Universitat de les Illes Balears

Facultat de Psicologia

Memòria del Treball de Fi de Grau

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Grau de Psicologia

Any acadèmic 2012-13

DNI de l'alumne: 43222187N

Treball tutelat pel Dr. Fabrice Parmentier
Departament de Psicologia

Paraules clau del treball:
Attention capture, distraction, deviant sounds, semantic effect, and congruency.

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Treball de Fi de Grau, 2013

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This research study is part of the Final Degree Project presented in 2013 by Miriam Kefauver Silva and of a research project directed by Dr. Fabrice Parmentier and funded by the Spanish Ministry of Economy and Competitiveness (project PSI-2009-08427) and Plan E.

Abstract

Unexpected perceptual changes in the environment (so called oddball stimuli), such as sounds deviating from a repeated stream of task-irrelevant auditory stimuli (deviant sounds among standard sounds), capture attention and can affect negatively task performance. This is known as distraction. The present study used a cross-modal oddball task in which participants had to categorize visual left and right arrows while instructed to ignore irrelevant sounds (standard and deviant sounds, "izquierda" and "derecha"). The deviant sounds could vary on their degree of congruency (20%, 50% or 80%) with the visual arrow depending on the experimental condition. The results show that deviant sounds delay responses to a visual target and, more importantly, that the semantic content of the deviant sounds is analyzed. This semantic effect varies depending on expectations regarding the relationship between distractor and target in each congruence condition. Furthermore, expectations can reduce the impact of conflict between target and distractors.

Key words: Attention capture, distraction, deviant sounds, semantic effect, and congruency.

Resumen

Cambios perceptivos inesperados en el medio ambiente (llamados estímulos "raros"), tales como sonidos que se desvían de una corriente repetida de estímulos auditivos irrelevantes para la tarea a realizar (sonidos infrecuentes entre sonidos estándar), capturan la atención y pueden afectar negativamente al desempeño de la tarea. Esto se conoce como distracción. En el presente estudio se utilizó una tarea, denominada "cross-modal oddball task", en el que los participantes tenían que clasificar flechas visuales, que iban hacia la izquierda o hacia la derecha, mientras se les instruyó ignorar los sonidos irrelevantes para la tarea (sonidos estándar y sonidos infrecuentes, "izquierda" y "derecha"). Los sonidos infrecuentes podrían variar en su grado de congruencia (20%, 50% o 80%) con la flecha visual, según la condición experimental. Los resultados mostraron que los sonidos infrecuentes prorrogan las respuestas ante el objetivo visual y, más importante aún, que el contenido de los sonidos infrecuentes es analizado semánticamente. Este efecto semántico varía en función de las expectativas sobre la relación entre el distractor y el objetivo en cada condición experimental Asimismo, las expectativas pueden reducir el impacto del conflicto entre el objetivo y los distractores.

Palabras clave: Atención, distracción, efecto semántico, sonido infrecuente, y concordancia.

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Introduction

While efficient everyday functioning often requires the ability to selectively attend to some stimuli, it is equally important to maintain a certain degree of distractibility by task-irrelevant but otherwise potentially relevant events. Detecting an unexpected but potentially important stimulus in the environment can for example warn of an imminent danger (e.g., an unexpected change in an aircraft engine's noise may signal a malfunction). That's why fast and efficient detection of changes in the environment is important for adaptive behaviour (Ljungberg & Parmentier, 2012; Parmentier, Elford, Escera, Andrés & San Miguel, 2008; Parmentier & Hebrero, 2013; Parmentier, Turner & Perez, 2013; Roye, Jacobsen, Schröger, 2007;).

According to Berti & Schröger's study on 2001, the system that captures, selects and storages information to later on, activate cognitive or motor processes, involves sensory and working memory functions. The human auditory modality reveals a highly developed system that continuously models the acoustic environment based on auditory sensory memory representations even outside the focus of attention and automatically registers changes that do not fit the model. This monitoring may result in the elicitation of an involuntary attention switch prioritizing the processing of the change and initiating an orienting response (Roye, et al. 2007).

Unexpected perceptual changes in our surroundings yield rapid, specific, and automatic brain responses. Our attention, even when we're performing a task, is captured by infrequent auditory or visual changes (so called oddball stimuli) in the environment, even when those stimuli are irrelevant to the performing of the task. (Berti & Schröger, 2001; Escera, Alho, Winkler & Näätänen, 1998; Parmentier et al. 2008; Parmentier, Elsley, Andrés, & Barceló, 2011; Parmentier et al. 2013).

