Familiarity modulates preference for curved drawings of common-use objects (#57478)

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Familiarity modulates preference for curved drawings of common-use objects

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Drawing is a way to represent common-use objects. We may prefer object drawings because they are familiar, or because of the formal characteristics of the drawings, among other aspects. In this research, we studied the influence of familiarity judgements in preference for curved or sharp-angled object drawings. We also examined the possibility that some individual differences modulated this preference. Experiment 1 consisted of a liking rating task. Experiment 2 consisted of a two-alternative forced-choice task simulating approach/avoidance responses. Both experiments also included a familiarity judgement task and a set of individual measures. We found a consistent preference for curvature in both experiments. This preference increased when the curved objects were judged as the most familiar ones. We also found preference for curvature when participants judged both the curved and sharp-angled objects as equally familiar. However, there was no preference for curvature or preference for angularity when participants judged the sharp-angled objects as the most familiar ones. In Experiment 2, holistic and affective types of intuition predicted higher preference for curvature. Conversely, more unconventional participants showed less preference for the curved drawings. We conclude that familiarity modulates preference for curvature and highlight the relevance of the representational and artistic content of object drawings.

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Abstract

Drawing is a way to represent common-use objects. We may prefer object drawings because they are familiar, or because of the formal characteristics of the drawings, among other aspects. In this research, we studied the influence of familiarity judgements in preference for curved or sharp-angled object drawings. We also examined the possibility that some individual differences modulated this preference. Experiment 1 consisted of a liking rating task. Experiment 2 consisted of a two-alternative forced-choice task simulating approach/avoidance responses. Both experiments also included a familiarity judgement task and a set of individual measures. We found a consistent preference for curvature in both experiments. This preference increased when the curved objects were judged as the most familiar ones. We also found preference for curvature when participants judged both the curved and sharp-angled objects as equally familiar. However, there was no preference for curvature or preference for angularity when participants judged the sharp-angled objects as the most familiar ones. In Experiment 2, holistic and affective types of intuition predicted higher preference for curvature. Conversely, more unconventional participants showed less preference for the curved drawings. We conclude that familiarity modulates preference for curvature and highlight the relevance of the representational and artistic content of object drawings.

Introduction

Common-use objects are perceived as utilitarian, familiar and hedonic products (Wang, Yu & Li, 2019). These characteristics influence how we interact with them daily. For instance, utility, familiarity and/or hedonism might be factors that contribute to generally preferring common-use objects with curved contours over sharp-angled ones (Bar & Neta, 2006, 2007; Munar et al., 2015). Preference for curvature was shown using drawings of car interiors (Leder & Carbon, 2005), pictures of windows (Naghibi Rad et al., 2019), furniture (Dazkir & Read, 2012), product packaging (Westerman et al., 2012), exterior façades (Ruta et al., 2019) and interior architectural environments (Van Oel & Van den Berkhof, 2013; Vartanian et al., 2013, 2017), among others. While most of these stimuli involve representational content, preference for curvature was also found using art-related stimuli such as artworks (N. Ruta et al., unpublished data) or abstract images and shapes (Bertamini et al., 2016, 2019).

Previous studies suggested that shared preferences are more usual with representational stimuli than abstract stimuli (Vessel & Rubin, 2010; Schepman et al., 2015; Schepman, Rodway & Pullen, 2015). Rodway et al. (2016) proposed that liking for representational stimuli is influenced by associations developed with the subject matter or semantic content of the picture. Therefore, our experience with the representational content of drawings might also make preference for these stimuli more systematic and predictable. However, drawings also are associated with innovation and creativity because of their art-related nature (Purcell & Gero, 1998). The experience of drawing embodies abstract and high-level design ideas, and allows some degree of uncertainty about the physical attributes of the represented object (Gross et al., 1988). Therefore, these characteristics might differentiate preference for representational drawings from preference for more realistic (i.e., photographs) or more abstract stimuli (i.e., irregular polygons). Skilled artists design representational drawings with relative ease (Kozbelt et al., 2010). The design process involves decisions about proportions, shading, lines, or colors, among others. However, representational drawings also involve implicit constraints such as the objects' functionality and usability, and sometimes even the cost of production (Lawson, 1980; Kavakli et al., 1999; Bertamini & Sinico, 2019).

Preference and familiarity

The consistency of visual preference for the representational content of stimuli highlights its association with familiarity (Reber, Winkielman & Schwarz, 1998; Reber, Wurtz & Zimmermann, 2004). Berlyne (1971) considered that familiarity strongly influences the psychobiological mechanisms underlying aesthetic experiences. Therefore, increased exposure to specific visual features might also modulate the potential preference for the same visual features. In this regard, some studies suggested that curved contours are more frequent in natural scenes than sharp-angled ones (Koenderink, 1984; Hoffman & Singh, 1997). Ruta et al. (2019) used a dynamic computational model of the visual cortex and a model that characterizes discomfort in terms of adherence to the statistics of natural images (Penacchio, Otazu & Dempere-Marco, 2013; Penacchio & Wilkins, 2015) to analyze the statistical properties of drawings of architectural façades with different contour types (curved, mixed, sharp-angled and rectilinear). They found that stimulus preference was related in both models and it matched the behavioural findings of preference for façades. Therefore, they suggested that the link between the statistical properties of natural scenes and preference for curvature might have evolved from human interaction with natural environments. Other studies suggested a faster speed of processing smooth contours over angular ones (Bertamini, Palumbo & Redies, 2019; Chuquichambi et al.,

2020). Bertamini, Palumbo and Redies (2019) argued that this advantage may be explained because curved features tend to match the statistics of the natural environment in which the visual system has evolved. However, preference for curvature may also be a context-specific effect, and not extend to all natural environment stimuli (Hůla & Flegr, 2016).
Drawings of common-use objects are characterised by meaningful and familiar content (Hekkert & Snelders, 1995; Hekkert, Snelders & Wieringen, 2003). They involve the perceiver's previous knowledge and momentary perceptual experience (Leder et al., 2004). Given that people might be more exposed to curved contours than to sharp-angled ones in daily life, the potential preference for curved drawings of common-use objects might be modulated or explained by the degree of familiarity of these objects. However, this relationship might be also modulated by the artistic reproduction of drawings.

Drawings as artistic works

Contrary to representational stimuli, Bornstein (1989) found that abstract paintings, drawings and matrices did not show a strong mere exposure effect. This effect proposes that affect increases with repeated unreinforced exposure of a stimulus, and therefore, familiarity (Zajonc, 1968). Leder (2001) also showed that repeated exposure had little effect on art-related stimuli. Instead, he suggested that familiarity-liking relations were weakened by knowledge and were greater in spontaneous judgements. These findings are compatible with the fact that novelty is an important factor in the appreciation of fine arts, where the seeking for novelty is a dominant force in its development (Matindale, 1990). Hekkert, Snelders and Wieringen (2003) showed typicality and novelty as equally effective predictors to explain aesthetic preference of consumer products (e.g., telephones, cars, etc.). They suggested that there should be a balance between novelty and typicality in the design of common-use objects. Interestingly, Park, Shimojo and Shimojo (2010) found segregation of preference across objects' categories, with familiarity dominant in faces, and novelty dominant in natural scenes. Given this context, the interaction between the representational content and art-related characteristics of drawings of common-use objects might contribute to understanding the role of familiarity in predicting aesthetic judgements (Sluckin, Hargreaves & Colman, 1982).

