_w & ebLCase_i &
ebLCase_t & ebLCase_h & ebSpace & ebLCase_t & ebLCase_h & ebLCase_e & ebSpace & ebLCase_m & ebLCase_o & ebLCase_s & ebLCase_t & ebSpace &
ebLCase_r & ebLCase_e & ebLCase_c & ebLCase_e & ebLCase_n & ebLCase_t & ebSpace & ebLCase_a & ebLCase_n & ebLCase_d & ebSpace & ebLCase_d &
ebLCase_e & ebLCase_v & ebLCase_i & ebLCase_c & ebLCase_e & ebSpace & ebLCase_s & ebLCase_p & ebLCase_e & ebLCase_c & ebLCase_i & ebLCase_f &
ebLCase_i & ebLCase_c & ebSpace & ebLCase_d & ebLCase_r & ebLCase_i & ebLCase_v & ebLCase_e & ebLCase_r & ebDot & ebLf & ebParenOpen &
ebUCase_S & ebLCase_t & ebLCase_a & ebLCase_n & ebLCase_d & ebLCase_a & ebLCase_r & ebLCase_d & ebSpace & ebUCase_D & ebLCase_i & ebLCase_s &
ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebSpace & ebUCase_A & ebLCase_d & ebLCase_a & ebLCase_p & ebLCase_t & ebLCase_e & ebLCase_r &
ebSpace & ebLCase_u & ebLCase_n & ebLCase_d & ebLCase_e & ebLCase_r & ebSpace & ebUCase_W & ebLCase_i & ebLCase_n & ebLCase_d & ebLCase_o &
ebLCase_w & ebLCase_s & ebSpace & ebUCase_V & ebLCase_i & ebLCase_s & ebLCase_t & ebLCase_a & ebSpace & ebLCase_o & ebLCase_r & ebSpace &
ebLCase_l & ebLCase_a & ebLCase_t & ebLCase_e & ebLCase_r & ebSpace & ebLCase_i & ebLCase_s & ebSpace & ebLCase_n & ebLCase_o & ebLCase_t &
ebSpace & ebLCase_c & ebLCase_o & ebLCase_m & ebLCase_p & ebLCase_a & ebLCase_t & ebLCase_i & ebLCase_b & ebLCase_l & ebLCase_e &
ebParenClose
                        Debug.Print strDisplayError
                        c.SetAttrib ebUCase_A & ebUCase_W & ebLCase_a & ebLCase_r & ebLCase_n & ebLCase_i & ebLCase_n & ebLCase_g & ebUCase_R &
ebLCase_e & ebLCase_f & ebLCase_r & ebLCase_e & ebLCase_s & ebLCase_h & ebUCase_R & ebLCase_a & ebLCase_t & ebLCase_e, strDisplayError
                End If

                'Determine RefreshRate range
                Dim dblDisplayMinRefreshRate As Double
                Dim dblDisplayMaxRefreshRate As Double
                dblDisplayMinRefreshRate = 39
                dblDisplayMaxRefreshRate = 201
                If c.AttribExists(Display.Name & ebDot & ebUCase_M & ebLCase_i & ebLCase_n & ebUCase_R & ebLCase_e & ebLCase_f & ebLCase_r &
ebLCase_e & ebLCase_s & ebLCase_h & ebUCase_R & ebLCase_a & ebLCase_t & ebLCase_e) Then dblDisplayMinRefreshRate =
CDbl(c.GetAttrib(Display.Name & ebDot & ebUCase_M & ebLCase_i & ebLCase_n & ebUCase_R & ebLCase_e & ebLCase_f & ebLCase_r & ebLCase_e &
ebLCase_s & ebLCase_h & ebUCase_R & ebLCase_a & ebLCase_t & ebLCase_e))
                If c.AttribExists(Display.Name & ebDot & ebUCase_M & ebLCase_a & ebLCase_x & ebUCase_R & ebLCase_e & ebLCase_f & ebLCase_r &
ebLCase_e & ebLCase_s & ebLCase_h & ebUCase_R & ebLCase_a & ebLCase_t & ebLCase_e) Then dblDisplayMaxRefreshRate =
CDbl(c.GetAttrib(Display.Name & ebDot & ebUCase_M & ebLCase_a & ebLCase_x & ebUCase_R & ebLCase_e & ebLCase_f & ebLCase_r & ebLCase_e &
ebLCase_s & ebLCase_h & ebUCase_R & ebLCase_a & ebLCase_t & ebLCase_e))

                'Ensure that the refresh rate is within range
                If Display.CalculatedRefreshRate < dblDisplayMinRefreshRate Or Display.CalculatedRefreshRate > dblDisplayMaxRefreshRate Then
                        'Unable to obtain a valid refresh rate.\n\nPlease ensure your display adapter is configured with the most recent and
device specific driver.\n(Standard Display Adapter under Windows Vista is not compatible)
                        Rte.AbortExperiment -999, ebUCase_U & ebLCase_n & ebLCase_a & ebLCase_b & ebLCase_l & ebLCase_e & ebSpace & ebLCase_t &
ebLCase_o & ebSpace & ebLCase_o & ebLCase_b & ebLCase_t & ebLCase_a & ebLCase_i & ebLCase_n & ebSpace & ebLCase_a & ebSpace & ebLCase_v &
ebLCase_a & ebLCase_l & ebLCase_i & ebLCase_d & ebSpace & ebLCase_r & ebLCase_e & ebLCase_f & ebLCase_r & ebLCase_e & ebLCase_s & ebLCase_h &
ebSpace & ebLCase_r & ebLCase_a & ebLCase_t & ebLCase_e & ebDot & ebLf & ebLf & ebUCase_P & ebLCase_l & ebLCase_e & ebLCase_a & ebLCase_s &
ebLCase_e & ebSpace & ebLCase_e & ebLCase_n & ebLCase_s & ebLCase_u & ebLCase_r & ebLCase_e & ebSpace & ebLCase_y & ebLCase_o & ebLCase_u &
ebLCase_r & ebSpace & ebLCase_d & ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebSpace & ebLCase_a & ebLCase_d &
ebLCase_a & ebLCase_p & ebLCase_t & ebLCase_e & ebLCase_r & ebSpace & ebLCase_i & ebLCase_s & ebSpace & ebLCase_c & ebLCase_o & ebLCase_n &
ebLCase_f & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e & ebLCase_d & ebSpace & ebLCase_w & ebLCase_i & ebLCase_t & ebLCase_h &
ebSpace & ebLCase_t & ebLCase_h & ebLCase_e & ebSpace & ebLCase_m & ebLCase_o & ebLCase_s & ebLCase_t & ebSpace & ebLCase_r & ebLCase_e &
ebLCase_c & ebLCase_e & ebLCase_n & ebLCase_t & ebSpace & ebLCase_a & ebLCase_n & ebLCase_d & ebSpace & ebLCase_d & ebLCase_e & ebLCase_v &
ebLCase_i & ebLCase_c & ebLCase_e & ebSpace & ebLCase_s & ebLCase_p & ebLCase_e & ebLCase_c & ebLCase_i & ebLCase_f & ebLCase_i & ebLCase_c &
ebSpace & ebLCase_d & ebLCase_r & ebLCase_i & ebLCase_v & ebLCase_e & ebLCase_r & ebDot & ebLf & ebParenOpen & ebUCase_S & ebLCase_t &
ebLCase_a & ebLCase_n & ebLCase_d & ebLCase_a & ebLCase_r & ebLCase_d & ebSpace & ebUCase_D & ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l &
ebLCase_a & ebLCase_y & ebSpace & ebUCase_A & ebLCase_d & ebLCase_a & ebLCase_p & ebLCase_t & ebLCase_e & ebLCase_r & ebSpace & ebLCase_u &
ebLCase_n & ebLCase_d & ebLCase_e & ebLCase_r & ebSpace & ebUCase_W & ebLCase_i & ebLCase_n & ebLCase_d & ebLCase_o & ebLCase_w & ebLCase_s &
ebSpace & ebUCase_V & ebLCase_i & ebLCase_s & ebLCase_t & ebLCase_a & ebSpace & ebLCase_i & ebLCase_s & ebSpace & ebLCase_n & ebLCase_o &
ebLCase_t & ebSpace & ebLCase_c & ebLCase_o & ebLCase_m & ebLCase_p & ebLCase_a & ebLCase_t & ebLCase_i & ebLCase_b & ebLCase_l & ebLCase_e &
ebParenClose
                End If
        End If

End Sub


'--------------------------------------------------------------------------
' InitObjects
'
'--------------------------------------------------------------------------
Sub InitObjects(c As Context)

