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Título: Diferencias individuales en la preferencia por la curvatura.

Títol: Diferències individuals en la preferència per la curvatura.

Title: Individual differences in preference for curvature.

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Preliminary considerations:

This research work has been carried out taking into account that it could eventually be submitted for publication to the journal *Psychology of Aesthetics, Creativity, and the Arts*. This journal is devoted to the production and appreciation of the arts and all aspects of creative endeavor. It publishes manuscripts presenting original empirical research and papers that synthesise and evaluate research that relates to the psychology of aesthetics, creativity, and the arts.

Abstract

People tend to prefer objects with curved contours to objects with sharp contours (Bar & Neta, 2006; Palumbo & Bertamini, 2016). Nevertheless, as with other aesthetic features (Jacobsen, 2004), there are also considerable differences among people in the extent to which they prefer curvature. The aim of the research presented here was to explore the possible reasons for such differences. Specifically, we sought to determine whether individual differences in preference for curvature were explained by participants' interest in art, studies, openness to experience, intelligence or sex. Thus, we asked 42 participants to perform a 2AFC preference for curvature task (Munar, Gómez-Puerto, Call & Nadal, 2015), answer questions of a Visual Art Interest and Education Scale (VAIES), answer the openness to experience scale from the NEO-PI-R (Costa & McCrae, 1992), and Raven's intelligence test. Linear mixed effects modeling was used to predict participants' preference for curvature using their experience with art, openness to experience, intelligence scores, studies, and sex as predictors. We found that openness to experience had a significant negative effect on the probability of choosing the curved alternative and that the probability of choosing the curved alternative was higher for women than for men. The effect of openness is weaker for art students than for others. There were no significant effects of intelligence. These results are discussed in terms of the multiplicity of cognitive and affective processes contributing to aesthetic appreciation (Leder & Nadal, 2014).

Keywords: preference, curvature, angularity, empirical aesthetics, individual differences.

Individual differences in preference for curvature

Record hypotheses related to art and aesthetics began with the work of Fechner (1876). It is usually considered that this work opened the field of empirical aesthetics, the second, after psychophysics, in experimental psychology (Carreras, 1998; Marty, 1997). Specifically, Fechner began to apply the experimental method to issues related to art, and to recorded the reactions of a sample of subjects taken as representative of the population. In his book *Vorschule der Ästhetik* (1876), he presented the results of several experiments conducted in laboratory and field experiments. Fechner defined experimental aesthetics as an aesthetics from below, which was based on particular facts and gradually, progressed to create generalizations. The vision of Fechner of aesthetic experience was markedly formalistic, while his interest was to understand the way in which certain formal aspects -especially the proportions governing relations between elements- influence the aesthetic appreciation of people. This formalistic perspective had, and still has, an enormous influence on the experimental investigation of the aesthetic phenomenon, while many of the studies continued, and continue, wanting to understand the impact on the aesthetic appreciation of factors such as regularity, symmetry, complexity, color, aspect lines, etc. (Nadal, Gomila, Galvez-Pol, 2014).

In addition to laying the conceptual foundations of experimental aesthetics, Fechner also developed three methods that are still used today. The first is the method of choice. It involves asking participants to choose a value to communicate how nice, lovely, or attractive, etc., are different objects. The second is the method of production, by which participants create an object that in their view is nice, beautiful, attractive, etc. And the third method is to examine works of art or other objects, looking for the features that are most frequently preferred by the society that created them. The method of choice is still the most commonly used today, but is carried out in different ways. The participants are asked to sort the objects according to the preference they have for them, or they are presented with objects in pairs and have to pick one, or subjects are asked to rate numerically the degree of preference for each object.