Individual differences

Individual differences also modulate aesthetic judgements (Child, 1962, 1965; Leder et al., 2019). However, the influence of individual differences in preference for curvature diverges between studies. Silvia and Barona (2009) investigated the role of artistic expertise in preference for curvature using arrays of circles and hexagons, and asymmetrical random polygons. Although they found an interaction between art training with angular stimuli, this interaction changed depending on the specific stimuli set. Vartanian et al. (2017) also found divergent results in preference for curvature among experts (architects or designers) and non-experts. They presented these participants with images of curvilinear and rectilinear architectural interior spaces in a beauty judgement task and an approach-avoidance decision task. Despite that the experts found curvilinear spaces more beautiful than rectilinear ones, contour did not affect their willingness to enter or exit these spaces. Conversely, contour had no effect on judgements of beauty among nonexperts, but they were more likely to enter curvilinear spaces than rectilinear ones. However, a more recent study did not confirm preference for curved interior spaces with quasi-experts in industrial design (Palumbo et al., 2020), hence highlighting that individual differences might also depend on the specific training received in the area of expertise. Cotter et al. (2017) also reported that artistic expertise, a personality trait such as openness to experience, along with other cognitive traits (i.e., holistic thinking) predicted higher preference for curvature using irregular polygons, but not using arrays of circles and hexagons. Corradi et al. (2019a) suggested that aesthetic sensitivity to curvature coexists with a remarkable individual variation on people's judgements. They presented real objects and abstract designs to art and non-art students in a two-alternative forced-choice task. They also were interested in the role of sex, openness to experience and artistic expertise. Both groups of students preferred the curved stimuli but none of the individual variables showed significant results.

The present study

In this study, we examined preference for contour using drawings of common-use objects in two experiments. The drawings consisted of pairs of the same object with a curved and a sharp-angled version created by quasi-expert students in Design as described in Bertamini and Sinico (2019). They were rated by non-experts for seven characteristics, confirming an association between curvature and beauty. In the current experiments, we examined whether familiarity judgements and specific individual differences modulated preference for contour. Each experiment had two tasks. The first tasks were a liking rating task in Experiment 1, and a two-alternative forced-choice (2AFC) task simulating approach/avoidance responses in Experiment 2. The second task was a familiarity task for the shape of the objects in both experiments. At the end of the experimental tasks, all participants were administered a set of individual measures: a Spanish adapted scale of Art interest and Art knowledge (Chatterjee et al., 2010), the Openness to experience Scale from the NEO-FFI (McCrae & Costa, 2004), the items of the Unconventionality facet from the HEXACO personality test (Lee & Ashton, 2004), and the Types of Intuition Scale (TIntS) (Pretz et al., 2014).

First, we hypothesized that participants would prefer the curved object drawings in both experiments because preference for curvature has shown to be consistent across different stimuli and experimental tasks (Palumbo & Bertamini, 2016; E. Chuquichambi et al., unpublished data). Second, we expected that the objects with a curved contour line would be perceived as the most familiar because of the predominant role of curvature on shape's perception (Pasupathy & Connor, 2002) and its suggested higher exposure in nature (Koenderink, 1984; Hoffman & Singh, 1997; Bertamini, Palumbo & Redies, 2019; Ruta et al., 2019). Third, familiarity judgements for curved objects might explain preference for curved drawings or only model it. That is, there could be preference for the curved object drawings without necessarily perceiving the shape of these objects as more familiar than the sharp-angled ones, or we could expect the higher the familiarity judgements for the curved objects would affect the higher preference for the curved drawings. Fourth, according to the divergences between studies, the variation in people's judgements and stimulus characteristics might explain the inconsistent role of some individual differences in preference for curvature (Corradi et al., 2019b). Therefore, the current study aimed to assess to what extent preference for curvature might be explained by familiarity with object drawings and whether this would be modelled by individual differences.

Experiment 1

Materials & Methods

Participants

Forty-nine adult students (41 female, Mage = 21.3, SDage= 4.95) at the University of the Balearic Islands (UIB) volunteered to participate in the experiment. All participants reported normal or corrected to normal vision and were naive concerning the experimental hypothesis. They provided written informed consent before the experiment and were treated in accordance with the Declaration of Helsinki (2008). The study received ethical approval from the Committee for Ethics in Research (CER) of the UIB (Ref: IB 3828/19 PI).

Apparatus and materials

Ninety drawings of familiar objects were selected from the IUAV image database (https://osf.io/cx62j/) (Bertamini & Sinico, 2019). The selected stimuli consisted of 45 pairs of drawings. Each pair represented the same object, a curved and a sharp-angled version. The drawings also differed in how they were made. Thirty pairs were hand-made and 15 were computer-made. Similarly, 30 pairs were shaded and 15 were not shaded. Out of the hand-made drawings, 13 pairs were shaded, and 17 pairs were not shaded. Out of the computer-made drawings, 2 pairs were shaded, and 13 pairs were not shaded. Each pair was equalized in size. Every stimulus was framed on an outline of 600 pixels height, 600 pixels width, and had 300 pixels resolution (*Fig. 1*).

Please insert Figure 1 about here

We used the same drawings in the liking rating task and the familiarity task. The liking task recorded ratings of each drawing using a horizontal sliding bar from 0 to 100. The ends of the bar had the labels "*I don't like it*" (0) on one side, and "*I like it very much*" (100) on the other side (*Fig. 2A*). Each stimulus was presented on the centre of the screen until the participant responded on the sliding bar using the mouse. The task had 8 practice trials and 90 experimental trials corresponding to the 45 stimuli pairs. Trial sequence was randomized.

The familiarity task presented each pair of drawings simultaneously, one on the left and the other on the right side of the screen, until the participant responded. The question was "*Which shape is the most familiar for this object?*" There were three-alternative responses labelled as left, equal, and right. If they chose the left-side drawing as the most familiar, they had to press the left key. If they chose the right-side drawing, they had to press the right key. They could also choose both objects as equally familiar by pressing the central key. The task had 8 practice trials and 45 experimental trials corresponding to the 45 pairs. Left-side and right-side presentation and trial sequence were randomized.

Please insert Figure 2 about here

Four questionnaires were administered. The first was an Art interest and Art knowledge scale adapted from Chatterjee et al.'s (2010) Art Training, Interest and Activities Scale. This scale was used in previous studies of aesthetic sensitivity (e.g., Corradi et al., 2019b). It consists of eight items with a 0–6 Likert scale. Five items (1-5) measure interest in art, and three (6-8) measure formal education in art. The second questionnaire was the Openness to experience Scale of the NEO-FFI (McCrae & Costa, 2004). It consists of twelve items rated on a scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The third questionnaire consists of four items about the Unconventionality facet of the Openness to experience domain from the HEXACO 100 Personality Inventory-Revised (Lee & Ashton, 2004). We included this measure because Cotter et al. (2017) showed that higher scores on the Unconventionality facet predicted greater preference for curvature using geometrical patterns. Finally, participants completed the Types of Intuition Scale (TIntS) to examine whether the way people make decisions and solve problems modulates preference for drawings (Pretz et al., 2014). This scale consists of 23 items (e.g., "I am a 'big picture' person'', ''I tend to use my heart as a guide for my actions'') rated on a scale ranging from 1 (*definitely false*) to 5 (*definitely true*). The items are grouped into four subscales: Holistic Abstract (HA, thinking about a problem in abstract terms), Holistic Big Picture (HB, focusing on the entire problem rather than details of the situation), Inferential (I, making decisions based on automatic, analytic processes), and Affective (A, making decisions by relying on emotional reactions to a situation).