This attention capture is understood as distraction, that relates to core aspects of cognition, such as its tendency to build mental models of events to help deal with upcoming stimuli, and its propensity to orient attention towards events violating such models (Berti & Schröger, 2001; Parmentier et al. 2008; Parmentier et al. 2011). This type of distraction is observed across different sensory channels: auditory (e.g., Berti, 2008; Berti & Schröger, 2003; Schröger, 1996, as cited in Li, Parmentier & Zhang, 2013), visual (e.g., Berti & Schröger, 2004; and Boll & Berti, 2009; as cited in Li et al. 2013), such as in the auditory-visual (e.g., Andrés, Parmentier & Escera, 2006 as cited in Li et al. 2013; and Ljungberg & Parmentier, 2012a) and tactile-visual modalities (Ljungberg & Parmentier, 2012b; Parmentier, Ljungberg, Elsey, & Lindkvist, 2011, as cited in Li et al. 2013).

Traditionally, empirical evidence supporting the existence of a change detection and orientation mechanism emerged from electrophysiological studies (e.g. Näätänen, 1990, 1992; Näätänen & Winkler, 1999; Schröger, 1996, 1997, as cited in Ljungberg & Parmentier, 2012), examining the brain's response to rare and unexpected novel or deviant sounds (so-called oddball stimuli) relative to a repeated acoustic signal (referred to as the standard). These electrophysiological studies led to a number studies where the behavioral aspects of distraction was examined more systematically (e.g. Berti & Schröger, 2001; Ljungberg & Parmentier, 2012a, 2012b; Parmentier, Turner & Esley, 2011), aiming to establish the cognitive mechanisms responsible for this effect. Although the vast majority of past studies focused on auditory deviance, fewer on visual deviance or bimodal deviance, and only two vibro-tactile deviance (Ljungberg & Parmentier, 2012; Parmentier, Ljungberg, Elsey, & Lindkvist, 2011).

Electrophysiological measures of distraction

From the electrophysiological standpoint, using event-related potentials (ERPs) measurements, the cognitive and neuronal basis of distraction by deviant and novel sounds is characterized by three specific responses, referred to as the "distraction potential", which are: the mismatch negativity (MMN), the P3a and the re-orientation negativity (RON) responses, explained below. The mismatch negativity (MMN) response reflects the pre-attentive detection of a change (or even the illusion of a change) in the auditory context. The underlying mechanism eliciting this response is a comparison between a memory trace of the acoustic regularities of past sound events and the current auditory signal; and the enhancement of N1 generators (when the distracter deviates a great deal from the repetitive background). The P3a response (sometimes referred to as novelty P3) reflects the involuntary orientation towards the deviant or novel stimuli. And the re-orientation negativity (RON) response is the index of the subsequent re-orientation of attention to process the task-relevant stimulus information. It's noteworthy that RON is not modality-specific, and it can be elicited in a paradigm that combines auditory-visual stimuli. Berti & Schröger suggested that this re-orienting of attention (RON) is performed at a working memory level to optimize performance in the primary task (Berti & Schröger, 2001; Parmentier, et al. 2008; Parmentier et al. 2011; Roye et al. 2007).

The processes that underlie these ERP components seem to play an important role in the selection and retention of relevant information while simultaneously keeping the cognitive system accessible for important changes in the environment (Berti & Schröger, 2001).

Involuntary attention shifts were originally explained by the orienting-reflex (OR) theory (Sokolov, 1963), proposing that a neuronal model is built from the repetitive features of the external environment, inhibiting the OR to identical but not to different stimuli. Further, Öhman (1979, 1992) proposed that a “call” for reallocation of central processing resources is issued by preattentive mechanisms detecting significant changes in incoming stimuli (Escera et al. 1998).

While electrophysiological studies have described in detail the pattern of responses triggered by deviant stimuli presented in the context of an otherwise repetitive standard sound (e.g., Schröger, 1996, 1997; Schröger, Giard & Wolff, 2000, as cited in Ljungberg, Parmentier, Leiva & Vega, 2012), deviant sounds also yield measurable behavioral effects, most typically in the form of slower responses (e.g., Berti & Schröger, 2001; Escera et al. 1998; Parmentier, 2008), but also in the form of a reduction in memory performance while performing a serial recall task (Hughes, Vachon, & Jones, 2005, 2007; Ljungberg, Parmentier, Hughes, Macken, & Jones, 2012; as cited in Ljungberg et al. 2012).