During the first half of the twentieth century, the methodology that Fechner opened for the study of experimental aesthetics, was harshly criticized and accused of being too empirical, quantitative, deterministic and reductionist. Many philosophers often pointed out, that cultural and historical factors that can influence the aesthetic preference, were totally ignored by Fechner's proposal. Later, Daniel Berlyne developed a comprehensive research program known as psychobiological aesthetics, which became the origin of contemporary experimental aesthetics. Berlyne's main objective was to understand how motivational principles influence aesthetic preference. Based on neurobiological discoveries of his time on the motivational and emotional systems, Berlyne (1971) argued that there are three neural systems whose activity induces motivational state of an organism. The first system is rewarding, the second is aversion, and the third is inhibition of aversion. The activity of the three systems, according to Berlyne, depends on the degree of excitation of the body, which in turn depends on the configuration of the stimulus. He proposed the term "hedonic tone" to explain the ability of the stimulus to generate a reward response of pleasure or preference in the subject, causing it to emit linguistic statements.

For Berlyne, not only the intrinsic formal properties of the object, as claimed by Fechner, create aesthetic experience. For him, it is the way in which the observer perceives the object, that organizes and generates aesthetic experience. Thus, Berlyne went beyond the strictly formal view of Fechner, and recognised the active role of the observer. Berlyne argued that a full understanding of human aesthetic experience can only emerge from multidisciplinary work of psychological approaches, neuroscientists and evolutionists. But advances in neuroscience and psychology, showed that the proposal of Berlyne was too simple and limited, which left experimental aesthetics without a general theoretical framework until the proposals of Leder et al. (2004) and Chatterjee (2004) that gave meaning to the discoveries and advances, psychological and neuropsychological, produced in previous decades. Leder et al. (2004) published a model of aesthetic experience conceived as a result of a complex interaction of cognitive and affective processes. The model is divided into five stages of information processing of the aesthetic experience. All of them are connected in sequence. The flow of information is one way in some parts of the model, and other bidirectional, which means that some stages contain bottom-up processing but also top-down. Also it works in parallel, an affective evaluation system on the output arising from the stages of information processing of aesthetic experience.

The model of Leder et al. (2004) explains that when a visual stimulus is presented to the subject, specific stimulus features are extracted in each of the five stages of information processing. In the first phase, perceptual analysis, where properties such as complexity or symmetry are detected, occurs. The second phase involves memory integration, where the perceptual information relates to past experiences. The third phase, involves explicit classification, where the art experience of the observer comes into play, affecting the processing of information. In the fourth phase a meaning, or interpretation, is assigned to the stimulus. At that time, we know what we see. The fifth phase is the evaluation phase, which results in an aesthetic judgment and an aesthetic positive or negative emotion, about the work of art. In their model, Leder et al. (2004) specify that there are certain visual properties that can potentially affect the aesthetic preferences, since it has been found that people's preference for objects is influenced by certain visual properties. Contrast (Ramachandran & Hirstein, 1999), complexity (Berlyne, 1970, 1974; Frith & Nias, 1974), symmetry (Julesz, 1971), color (Martindale & Moore, 1998), and grouping (Marr, 1982), have been some of the visual properties that have been taken into account to study aesthetic preference during the 1990s. But in the last decade, preference for curvature has also received attention from researchers.

Lundholm (1921), was the first to show that the angular lines were perceived as angry, serious and difficult, while curved lines were associated with what it is calm, sad, gentle and kind. That is, Lundholm (1921) conducted the first experiment that showed that humans experience differently curved and angular lines. Subsequently, Poffenberger and Barrows (1924) corroborated Lundholm's experiment with the same results: curved lines and forms were considered more harmonious, pleasant and relaxing (Gómez-Puerto, Munar, Nadal, 2016). But Bertamini et al. (2015) clarified that the curved lines are not only associated with positive terms such as "friendly" or "relaxed", but also with negative, as "sad" or "lazy". Bertamini et al. (2015) also found that the angular lines are considered more complex than curved.

Uher (1991) studied the relationship between the zigzag lines in different cultures, and found that they were associated with adjectives of fighting, while curved lines were associated with adjectives of kindness (Gómez-Puerto, Munar, Nadal, 2016). Larson et al. (2007), once again showed that people associate geometric forms V-shaped, or angled, with the feeling of anger, while the curved, are associated with happiness.