Please insert Table 1 about here

All tasks were designed with OpenSesame (3.2) software (Mathôt, Schreij & Theeuwes, 2012). They were implemented in computers equipped with Intel i5 processors and 21–inch screens set at 1920 x 1080 pixels.

Procedure

The experimental session was carried out at the Psychology Laboratory of the UIB, using isolated cabins and individual computers with the same software and light conditions. Participants were welcomed at the laboratory and they provided written informed consent. They received verbal and written instructions before starting each task. The liking task was the first one. Participants were told that a drawing would be presented at the centre of the computer screen. They had to indicate how much they liked the drawing with a mouse click on the horizontal sliding bar. Next, participants carried out the familiarity task. They were told that pairs of drawings would be presented on the computer screen, one on the left and the other on the right side of the screen. They had to decide which shape was the most familiar for the object in the drawing, or whether both shapes were equally familiar, by pressing the appropriate key. After these tasks, participants filled in the four questionnaires. The experimental session lasted about 20 minutes. Finally, participants were debriefed and thanked.

Data analysis

Data analysis was carried out with the R environment for statistical computing (R Core Team, 2018). Participants' responses in the liking task, the familiarity task and questionnaires were analysed by means of linear mixed effects models (Hox, 2010; Snijders & Bosker, 2012). These models account simultaneously for the between-subject and within-subject effects of the independent variables (Baayen, Davidson & Bates, 2008). They have been previously used to analyse preference judgements and individual differences (e.g., Corradi et al., 2019a; 2019b). The 'lmer' function from the lme4 package was used to fit the models (Bates et al., 2015). The afex package (Singmann et al., 2016), with the likelihood ratio test, was used to produce the inferential statistics and p values. The lsmeans package was used to obtain predicted means for the fixed effects (Lenth, 2016). Model fitting and selection was carried out following Barr et al.'s (2013) and Brauer and Curtin's (2018) guidelines to choose the maximal random-effects structure justified by the experimental design. Finally, we performed a study of influential cases based on Cook's distance (Cook's D) in each model. This measure evaluates each participant's influence on the results by examining the impact of its removal from the data set (Corradi et al., 2018).

Results

We performed three models. The first model tested preference for curvature and its relation to the other stimulus properties: computer-made versus hand-made, and shaded versus not shaded. The second model analysed the relationship between preference for curvature and familiarity judgements. The third model tested the influence of the individual measures (i.e., personality and art expertise) on the liking ratings related to preference for curvature.

The first model aimed to predict liking ratings based on Contour (curved vs. sharp-angled), Category (computer-made vs. hand-made) and Shading (shaded vs. not shaded) as factors of fixed effects. As the influence of Contour on liking was our main objective, we also included the interactions between Contour and Category, on the one hand, and Contour and Shading, on the other hand. The maximal model that converged included participant and stimulus as random effects, as well as random slopes within participant. Influential cases analysis revealed no influential cases whose Cook's D value exceeded the recommended cut-off point, which was .089. Participants significantly liked the curved drawings (M = 55.2, 95% CI [50.1, 60.3]) more than the sharp-angled ones (M = 50.6, 95% CI [45.6, 55.6]), β = 4.6, SE = 1.5, t(60.05) = 3.06, *p* = .003, 95% CI [1.7, 7.6] (*Fig. 3A*). There was no significant interaction of Contour x Category, β = -2.37, SE = 1.56, t(504.82) = -1.5, *p* = .13, 95% CI [-5.4, 0.7], or Contour x Shading, β = 2.47, SE = 1.53, t(4218) = 1.6, *p* = .10, 95% CI [-.5, 5.5]. Participants also significantly liked the drawings with shading (M = 62.4, 95% CI [55, 69.7]) more than the drawings with no shading (M = 43.4, 95% CI [38.3, 48.6]), β = 17.7, SE = 4.03, t(45.25) = 4.38, *p* < .001, 95% CI [10, 25.4]. There was no significant difference between the hand-made (M = 50.4, 95% CI [45.2, 55.5]) and the computer-made drawings, (M = 55.4, 95% CI [47.8, 63]), β = -3.9, SE = 4.3, t(56.5) = -.9, *p* = .37, 95% CI [-12, 4.3].

The second model included liking rating as the variable to be predicted, and Contour type and Familiarity judgements as categorical fixed effects. The interaction between the two factors was also included, as it was our main objective. Familiarity judgements included three levels: the curved object judged as the most familiar, the sharp-angled object judged as the most familiar, and both objects judged as equally familiar. The curved objects were judged as the most familiar ones with an average of .49, the sharp-angled objects were judged as the most familiar ones with an average of .22, and both objects were judged as equally familiar with an average of .29. The maximal model that converged included participant and stimulus as random effects. The model also included random slopes within participant and stimulus. Influential cases analysis revealed two influential cases exceeding the recommended cut-off point, which was .087. Therefore, these participants were excluded from the analysis. Results showed that the Contour x Familiarity Judgements interaction was significant when we considered the curved and sharp-angled responses in the Familiarity Judgements factor, $\beta = 2.76$, SE = .57, t(79.5) = 4.8, $p < .001$, 95% CI [1.6, 3.9]. Specifically, participants liked the curved drawings (M = 52.9, 95% CI [47.3, 58.4]) more than the sharp-angled ones (M = 43.3, 95% CI [38, 48.6]) when the curved objects were judged as the most familiar ones, $\beta = 9.6$, SE = 1.6, t(45) = 5.8, $p < .001$. Conversely, when the sharp-angled objects were judged as the most familiar ones, liking ratings did not differ significantly between the sharp-angled drawings (M = 50.3, 95% CI [43.7, 56.8]) and the curved ones (M = 47.3, 95% CI [41.8, 52.8]), $\beta = 3$, SE = 2.1, t(23.7) = 1.4, $p = .16$ (*Fig. 3B*). On the other hand, the Contour x Familiarity Judgements interaction was not significant when we considered familiarity judgements for the curved objects and both objects judged as equally familiar, $\beta = .76$, SE = .57, t(108.8) = 1.3, $p = .18$, 95% CI [-.4, 1.9]. Therefore, when both the curved and sharp-angled objects were judged as equally familiar, participants still liked the curved drawings (M = 50.8, 95% CI [45, 56.6]) more than the sharp-angled ones (M = 45.2, 95% CI [39.5, 50.8]), $\beta = 5.6$, SE = 1.5, t(25) = 3.6, $p = .001$. In conclusion, we found an effect of preference for curvature when the curved objects were judged as the most familiar ones and when both objects were judged as equally familiar. However, there was no effect of preference when the sharp-angled objects were judged as the most familiar ones.

Please insert Figure 3 about here

Regarding the individual measures, we analysed whether they modulated liking ratings related to the curved and sharp-angled drawings. The model predicted liking ratings based on Contour and its interactions with Art interest, Art knowledge, Openness to experience, the Unconventionality facet, and TIntS subscales (HA, HB, I and A) as predictors. All continuous predictors were centred on the grand mean. The maximum model that converged included participant and stimulus as random effects. The model also included random slopes within participant and stimulus. Influential cases analysis showed no influential cases whose value exceeded the recommended cut-off point, which was .10. Results revealed that participants who scored higher in the Holistic Big Picture Subscale (HB) showed higher liking ratings for all the drawings, $\beta =$

1.5, SE = .43, t(27.1) = 3.5, *p* = .002, 95% CI [.66, 2.34]. All other effects and interactions were nonsignificant. All effects are included in *Table S1* as supplementary material.