        Set Blocklist = New List
```

```
	Blocklist.Name = ebUCase_B & ebLCase_l & ebLCase_o & ebLCase_c & ebLCase_k & ebLCase_l & ebLCase_i & ebLCase_s & ebLCase_t
	'{AAA1DA5F-A2B9-4BA4-91B2-A0BBD0138007}
	Blocklist.Guid = CGuid(&HAAA1DA5F, &HA2B9, &H4BA4, &H91B2, &HA0BBD013, &H8007)
	Blocklist.Tag = ebEmptyText

	'Initialization for Blocklist

	Set Blocklist.Order = New SequentialOrder
	Set Blocklist.Deletion = NoDeletion
	Blocklist.ResetEveryRun = False

	Blocklist.LoadProperties

	Set Blocklist.TerminateCondition = Cycles(1)
	Set Blocklist.ResetCondition = Samples(4)
	Blocklist.Reset

	Set SessionProc = New Procedure
	SessionProc.Name = ebUCase_S & ebLCase_e & ebLCase_s & ebLCase_s & ebLCase_i & ebLCase_o & ebLCase_n & ebUCase_P & ebLCase_r & 
ebLCase_o & ebLCase_c
	'{75916D09-5584-4C42-80A2-466FB7119E71}
	SessionProc.Guid = CGuid(&H75916D09, &H5584, &H4C42, &H80A2, &H466FB711, &H9E71)
	SessionProc.Tag = ebEmptyText

	SessionProc.LoadProperties
	SessionProc.Subroutine = ebUCase_S & ebLCase_e & ebLCase_s & ebLCase_s & ebLCase_i & ebLCase_o & ebLCase_n & ebUCase_P & ebLCase_r & 
ebLCase_o & ebLCase_c & ebUnderscore & ebUCase_R & ebLCase_u & ebLCase_n

	Set GoTrial = New Procedure
	GoTrial.Name = ebUCase_G & ebLCase_o & ebUCase_T & ebLCase_r & ebLCase_i & ebLCase_a & ebLCase_l
	'{01FBA034-0A06-4EC8-BCD8-E5FE7C0AFB70}
	GoTrial.Guid = CGuid(&H01FBA034, &H0A06, &H4EC8, &HBCD8, &HE5FE7C0A, &HFB70)
	GoTrial.Tag = ebEmptyText

	GoTrial.LoadProperties
	GoTrial.Subroutine = ebUCase_G & ebLCase_o & ebUCase_T & ebLCase_r & ebLCase_i & ebLCase_a & ebLCase_l & ebUnderscore & ebUCase_R & 
ebLCase_u & ebLCase_n

	Set Instructions1 = New TextDisplay
	Instructions1.Name = ebUCase_I & ebLCase_n & ebLCase_s & ebLCase_t & ebLCase_r & ebLCase_u & ebLCase_c & ebLCase_t & ebLCase_i & 
ebLCase_o & ebLCase_n & ebLCase_s & ebDigit_1
	'{9A2B0840-E59E-475B-9452-5C9495CB7381}
	Instructions1.Guid = CGuid(&H9A2B0840, &HE59E, &H475B, &H9452, &H5C9495CB, &H7381)
	Instructions1.Tag = ebEmptyText

	Set Instructions1EchoClients = New EchoClientCollection

	Instructions1.LoadProperties

	Set Goodbye = New TextDisplay
	Goodbye.Name = ebUCase_G & ebLCase_o & ebLCase_o & ebLCase_d & ebLCase_b & ebLCase_y & ebLCase_e
	'{A6CEC63A-284F-41DF-98E4-C5EA4AC3F3DE}
	Goodbye.Guid = CGuid(&HA6CEC63A, &H284F, &H41DF, &H98E4, &HC5EA4AC3, &HF3DE)
	Goodbye.Tag = ebEmptyText

	Set GoodbyeEchoClients = New EchoClientCollection

	Goodbye.LoadProperties

	Set FixationGo = New TextDisplay
	FixationGo.Name = ebUCase_F & ebLCase_i & ebLCase_x & ebLCase_a & ebLCase_t & ebLCase_i & ebLCase_o & ebLCase_n & ebUCase_G & 
ebLCase_o
	'{1A8D24EA-CA22-49BA-A0A8-4B8F623A3E94}
	FixationGo.Guid = CGuid(&H1A8D24EA, &HCA22, &H49BA, &HA0A8, &H4B8F623A, &H3E94)
	FixationGo.Tag = ebEmptyText

	Set FixationGoEchoClients = New EchoClientCollection

	FixationGo.LoadProperties

	Set BlockProc = New List
	BlockProc.Name = ebUCase_B & ebLCase_l & ebLCase_o & ebLCase_c & ebLCase_k & ebUCase_P & ebLCase_r & ebLCase_o & ebLCase_c
	'{C64AECC7-1BA2-47BE-9425-F5B044A5A6E3}
	BlockProc.Guid = CGuid(&HC64AECC7, &H1BA2, &H47BE, &H9425, &HF5B044A5, &HA6E3)
	BlockProc.Tag = ebEmptyText

	'Initialization for BlockProc

	Set BlockProc.Order = New SequentialOrder
	Set BlockProc.Deletion = NoDeletion
	BlockProc.ResetEveryRun = False

	BlockProc.LoadProperties

	Set BlockProc.TerminateCondition = Cycles(1)
	Set BlockProc.ResetCondition = Samples(128)
	BlockProc.Reset

	Set Figure = New ImageDisplay
	Figure.Name = ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e
	'{8AE7217D-394C-49CB-AFFD-962F56C3D373}
	Figure.Guid = CGuid(&H8AE7217D, &H394C, &H49CB, &HAFFD, &H962F56C3, &HD373)
	Figure.Tag = ebEmptyText

	Set FigureEchoClients = New EchoClientCollection

	Figure.LoadProperties

	Set GetReady = New TextDisplay
	GetReady.Name = ebUCase_G & ebLCase_e & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_a & ebLCase_d & ebLCase_y
	'{64D5FD75-9A06-4A69-9CC1-432A9D83D71E}
	GetReady.Guid = CGuid(&H64D5FD75, &H9A06, &H4A69, &H9CC1, &H432A9D83, &HD71E)
	GetReady.Tag = ebEmptyText

	Set GetReadyEchoClients = New EchoClientCollection

	GetReady.LoadProperties

	Set SoundOut3 = New SoundOut
	SoundOut3.Name = ebUCase_S & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d & ebUCase_O & ebLCase_u & ebLCase_t & ebDigit_3
	'{A9118151-45DA-46FF-ABD5-3766280A37F7}
	SoundOut3.Guid = CGuid(&HA9118151, &H45DA, &H46FF, &HABD5, &H3766280A, &H37F7)
	SoundOut3.Tag = ebEmptyText

	Set SoundOut3EchoClients = New EchoClientCollection

	SoundOut3.LoadProperties

	Set StopTrial = New Procedure
	StopTrial.Name = ebUCase_S & ebLCase_t & ebLCase_o & ebLCase_p & ebUCase_T & ebLCase_r & ebLCase_i & ebLCase_a & ebLCase_l
	'{5AD90772-1B2D-4CD7-96D5-4A1B3AE26EBC}
	StopTrial.Guid = CGuid(&H5AD90772, &H1B2D, &H4CD7, &H96D5, &H4A1B3AE2, &H6EBC)
	StopTrial.Tag = ebEmptyText
```

```
        StopTrial.LoadProperties
        StopTrial.Subroutine = ebUCase_S & ebLCase_t & ebLCase_o & ebLCase_p & ebUCase_T & ebLCase_r & ebLCase_i & ebLCase_a & ebLCase_l &
ebUnderscore & ebUCase_R & ebLCase_u & ebLCase_n
Set StopTrial_theCollection = New RteCollection

        Set PostSig1 = New Slide
        PostSig1.Name = ebUCase_P & ebLCase_o & ebLCase_s & ebLCase_t & ebUCase_S & ebLCase_i & ebLCase_g & ebDigit_1
        '{38B513C9-AA5E-4695-BBBA-C3CC5ED8941A}
        PostSig1.Guid = CGuid(&H38B513C9, &HAA5E, &H4695, &HBBBA, &HC3CC5ED8, &H941A)
        PostSig1.Tag = ebEmptyText

        Set PostSig1EchoClients = New EchoClientCollection

        PostSig1.LoadProperties

        Set FixationStop = New TextDisplay
        FixationStop.Name = ebUCase_F & ebLCase_i & ebLCase_x & ebLCase_a & ebLCase_t & ebLCase_i & ebLCase_o & ebLCase_n & ebUCase_S &
ebLCase_t & ebLCase_o & ebLCase_p
        '{5C91D556-E118-4D1D-8583-53429F88FDD5}
        FixationStop.Guid = CGuid(&H5C91D556, &HE118, &H4D1D, &H8583, &H53429F88, &HFDD5)
        FixationStop.Tag = ebEmptyText