Contour curvature is preferred in broad range of visual stimuli: people prefer objects (Bar & Neta, 2006), rooms (Vartanian et al., 2013), designs (Westerman et al., 2012), and geometric figures (Silvia & Barona, 2009; Palumbo et al., 2015; Bertamini et al., 2016;

Palumbo et al., 2016) with curved contours to those with sharp-angled contours. Bar and Neta (2006; 2007) proved that indeed a preference for the curvature occurred, since the type of contour of an object influences the kind of behavior that people showed towards them. Preference for curvature is greater on real objects. The explanation provided for this phenomenon was affirming a refusal of sharp angles, because they evoke a sense of threat, triggering a strong activation of the amygdala. This idea of rejection of the angular was also argued by Aiken (1998) when she explained that the preference for the curvature was actually motivated by the fear that induces sharp lines, which is a fear that served our ancestors to avoid threats (Gomez-Puerto, Munar, & Nadal, 2016). People prefer curved contours even when stimuli are shown very briefly (Bar & Neta, 2006, 2007).

Fantz & Miranda (1975) found evidence that there is a tendency in children a week of life, to maintain attention for longer to stimuli curved than angular stimuli, which is an evidence supporting the results of Bertamini et al. (2015), who deny that objects with curved contour are preferred because of a rejection of sharp angles. The results of their experiments, shown that preference for curvature occurs because of the characteristics of the curve itself. But it only happens when the curved contour is in objects whose affective valence is positive or neutral to the subject (Bertamini et al., 2015).

Munar, Gómez-Puerto, Call and Nadal (2015), investigated whether human preference for curvature is also found in other primates or not. They found that both humans and non-human primates show a preference for curved objects, and a rejection of the angular ones. Preference for curvature occurs in humans especially when stimuli are presented for a limited time. But the opposite happens with the non-human primates, which showing a preference for curved objects only in free time.

These findings imply that human preference for curved objects evolved from our ancient primate ancestors. That is, preference for curvature is a primitive trait that has been strengthened in humans, and is now capable of higher cognitive processes, and preference for other visual characteristics (Munar et al., 2015). But it is not clear yet whether the phenomenon of preference for curvature is due solely to the characteristics presented the curve itself, or is due to a rejection of the angular, or due to both, since one does not exclude the other. In all of these findings about preference for curvature, individual differences were ignored and were not taken into account. Jacobsen (2004) made explicit that individual differences have to be taken into account when studying aesthetic judgments, and he found them by comparing quantitative group and individual performance models of the judgment processes, but he did not paid attention to preference for curvature when studying differences in aesthetics judgments. We only know that his participants showed noted individual differences, but nothing we know about individual differences in preference for curvature. What Jacobsen (2004) found is that certain features of the stimulus material, which were considered to contribute to the picture's beauty by one participant, were used in an opposing fashion by another.

The model of Leder et al. (2004) explains that when a visual stimulus is presented to the participant, specific stimulus features are extracted in each of the five stages of information processing. Therefore, following the model of Leder, curvature is a feature that is extracted in the first stage of information processing and affects the aesthetic preference, in a different way for each individual, because there are individual differences in aesthetic judgments (Jacobsen, 2004).

The aim of this research is to explore the possible causes of individual differences in preference for curvature. Specifically I seek to determine whether individual differences in preference for curvature are due to participants' interest in art, art history studies, openness to experience, intelligence, or sex.

Method

Participants

Forty two students from the University of the Balearic Islands took part in the study (10 male and 10 female students of art history, 10 male and 12 female students of different university degrees, M_{age} = 22.1 years, SD = 4.4, ranging all of them from 21 to 25). Participants provided written informed consent to take part in the experiments. All of them were unaware of the goals of the experiment and had normal or corrected to normal vision. The experiment and their consent procedure were approved by the Ethical Committee of the Comunidad Autónoma de las Islas Baleares (Spain). The experiment took approximately one hour to complete, and participants received nothing in return for their participation.