Discussion

Experiment 1 showed that participants liked the curved drawings more than the sharp-angled ones. This result supports the curvature effect (Corradi & Munar, 2020). On the other hand, when the curved objects were judged as the most familiar ones, the curved drawings were still liked more than the sharp-angled drawings. This finding supports the role of familiarity in predicting aesthetic preference (Verhaeghen, 2018; Chmiel & Schubert, 2019). That is, the drawings that the participants like more represent the objects they also judge as more familiar. However, we also found that when the curved and sharp-angled objects were judged as equally familiar, participants also liked the curved drawings more than the sharp-angled ones. This finding suggests that familiarity does not completely explain participants' preference for the curved drawings of common-use objects.

Individual measures analysis showed that participants with higher scores in the Holistic Big Picture subscale liked all the drawings more than participants with lower scores. All the other measures did not significantly influence liking ratings. These findings are in line with studies suggesting an uncertain role of some individual measures on preference for curvature (Corradi et al., 2019b).

Experiment 2

Experiment 2 consisted of a 2AFC task simulating approach/avoidance responses (*Fig. 2B*). Approach/avoidance procedures have been previously used in preference for curvature research (Vartanian et al., 2013; Palumbo, Ruta & Bertamini, 2015). Participants carried out the same familiarity task and questionnaires as in Experiment 1. In the 2AFC task, each pair of drawings was presented on the screen until participants responded as in previous studies (Munar et al., 2015; Corradi et al., 2018). However, although these studies reported preference for images of curved real objects in short and medium presentation times, the effect disappeared in the until-response condition. Similarly, these authors reported preference for curved abstract patterns in short and medium presentation times, but in this case, the effect increased in the until-response condition. Palumbo and Bertamini (2016) showed that preference for curvature was consistent across tasks using irregular shapes. Considering these studies and the results from Experiment 1, we expected that participants would prefer the curved object drawings more than the sharp-angled ones. Furthermore, we expected that familiarity would also modulate preference for curvature.

Materials & Methods

Participants

Forty-nine adult students (35 female, M_{age} = 26.3 , SD_{age} = 6.5) at the UIB volunteered to participate in the experiment. All participants reported normal or corrected to normal vision and were naïve concerning the experimental hypothesis. They provided written informed consent before the experiment and were treated in accordance with the Declaration of Helsinki (2008).

The study received ethical approval from the Committee for Ethics in Research (CER) of the UIB (Ref: IB 3828/19 PI).

Apparatus and materials

We used the same 90 drawings as in Experiment 1 (*Fig. 1*). They were presented both in the 2AFC task and the familiarity task. In the 2AFC task, each pair of stimuli was presented until response, a drawing on the left and the other on the right side of the computer screen (*Fig. 2B*). Participants had to select one of the two object drawings, and instructions avoided the words 'liking', 'wanting' and 'preference' as in Munar et al. (2015) and Corradi et al. (2018). Later, the selected drawing was enlarged to twice its previous size, while the non-selected one was shrunk to half its previous size at the same position for 1000 ms. This action simulated an approach/avoidance behaviour (Bamford et al., 2015). The 2AFC task had 8 practice trials and 45 experimental trials. Left-side and right-side stimulus presentation and trial sequence were randomized. The familiarity task and the set of questionnaires were the same as in Experiment 1.

Please insert Table 2 about here

Procedure

First, participants carried out the 2AFC task. Next, they carried out the familiarity task. Lastly, they filled in the questionnaires using the same computer. The experimental session lasted about 20 minutes. Finally, participants were debriefed and thanked.

Data analysis

Analyses were carried out with the R environment for statistical computing (R Core Team, 2018). We mainly modelled responses by means of linear mixed effects models. Model fitting and selection were performed following the same considerations outlined in Experiment 1.

Results

We carried out three analyses. First, we analysed preference for curvature and its relationship with the other stimulus characteristics. The second analysis was based on a model to test the relationship between preference for curvature and familiarity judgements. The third analysis examined the influence of the individual measures on preference for curvature.

In the 2AFC task, the variable to be predicted by the models was the kind of contour the participants selected, the curved or the sharp-angled one. Therefore, we first carried out a t-test on the preference for curvature as compared to angularity. Results showed that participants chose the curved drawings significantly above chance level (M = .61), $t(48) = 5.54$, $p < .001$, 95% CI [.57, .65] (*Fig. 4A*). Next, we modelled the curved choices as the variable to be predicted. The model included Category (computer-made vs. hand-made), Shading (shaded vs. not shaded) and the interaction between these factors as fixed effects. The maximal model that converged included participant and stimulus as random effects, as well as random slopes within these effects. Influential cases analysis revealed no influential cases exceeding the recommended cut-off point, which was .087. Results revealed no significant effect either for Category, β = .42, SE = .24, Z = -1.7, $p = .08$, 95% CI [-.06, .90], Shading, β = .28, SE = .24, Z = 1.2, $p = .23$, 95% CI

[-.20, .76], or their interaction, β = .10, SE = .24, Z = .43, *p* = .66, 95% CI [-.37, .58]. These results indicated that the choice of the curved drawing does not depend on the category of the drawing and whether or not it is shaded.

On the other hand, we modelled whether familiarity judgements predicted preference in the 2AFC task. The model included curved choices as the variable to be predicted. Familiarity judgements and Lateralization (left vs. right) were included as categorical fixed effects. As in Experiment 1, Familiarity judgements included three levels: the curved object as the most familiar (M = .45), the sharp-angled object as the most familiar (M = .21), and both objects as equally familiar (M = .34). The maximal model that converged included participant and stimulus as random effects, as well as random slopes within participant. Influential cases analysis revealed one extreme case value exceeding the recommended cut-off point, which was .087. Therefore, this participant was excluded from the analysis. Results showed that familiarity judgements for the curved stimuli predicted higher curved preference (M = .83, 95% CI [.74, .89]) than familiarity judgements for the sharp-angled stimuli (M = .42, 95% CI [.31, .54]), β = 1.04, SE = .19, Z = 5.5, *p* < .001, 95% CI [.67, 1.42]. That is, when participants judged the curved objects as the most familiar ones, they also mostly preferred the curved drawings over the sharp-angled ones in the 2AFC task, but this was not the case when participants judged the sharp-angled objects as the most familiar ones. Similarly, familiarity judgements for the curved objects also predicted higher curved preference choices than when the objects were judged as equally familiar (M = .59, 95% CI [.50, .67]), β = .87, SE = .18, Z = 4.7, *p* < .001, 95% CI [.51, 1.23]. In contrast, stimuli judged as equally familiar did not predict higher curved preference choices than familiarity judgements for the sharp-angled stimuli, β = .17, SE = .11, Z = 1.5, *p* = .13, 95% CI [-.05, .40]. Subsequently, we compared the estimated means of curved preference choices in the 2AFC task with chance level (.50) considering the three-alternative responses of the familiarity task. With familiarity judgements for the curved stimuli, curved choices in the 2AFC task were significantly higher than chance level, Z = 5.9, *p* < .001, *d* = 1.3, with a large effect size. With both objects judged as equally familiar, curved choices in the 2AFC task did not reach significance compared to chance, Z = 2, *p* = .14, *d* = .3, although the effect size was between medium and small. Similarly, with familiarity judgements for the sharp-angled stimuli, curved preference choices were not significantly different than expected by chance, Z = -1.3, *p* = .53, *d* = -.2, with a small negative effect size (*Fig. 4B*). These results suggest that participants preferred the drawings they judged as more familiar. They also support the findings from Experiment 1, suggesting that familiarity judgements modulate preference for curvature between tasks.

