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Emotional valence modulates the preference for curved objects

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Abstract. Previous studies have shown that people prefer objects with curved contours over objects with sharp contours. However, those studies used stimuli that were mainly neutral in emotional valence. We tested here the interplay between visual features and general valence as positive or negative. After replicating curvature preferences for neutral objects, we used positive (cake, chocolate) and negative (snake, bomb) stimuli to examine if emotional valence—through response prioritisation—modulates the preference for curved objects. We found that people indeed preferred the curved versions of objects to the sharp versions of the same objects, but only if the objects were neutral or positive in emotional valence. There were no difference in liking for objects with negative emotional valence. This is evidence that the aesthetic response is adaptive, in this case prioritising valence over contour as demanded by the general semantic classification.

1 Introduction

The human mind is equipped to deal with different aspects of the environment that vary in their demands for specific responses. These demands require corresponding response mechanisms (eg fight or flight), which have been subjected to adaptive refinement during the course of human evolutionary history. One basic mechanism of the human visual system responds to low-level stimulus features. Such stimulus features influence reactions, such as those related to preferences and aesthetic responses (Bar and Neta 2006; Fechner 1876). For example, it has been shown that people prefer stimuli that are symmetrical rather than asymmetrical (eg Jacobsen and Höfel 2002; Tinio and Leder 2009); often, but not always, complex rather than simple (eg Imamoglu 2000, but see Phillips et al 2010); and large rather than small (Silvera et al 2002).

In this study, we investigated one such visual feature: contour—whether curved or sharp contour influences how objects are perceived and judged aesthetically (Bar and Neta 2006, 2007; Leder and Carbon 2005). Contour is a defining element in how an object is seen. In the area of product design, there has been a recent trend towards designing objects that are generally more rounded, compared with the designs of approximately three decades ago (Carbon 2010). Objects such as cars, furniture, and electronic devices have become more curved in their appearance. This trend has been paralleled by recent studies supporting the positive bias in preference towards stimuli with curved contours. For example, it has been shown that people prefer car interiors with curved rather than sharp elements (Leder and Carbon 2005). Several other studies (Bar and Neta 2006, 2007; Silvia and Barona 2009) that used various types of stimuli have supported and expanded our understanding of this preference for curvature.

Bar and Neta (2006, 2007, 2008) suggested that the reason why sharp objects are liked less is that they appear as potential threats. They further posited that the difference in preference judgments between curved and sharp objects might stem from increased arousal in response to sharp objects. Bar and Neta explored this hypothesis using fMRI to examine differential activations in the brain as a function of exposure to curved or sharp objects. The responses to sharp as compared to round objects indeed were associated with greater activation in the amygdala (Bar and Neta 2007), an area of the brain linked to the fear response and general arousal (eg Adolphs 2002; Adolphs et al 1999a, 1999b; Whalen 1998). This is evidence of a fear-related response elicited by sharp contours.

Thus, psychological studies indicate that people prefer curved contours. Although fashion may change this preference, it nevertheless seems to be a basic visual primitive with an evolutionary-based function (Carbon 2010). The stimuli used in past research on contour preference consisted of basic shapes such as circles (Hevner 1935) and polygons (Silvia and Barona 2009), but also real-world objects such as furniture and other household goods (Bar and Neta 2006, 2007). Importantly, those stimuli were characteristically neutral in emotional valence. However, many objects that we encounter in our everyday lives are associated with previous experiences—some positive, some negative. Such semantic meanings could impact preferences for objects. This could be the case if an object's visual features and semantic meaning impact our preference in a hierarchical way.

Because of the influx of environmental cues available at any given moment, different response mechanisms may be simultaneously activated, and in some circumstances, such mechanisms might compete for priority (eg Cosmides and Tooby 2000; Tooby and Cosmides 2005). Thus, if a particular situation demands several simultaneous responses, it is crucial that priority is placed on producing the response for the most pressing—in terms of survival—demands. Thus, in terms of behavioural responses that are directed towards survival and other more specific adaptive problems, objects that are associated with a positive affective value should be approached and those associated with negative past experiences avoided. However, what happens if two sources that affect preference—semantic meaning and contour—conflict? Would preference depend on contour or higher-level semantic affective value?

We report here a study in which the influence of emotional valence on the preference for curvature was examined directly by using stimuli that varied in valence. The assumption that the threat posed by an object results in the object being disliked may be true. If so, the threatening element of an object could override its positive elements, such as its curved contours. Therefore, we specifically examined the possibility that people would only show preference for objects with curved contours if the objects are associated with *semantically* non-threatening information—either neutral or positive. In this case preference for curvature should be present for stimuli with neutral or positive valence. However, when people encounter objects with negative valence, semantically threatening information becomes prominent and subsequently overcomes the influence of contour. This would be the case if the objects with negative valence, perceived as threatening, elicit an aversive response. It would show whether this response then overrides the effects of visual features such as contours.