Materials and procedure

To study the preference for curvature, I used a 2-alternative forced choice (2AFC) paradigm with a 80ms stimuli presentation time. Based on the literature surveyed above, I predicted that humans would show a preference for curved objects by selecting the curved object above chance levels (50%). One hundred forty four gray-scale photographs of real objects were used -a subset of those used in previous studies (Bar & Neta, 2006, 2007). Each image had a resolution of 340x340 pixels so, when being shown on a 19-inch screen at 1440 x 900px (89.37 PPI), its real size was of 9.66 x 9.66 cm.

The images were paired in order to create two sorts of pairings. A set of 36 contour pairs was created, each consisting of two versions of the same object that differed only in the curvature of its contour (one of the alternatives was curved, the other sharp-angled). These images were distributed into two equivalent blocks. The two blocks were identical, except that, for each pair the alternatives appeared on the opposite side of the screen. The forced choice was followed by the selected image being shown as being closer to the participant, thus making the task self-evident. Participants undertook only one session.

Procedure

They sat 50 to 60 cm from the screen in an isolated cabin. In each trial of the task, participants were presented with a pair of images varying in their contour or semantic content and were instructed to select one of the images by pressing a keyboard arrow. The instructions were simple, and specifically avoided the use of terms such as *wanting*, *liking* or *preferring*. The action of choosing was made meaningful in a non-verbally dependent way by implementing the effect of approaching the chosen image upon selection. This was achieved by immediately displaying the chosen image on its own, centered and enlarged. A trial consisted of a fixation cross, shown for 500ms, followed by a pair of stimuli displayed for 80ms. This pair was the immediately replaced by a pair of grey squares, which minimized possible after-effects and served as a non-verbal cue signalling participants to make a choice. Once on of the options had been selected, the chosen image was shown once again for one second, centered, at twice its original size. This manipulation was aimed at simulating the act of approaching the preferred image (by enlarging it) and minimizing the task's verbal requirements. Data were recorded by the computer and I measured one dependent variable: choice preference, defined as the percentage of trials in which participants selected the curved contour alternative.

To study whether the individual differences in art interest influence the preference for the curvature, I used a Visual Art Interest and Education Scale (VAIES), which is an adaptation of the questionnaire constructed by Chatterjee et al. (2010). The scale includes questions about classroom experience in art, art history education, art theory, art interest and habits, such a visits to museums and galleries, making art, reading about art, and looking at art.

To study whether the individual differences in intelligence influence the preference for curvature, I used Raven's *Progessive matrices: A perceptual test of intelligence* (1938). This is a non-verbal test, in which is intended that the subject use perceptual skills, observation and analogical reasoning to infer the missing in a matrix. It requires participants to analyse a set of series following horizontal and vertical sequences, choosing the one that fits perfectly in both directions, horizontally and vertically, and takes around one hour to complete.

To study whether individual differences in personality influence preference for curvature, I used 12 items translated from the NEO-FFI-R (McCrae & Costa, 2004), ranked with a 5 points Likert Scale from "Totally disagree" to "Totally agree". Openness to experience is one of the Big Five factors of personality (McCrae & Costa, 1997). The Big Five factors of personality constructs, represent a powerful frame of reference in psychological reasoning about the structure of interindividual differences in personality dimensions (John & Srivastava, 1999; McCrae & Costa, 1997). The five factors have been defined as openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. Openness to experience describes people who tend to be imaginative, creative people from practical, conventional people. People who score highly on Openness are intellectually curious, appreciative of art, and interested in new ideas. People who are low in this dimension tend to have common, conventional interests, and prefer the simple and familiar to the novel or complex.

To study whether sex influences preference for the curvature I attempted to keep the numbers of men and women approximately equal.