Behavioral distraction

At the behavioral level, deviant and novel sounds yield distraction too, usually reflected by response delays associated to the shifts of attention to and from the novel or deviant sounds in a primary task (Parmentier et al. 2008; Parmentier & Hebrero, 2013; Parmentier et al. 2013; Schröger, 1996). In Parmentier et al. (2011) study, distraction was not induced by the novel sound, in fact, their findings showed that behavioral distraction can happen because the incoming deviant or novel auditory stimulus violates the cognitive system expectations and because it's perceptually different from the previous sound.

Behavioral distraction by deviant sounds has recently been the focus of an increasing number of studies using the so-called cross-modal task. In that task, participants categorize visual stimuli presented in sequence (e.g. digits) on the basis of some criterion (e.g. parity). Each visual target is preceded by an auditory stimulus (standard sound on most trials, deviant sound on rare trials) that participants are instructed to ignore (Escera et al. 1998; Ljungberg et al. 2012; Näätänen, 1998; Parmentier, 2008; Parmentier et al. 2011; Parmentier et al. 2013).

In Parmentier's (2008) study, two main effects, the deviance and the semantic effect (further explained below), affected task performance. The origins of these effects were discussed in his study, where Parmentier proposed four possible explanations of the deviance distraction. Firstly, this effect could be caused by the different spatial locations of the auditory distractors and the visual targets. The second possible explanation was the time penalties caused by the shift of perceptual modalities (from visual to auditory, and vice versa). The third explanation was that the shift could also be between task sets, from one set of stimulus–response mappings (visual targets to corresponding response keys) to another, where the stimulus is the deviant sound and the required response is to refrain from producing any behavior. And the fourth possible explanation is that novels may also affect performance in a visual task because they cause contextual changes, making the selection of appropriate and context-specific stimulus–response mapping relatively difficult. He suggested that given the deviants meaning, participants may have failed to switch to a sound–no response mapping, resulting in the semantic analysis of the novels and in a negative impact of task performance.

Semantic effect

Several studies reported that the preattentive processing of a change is modulated by long-term memory representations, most frequently investigated in the domains of speech and music. In detail, using speech stimuli, material we are most familiar with, it has been shown robustly that enduring long-term memory representations concerning phonemes, syllables or words of the own language affect the preattentive auditory processing of an acoustic change (Roye et al. 2007).

Versions of early selection theories such as the filter-attenuation theory (Treisman, 1960, as cited in Escera, Yago, Corral, Corbera & Nuñez, 2003) proposed the existence of an attention filter that reduces the information available in the rejected channel, which is nevertheless sufficient to activate highly primed entries in the "mental dictionary". Late-selection theories, in turn, have proposed that perceptual processing to the semantic level is entirely automatic, leaving to executive attention the control of the access of irrelevant stimuli to consciousness, memory and response mechanisms (Deutsch & Deutsch, 1963, as cited in Escera et al. 2003).

More recently, in a comprehensive review of the contribution of event-related brain potential (ERP) studies to the understanding of human attention (Näätänen, 1990, 1992, as cited in Escera et al. 2003) Näätänen (1990, 1992) proposed that semantic analysis of significant stimuli only occurs after transitory involuntary attention switching to the eliciting sounds, and that these transitory attention switches can be triggered by a transient-detector mechanism reacting to sudden changes in stimulus energy, or by a change-detector mechanism activated by violations of the acoustic regularity, these two mechanisms being reflected, respectively, in the auditory N1 and mismatch negativity (MMN) ERPs.

Pulvermüller (2001, as cited in Parmentier et al. 2013) argued that the presentation of an oddball-spoken word activates automatically vast cortical networks involving assemblies of neurons coding for the "meaning" of a word.