        Set FixationStopEchoClients = New EchoClientCollection

        FixationStop.LoadProperties

        Set PreSig = New ImageDisplay
        PreSig.Name = ebUCase_P & ebLCase_r & ebLCase_e & ebUCase_S & ebLCase_i & ebLCase_g
        '{625DF8B0-BB2B-42A1-B3F8-3A5C97129C4F}
        PreSig.Guid = CGuid(&H625DF8B0, &HBB2B, &H42A1, &HB3F8, &H3A5C9712, &H9C4F)
        PreSig.Tag = ebEmptyText

        Set PreSigEchoClients = New EchoClientCollection

        PreSig.LoadProperties

        Set SSD = New TextDisplay
        SSD.Name = ebUCase_S & ebUCase_S & ebUCase_D
        '{5852371D-17BC-4299-97ED-2C762DC135C0}
        SSD.Guid = CGuid(&H5852371D, &H17BC, &H4299, &H97ED, &H2C762DC1, &H35C0)
        SSD.Tag = ebEmptyText

        Set SSDEchoClients = New EchoClientCollection

        SSD.LoadProperties

        Set Figure3 = New ImageDisplay
        Figure3.Name = ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e & ebDigit_3
        '{B6BB4B6D-51AA-464D-AA4E-79B7A46B1275}
        Figure3.Guid = CGuid(&HB6BB4B6D, &H51AA, &H464D, &HAA4E, &H79B7A46B, &H1275)
        Figure3.Tag = ebEmptyText

        Set Figure3EchoClients = New EchoClientCollection

        Figure3.LoadProperties

        Set SoundOut4 = New SoundOut
        SoundOut4.Name = ebUCase_S & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d & ebUCase_O & ebLCase_u & ebLCase_t & ebDigit_4
        '{F609D5B1-9FE0-446E-918B-A382460F4A30}
        SoundOut4.Guid = CGuid(&HF609D5B1, &H9FE0, &H446E, &H918B, &HA382460F, &H4A30)
        SoundOut4.Tag = ebEmptyText

        Set SoundOut4EchoClients = New EchoClientCollection

        SoundOut4.LoadProperties

        Set FixationStop1 = New TextDisplay
        FixationStop1.Name = ebUCase_F & ebLCase_i & ebLCase_x & ebLCase_a & ebLCase_t & ebLCase_i & ebLCase_o & ebLCase_n & ebUCase_S &
ebLCase_t & ebLCase_o & ebLCase_p & ebDigit_1
        '{3D624FBB-E9B2-4DB8-AE91-2C28B954A202}
        FixationStop1.Guid = CGuid(&H3D624FBB, &HE9B2, &H4DB8, &HAE91, &H2C28B954, &HA202)
        FixationStop1.Tag = ebEmptyText

        Set FixationStop1EchoClients = New EchoClientCollection

        FixationStop1.LoadProperties

        Set Practice = New List
        Practice.Name = ebUCase_P & ebLCase_r & ebLCase_a & ebLCase_c & ebLCase_t & ebLCase_i & ebLCase_c & ebLCase_e
        '{99F80692-944E-41AA-A015-C29D190E552D}
        Practice.Guid = CGuid(&H99F80692, &H944E, &H41AA, &HA015, &HC29D190E, &H552D)
        Practice.Tag = ebEmptyText

        'Initialization for Practice

        Set Practice.Order = New SequentialOrder
        Set Practice.Deletion = NoDeletion
        Practice.ResetEveryRun = False

        Practice.LoadProperties

        Set Practice.TerminateCondition = Cycles(1)
        Set Practice.ResetCondition = Samples(15)
        Practice.Reset

        Set BlockProc2 = New List
        BlockProc2.Name = ebUCase_B & ebLCase_l & ebLCase_o & ebLCase_c & ebLCase_k & ebUCase_P & ebLCase_r & ebLCase_o & ebLCase_c &
ebDigit_2
        '{752AF858-FB52-42D1-9C57-54B84E5180DA}
        BlockProc2.Guid = CGuid(&H752AF858, &HFB52, &H42D1, &H9C57, &H54B84E51, &H80DA)
        BlockProc2.Tag = ebEmptyText

        'Initialization for BlockProc2

        Set BlockProc2.Order = New SequentialOrder
        Set BlockProc2.Deletion = NoDeletion
        BlockProc2.ResetEveryRun = False

        BlockProc2.LoadProperties

        Set BlockProc2.TerminateCondition = Cycles(1)
        Set BlockProc2.ResetCondition = Samples(128)
        BlockProc2.Reset

        Set Pract = New Procedure
        Pract.Name = ebUCase_P & ebLCase_r & ebLCase_a & ebLCase_c & ebLCase_t
        '{579C5FF5-3B2B-4496-B21E-1A8ED37CFC6F}
        Pract.Guid = CGuid(&H579C5FF5, &H3B2B, &H4496, &HB21E, &H1A8ED37C, &HFC6F)
        Pract.Tag = ebEmptyText

        Pract.LoadProperties
        Pract.Subroutine = ebUCase_P & ebLCase_r & ebLCase_a & ebLCase_c & ebLCase_t & ebUnderscore & ebUCase_R & ebLCase_u & ebLCase_n
```

```
Set Pract_theCollection = New RteCollection

        Set Run1 = New Procedure
        Run1.Name = ebUCase_R & ebLCase_u & ebLCase_n & ebDigit_1
        '{D6173561-7FE8-4272-9E86-3FB94EED8123}
        Run1.Guid = CGuid(&HD6173561, &H7FE8, &H4272, &H9E86, &H3FB94EED, &H8123)
        Run1.Tag = ebEmptyText

        Run1.LoadProperties
        Run1.Subroutine = ebUCase_R & ebLCase_u & ebLCase_n & ebDigit_1 & ebUnderscore & ebUCase_R & ebLCase_u & ebLCase_n
Set Run1_theCollection = New RteCollection

        Set Run2 = New Procedure
        Run2.Name = ebUCase_R & ebLCase_u & ebLCase_n & ebDigit_2
        '{BE01613C-203F-4094-98C1-A68AAEB6058F}
        Run2.Guid = CGuid(&HBE01613C, &H203F, &H4094, &H98C1, &HA68AAEB6, &H058F)
        Run2.Tag = ebEmptyText

        Run2.LoadProperties
        Run2.Subroutine = ebUCase_R & ebLCase_u & ebLCase_n & ebDigit_2 & ebUnderscore & ebUCase_R & ebLCase_u & ebLCase_n
Set Run2_theCollection = New RteCollection

        Set GoTrial8 = New Procedure
        GoTrial8.Name = ebUCase_G & ebLCase_o & ebUCase_T & ebLCase_r & ebLCase_i & ebLCase_a & ebLCase_l & ebDigit_8
        '{000EB556-512D-4066-992D-527FC895DDC4}
        GoTrial8.Guid = CGuid(&H000EB556, &H512D, &H4066, &H992D, &H527FC895, &HDDC4)
        GoTrial8.Tag = ebEmptyText

        GoTrial8.LoadProperties
        GoTrial8.Subroutine = ebUCase_G & ebLCase_o & ebUCase_T & ebLCase_r & ebLCase_i & ebLCase_a & ebLCase_l & ebDigit_8 & ebUnderscore &
ebUCase_R & ebLCase_u & ebLCase_n

        Set StopTrial8 = New Procedure
        StopTrial8.Name = ebUCase_S & ebLCase_t & ebLCase_o & ebLCase_p & ebUCase_T & ebLCase_r & ebLCase_i & ebLCase_a & ebLCase_l &
ebDigit_8
        '{8227DC05-87B4-4ABC-9604-9F5926B410CD}
        StopTrial8.Guid = CGuid(&H8227DC05, &H87B4, &H4ABC, &H9604, &H9F5926B4, &H10CD)
        StopTrial8.Tag = ebEmptyText

        StopTrial8.LoadProperties
        StopTrial8.Subroutine = ebUCase_S & ebLCase_t & ebLCase_o & ebLCase_p & ebUCase_T & ebLCase_r & ebLCase_i & ebLCase_a & ebLCase_l &
ebDigit_8 & ebUnderscore & ebUCase_R & ebLCase_u & ebLCase_n
Set StopTrial8_theCollection = New RteCollection