Data analyses

I analyzed the effects of intelligence, openness to experience, studies, sex, and VAIES score on participants' choices by means of generalized mixed effects models (Hox, 2010; Snijders & Bosker, 2012). This method accounts simultaneously for between-subjects and within-subjects effects of the independent variables (Bayen, Davidson, & Bates, 2008). It is thus especially suitable for understanding aesthetic appreciation, which may vary from person to person, and from image to image (Silva, 2007). The model was primarily set up to study the impact of intelligence, sex, VAIES score, and the interaction between openness to experience and studies. Sex and studies are categorical variables, and the reference levels were *men* for *sex, and art history* for *studies.* All continuous variables (intelligence, openness to experience, and VAIES score) were centered. In setting the model up, we followed Barr, Levy, Scheepers, and Tily's (2013) guidelines. They suggest modeling the maximal random effects structure justified by the experimental design, which, in addition to avoiding the loss of power and reducing Type-I error, enhances the possibility of generalizing results to other participants and stimuli. Thus, the model included intelligence, sex, VAIES score, and the interaction between openness to experience and studies, and random intercepts and slopes for the interaction between openness and studies within stimuli, and random intercept within participants. The analysis was carried out within the R environment for statistical computing (R Development Core Team, 2008), using the *glmer()* function of the 'Ime4' package (Bates, Maechler, & Bolker, 2013), depending on the nature of the outcome variable (dichotomous or scale). The 'lmerTest' package (Kuznetsova, Brockho, Christensen, 2012) was used to estimate the *p*-values for the *t*-test based on the Satterthwaite approximation for degrees of freedom.

Results

Descriptive analysis

Openness to experience:

In the total sample after centering this variable, openness to experience, has a m = 0, SD = 1.013, min = -2.06 and max = 1.75. For two of the participants I do not have data for this variable.

For the group of experts once focused the variable, it has a m = 0.028, SD = 0.99. For the non experts group, it has a m = -0.02, SD = 1.05.

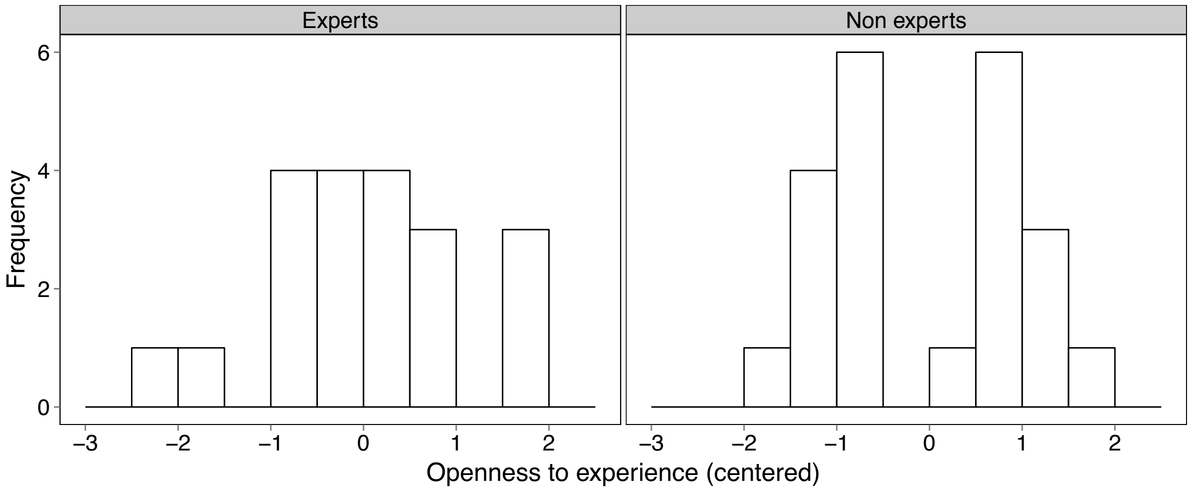

Figure 1. Histogram of openness to experience for both groups of participants.

VAIES:

In the total sample after centering this variable, VAIES, has an m = 0, SD = 12.54, min = -20.39 and max = 17.62. For two of the participants I do not have data for this variable.

For the group of experts once focused the variable, it has an m= 10.62, SD = 6.86. For the non experts group, it has an m = -8.69, SD = 8.84.