Behavioral performance is affected when there's a conflict between the semantic activations originated from the involuntary processing of deviant spoken words and the voluntary processing of target stimuli, where inhibition mechanisms are needed for the task performance (Parmentier, Turner, & Elsley, 2011), for example, when task-irrelevant congruent and incongruent deviant words ("left", "right") are presented before visual arrows in a left–right categorization task. Parmentier (2008) examined the cognitive aftermath of attention capture by auditory novelty, and more specifically (1) whether the shift of attention to novels is followed by an analysis of their content and (2) whether the result of such analysis can interfere with subsequent behavior. In his study, participants categorized visual arrows pointing to the left or to the right, which were preceded by a standard (on most trials) or a deviant (on rare trials) sound. The deviants consisted of the spoken words "left" and "right". On half the deviant trials, target and deviants were congruent (e.g., "left" followed by a left arrow) and incongruent on the remaining deviant trials (e.g., "left" followed by a right arrow). The purpose of his study was to confirm that if deviant sounds are semantically processed, then both congruent and incongruent deviant sounds should delay responses in the arrow task for being acoustically different from the standard sounds ("novelty effect") and, moreover, that there should be a conflict between the irrelevant sound processing and the visual target processing, shown in longer RTs in the incongruent deviant trials than in the congruent deviant trials ("semantic effect"). Parmentier (2008) argued that both congruent and incongruent deviants should produce deviance distraction in the visual task for being acoustically deviant, and that a semantic analysis of the deviants' content should follow the orientation response triggered by their unexpected occurrence but the deviants. The results showed that incongruent auditory deviants disrupted task performance over and above congruent deviants (semantic effect) while both types of deviants delayed responses in the visual task compared to standard (deviance distraction).

Parmentier et al. (2011) also examined how the involuntary semantic processing of unexpected spoken distractors contributes to distraction. Their findings showed that participants were slower performing the visual-arrow task before novel sounds (novelty distraction), and that the conflict between the novels meaning and the visual arrow added more interference to the task performance (semantic effect). Their results also showed that the semantic effect (but not novelty distraction) increased, as more time was available to build up semantic activations related to the novel sound content. Their findings also reiterated the Parmentier's (2008) model's functional dissociation between novelty distraction and the semantic effect. Combined with Parmentier's (2008) finding that practice and the contrast between standard and novel affected novelty distraction and not the semantic effect, their study helps to establish a double dissociation between the two contributors to behavioral distraction.

In sum, attention capture is followed by an involuntary semantic analysis of the novels' or deviants' content which, when in conflict with a target stimulus (interfering with its processing), is followed by the inhibition of the distracter (Parmentier et al. 2011).

The present study

The present study was based on Parmentier's (2008) about the role of auditory deviance distraction (involuntary attention processing) and the semantic effect caused by the deviants' content. In this study we used the cross-modal oddball task developed by Parmentier (2008) to (1) replicate the finding that of the semantic effect (longer response times following incongruent than congruent deviants); and (2) to test a new hypothesis, namely that the semantic effect might be mediated by implicit expectations about the probability of congruency between deviants and targets.

Participants were randomly distributed in three experimental conditions. In the 20% congruency condition, only 20% of the deviant trials were congruent with the upcoming visual arrow (e.g., "izquierda" followed by a left arrow). The 50% and 80% congruency conditions included 50% and 80% of congruent deviants respectively. Participants were asked to judge if an arrow presented on the computer screen pointed to the left or to the right, using the left and right response keys respectively. Immediately before each arrow, a short sound was presented. On most trials, this sound was a simple tone (standard sound). On rare trials, this standard sound was replaced by the words "izquierda" or "derecha" (deviant sounds), and their level of congruency with the upcoming arrow was varied across participants: 20%, 50% or 80% congruent.

We predicted, as in Parmentier's (2008) findings, and based on the notion that behavioral distraction relates to the relationship between expectations and events, that if deviant sounds are semantically processed, then both congruent and incongruent deviants should delay responses in the arrow task by virtue of being acoustically different from the standard (deviance effect) across the three congruence conditions (20%, 50% and 80%). More over, we also hypothesized that there should be a conflict between the processing of the irrelevant sounds and the processing of the visual target, showed in the 50% congruence condition by longer RTs in the incongruent deviant trials relative to the congruent deviant trials (semantic effect); and that this semantic effect should be mediated by expectations (depending on the degree of congruency, 20%, 50% or 80%). Specifically, compared to the 50% congruence condition, the semantic effect should be reduced in the 20% congruence condition because the negative effect of the deviant's incongruence should be diminished by its predictability. Conversely, the semantic effect should be enhanced in the 80% congruence condition because in that case, incongruent trials not only clash with the target stimulus but also violate the expectation of congruency. If the capture of attention is not followed by a semantic analysis of the deviant sound, then both congruent and incongruent deviants should produce the same levels of distraction in the visual task by virtue of being acoustically deviant.

Method

Participants

The experiment involved sixty under-graduate students (46 females and 14 males) from the Balearic Islands University, in exchange for course credit or a small payment. All the participants were native Spanish speakers and reported normal hearing and normal or corrected-to-normal vision. The mean age of participants was 20.72 years (SD = 1.84).