This study consisted of two parts. The aim of the first part was to establish the effects found by Bar and Neta (2006, 2007) that people like curved objects more than sharp objects in the case of objects with neutral valence. This first part was conducted to ensure that the effects would be found in a different context—in terms of physical setting, language (instructions in German), and slight modifications of the procedure (eg experimental control software and presentation screen). Having established these effects, we tested the same participants in a second part, which was aimed at directly assessing response prioritisation in situations where there is competition between the effect of semantic information (eg snake versus lollipop) and the liking bias elicited by contour (sharp versus curved). In addition to liking ratings, we also determined valence ratings to better characterise the emotional valence factor. We also determined arousal ratings, as there is some evidence that negative emotions generate higher levels of arousal than positive emotions (Ekman et al 1983).

2 Part 1. Preference for curvature—stimuli with neutral valence

2.1 *Method*

2.1.1 *Participants.* Thirty-seven psychology students (twenty-four female) from the University of Vienna participated in the study. Their age ranged from 18 to 29 years with a mean age of 22.00 years (SD = 2.51 years). The nature of the procedures was explained to, and informed consent was obtained from, each participant prior to data collection. All participants had normal or corrected-to-normal vision and none was aware of the purpose of the study.

2.1.2 *Materials.* Three sets of stimuli with neutral emotional valence used previously by Bar and Neta (2006, 2007) were employed. The first set included 140 pairs of real objects, with each pair consisting of a curved- and a sharp-contoured version; that is, there were two versions of each object (eg stapler): a curved version (stapler with rounded contours) and a sharp version (stapler with sharp-angled contours). The two versions of the same object were visually similar in dimensions, but opposite in their curvature characteristics. The second set of stimuli included 140 pairs of abstract patterns, each pair consisting of a curved- and a sharp-contoured version, as with the real objects. The third set was a control set of real objects (eg table, hammer, lantern, and leaf) that were also neutral in valence, and consisted of 80 objects with approximately equal numbers of curved- and sharp-contoured objects. The full set can be seen on http://barlab.mgh.harvard.edu/Objects.htm.

2.1.3 *Procedure.* All stimuli (9.03 cm $\times$ 9.03 cm) were presented in greyscale on a grey (193, 193, 193) background using Presentation software (Presentation, Albany, CA, USA; version 10.3, www.neurobs.com). The general structure was as follows (in order of presentation): instructions, practice trials, and main trials. Each trial consisted of the following sequence: a fixation cross for 500 ms; the stimulus for 84 ms; a cue for 1916 ms; and an inter-trial interval for 2000 ms. The short presentation duration was identical to that used by Bar and Neta (2006) and was chosen to show, as in their study, that contour processing occurs during the very early stage of visual representation. In order to become familiar with the trial structure, participants were given 60 practice trials (10 round real objects; 10 sharp real objects; 10 round abstract objects; 10 sharp abstract objects; and 20 control objects), which were identical in structure to the main trials. The high number of practice trials was consistent with Bar and Neta's (2006) procedures. The stimuli used in the practice trials were not included in the main trials. For the main trials, each participant viewed one version of each object (either round or sharp, counterbalanced across subjects) and all the control objects.

Participants provided their responses during the time interval in which the cue "Like? or Dislike?" was presented on the screen. Two buttons on the keyboard corresponded to the two response choices. The participants were instructed to provide their ratings spontaneously. In addition, they were tested individually and the presentation of the objects was fully randomised.

2.2 *Results and discussion*

The dependent measure was calculated as the proportion of "like" responses to the total number of responses. Means, sampled over participants, were 0.71 for round objects, 0.68 for sharp objects, 0.29 for round abstract patterns, and 0.21 for sharp abstract patterns. A repeated-measures analysis of variance (ANOVA) with contour (round and sharp) and object type (real objects and abstract patterns) as within-subjects factors was performed. In general, there was a main effect of contour ($F_{1,36} = 10.46$, $p = 0.01$, $\eta_p^2 = 0.225$); thus participants preferred curved over sharp stimuli; and a main effect of object type ($F_{1,36} = 76.43$, $p < 0.01$, $\eta_p^2 = 0.68$) with real objects preferred to abstract patterns. There was also a significant interaction between contour and object type

($F_{1,36} = 4.28$, $p < 0.05$, $\eta_p^2 = 0.106$), indicating that the difference in liking between round and sharp was greater for abstract patterns than real objects. Directed t-tests confirmed these higher preferences for the round over sharp real objects ($t_{36} = 1.82$, $p < 0.05$) and abstract patterns ($t_{36} = 3.20$, $p < 0.01$).