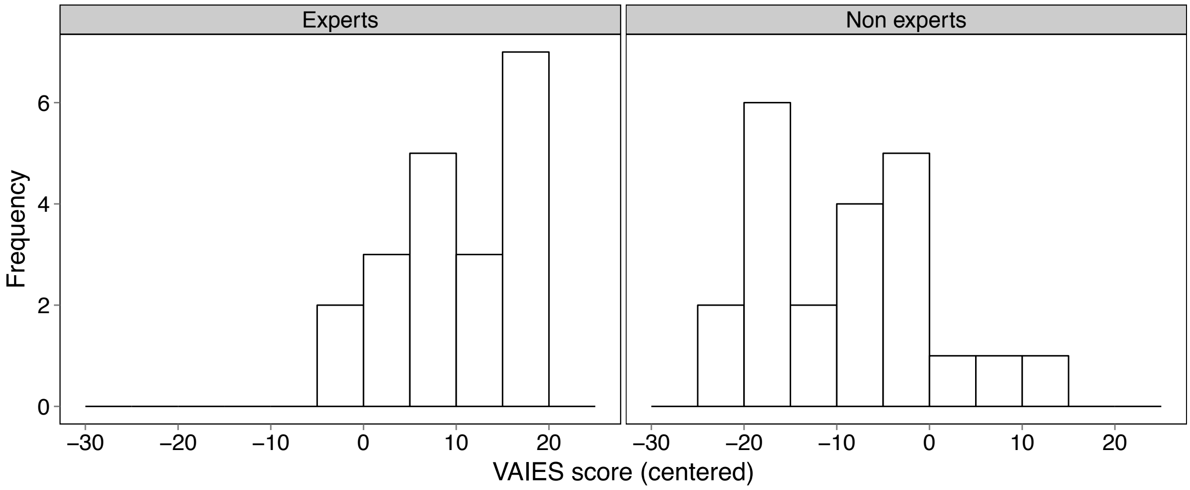

Figure 2. Histogram of VAIES scores for both groups of participants.

Intelligence:

In the total sample after centering this variable, intelligence, has a m = 0, SD = 1.01, min = -2.35 and max = 1.75. For two of the participants I do not have data for this variable.

For the group of experts once focused the variable, it has a m = -0.07, SD = 0.86. For the non experts group, it has a m = 0.06, SD = 1.14.

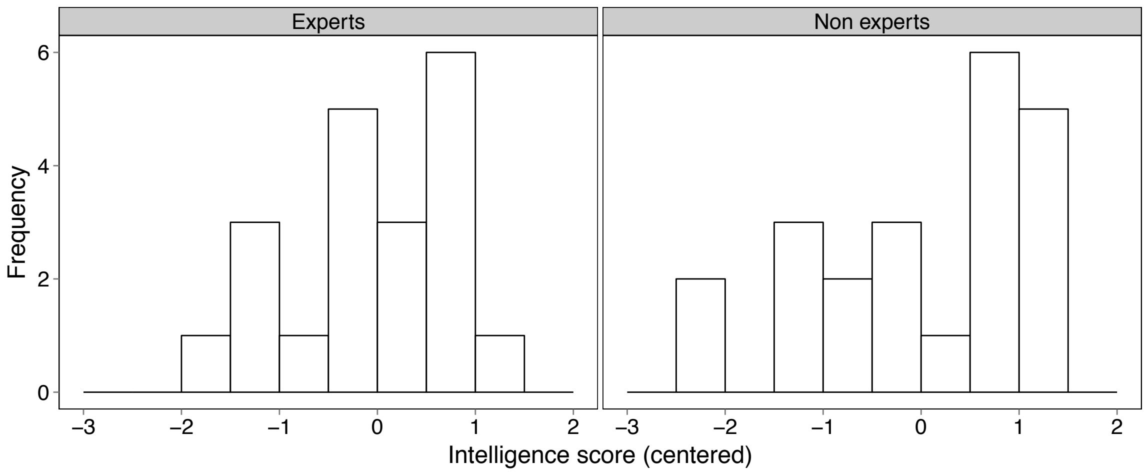

Figure 3. Differences in Intelligence between groups.