Materials and stimuli

Three sounds were used in this experiment. The standard sound was a 400 ms sinewave tone of a frequency of 600 Hz, with 10 ms intensity ramps at the onset and the offset. The deviant sounds were the words "izquierda" and "derecha" spoken in Spanish and in a female voice. These sounds were digitally edited to last 400 ms. All sounds were normalized and presented to participants at approximately 70 dB, binaurally, through headphones. And all sounds were recorded at a sampling rate of 44 kHz and sample size of 16bit (mono). The task was programmed in E-Prime and executed on a computer equipped with a 17 in. screen.

Design and procedure

Participants were presented with five blocks of 160 trials each (see Figure 1). A fixation cross was displayed at the center of the screen for the duration of the trial except during the presentation of an arrow. Each trial started with the presentation of a 400 ms sound, followed 100 ms laterby a visual arrow sustaining a viewing angle of approximately 90° appeared at the center of the screen for 150 ms. The fixation cross re-appeared and remained visible for 700 ms, after which the next trial was automatically initiated. Participants therefore had a maximum of 850 ms (150 ms + 700 ms) to categorize the arrow's direction (left or right) by pressing the left and right arrow key on the keyboard (using the index fingers from their hands, the left one had to press the left key, and the right index finger the right key). Before the task, participants were instructed to ignore the sounds, to concentrate on the visual task and to respond as quickly and accurately as possible. They were allowed a short break between blocks.

Across the trials of each block, left and right arrows were used equally often and were presented in a random order (different for every participant). Three sound conditions were compared. In the standard condition, the standard sound was presented on 120 of the trials (75% of the trials). In the congruent and incongruent deviant conditions, where the proportions of congruent/incongruent vary depending on the condition, "left" and "right" were used as deviant in 12.5% of trials each. That remains true in all conditions.

The key manipulation of the study was the degree of congruency of the deviant trials, which was manipulated between participants. Participants were randomly distributed in three experimental conditions. In the 20% congruency condition, only 20% of the deviant trials were congruent with the upcoming visual arrow (e.g., "izquierda" followed by a left arrow). The 50% and 80% congruency conditions included 50% and 80% of congruent deviants respectively.

Figure 1. Sequence followed on each trial.

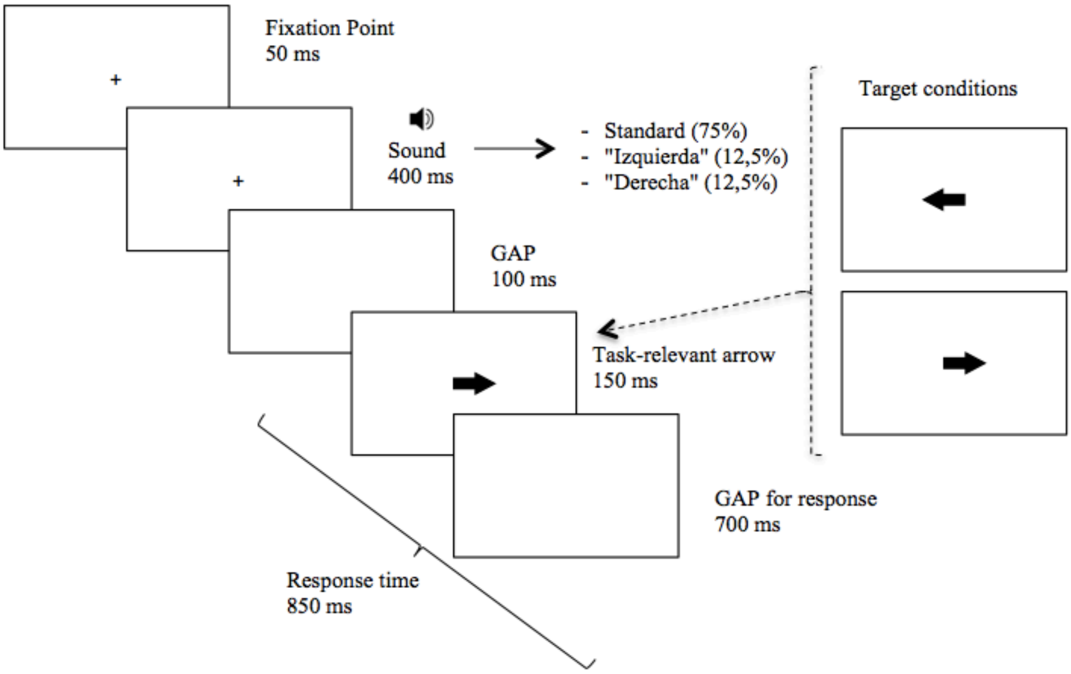


Fig. 1. Sequence of followed on each trial of each block. The difference between trials is the type of sound presented and the visual arrows, which can be unrelated (e.g., standard sound), congruent (e.g., "izquierda" presented before a left visual arrow) or incongruent (e.g., "izquierda" presented before a right visual arrow). The degree of congruency depends on the congruence condition, explained bellow.