        Set FixationGo1 = New TextDisplay
        FixationGo1.Name = ebUCase_F & ebLCase_i & ebLCase_x & ebLCase_a & ebLCase_t & ebLCase_i & ebLCase_o & ebLCase_n & ebUCase_G &
ebLCase_o & ebDigit_1
        '{78E88777-CC1C-4323-9DBF-A277386BFDA5}
        FixationGo1.Guid = CGuid(&H78E88777, &HCC1C, &H4323, &H9DBF, &HA277386B, &HFDA5)
        FixationGo1.Tag = ebEmptyText

        Set FixationGo1EchoClients = New EchoClientCollection

        FixationGo1.LoadProperties

        Set Figure1 = New ImageDisplay
        Figure1.Name = ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e & ebDigit_1
        '{E0DAE64E-4301-4AAF-A066-E714FAC4A1EA}
        Figure1.Guid = CGuid(&HE0DAE64E, &H4301, &H4AAF, &HA066, &HE714FAC4, &HA1EA)
        Figure1.Tag = ebEmptyText

        Set Figure1EchoClients = New EchoClientCollection

        Figure1.LoadProperties

        Set FeedbackDisplay3 = New FeedbackDisplay
        FeedbackDisplay3.Name = ebUCase_F & ebLCase_e & ebLCase_e & ebLCase_d & ebLCase_b & ebLCase_a & ebLCase_c & ebLCase_k & ebUCase_D &
ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebDigit_3
        '{FC7593B7-0FA5-48F7-9875-70CA327D9B4A}
        FeedbackDisplay3.Guid = CGuid(&HFC7593B7, &H0FA5, &H48F7, &H9875, &H70CA327D, &H9B4A)
        FeedbackDisplay3.Tag = ebEmptyText

        FeedbackDisplay3.LoadProperties

        Set FixationStop2 = New TextDisplay
        FixationStop2.Name = ebUCase_F & ebLCase_i & ebLCase_x & ebLCase_a & ebLCase_t & ebLCase_i & ebLCase_o & ebLCase_n & ebUCase_S &
ebLCase_t & ebLCase_o & ebLCase_p & ebDigit_2
        '{6D763DBD-B56F-4249-88D8-033149006BC1}
        FixationStop2.Guid = CGuid(&H6D763DBD, &HB56F, &H4249, &H88D8, &H03314900, &H6BC1)
        FixationStop2.Tag = ebEmptyText

        Set FixationStop2EchoClients = New EchoClientCollection

        FixationStop2.LoadProperties

        Set PreSig1 = New ImageDisplay
        PreSig1.Name = ebUCase_P & ebLCase_r & ebLCase_e & ebUCase_S & ebLCase_i & ebLCase_g & ebDigit_1
        '{2529F2C8-4905-4EA9-9E5D-FDE99A11ED8A}
        PreSig1.Guid = CGuid(&H2529F2C8, &H4905, &H4EA9, &H9E5D, &HFDE99A11, &HED8A)
        PreSig1.Tag = ebEmptyText

        Set PreSig1EchoClients = New EchoClientCollection

        PreSig1.LoadProperties

        Set SoundOut5 = New SoundOut
        SoundOut5.Name = ebUCase_S & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d & ebUCase_O & ebLCase_u & ebLCase_t & ebDigit_5
        '{A5C09D5E-F2B5-48E9-9389-B1BF0177E7A4}
        SoundOut5.Guid = CGuid(&HA5C09D5E, &HF2B5, &H48E9, &H9389, &HB1BF0177, &HE7A4)
        SoundOut5.Tag = ebEmptyText

        Set SoundOut5EchoClients = New EchoClientCollection

        SoundOut5.LoadProperties

        Set PostSig2 = New Slide
        PostSig2.Name = ebUCase_P & ebLCase_o & ebLCase_s & ebLCase_t & ebUCase_S & ebLCase_i & ebLCase_g & ebDigit_2
        '{BC07D345-8134-4E73-9157-41E4EA987C49}
        PostSig2.Guid = CGuid(&HBC07D345, &H8134, &H4E73, &H9157, &H41E4EA98, &H7C49)
        PostSig2.Tag = ebEmptyText

        Set PostSig2EchoClients = New EchoClientCollection

        PostSig2.LoadProperties

        Set FeedbackDisplay5 = New FeedbackDisplay
        FeedbackDisplay5.Name = ebUCase_F & ebLCase_e & ebLCase_e & ebLCase_d & ebLCase_b & ebLCase_a & ebLCase_c & ebLCase_k & ebUCase_D &
ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebDigit_5
        '{8BAAC234-B832-4DED-B4D1-AC6D757BE0BC}
        FeedbackDisplay5.Guid = CGuid(&H8BAAC234, &HB832, &H4DED, &HB4D1, &HAC6D757B, &HE0BC)
        FeedbackDisplay5.Tag = ebEmptyText

        FeedbackDisplay5.LoadProperties
```

```
	Set FixationStop3 = New TextDisplay
	FixationStop3.Name = ebUCase_F & ebLCase_i & ebLCase_x & ebLCase_a & ebLCase_t & ebLCase_i & ebLCase_o & ebLCase_n & ebUCase_S & 
ebLCase_t & ebLCase_o & ebLCase_p & ebDigit_3
	'{FE80A813-CC59-4600-8538-10CC9DB42A5E}
	FixationStop3.Guid = CGuid(&HFE80A813, &HCC59, &H4600, &H8538, &H10CC9DB4, &H2A5E)
	FixationStop3.Tag = ebEmptyText

	Set FixationStop3EchoClients = New EchoClientCollection

	FixationStop3.LoadProperties

	Set SoundOut6 = New SoundOut
	SoundOut6.Name = ebUCase_S & ebLCase_o & ebLCase_u & ebLCase_n & ebLCase_d & ebUCase_O & ebLCase_u & ebLCase_t & ebDigit_6
	'{F9314CCE-B861-42E4-A1F1-A5D2C30DB00B}
	SoundOut6.Guid = CGuid(&HF9314CCE, &HB861, &H42E4, &HA1F1, &HA5D2C30D, &HB00B)
	SoundOut6.Tag = ebEmptyText

	Set SoundOut6EchoClients = New EchoClientCollection

	SoundOut6.LoadProperties

	Set SSD1 = New TextDisplay
	SSD1.Name = ebUCase_S & ebUCase_S & ebUCase_D & ebDigit_1
	'{083A9392-BDD7-4CE7-9E4B-A08D78F396C4}
	SSD1.Guid = CGuid(&H083A9392, &HBDD7, &H4CE7, &H9E4B, &HA08D78F3, &H96C4)
	SSD1.Tag = ebEmptyText

	Set SSD1EchoClients = New EchoClientCollection

	SSD1.LoadProperties

	Set Figure4 = New ImageDisplay
	Figure4.Name = ebUCase_F & ebLCase_i & ebLCase_g & ebLCase_u & ebLCase_r & ebLCase_e & ebDigit_4
	'{396F4432-0959-40A7-8C2D-87BFF7A18552}
	Figure4.Guid = CGuid(&H396F4432, &H0959, &H40A7, &H8C2D, &H87BFF7A1, &H8552)
	Figure4.Tag = ebEmptyText

	Set Figure4EchoClients = New EchoClientCollection

	Figure4.LoadProperties

	Set FeedbackDisplay6 = New FeedbackDisplay
	FeedbackDisplay6.Name = ebUCase_F & ebLCase_e & ebLCase_e & ebLCase_d & ebLCase_b & ebLCase_a & ebLCase_c & ebLCase_k & ebUCase_D & 
ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebDigit_6
	'{784DC476-45BE-417E-A706-8F0D41FC3960}
	FeedbackDisplay6.Guid = CGuid(&H784DC476, &H45BE, &H417E, &HA706, &H8F0D41FC, &H3960)
	FeedbackDisplay6.Tag = ebEmptyText

	FeedbackDisplay6.LoadProperties

	Set Bienvenida = New Slide
	Bienvenida.Name = ebUCase_B & ebLCase_i & ebLCase_e & ebLCase_n & ebLCase_v & ebLCase_e & ebLCase_n & ebLCase_i & ebLCase_d & 
ebLCase_a
	'{E2423919-6AEB-43CA-B2FD-6E825F79BDAD}
	Bienvenida.Guid = CGuid(&HE2423919, &H6AEB, &H43CA, &HB2FD, &H6E825F79, &HBDAD)
	Bienvenida.Tag = ebEmptyText