Linear mixed effects modeling of participants' choices revealed that the overall probability of choosing the curved alternative was .59, and that this value differs significantly from chance (.5) [$\boldsymbol{\beta}_0 = 0.36$; $z = 3.146$; $p = .002$]. Furthermore, the results indicate that openness to experience had a significant negative effect on the probability of choosing the curved alternative [$\boldsymbol{\beta}_{\text{opennes}} = -0.287$; $z = 2.59$; $p = .0096$], such that as openness to experience increases, the probability of choosing the curved alternative decreases (see figure 4).

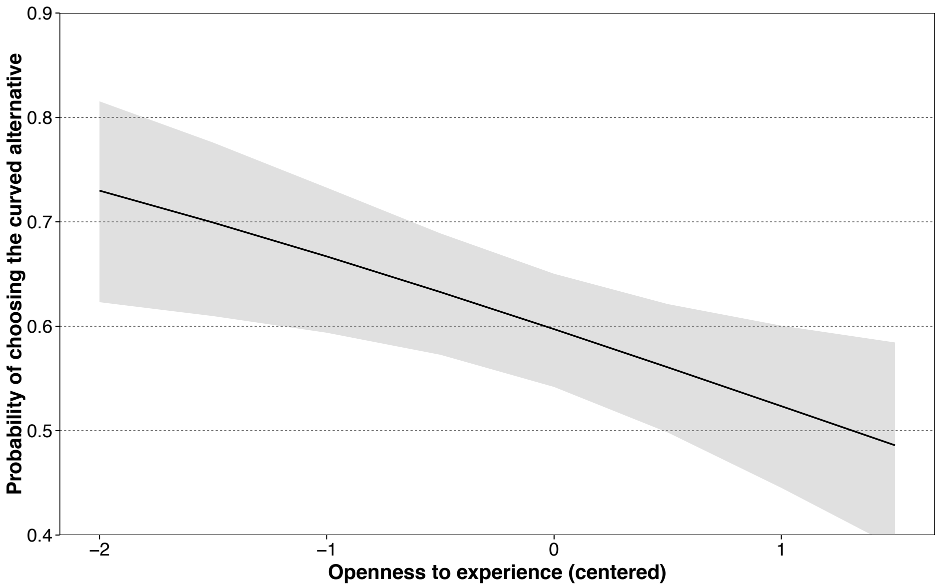

Figure 4. Influence of openness to experience on preference for curvature.

The analysis also revealed differences between the sexes (see figure 5). The probability of choosing the curved alternative was higher for women [0.64; 95% CI (0.57, 0.71)] than for men [0.54; 95% CI (0.46, 0.61)] [$\boldsymbol{\beta}_{\text{sex}} = 0.426$; $z = 2{,}177$; $p = .0296$].

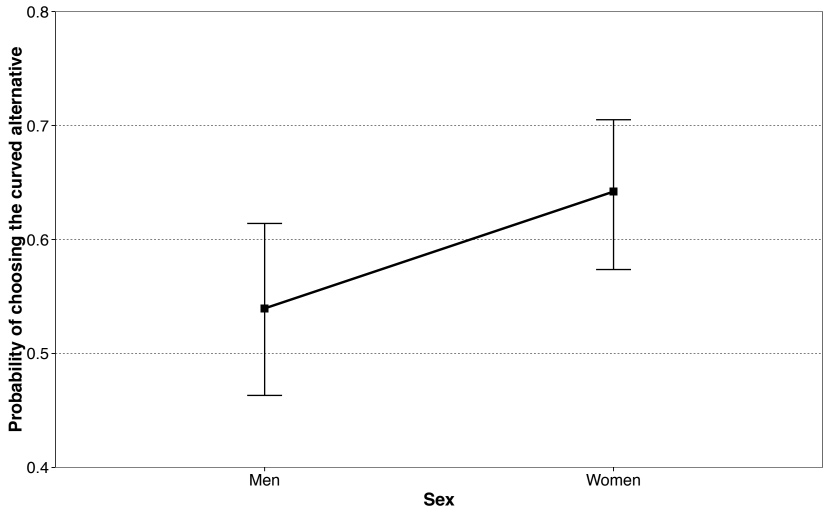

Figure 5. Sex differences in preference for curvature.