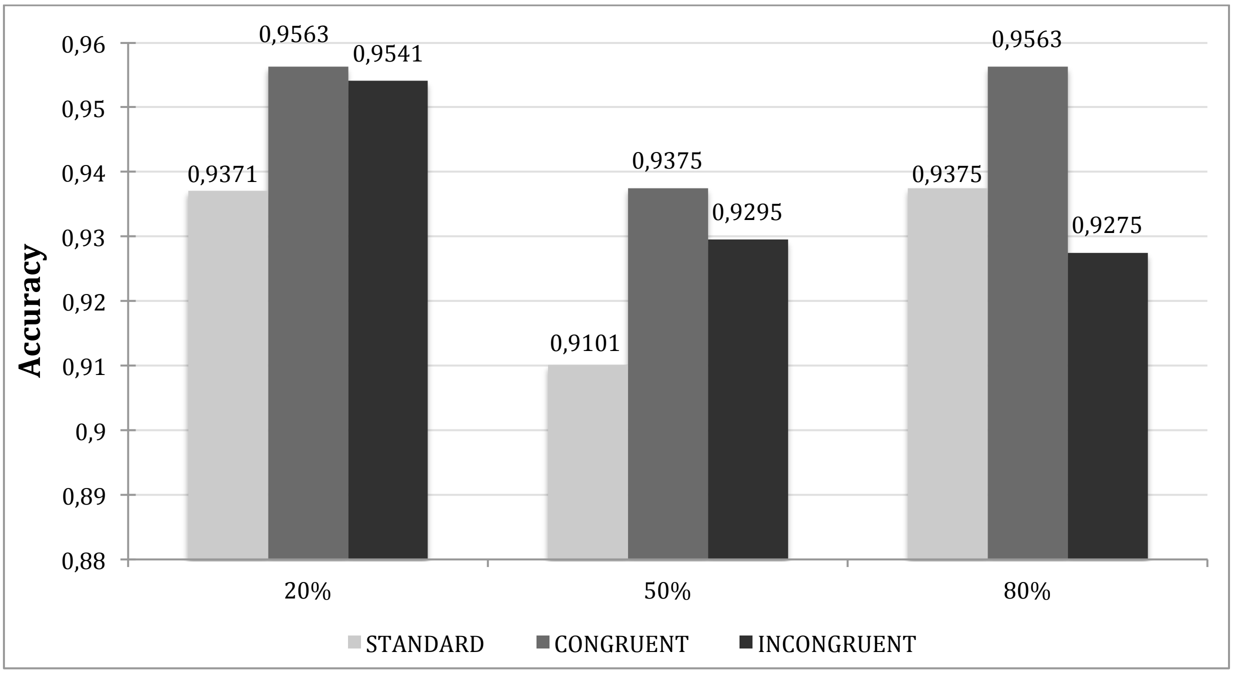
Results

Both mean accuracy and response times (RTs) for correct responses were analyzed using 3 (cue condition, between-participants: 20% congruent, 50% congruent, 80% congruent) x 3 (type of sound, within-participant: standard, congruent deviant, incongruent deviant) analyses of variance (ANOVAs). Deviance distraction was defined as the difference in performance between the deviant conditions combined and the standard condition. The semantic effect was defined as the difference in performance between the congruent and incongruent deviant conditions.