Please insert Figure 4 about here

Regarding the individual measures, we modelled whether they modulated contour preference choices. The model included Art interest, Art knowledge, Openness to experience, Unconventionality facet, and TIntS subscales (HA, HB, I and A) as predictors. These predictors were centred on the grand mean. The maximum model that converged included participant and stimulus as random effects. The model also included random intercepts within participant and stimulus. Influential cases analysis based on Cook's distance of participants revealed four influential cases exceeding the recommended cut-off point, which was .10. Thus, these participants were excluded from the analysis. Results showed that participants who scored higher in the HB subscale showed a significantly higher preference for curved drawings, $\beta = .13$, SE = .04, Z = 3.5, $p < .001$, 95% CI [.06, .20]. Those who scored higher in the A subscale also showed a significantly higher preference for curved drawings, $\beta = .052$, SE = .016, Z = 3.3, $p < .001$, 95% CI [.02, .08]. In contrast, participants who scored higher in the Unconventionality facet showed significant lower preference for curved drawings, $\beta = -.09$, SE = .041, Z = -2.2, $p = .028$, 95% CI [-.17, -.01]. The other effects were nonsignificant. All effects are included in *Table S2* as supplementary material.

Correlations between experiments

We analysed the correlation between the data from the two experiments to determine the consistency of responses to the same drawings from different participants. First, we performed a correlation analysis based on drawings between liking ratings in Experiment 1 and preference choices in Experiment 2. From Experiment 1, we calculated the difference between the liking for the curved drawing and the sharp-angled drawing of each pair. We correlated these values with the choice mean (between 0 a 1) for each pair of drawings from the 2AFC task in Experiment 2. Results revealed a significant positive correlation between the liking ratings and curved preference choices, $r_s(45) = .66$, $p < .001$. This result supported a positive relationship of preference for drawings between tasks (*Fig. 5A*).

Second, we compared the familiarity judgements from Experiment 1 and the familiarity judgements from Experiment 2. We obtained a familiarity value for each pair of stimuli regarding the three-alternative responses from the familiarity tasks. That is, we grouped the trials where participants judged the curved object as the most familiar (+1), the sharp-angled object as the most familiar (-1) and both objects as equally familiar (0) to obtain a familiarity value between -1 and 1 for each pair of stimuli. Then, we correlated these values between both familiarity tasks. Results showed a strong positive association of familiarity judgements between the two experiments, $r_s(45) = .92$, $p < .001$. These results supported that familiarity of the objects was consistent across different participants (*Fig. 5B*).

Please insert Figure 5 about here

Discussion

Experiment 2 showed that participants preferred the curved drawings over the sharp-angled ones. This result supported our main hypothesis about the curvature effect (Corradi & Munar, 2020). Therefore, together with the results from Experiment 1, we suggest a consistent preference for the curved drawings of common-use objects between tasks.

We also found that familiarity judgements for the curved stimuli predicted a higher preference for curvature in the 2AFC task than familiarity judgements for the sharp-angled stimuli and the stimuli judged as equally familiar. That is, when the curved objects were judged as the most familiar ones, there was a higher preference for curvature. However, the objects judged as equally familiar did not predict a higher preference for curvature. Similarly, when the sharp-angled objects were judged as the most familiar ones, there was no significant preference for angularity or for curvature. These results support the influence of familiarity judgements on preference. However, they also showed that familiarity is not the only factor determining preference for drawings of common-use objects.

On the other hand, some individual measures influenced preference choices. Specifically, participants who scored higher in the HB and A subscales of the TIntS showed a higher preference for the curved drawings. In contrast, those who scored higher in the Unconventionality facet showed less preference for the curved drawings. These results suggest that the 2AFC task is a more sensitive procedure to find the potential influence of individual differences in preference for curvature than the liking rating task. Conversely, the results also suggest an uncertain influence of some individual measures (e.g., art expertise or openness to experience) on preference for curvature (Corradi et al., 2019b).

Finally, the correlation analysis between the data from the two experiments showed a similar pattern of preference for the pair of drawings. On another hand, the perception of familiarity of the representational content of the objects was highly consistent using two different groups of participants.

General discussion

We examined preference for curvature and its relationship with familiarity using drawings of common-use objects in two experiments. Experiment 1 consisted of a liking rating task, a familiarity task, and a set of individual measures. Experiment 2, using the same stimuli and different participants, consisted of a 2AFC task simulating approach/avoidance responses, and the same familiarity task and individual measures of Experiment 1.

In Experiment 1, we found higher liking ratings for the curved than the sharp-angled drawings. Similarly, in Experiment 2, participants preferred the curved drawings over chance level in the 2AFC task. These findings support the curvature effect using drawings of common-use objects (Corradi & Munar, 2020). They also support the preference for curvature as a consistent effect between different experimental designs (Palumbo & Bertamini, 2016; E. Chuquichambi et al., unpublished data). Conversely, our findings diverge from those of some previous studies using images of real-objects. Munar et al. (2015) did not find preference for curved objects in a 2AFC task in the until-response condition. Similarly, Corradi et al. (2018) found that the effect of preference for curvature decreased as the presentation time increased using the same task and stimuli. They suggested a higher influence of the meaning and content-related information of stimuli as the presentation time increased. In this regard, they found that the effect of preference for curvature was stronger when presenting abstract patterns in longer presentation time compared to brief presentations. With Japanese participants, Maezawa, Tanda and Kawahara (2020) did not find a preference in curvature using similar stimuli as Corradi et al. (2018) and like/dislike and rating scale tasks. A possible explanation of these divergences may be related to the interaction between the meaningful and representational content of the object, familiarity with the objects, and the artistic view of the drawings because of their design and art-related nature (Schroll, Schnurr & Grewal, 2018).

The curved drawings were mostly preferred when the curved object was judged as the most familiar or when the two objects were judged as equally familiar, but not when the sharp-angled object was judged as the most familiar. Further, in both experiments, preference for the curved drawings was higher when the curved object was judged as the most familiar than when both objects were judged as equally familiar. These findings support familiarity as a strong predictor of preference (Reber, Winkielman & Schwarz, 1998; Reber, Schwarz & Winkielman, 2004; Verhaeghen, 2018; Chmiel & Schubert, 2019). However, the findings of Experiment 1 also suggest that familiarity is not the only factor determining preference for curvature because participants still preferred the curved drawings over the sharp-angled ones when the two objects were judged as equally familiar. Moreover, there was no preference for the sharp-angled drawings when the sharp-angled object was judged as the most familiar.

Our results on the relationship between preference for curvature and familiarity might be connected to the predominant role of curvature on shape's perception (Pasupathy & Connor, 2002). Our visual system might integrate curved features more efficiently because they tend to match the statistic regularities of the natural environment (Sigman et al., 2001; Bertamini, Palumbo & Redies, 2019; Stanischewski et al., 2020). Relatedly, our results might also be explained because of a higher frequency of curved contours in natural scenes (Ruta et al., 2019). In a recent study, Yue, Robert and Ungerleider (2020) found a specialized cortical network for curvature processing in humans. They suggested the interaction between preference for curvilinearity with central-peripheral processing biases as an important organizing principle for temporal cortex topography. Interestingly, they also found a possible link between curvature-preferring areas and face-selective areas. Altogether, these studies and the interaction between the representational and artistic characteristics of the object drawings may explain our results of the role of familiarity in preference for curvature.