It is also worth noting that a trend towards significance with regards to the interaction between openness to experience and studies also appeared [$\boldsymbol{\beta}_{obys}$ = -0390; z = 1,778; p = .075]. As shown in figure 6, the effect of openness is weaker for art students than for other students.

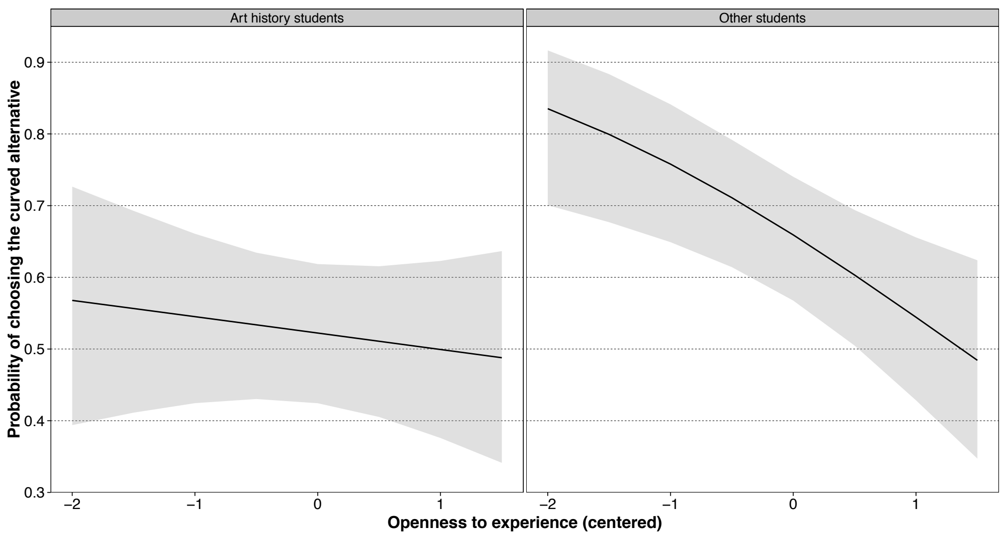

Figure 6. Interaction between Openness to experience and studies.

There were no significant effects of intelligence [$\boldsymbol{\beta}_{intelligence}$ = -0.045; z = 0.474; p = .635] on choices for curved contour objects. There was, however, a slight trend toward significance of studies [$\boldsymbol{\beta}_{studies}$ = 0.570; z = 1.751; p = .080].

Discussion

In this study I attempted to determine whether individual differences in preference for curvature are due to participants' interest in art, to their art education, their openness to experience, intelligence or sex. My results suggest that even though participants in this study generally preferred curved contours to sharp-angled ones, and that this preference was in the range (.59) of previous studies (e.g., Bar & Neta, 2006, 2007; Munar et al., 2015), there were also important differences in the extent of this preferences among participants. Moreover, such differences could be predicted based on participants' openness to experience and sex. The results indicate that openness to experience had a significant negative effect on the probability of choosing the curved alternative, such that as openness to experience increases, the probability of choosing the curved alternative decreases. The analysis also revealed differences between the sexes. The probability of choosing the curved alternative was higher for women than for men. A trend towards significance with regards to the interaction between openness to experience and studies also appeared. The effect of openness is weaker for art students than for other students. There were no significant effects of intelligence on choices for curved contour objects.

In conclusion, individual differences in preference for curvature exist, being sex and openness to experience the more significant causes that influence aesthetic preference for curvature, because intelligence and interest in art seem not to be direct causes of differences in preference for curvature. Further studies will have to take this into account for future research in preference for curvature can be considered complete. Future studies are also required to explain why openness to experience has a negative effect on the probability of choosing curvature, and to explain why women choose the curved alternative more than do men.

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