Accuracy

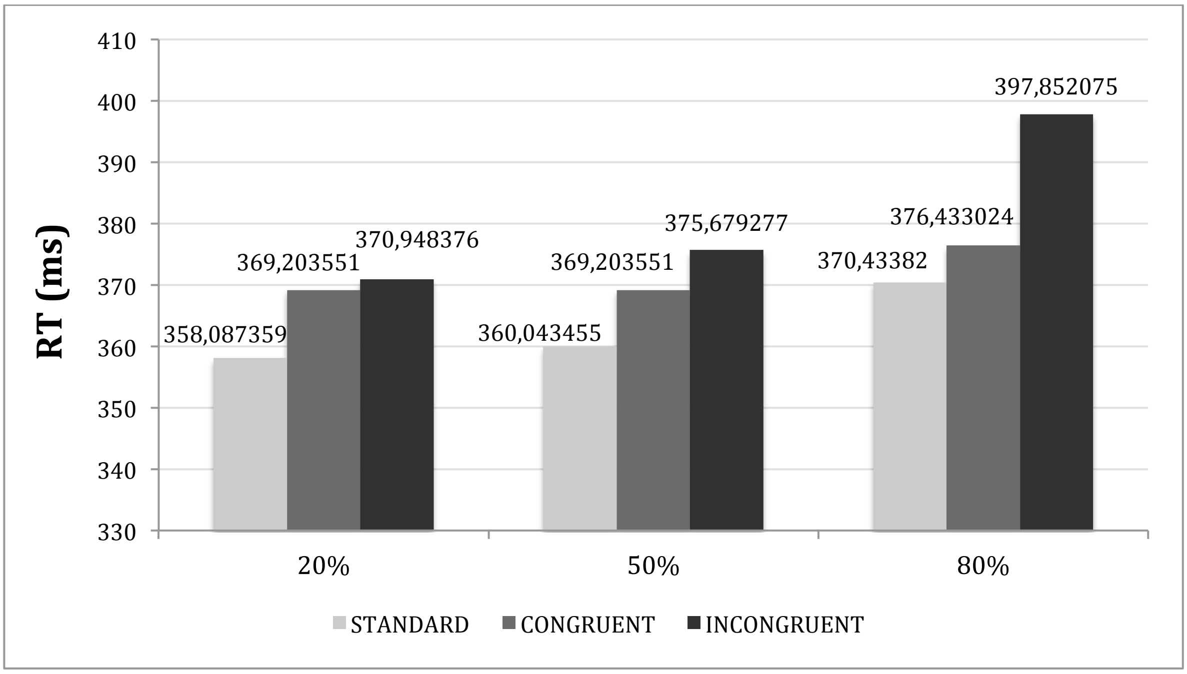
The analysis of accuracy levels revealed a main effect of type of sound condition, $F(2,114) = 7.379$, $MSE = 0.111$, $p < .001$. The main effect of congruency was not significant, F(2,57)=1.046, p=0.358, and neither was the interaction between congruency condition x type of sound, F(4,114)=1.655, MSE=0.111, p=0.165.

To know if the deviant conditions elicit deviance distraction per se, contrasts were carried out. Significant differences were found between the standard and congruent conditions, F(1,57)=23.480, p<0.001; and between the congruent and incongruent conditions, F(1,57)=4.306, p=0.043; being higher between the standard and the congruent deviants. No difference was found between the standard and the incongruent sounds, F(1,57)=2.024, p=0.160.



Response Times

The analysis of mean response times revealed a main effect of type of sound, F(2,114)=14.444, MSE=41175.724, p<0.001; as a main effect of the interaction between congruency x type of sound, F(4,114)=4.210, MSE=15024, p=0.003240. The main effect of congruency was not significant, F(2,57)=1.554, MSE=154384.792, p=0.220.



Further contrasts were carried out to analyze the interaction. To measure deviance distraction, RTs were compared between each of the deviant conditions and the standard condition, in each of the congruence conditions separately. In the 20% congruence condition, RTs were significantly longer between the standard and the congruent sound conditions, $F(1,19)=9.545$, $p=0.006$; than between the congruent and incongruent sound conditions, $F(1,19)=0.468$, $p=0.007$; but no significant differences were found between the standard and incongruent conditions, $F(1,19)=9.011$, $p=0.502$. In the 50% congruence condition, RTs were significantly longer between standard and incongruent sound condition, $F(1,19)=41.210$, $p=0.0001$, than between standard and congruent condition, $F(1,19)=0.710$, $p=0.410$; and between the congruent and incongruent sound condition, $F(1,19)=0.413$, $p=0.528$. In the 80% congruence condition, RTs were significantly longer between the standard and the incongruent sound conditions, $F(1,19)=32.056$, $p=0.0001$; than between the congruent and incongruent sound condition, $F(1,19)=34.475$, $p<0.0001$; but no significant differences were found between the standard and the congruent conditions, $F(1,19)=1.451$, $p=0.243$.