Previous studies reported that individual measures modulated preference for curvature (e.g., Cotter et al., 2017; Silvia & Barona, 2009). In Experiment 1, we only found that higher scores in the HB subscale predicted higher preference for all the drawings. However, we found some individual differences in Experiment 2, which leads us to suggest that the 2AFC task is more sensitive to finding them than the liking rating task. Specifically, participants with higher scores in the HB and A subscales showed a higher preference for curvature. The influence of the HB type of intuition in preference for curvature might be explained because curved contours facilitate fluent global processing of the stimuli (Reber, Schwarz & Winkielman, 2004; Gómez-Puerto, Munar & Nadal, 2016). On the other hand, the relationship between the A subscale and the preference for curvature could result from associations with positive valence underlying preference for curvature (Palumbo, Ruta & Bertamini, 2015).

Our results also showed that higher scores in the Unconventionality facet predicted less preference for the curved drawings in Experiment 2. This might be related to the idea that the sharp-angled shapes are perceived as more avant-garde (N. Ruta et al., unpublished data) and unconventional people tend to show a higher preference for innovative designs. Interestingly, Cotter et al. (2017) found that higher unconventionality scores predicted more preference for curvature using irregular polygons. However, they found no effect using arrays of circles and hexagons. Using the same arrays of circles and hexagons, Silvia and Barona (2009) found preference for curvature in participants without art training –probably more conventional people– but there was no effect with art-trained participants –probably more unconventional people. Artists may show more unconventional thinking and express it in their art because this may make their work more impactful than more conventional artistic styles (Stamkou, van Kleef & Homan, 2018). Conversely, these authors found preference for curvature in art-trained participants but not in participants without training when they rated complex polygons. Considering these studies, preference for curvature might be higher in art-trained and unconventional participants when the stimuli are more complex. However, we found no influence on preference for curvature from the Art interest and Art knowledge Scales, as in Corradi et al. (2019b). These authors reported that the influence of art interest and art knowledge on aesthetic sensitivity was inconsistent. Altogether, our findings suggest that the influence of individual differences in preference for curvature might depend on the kind of stimuli, and further research is needed in this line.

On another hand, we found significant positive correlations between the results of both experiments. The difference in liking ratings between curved and sharp-angled drawings (Experiment 1), and the preference choices for the curved drawings (Experiment 2) showed a similar pattern of preference. It endorses a consistent and predictable preference for drawings as representational images ((Vessel & Rubin, 2010; Schepman et al., 2015; Schepman, Rodway & Pullen, 2015). However, drawings also have art-related characteristics that, in our results, do not weaken the preference consistency between participants. On the other hand, the highly positive correlation between the familiarity tasks endorses a robust concept of familiarity of object drawings regardless of the participants.

A possible limitation of this study is that we used a subjective measure of familiarity. The familiarity values came from the direct response of what participants considered familiar. Previous studies used measures based on the exposure time or the number of presentations of the stimulus, that is, a process of familiarization (e.g., Berlyne, 1970, 1971; Tinio & Leder, 2009). However, Sluckin, Hargreaves and Colman (1982) argued that subjective measures of familiarity, compared to objective measures, might be more suitable because of a larger variance within each individual and stimulus. Moreover, the drawings involved content-related information. Repeated exposure would likely lead to habituation and, as a consequence, preference could decline (Biederman & Vessel, 2006). Using subjective measures, participants only need a single presentation of the stimulus to evaluate its representational content as more or less familiar

Conclusions

In summary, we found preference for curvature using drawings of common-use objects in two experiments. The curved objects were also judged as the most familiar ones in both experiments. When the curved objects were judged as the most familiar, and when both objects were judged as equally familiar, participants showed preference for the curved drawings. However, when the sharp-angled objects were judged as the most familiar, participants did not show preference for curvature or for angularity. These findings support that familiarity modulates preference for drawings of common-use objects. However, they also indicate that the influence of familiarity is not the only factor explaining the preference for curved drawings. The influence of individual differences in preference for the drawings suggested that the kind of stimuli and the experimental task may predict divergencies across studies and measures. Correlation analyses between experiments also supported a consistent relationship of preference between tasks, and a coherent concept of familiarity of the same pair of object drawings. Altogether, our findings endorse the curvature effect using drawings of common-use objects and familiarity judgements as an important predictor of preference.

Acknowledgements

We are grateful to Marco Bertamini, and Michele Sinico for making the stimuli set available.

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Figure 1

Examples of the pairs of drawings (IUAV image database).

Each pair has a curved and sharp-angled version. Left-side, computer-made. Right-side, hand-made. Top, not shaded. Bottom, shaded.

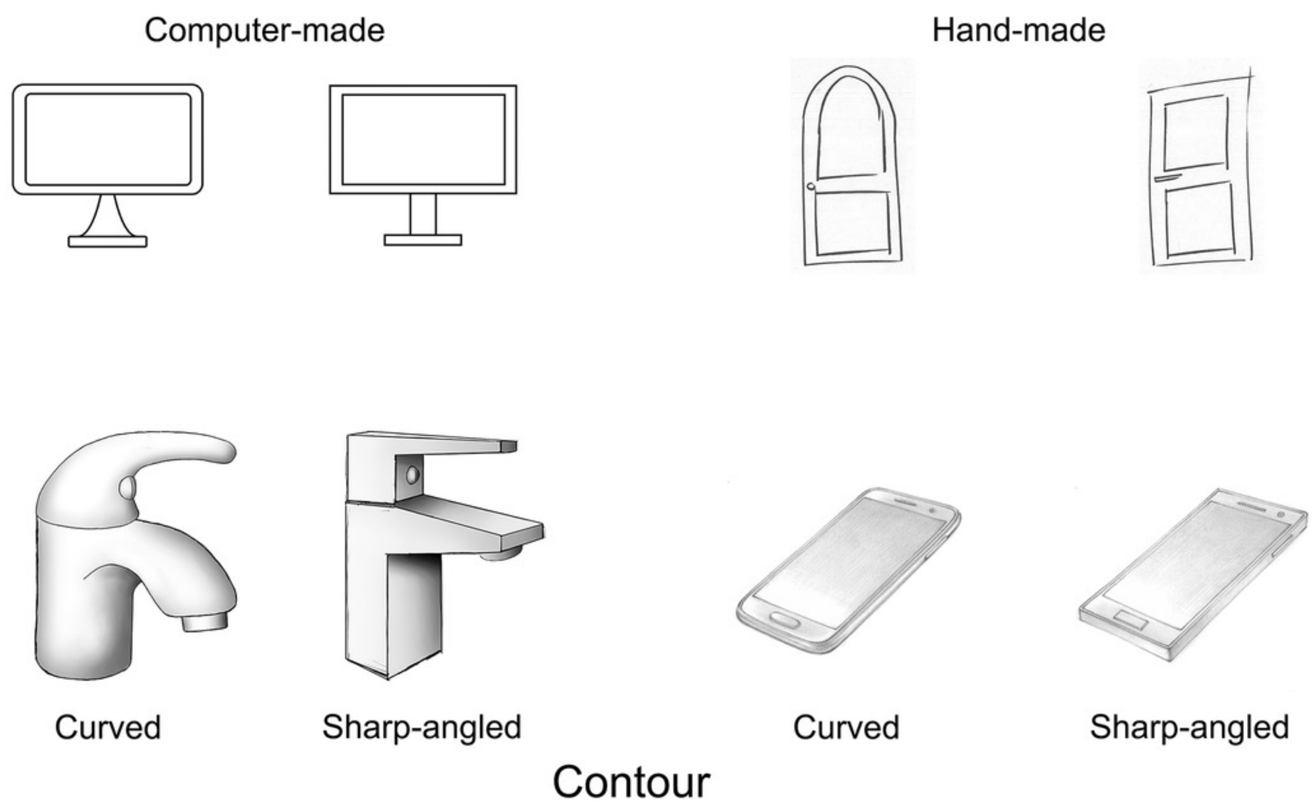

Figure 2

Trials sequence in the preference tasks of experiments 1 and 2.