	Set BienvenidaEchoClients = New EchoClientCollection

	Bienvenida.LoadProperties

	Set GetReady1 = New TextDisplay
	GetReady1.Name = ebUCase_G & ebLCase_e & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_a & ebLCase_d & ebLCase_y & ebDigit_1
	'{C34B715E-DCB7-4A44-B4D1-5D49722B705D}
	GetReady1.Guid = CGuid(&HC34B715E, &HDCB7, &H4A44, &HB4D1, &H5D49722B, &H705D)
	GetReady1.Tag = ebEmptyText

	Set GetReady1EchoClients = New EchoClientCollection

	GetReady1.LoadProperties

	Set Descanso = New TextDisplay
	Descanso.Name = ebUCase_D & ebLCase_e & ebLCase_s & ebLCase_c & ebLCase_a & ebLCase_n & ebLCase_s & ebLCase_o
	'{F9FE6CBF-8C67-4E0D-8D02-5B45EAE74292}
	Descanso.Guid = CGuid(&HF9FE6CBF, &H8C67, &H4E0D, &H8D02, &H5B45EAE7, &H4292)
	Descanso.Tag = ebEmptyText

	Set DescansoEchoClients = New EchoClientCollection

	Descanso.LoadProperties

	Set Run3 = New Procedure
	Run3.Name = ebUCase_R & ebLCase_u & ebLCase_n & ebDigit_3
	'{A3932014-3CF3-4414-8A5B-9448C71E4ADB}
	Run3.Guid = CGuid(&HA3932014, &H3CF3, &H4414, &H8A5B, &H9448C71E, &H4ADB)
	Run3.Tag = ebEmptyText

	Run3.LoadProperties
	Run3.Subroutine = ebUCase_R & ebLCase_u & ebLCase_n & ebDigit_3 & ebUnderscore & ebUCase_R & ebLCase_u & ebLCase_n
Set Run3_theCollection = New RteCollection

	Set BlockProc3 = New List
	BlockProc3.Name = ebUCase_B & ebLCase_l & ebLCase_o & ebLCase_c & ebLCase_k & ebUCase_P & ebLCase_r & ebLCase_o & ebLCase_c & 
ebDigit_3
	'{AF677909-AB94-4B57-AD43-3488C25E6800}
	BlockProc3.Guid = CGuid(&HAF677909, &HAB94, &H4B57, &HAD43, &H3488C25E, &H6800)
	BlockProc3.Tag = ebEmptyText

	'Initialization for BlockProc3

	Set BlockProc3.Order = New SequentialOrder
	Set BlockProc3.Deletion = NoDeletion
	BlockProc3.ResetEveryRun = False

	BlockProc3.LoadProperties

	Set BlockProc3.TerminateCondition = Cycles(1)
	Set BlockProc3.ResetCondition = Samples(128)
	BlockProc3.Reset

	Set GetReady2 = New TextDisplay
	GetReady2.Name = ebUCase_G & ebLCase_e & ebLCase_t & ebUCase_R & ebLCase_e & ebLCase_a & ebLCase_d & ebLCase_y & ebDigit_2
	'{6F79694B-0DEF-4680-968E-94144BA94A95}
	GetReady2.Guid = CGuid(&H6F79694B, &H0DEF, &H4680, &H968E, &H94144BA9, &H4A95)
	GetReady2.Tag = ebEmptyText

	Set GetReady2EchoClients = New EchoClientCollection

	GetReady2.LoadProperties


End Sub
```

```
'---------------------------------------------------------------------------
' InitPackages
'
'---------------------------------------------------------------------------
Sub InitPackages(c As Context)

End Sub


'---------------------------------------------------------------------------
' InitGlobals
'
'---------------------------------------------------------------------------
Sub InitGlobals(c As Context)


       'Assign Context to the StartupInfo object
       Set Rte.StartupInfo.Context = c

       'Load and Transfer external StartupInfo
       Rte.StartupInfo.Load
       Rte.StartupInfo.Transfer

End Sub



'---------------------------------------------------------------------------


'---------------------------------------------------------------------------
'---------------------------------------------------------------------------
' UnInitGlobals
'---------------------------------------------------------------------------
Sub UnInitGlobals()

       'Close the external StartupInfo
       Rte.StartupInfo.Close

End Sub
'---------------------------------------------------------------------------
' UnInitDevices
'---------------------------------------------------------------------------
Sub UnInitDevices()

       'UnInit All Devices
       Rte.DeviceManager.UnInit
       Display.Close
       Set Display = Nothing
       Sound.Close

       Keyboard.Close
       Set Keyboard = Nothing

       Mouse.Close
       Set Mouse = Nothing

End Sub


'---------------------------------------------------------------------------
'---------------------------------------------------------------------------
' UnInitPackages
'---------------------------------------------------------------------------
Sub UnInitPackages()
End Sub


'---------------------------------------------------------------------------
' UnInitObjects
'
'---------------------------------------------------------------------------
Sub UnInitObjects()

       Set Blocklist = Nothing

       Set SessionProc = Nothing

       Set GoTrial = Nothing

       Set Instructions1 = Nothing

       Set Instructions1EchoClients = Nothing

       Set Goodbye = Nothing

       Set GoodbyeEchoClients = Nothing

       Set FixationGo = Nothing

       Set FixationGoEchoClients = Nothing

       Set BlockProc = Nothing

       Set Figure = Nothing

       Set FigureEchoClients = Nothing

       Set GetReady = Nothing

       Set GetReadyEchoClients = Nothing

       Set SoundOut3 = Nothing

       Set SoundOut3EchoClients = Nothing
       Set SoundOut3SoundBuffer = Nothing

       Set StopTrial = Nothing

       Set PostSig1 = Nothing

       Set PostSig1EchoClients = Nothing

       Set FixationStop = Nothing

       Set FixationStopEchoClients = Nothing

       Set PreSig = Nothing

       Set PreSigEchoClients = Nothing
```

```
        Set SSD = Nothing

        Set SSDEchoClients = Nothing

        Set Figure3 = Nothing

        Set Figure3EchoClients = Nothing

        Set SoundOut4 = Nothing

        Set SoundOut4EchoClients = Nothing
        Set SoundOut4SoundBuffer = Nothing

        Set FixationStop1 = Nothing

        Set FixationStop1EchoClients = Nothing

        Set Practice = Nothing

        Set BlockProc2 = Nothing

        Set Pract = Nothing

        Set Run1 = Nothing

        Set Run2 = Nothing

        Set GoTrial8 = Nothing

        Set StopTrial8 = Nothing

        Set FixationGo1 = Nothing

        Set FixationGo1EchoClients = Nothing

        Set Figure1 = Nothing

        Set Figure1EchoClients = Nothing

        Set FeedbackDisplay3 = Nothing

        Set FixationStop2 = Nothing

        Set FixationStop2EchoClients = Nothing

        Set PreSig1 = Nothing

        Set PreSig1EchoClients = Nothing

        Set SoundOut5 = Nothing

        Set SoundOut5EchoClients = Nothing
        Set SoundOut5SoundBuffer = Nothing

        Set PostSig2 = Nothing

        Set PostSig2EchoClients = Nothing

        Set FeedbackDisplay5 = Nothing

        Set FixationStop3 = Nothing

        Set FixationStop3EchoClients = Nothing

        Set SoundOut6 = Nothing

        Set SoundOut6EchoClients = Nothing
        Set SoundOut6SoundBuffer = Nothing

        Set SSD1 = Nothing

        Set SSD1EchoClients = Nothing

        Set Figure4 = Nothing

        Set Figure4EchoClients = Nothing

        Set FeedbackDisplay6 = Nothing

        Set Bienvenida = Nothing

        Set BienvenidaEchoClients = Nothing

        Set GetReady1 = Nothing

        Set GetReady1EchoClients = Nothing

        Set Descanso = Nothing

        Set DescansoEchoClients = Nothing

        Set Run3 = Nothing

        Set BlockProc3 = Nothing

        Set GetReady2 = Nothing

        Set GetReady2EchoClients = Nothing

End Sub

'--------------------------------------------------------------------------
' Main
'
'--------------------------------------------------------------------------
Sub Main()

        ' Create and initialize the default context, data file,
        ' and provide global access to the context.
        Dim c As Context
        Set c = New Context
        c.Name = "ebContext"
        Set c.DataFile = New DataFile
        c.PushNewFrame
        Set ebContext = c

        ' Set the log level names
        c.SetLogLevelName 1, "Session"
        c.SetLogLevelName 2, "Block"
        c.SetLogLevelName 3, "Trial"
```

```
        c.SetLogLevelName 4, "SubTrial"
        c.SetLogLevelName 5, "LogLevel5"
        c.SetLogLevelName 6, "LogLevel6"
        c.SetLogLevelName 7, "LogLevel7"
        c.SetLogLevelName 8, "LogLevel8"
        c.SetLogLevelName 9, "LogLevel9"
        c.SetLogLevelName 10, "LogLevel10"