Thus, the results confirmed earlier findings (Bar and Neta 2006, 2007; Silvia and Barona 2009) that curved objects are liked more than sharp objects. This effect was observed both for real objects and abstract patterns, with both sets of stimuli possessing inherent neutral valence. Next we examined whether the preference for curved contours would interact with the valence of an object. Using two sets of stimuli that varied in their emotional valence, we aimed to directly examine semantic valence as mediator between competing responses.

3 Part 2. Preference for curvature—stimuli with positive and negative valence

The aim of this study was to directly compare the effects of contour on preference judgments for objects that had positive and negative emotional valence. In addition to measuring liking ratings, we also measured valence and arousal ratings.

3.1 *Method*

3.1.1 *Participants.* The same group of participants as in part 1 was used.

3.1.2 *Materials.* A new set of objects (see figure 1 for examples) was produced for part 2. The visual characteristics (eg size, brightness, contrast, and background colour) of these stimuli were standardised to match the set used in part 1. However, in contrast to the previous set, the objects in the new set were chosen because they were objects commonly known to have strongly positive (eg slice of cake, chocolates) or strongly negative (eg snake, battle-axe, bomb) emotional valence.

The stimuli consisted of 20 pairs of real objects with positive valence (eg birthday cake, pralines, sailboat, ice cream, and teddy bear), with each pair consisting of a round and a sharp version; and 20 pairs of real objects with negative valence (eg razor blade, sword, toilet brush, spider, dentist's chair), with each pair consisting of a round and a sharp version. Thus, there were four groups of objects: 10 round positive; 10 round negative; 10 sharp positive; and 10 sharp negative real objects. The full set can be seen on http://ppcms.univie.ac.at/uploads/media/Images_Perception.pdf

The stimuli were produced by first listing objects that fit into these valence categories. Next, we searched for pictures that portrayed these objects in isolation (plain backgrounds) and that depicted them at a normal angle. We then produced two different versions of each object—a curved and a sharp version—by carefully digitally manipulating all possible contour elements. Thus, unlike the stimuli in part 1, the two versions of each object in part 2 differed only in curvature.

3.1.3 *Procedure.* The study consisted of three blocks. The first block involved liking ratings of the stimuli in the same manner as in part 1. The second block involved forced-choice "pleasant" or "unpleasant" valence ratings. Finally, the third block consisted of arousal ratings on a seven-point scale with '1' indicating 'calm' and '7' indicating 'exciting'. All participants performed the liking block first. Then, the order of the second and third blocks—the valence and arousal ratings—was balanced across participants. This order assured that liking (the primary measure) was always measured at the first viewing of each object, and thus would be unaffected by the other measures. Moreover, we assumed that valence or arousal evaluations would be affected negligibly by the previous tasks.

The general structure of the study and the sequence and timing characteristics of the stimulus events for the liking and valence ratings were the same as in part 1. To provide the participants with sufficient time to use the 1 – 7 scale for the arousal ratings, the response window was increased to 2916 ms. To make participants familiar with the trial structure, they were given 12 practice trials (3 round positive; 3 round negative; 3 sharp positive; and 3 sharp negative objects), which were identical in structure to the main trials. The number of practice trials (12) in part 2 was much smaller than the number of practice trials (60) in part 1. This lower number was chosen because it was commensurate with the smaller number of stimuli in part 2. The stimuli used in the practice trials were not included in the main trials. During the main trials, each participant viewed one version of each object, either round or sharp (20 positive and 20 negative objects for a total of 40 trials) counterbalanced across participants. Consequently, for each participant, the same set of objects was used for all three blocks.

3.2 *Results and discussion*

Regarding the preferences (first block) a repeated-measures ANOVA was performed with contour (round and sharp) and valence (positive and negative) as within-subjects factors and the proportion of like responses to the total number of responses as dependent variable. Means, sampled over participants, were 0.82 for round positive, 0.78 for sharp positive, 0.25 for round negative, and 0.28 for sharp negative objects. The analysis revealed a main effect of valence: participants preferred positive over negative objects ($F_{1,36} = 132.17$, $p < 0.01$, $\eta_p^2 = 0.79$). There was no main effect of contour ($p = 0.63$, $\eta_p^2 = 0.007$), but there was a significant interaction between contour and valence ($F_{1,36} = 5.34$, $p = 0.027$, $\eta_p^2 = 0.13$). *t*-Tests revealed that this interaction was due to a lack of difference between negative round and negative sharp objects ($p = 0.32$); and a preference for positive round objects over positive sharp objects ($t_{36} = 2.83$, $p = 0.01$).