To evaluate our key hypothesis, namely that the semantic effect would vary according to the probability of congruency of the deviant sounds, we computed a semantic effect metric

(RT incongruent – RT congruent) and analyzed it using a univariant ANOVA with the congruence condition as between-participants factor. A significant effect of congruence condition was found, $F(2,57)=11.93175$, $MSE=9405.611$, $p<0.000047$. T-tests for independent samples revealed that the semantic effect was significant between all the congruence conditions, $t(38, 0.025)=-2.245$, $p=0.030644$ between 20%-50% conditions; $t=(38, 0.025)=-4.42047$, $p<0.00008$ between 20%-80% conditions; and $t(38, 0.025)=-2.82733$, $p=0.007448$ between 50%-80% conditions; being greater in the 20-80% congruence conditions, and lower in the 20-50% conditions.

General Discussion

The present study used a cross-modal oddball task in which participants categorized visual arrows preceded shortly before an irrelevant sound (standard or deviant) that participants were asked to ignore. And as we mentioned before, the key manipulation of our study was the degree of congruency of the deviant trials, leading to three experimental conditions: 20%, 50% and 80% congruence conditions, in which participants were randomly distributed. We analyzed accuracy and response times and the results coincide with our predictions. In the 20% and 80% congruence conditions, both congruent and incongruent deviants delay responses and affect task performance. Also, in the 50% and 80% congruence condition, the congruent and the deviant sounds don't differ because the facilitation yielded by the congruency counteracts deviance distraction; this doesn't happen in the 20% congruence condition, because although it yields some semantic facilitation, it also violates expectations, counteracting facilitation.

More over, confirming our hypotheses, there's a semantic effect between all congruence conditions, as indicated by longer RTs in the incongruent deviant trials relative to the congruent deviant trials, corroborating the deviant's content analysis. Thus, the results show that deviant sounds delay responses to a visual target and, more importantly, that the semantic content of the deviant sounds is analyzed, as Parmentier's (2008) findings in the experiment 1.

The probability of congruence and incongruence was manipulated for trials - being 0.125 and 0.125 respectively in the 50% congruence condition; 0.5 and 0.2 in the 80% condition; and 0.2 and 0.5 in the 20% condition - that represented only a small proportion of trials (deviant sounds only represented 25% of trials). A key finding of our study is that the semantic effect varies depending on expectations regarding the relationship between distractor and target stimulus in each congruence condition. These expectations are not referred to the presentation of the target stimulus, as Parmentier, Elsley & Ljungberg (2010) and Ljungberg, et al. (2012) examined. The results show that the semantic effect is greater in the 80% congruence condition, and lower in the 20% congruence condition. Therefore, the cognitive system is able to compute predictions based on (e.g., in the 80% condition), 5% and 20% of the task's trials. The semantic effect may be higher in the 80% congruence condition because not only there's a conflict between the incongruent deviants and the target visual stimulus, but the incongruent deviants also violate the expectation of congruency. Conversely, the semantic effect may be lower because of the incongruent deviant's predictability.

Similar conflict effects were examined in other interference studies, such as in Eriksen & Eriksen's (1974) Flanker task, and in the Stroop task (Stroop, 1935), as cited in Purmann, Badde, Luna-Rodriguez & Wendt (2011) and in Correa, Rao & Nobre (2008). In Gratton, Coles & Donchin's (1992) flanker task (Eriksen & Eriksen, 1974), as cited in Correa et al. 2008, the conflict effect (the difference between congruent and incongruent RTs) decreased when it was preceded by an incongruent trial, rather than a congruent one. And in Zbrodoff's (1982) Stroop (1935) task, as cited in Correa et al. 2008, the conflict effect was reduced by the expectation of an incongruent trial. Although, it's noteworthy that contrary with our study, the proportion of congruent and incongruent trials represents 100% of the task's trials; in our study, as mentioned before, congruent and incongruent trials represent together 25% of the task's trials.

Our findings, such as in the interference studies listed above, suggest that expectations can reduce the impact of conflict between target and distractors, showed by the reducing interference when a cue stimulus (e.g. deviant sound) announces a conflict.

Regarding possible limitations of our study, one possible variation source that may have affected task performance results is the long duration of the task, which might have made some subjects lose concentration and decrease differences between the conditions. Also, another possible limitation is that we didn't collect any data to know whether participants explicitly noticed the proportion of congruent trials (e.g., did subjects in the 80% condition become aware that most deviants were congruent?) in order to know if the variation of the semantic effect across the 20%, 50%, 80% conditions reflected implicit or explicit (or both) learning of these proportions.

About possible avenues for future experiments, these limitations should be take in account, and in contrast with our study, where we manipulated three percentages of congruence, future work could include a more parametric variation of congruency, to try to identify the shape of the change of the semantic effect (e.g., would it be linear? Curvilinear?).

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