        ' Set standard logging items
        ebContext.SetAttrib "Experiment", "Experimento_Verbruggen_3_runs_V1"
        ebContext.SetAttrib "SessionDate", Date$
        ebContext.SetAttrib "SessionTime", Time$
        ebContext.SetAttrib "SessionStartDateTimeUtc", NowUtc()

        'Initialize global variables for packages
        InitGlobals c

        ' Initialize the Display Device(s) for runtime
        Dim DisplayDisplayDeviceInfo As DisplayDeviceInfo
        DisplayDisplayDeviceInfo.DefaultColor = Color.White
        DisplayDisplayDeviceInfo.DisplayIndex = 1
        If c.AttribExists(ebUCase_D & ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebDot & ebUCase_D & ebLCase_e &
ebLCase_f & ebLCase_a & ebLCase_u & ebLCase_l & ebLCase_t & ebUCase_C & ebLCase_o & ebLCase_l & ebLCase_o & ebLCase_r) Then
DisplayDisplayDeviceInfo.DefaultColor = CColor(c.GetAttrib(ebUCase_D & ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y
& ebDot & ebUCase_D & ebLCase_e & ebLCase_f & ebLCase_a & ebLCase_u & ebLCase_l & ebLCase_t & ebUCase_C & ebLCase_o & ebLCase_l & ebLCase_o &
ebLCase_r))
        If c.AttribExists(ebUCase_D & ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebDot & ebUCase_D & ebLCase_i &
ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebUCase_I & ebLCase_n & ebLCase_d & ebLCase_e & ebLCase_x) Then
DisplayDisplayDeviceInfo.DisplayIndex = CLng(c.GetAttrib(ebUCase_D & ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y &
ebDot & ebUCase_D & ebLCase_i & ebLCase_s & ebLCase_p & ebLCase_l & ebLCase_a & ebLCase_y & ebUCase_I & ebLCase_n & ebLCase_d & ebLCase_e &
ebLCase_x))



        CreateDefaultPort DisplayDisplayDeviceInfo.DefaultColor, "", DisplayDisplayDeviceInfo.DisplayIndex

        If Basic.OS = ebWin32 Then
                WinActivate "E-Run Experiment Window"
        End If

        ' Get the StartupInfo

        ' Set the defaults for all of the StartupInfo
        If Not c.AttribExists("Subject") Then c.SetAttrib "Subject", "1"
        If Not c.AttribExists("Session") Then c.SetAttrib "Session", "1"

        ' Determine if StartupInfo.UseDefaults exists and is True/False to override prompts for StartupInfo parameters
        Dim bStartupInfoUseDefaults As Boolean
        bStartupInfoUseDefaults = False
        If c.AttribExists("StartupInfo.UseDefaults") Then bStartupInfoUseDefaults = CLogical(c.GetAttrib("StartupInfo.UseDefaults"))
        If Not bStartupInfoUseDefaults Then

                Dim vAnswer As Variant
StartupInfo_Begin:

StartupInfoPrompt_Subject:
                vAnswer = AskBox("Please enter the Subject Number (1-32767, 0=No Data Logging):", c.GetAttrib("Subject"))
                If Not IsEmpty(vAnswer) Then
                        If Not IsNumeric(vAnswer) Then
                                MsgBox "Please enter an integer value"
                                GoTo StartupInfoPrompt_Subject
                        ElseIf CLng(vAnswer) < 0 Then
                                MsgBox "The value for Subject must not be less than 0"
                                GoTo StartupInfoPrompt_Subject
                        ElseIf CLng(vAnswer) > 32767 Then
                                MsgBox "The value for Subject must not be greater than 32767"
                                GoTo StartupInfoPrompt_Subject
                        End If
                Else
                        GoTo ExperimentAbort
                End If

                c.SetAttrib "Subject", CStr(vAnswer)

StartupInfoPrompt_Session:
                vAnswer = AskBox("Please enter the Session Number (1-32767):", c.GetAttrib("Session"))
                If Not IsEmpty(vAnswer) Then
                        If Not IsNumeric(vAnswer) Then
                                MsgBox "Please enter an integer value"
                                GoTo StartupInfoPrompt_Session
                        ElseIf CLng(vAnswer) < 1 Then
                                MsgBox "The value for Session must not be less than 1"
                                GoTo StartupInfoPrompt_Session
                        ElseIf CLng(vAnswer) > 32767 Then
                                MsgBox "The value for Session must not be greater than 32767"
                                GoTo StartupInfoPrompt_Session
                        End If
                Else
                        GoTo ExperimentAbort
                End If

                c.SetAttrib "Session", CStr(vAnswer)

                ' Display the summary
                Dim strSummary As String
                strSummary = "Subject:    " & c.GetAttrib("Subject") & "\n"
                strSummary = strSummary & "Session:    " & c.GetAttrib("Session") & "\n"
                strSummary = strSummary & "\nContinue with the above startup info?"

                Dim nSummaryAnswer As Integer
                nSummaryAnswer = MsgBox(strSummary, ebYesNoCancel + ebQuestion, "Summary of Startup Info")
                If nSummaryAnswer = ebNo Then
                                GoTo StartupInfo_Begin
                ElseIf nSummaryAnswer = ebCancel Then
                                GoTo ExperimentAbort
                End If

        End If


        'Assign the Clock.Scale value
        Clock.Scale = 1.000000

        'If the attribute Clock.Scale.Override exists
        '  then use it for to set the Clock.Scale value
        If c.AttribExists("Clock.Scale.Override") Then
                Clock.Scale = CDbl(c.GetAttrib("Clock.Scale.Override"))
        End If

        ' Set the Filenames for the data files
        Dim strFilenameBase As String
        Dim strFilenameRecovery As String
        Dim strFilenameEDAT As String
```

```
	'If the attribute DataFile.Filename.Override exists
	'  then use it for the .txt and .edat2 filenames
	If c.AttribExists("DataFile.Filename.Override") Then

		' Set the default Data Filename
		strFilenameBase = CStr(c.GetAttrib("DataFile.Filename.Override"))

	Else

		' Set the default Data Filename
		strFilenameBase = CStr(c.GetAttrib("Experiment")) & "-" & CStr(c.GetAttrib("Subject")) & "-" & CStr(c.GetAttrib("Session"))

	End If

	'Set the name of the data file
	strFilenameRecovery = strFilenameBase & ".txt"
	strFilenameEDAT = strFilenameBase & ".edat2"
	c.DataFile.Filename = strFilenameRecovery
	c.SetAttrib "DataFile.Basename", strFilenameBase

	' If we are logging data, then prompt to overwrite the data file if it exists
	If CLng(c.GetAttrib("Subject")) <> 0 Then
		If FileExists(c.DataFile.Filename) Or FileExists(strFilenameEDAT) Then
			If ebYes <> MsgBox("WARNING: The data file and/or recovery file already exists:\nFILE: " & c.DataFile.Filename & "\n\nDo
you want to overwrite?", ebYesNo + ebQuestion) Then
				GoTo ExperimentAbort
			End If
			' If you receive an error here then ensure that your E-Recovery (txt) file or
			' the edat2 file is not open and then try the experiment run again.
			If FileExists(strFilenameEDAT) Then Kill strFilenameEDAT
			If FileExists(c.DataFile.Filename) Then Kill c.DataFile.Filename
		End If
	End If

	' Set defaults for RandomSeed and GroupNumber if StartupInfo did not assign their values
	If Not c.AttribExists("RandomSeed") Then c.SetAttrib "RandomSeed", PRNG.GetSeed()
	If Not c.AttribExists("Group") Then c.SetAttrib "Group", "1"

	'Set the random seed
	Randomize CLng(c.GetAttrib("RandomSeed"))

	' Initialize Experiment Advisor Properties
	Rte.ExperimentAdvisor.LoadProperties
	If c.AttribExists("Rte.ExperimentAdvisor.Enabled") Then Rte.ExperimentAdvisor.Enabled =
CLogical(c.GetAttrib("Rte.ExperimentAdvisor.Enabled"))
	If c.AttribExists("Rte.ExperimentAdvisor.Filename") Then Rte.ExperimentAdvisor.Filename =
CStr(c.GetAttrib("Rte.ExperimentAdvisor.Filename"))


	Dim nPriority As Long
	'Priority for init routines
	nPriority = 3

	'Determine if the priority should use the override value
	If c.AttribExists("SetOSThreadPriority.Init.Override") Then
		nPriority = c.GetAttrib("SetOSThreadPriority.Init.Override")
	End If