(A) An example trial in the liking rating task from Experiment 1. (B) An example trial in the two-alternative forced-choice task from Experiment 2. The example shows that the left object was selected. In the next slide, the left object (selected) and the right object (non-selected) simulated approach and avoidance actions, respectively.

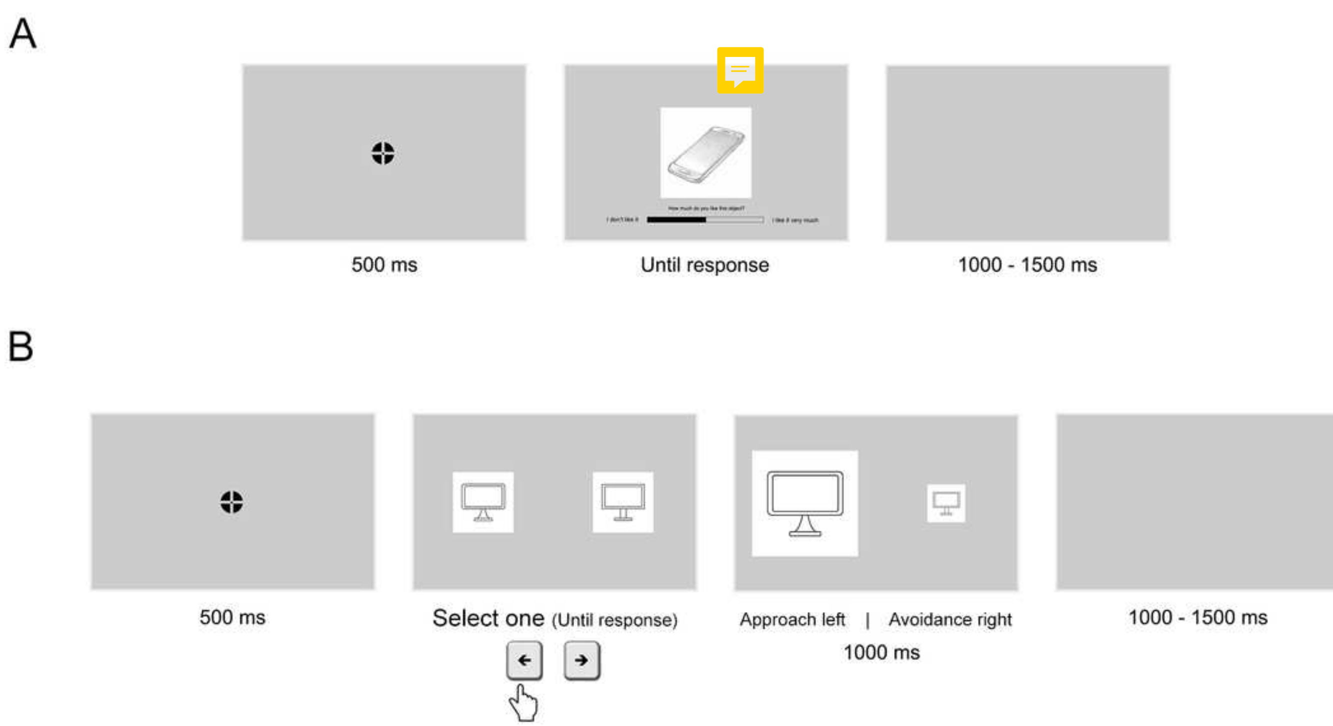

Figure 3

Liking ratings and familiarity judgements of Experiment 1.

(A) Mean liking ratings for the curved and sharp-angled drawings. (B) Mean liking ratings for the drawings within the three alternative responses of the Familiarity task. Left graphic represents familiarity judgements for the curved stimuli, middle graphic represents both stimuli judged as equally familiar, and right graphic represents familiarity judgements for the sharp-angled stimuli. Each one of these graphics show mean liking ratings for the curved and sharp-angled drawings. The curved drawings were liked more when the curved stimuli were judged as the most familiar ones, or when both stimuli were judged as equally familiar, but not when the sharp-angled stimuli were judged as the most familiar ones. Error bars represent 95% CI (** $p \leq .01$,*** $p \leq .001$, n.s.: not significant).

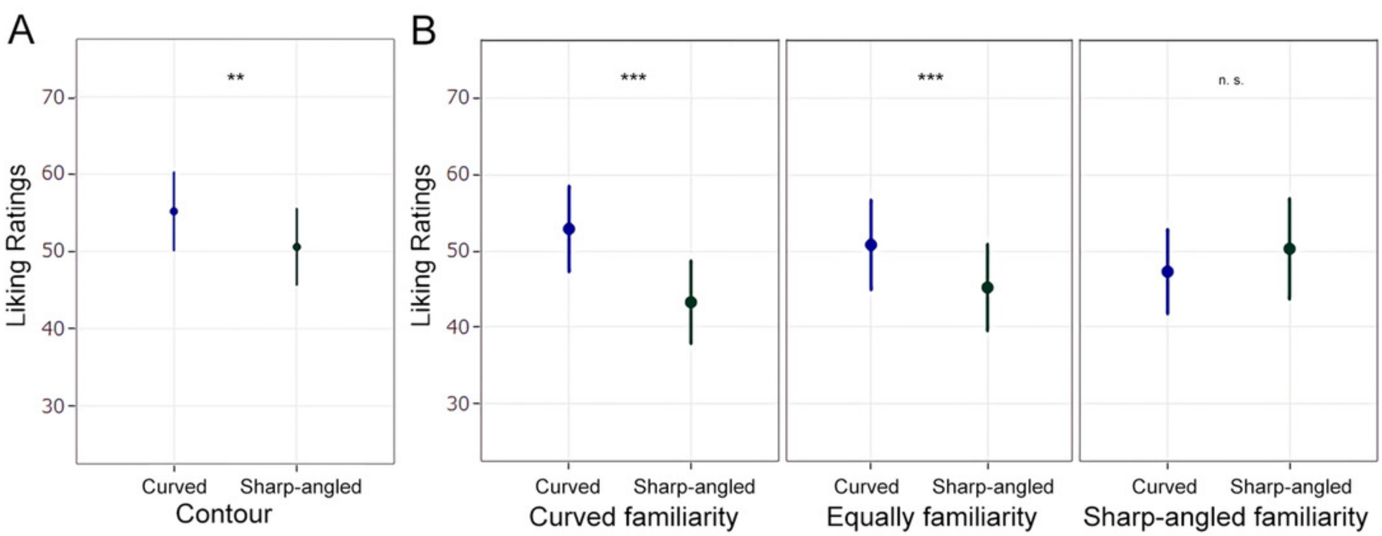

Figure 4

Preference choices and familiarity judgements of Experiment 2.

(A) Mean choices of the curved and sharp-angled drawings in the 2AFC task. (B) Probability of choosing the curved drawings in the 2AFC task within the three alternative responses of the Familiarity task. Familiarity judgements for the curved stimuli predicted a higher probability of choosing the curved drawings in the 2AFC. Error bars represent 95% CI (*** *p* < .001).