	'Update E-Prime Priority for INIT routines
	SetOSThreadPriority nPriority

	' Initialize all system devices, packages, and objects
	InitDevices c
	InitPackages c
	InitObjects c

	'Priority for start of experiment
	nPriority = -1

	'Determine if the priority should use the override value
	If c.AttribExists("SetOSThreadPriority.Override") Then
		nPriority = c.GetAttrib("SetOSThreadPriority.Override")
	End If

	'Update E-Prime Priority for start of experiment
	SetOSThreadPriority nPriority

	'Disable System power save mode
	Rte.PreventSystemIdle = True

	If CLng(c.GetAttrib("Subject")) < 0 Then
		Rte.AbortExperiment 12102, ebUCase_S & ebLCase_u & ebLCase_b & ebLCase_j & ebLCase_e & ebLCase_c & ebLCase_t & ebSpace &
ebLCase_c & ebLCase_a & ebLCase_n & ebLCase_n & ebLCase_o & ebLCase_t & ebSpace & ebLCase_b & ebLCase_e & ebSpace & ebLCase_l & ebLCase_e &
ebLCase_s & ebLCase_s & ebSpace & ebLCase_t & ebLCase_h & ebLCase_a & ebLCase_n & ebSpace & ebDigit_0 & ebDot
	End If

	If CLng(c.GetAttrib("Session")) < 1 Then
		Rte.AbortExperiment 12103, ebUCase_S & ebLCase_e & ebLCase_s & ebLCase_s & ebLCase_i & ebLCase_o & ebLCase_n & ebSpace &
ebLCase_c & ebLCase_a & ebLCase_n & ebLCase_n & ebLCase_o & ebLCase_t & ebSpace & ebLCase_b & ebLCase_e & ebSpace & ebLCase_l & ebLCase_e &
ebLCase_s & ebLCase_s & ebSpace & ebLCase_t & ebLCase_h & ebLCase_a & ebLCase_n & ebSpace & ebDigit_1 & ebDot
	End If

	' If we are logging data, then open the datafile
	If CLng(c.GetAttrib("Subject")) <> 0 Then
		c.DataFile.Open
		c.LogHeader
	End If


	'Setup the DataFile.BaseName attribute
	c.SetAttrib "DataFile.BaseName", Replace(c.DataFile.Filename, ".txt", ebEmptyText)

	' Log clock timing information
	c.SetAttrib "Clock.Information", Clock.Information

	' Log E-Studio version
	c.SetAttrib "StudioVersion", "2.0.10.147"

	' Log runtime version.
	c.SetAttrib "RuntimeVersion", Rte.Version.Major & ebDot & Rte.Version.Minor & ebDot & Rte.Version.Internal & ebDot & Rte.Version.Build
	c.SetAttrib "RuntimeVersionExpected", 2 & ebDot & 0 & ebDot & 10 & ebDot & 242

	' Log experiment version
	c.SetAttrib "ExperimentVersion", "1.0.0.2110"

	' ExperimentStart
	 Rte.ExperimentStart
	' Start the running of the Experiment
	SessionProc.Run c
	' ExperimentFinish
	 Rte.ExperimentFinish
	' Log clock timing information
```

```
	c.SetAttrib "Clock.Information", Clock.Information
	ebContext.SetAttrib "SessionFinishDateTimeUtc", NowUtc()

	' Clean up the context and close the datafile
	If CLng(c.GetAttrib("Subject")) <> 0 Then
		c.DataFile.Close
		' Attempt to convert the recovery file into a data file
		Dim nConvert As Long
		nConvert = c.DataFile.Convert(ebProgressSimple)
		If nConvert = 0 Then
			' Settings in E-Studio are set to not remove E-Recovery file
		Else
			' The datafile failed to convert!
			MsgBox "ERROR: The datafile did not convert!\nFILE: " & c.DataFile.Filename & "\n\nIt is recommended that you recover
your data with the E-Recovery utility"
			MsgBox c.DataFile.GetLastErrorMessage()
		End If
	End If
ExperimentFinish:

	UnInitObjects

	UnInitPackages
	UnInitDevices

	UnInitGlobals

	' Experiment Advisor Report Generation
	If Rte.ExperimentAdvisor.Enabled = True Then
		If Len(Rte.ExperimentAdvisor.Filename) = 0 Then Rte.ExperimentAdvisor.Filename = Replace(c.DataFile.Filename, ".txt", "-
ExperimentAdvisorReport.xml")
		Rte.ExperimentAdvisor.GenerateReport


	End If


ExperimentAbort:

	' Clean up the context
	c.PopFrame
	Set c = Nothing
	Set ebContext = Nothing

	DestroyDefaultPort

End Sub
```

Annex VII: Mean FA (standard deviations in brackets).

Tract	Group	FA N	FA Mean (SD)	FA p value
Precentral	Active	22	0.43 (0.02)	0.175
	Passive	18	0.42 (0.02)	
Precentral - Putamen	Active	1	0.41 (-)	-
	Passive	0	-	
Precentral - Frontal Inf Oper	Active	21	0.41 (0.02)	0.735
	Passive	16	0.4 (0.03)	
Frontal Inf Oper	Active	13	0.4 (0.02)	0.93
	Passive	12	0.4 (0.03)	
Frontal Inf Tri - Precentral	Active	16	0.4 (0.03)	0.33
	Passive	12	0.39 (0.03)	
Frontal Inf Tri – Frontal Inf Oper	Active	15	0.38 (0.02)	0.358
	Passive	12	0.38 (0.01)	
Frontal Inf Tri	Active	12	0.39 (0.02)	0.084
	Passive	9	0.37 (0.03)	
Frontal Inf Orb - Frontal Inf Oper	Active	2	0.36 (0.02)	0.238
	Passive	2	0.38 (-)	
Frontal Inf Orb – Frontal Inf Tri	Active	2	0.36 (0.04)	0.843
	Passive	5	0.37 (0.03)	
Frontal Inf Orb	Active	2	0.42 (0.05)	0.362
	Passive	1	0.32 (-)	
Frontal Inf Orb - Putamen	Active	1	0.37 (-)	-
	Passive	0		
Supp Motor Area - Precentral	Active	9	0.42 (0.06)	0.763
	Passive	4	0.42 (0.03)	
Supp Motor Area - Frontal Inf Oper	Active	5	0.41 (0.03)	0.842
	Passive	5	0.41 (0.03)	
Supp Motor Area – Frontal Inf Tri	Active	5	0.42 (0.01)	0.12
	Passive	3	0.39 (0.03)	
Supp Motor Area – Frontal Inf Orb	Active	0	-	-
	Passive	1	0.37 (-)	
Supp Motor Area	Active	13	0.42 (0.06)	0.064
	Passive	10	0.38 (0.03)	
Caudate - Precentral	Active	5	0.46 (0.04)	0.726
	Passive	2	0.48 (0.08)	
Caudate – Supp Motor	Active	5	0.4 (0.03)	0.129
	Passive	1	0.46 (-)	
Caudate	Active	1	0.35 (-)	-
	Passive	1	0.31 (-)	
Putamen - Precentral	Active	17	0.4 (0.03)	0.812
	Passive	13	0.4 (0.04)	
Putamen – Frontal Inf Oper	Active	6	0.38 (0.03)	0.733
	Passive	2	0.37 (-)	
Putamen - Frontal Inf Tri	Active	18	0.37 (0.02)	0.509
	Passive	8	0.37 (0.01)	
Putamen - Frontal Inf Orb	Active	15	0.38 (0.03)	0.919
	Passive	11	0.38 (0.04)	
Putamen - Supp Motor Area	Active	13	0.39 (0.03)	0.698
	Passive	8	0.4 (0.02)	
Putamen - Caudate	Active	2	0.36 (0.01)	0.285
	Passive	4	0.39 (0.04)	
Putamen	Active	4	0.42 (0.07)	0.916
	Passive	3	0.42 (0.07)	
Pallidum - Precentral	Active	19	0.42 (0.03)	0.497
	Passive	16	0.43 (0.04)	
Pallidum – Front Inf Oper	Active	1	0.39 (-)	-
	Passive	1	0.37 (-)	
Pallidum - Front Inf Tri	Active	12	0.38 (0.02)	0.716
	Passive	7	0.38 (0.02)	
Pallidum - Front Inf Orb	Active	6	0.38 (0.04)	0.531
	Passive	7	0.37 (0.02)	
Pallidum - Supp Motor Area	Active	11	0.39 (0.03)	0.414
	Passive	11	0.4 (0.02)	
Pallidum - Caudate	Active	0		-
	Passive	1	0.37 (-)	
Pallidum - Putamen	Active	2	0.41 (0.08)	0.887
	Passive	2	0.4 (0.02)	
Pallidum	Active	0		-
	Passive	1	0.37 (-)	
Thalamus - Precentral	Active	20	0.43 (0.03)	0.358
	Passive	14	0.44 (0.05)	

Continuation.

Tract	Group	FA		
		N	Mean (SD)	p value
Thalamus – Frontal Inf Tri	Active	4	0.41 (0.01)	0.006*
	Passive	2	0.46 (0.01)	
Thalamus - Frontal Inf Orb	Active	3	0.38 (0.01)	0.469
	Passive	2	0.4 (0.02)	
Thalamus - Supp Motor Area	Active	20	0.42 (0.02)	0.866
	Passive	14	0.42 (0.02)	
Thalamus - Caudate	Active	19	0.35 (0.03)	0.979
	Passive	16	0.35 (0.02)	
Thalamus - Putamen	Active	13	0.4 (0.06)	0.569
	Passive	14	0.38 (0.05)	
Thalamus - Pallidum	Active	5	0.36 (0.02)	0.01*
	Passive	4	0.41 (0.02)	
Thalamus	Active	3	0.35 (0.03)	1
	Passive	3	0.35 (0.04)	
STN - Precentral	Active	10	0.46 (0.03)	0.177
	Passive	6	0.48 (0.02)	
STN – Frontal Inf Tri	Active	5	0.48 (0.03)	0.509
	Passive	3	0.49 (0.01)	
STN – Frontal Inf Orb	Active	5	0.46 (0.03)	0.871
	Passive	2	0.46 (0.01)	
STN – Supp Motor Area	Active	14	0.48 (0.03)	0.098
	Passive	8	0.46 (0.02)	
STN - Caudate	Active	1	0.43 (-)	-
	Passive	1	0.49 (-)	
STN - Putamen	Active	1	0.45 (-)	-
	Passive	1	0.47 (-)	
Frontal Sup R - Precentral	Active	19	0.41 (0.04)	0.55
	Passive	17	0.4 (0.03)	
Frontal Sup R	Active	18	0.44 (0.06)	0.58
	Passive	18	0.43 (0.06)	
Frontal Sup R - Frontal Inf Oper R	Active	19	0.4 (0.03)	0.39
	Passive	16	0.41 (0.03)	
Frontal Sup R - Frontal Inf Tri R	Active	17	0.39 (0.03)	0.45
	Passive	11	0.38 (0.02)	
Frontal Sup R - Frontal Inf Orb R	Active	9	0.36 (0.02)	0.22
	Passive	3	0.38 (0.02)	
Frontal Sup R - Supp Mot R	Active	2	0.47 (0.04)	0.37
	Passive	4	0.43 (0.05)	
Frontal Sup R - Postcentral R	Active	10	0.41 (0.02)	0.59
	Passive	9	0.4 (0.03)	
Frontal Sup R - Parietal Sup R	Active	10	0.4 (0.02)	0.83
	Passive	14	0.4 (0.02)	
Frontal Sup R - Precuneus R	Active	9	0.42 (0.05)	0.72
	Passive	10	0.42 (0.02)	
Frontal Sup R - Caudate R	Active	13	0.36 (0.05)	0.97
	Passive	10	0.36 (0.03)	
Frontal Sup R - Putamen R	Active	19	0.38 (0.02)	0.59
	Passive	15	0.38 (0.02)	
Frontal Sup R - Pallidum R	Active	19	0.39 (0.03)	0.75
	Passive	15	0.39 (0.03)	
Frontal Sup R - Thalamus R	Active	23	0.41 (0.02)	0.09
	Passive	17	0.39 (0.02)	
Frontal Sup R - Stn	Active	19	0.48 (0.03)	0.29
	Passive	15	0.47 (0.03)	
Postcentral R - Precentral R	Active	23	0.43 (0.02)	0.45
	Passive	19	0.42 (0.03)	
Postcentral R - Frontal Inf Oper R	Active	6	0.39 (0.01)	0.30
	Passive	8	0.4 (0.03)	
Postcentral R - Frontal Inf Tri R	Active	11	0.41 (0.04)	0.93
	Passive	9	0.41 (0.01)	
Postcentral R - Frontal Inf Orb R	Active	1	0.41 (.)	-
	Passive	0	. (.)	
Postcentral R - Supp Motor R	Active	4	0.41 (0.02)	0.47
	Passive	2	0.43 (0.02)	
Postcentral R	Active	20	0.4 (0.03)	0.70
	Passive	18	0.4 (0.03)	

Continuation.

Tract	Group	FA		
		N	Mean (SD)	p value
Parietal Sup R - Precentral R	Active	19	0.43 (0.04)	0.96
	Passive	17	0.43 (0.03)	
Parietal Sup R - Frontal inf Oper R	Active	4	0.41 (0.01)	0.12
	Passive	3	0.46 (0.04)	
Parietal Sup R - Frontal inf Tri R	Active	13	0.42 (0.03)	0.70
	Passive	10	0.42 (0.02)	
Parietal Sup R - Frontal Inf Orb R	Active	11	0.41 (0.02)	0.32
	Passive	7	0.42 (0.02)	
Parietal Sup R - Supp Motor R	Active	2	0.41 (0.01)	0.70
	Passive	2	0.41 (0.01)	
Parietal Sup R - Postcentral R	Active	23	0.41 (0.03)	0.31
	Passive	19	0.42 (0.02)	
Parietal Sup R	Active	20	0.43 (0.04)	0.82
	Passive	13	0.42 (0.03)	
Precuneus R - Precentral R	Active	1	0.51 (.)	-
	Passive	1	0.38 (.)	
Precuneus R - Frontal Inf Oper R	Active	1	0.41 (.)	-
	Passive	0	. (.)	
Precuneus R - Frontal Inf Tri R	Active	2	0.43 (0.01)	0.39
	Passive	4	0.43 (0.01)	
Precuneus R - Frontal Inf Orb R	Active	5	0.42 (0.02)	0.67
	Passive	5	0.43 (0.02)	
Precuneus R - Supp Motor R	Active	18	0.42 (0.03)	0.72
	Passive	14	0.42 (0.04)	
Precuneus R - Postcentral R	Active	3	0.51 (0.05)	0.58
	Passive	1	0.47 (.)	.
Precuneus R - Parietal Sup R	Active	8	0.45 (0.04)	0.75
	Passive	9	0.44 (0.02)	
Precuneus R	Active	17	0.41 (0.02)	0.10
	Passive	12	0.43 (0.02)	
Postcentral R - Caudate R	Active	15	0.42 (0.04)	0.08
	Passive	12	0.39 (0.03)	
Postcentral R - Putamen R	Active	22	0.44 (0.03)	0.72
	Passive	15	0.44 (0.02)	
Postcentral R - Pallidum R	Active	22	0.47 (0.02)	0.95
	Passive	16	0.47 (0.02)	
Postcentral R - Thalamus R	Active	20	0.45 (0.03)	0.81
	Passive	15	0.44 (0.06)	
Postcentral R - Stn	Active	2	0.49 (0.01)	0.18
	Passive	1	0.55 (.)	.
Parietal Sup R - Caudate R	Active	17	0.41 (0.04)	0.44
	Passive	11	0.4 (0.03)	
Parietal Sup R - Putamen R	Active	21	0.44 (0.03)	0.48
	Passive	15	0.44 (0.02)	
Parietal Sup R - Pallidum R	Active	20	0.46 (0.02)	0.36
	Passive	16	0.47 (0.02)	
Parietal Sup R - Thalamus R	Active	23	0.43 (0.04)	0.97
	Passive	17	0.43 (0.05)	
Parietal Sup R - Stn	Active	1	0.42 (.)	-
	Passive	0	. (.)	
Precuneus R - Caudate R	Active	8	0.39 (0.02)	0.38
	Passive	7	0.4 (0.04)	
Precuneus R - Putamen R	Active	8	0.45 (0.03)	0.76
	Passive	12	0.44 (0.05)	
Precuneus R - Pallidum R	Active	10	0.46 (0.02)	0.21
	Passive	6	0.48 (0.02)	
Precuneus R - Thalamus R	Active	20	0.42 (0.03)	0.45
	Passive	15	0.42 (0.03)	
Precuneus R - Stn	Active	0	. (.)	-
	Passive	0	. (.)	

Note: Number of participants having a tract is specified by group (N). P values are also provided. Note: PF Inf = Prefrontal inferior lobe; Oper = opercular; Tri = triangular; Orb = orbital; Supp = supplementary.