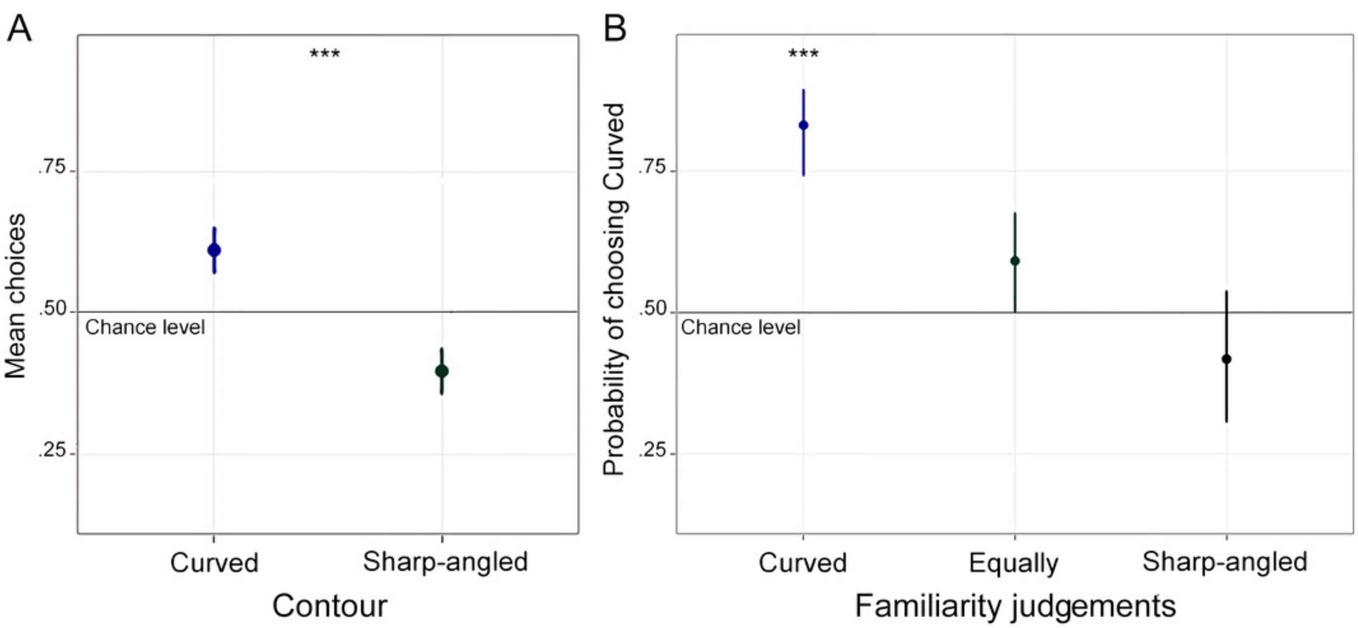

Figure 5

Scatterplots showing the relation between the data from experiments 1 and 2.

(A) Relation between the liking ratings (Experiment 1) and the curved choices in the 2AFC (Experiment 2). (B) Relation between the familiarity judgements data of Experiment 1 and 2. Each point represents a pair of drawings. All *p*'s < .001.

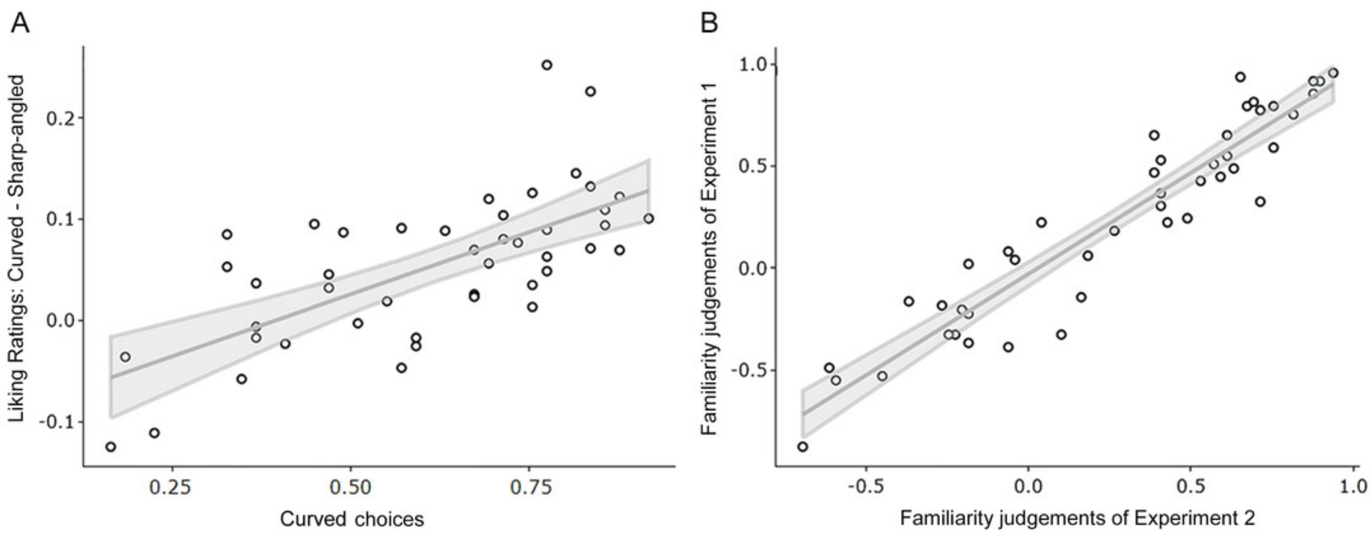

Table 1(on next page)

Descriptive statistics for the individual differences measures of Experiment 1 (n = 49).

Score ranges: Art interest (0 – 30), Art knowledge (0 – 18), Openness to experience (12 – 60), Unconventionality (4 – 20), HA (3 – 15), HB (4 – 20), I (8 – 40), A (8 – 40).

Variable	*Mean*	*Median*	*SD*	*Min – Max*
Art interest	10.6	12	5.44	1 – 20
Art knowledge	1.43	1	2.03	0 – 11
NEO: Openness to experience	47.4	48	5.94	30 – 59
HEXACO: Unconventionality	3.61	3.75	.57	2.25 – 5
TIntS: Holistic Abstract (HA)	8.4	8	2	3 – 14
TIntS: Holistic Big picture (HB)	13.3	13	2.47	8 – 19
TIntS: Inferential (I)	28.5	29	3.4	19 – 35
TIntS: Affective (A)	25	25	5.03	16 – 36

Table 2(on next page)

Descriptive statistics for the individual differences measures of Experiment 2 (n = 49).

Score ranges: Art interest (0 – 30), Art knowledge (0 – 18), Openness to experience (12 – 60), Unconventionality (4 – 20), HA (3 – 15), HB (4 – 20), I (8 – 40), A (8 – 40).

Variable	*Mean*	*Median*	*SD*	*Min – Max*
Art interest	10	9	6.22	0 – 26
Art knowledge	2.35	1	2.94	0 – 12
NEO: Openness to experience	46.3	45	5.53	36 – 58
HEXACO: Unconventionality	3.58	3.5	.58	2.5 – 5
TIntS: Holistic Abstract (HA)	7.94	8	2.21	3 – 13
TIntS: Holistic Big picture (HB)	12.8	12	2.55	7 – 20
TIntS: Inferential (I)	29.5	30	3.33	20 – 38
TIntS: Affective (A)	25.3	25	5.53	12 – 35