Regarding the valence ratings, an ANOVA with contour and valence as within-subjects factors and valence ratings as the dependent variable revealed a significant main effect of valence ($F_{1,36} = 202.461$, $p < 0.001$, $\eta_p^2 = 0.849$). The participants found the positive stimuli (mean proportion $= 0.83$) more pleasant than the negative stimuli (mean proportion $= 0.19$), and this was independent of contour. There were no other

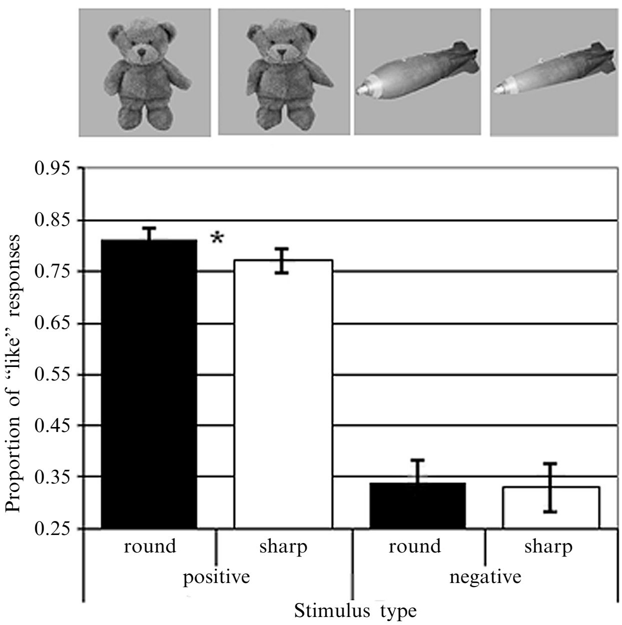

Figure 1. Examples of stimuli and results of preference classifications.

significant effects. Planned *t*-tests did not reveal significant differences in valence ratings between round positive (mean proportion = 0.84) and sharp positive (mean proportion = 0.82) objects, and between round negative (mean proportion = 0.18) and sharp negative (mean proportion = 0.20) objects ($p = 0.09$ and $p = 0.67$, respectively).

Regarding the arousal, an ANOVA with contour and valence as within-subjects factors and arousal ratings as the dependent variable showed a significant main effect of valence ($F_{1,36} = 53.36$, $p < 0.01$, $\eta_p^2 = 0.60$). Participants found the negative objects more arousing (mean = 4.80) than the positive objects (mean = 3.30). There were no other significant effects. Again, planned *t*-tests also did not reveal significant differences in arousal ratings between round positive (mean = 3.34) and sharp positive (mean = 3.26) objects, and between round negative (mean = 4.86) and sharp negative (mean = 4.74) objects ($p = 0.337$ and $p = 0.326$, respectively). These results support the hypothesis that negative emotions might come along with higher arousal than positive emotions (Ekman et al 1983). Regarding the interplay of valence and contour, the findings of part 2 provide clear evidence that contour modulates preferences only for objects that are positive but not negative in emotional valence.

4 General discussion

First, regarding objects neutral in valence, we found a preference for curved objects, validating the findings of previous studies (Bar and Neta 2006). Thus, for objects with neutral valence, preference for curved contours seems to be robust. When we tested objects that varied clearly according to valence, we found that preference for curved objects was modulated by emotional valence. Results showed that objects that were neutral and positive in emotional valence revealed clear effects based on contour characteristics; the curved versions of objects were liked more than the corresponding sharp versions of the same objects. However, this contour-based liking bias was not found for objects that were clearly negative in emotional valence.

These results indicate that the affective evaluation system involves some sort of prioritisation scheme: when confronted with negative objects, inherent basic visual features are not considered for the response as highly as the semantically based affective value of those objects. Consistent with assumptions in theories of aesthetics, the pleasantness of a visual stimulus is restricted to non-threatening, positive, or at least neutral objects (see Leder et al 2004). The results also indicate that aesthetic responses are adaptive to the specific demands of the context. Such demands may involve something physical, such as the sharpness of an object (Bar and Neta 2006); social, such as a person's suitability as a romantic partner (Leder et al 2010); or emotional, such as the level of threat or negative semantic posed by an object, as was found in this study.

It remains to be shown what underlying mechanisms are involved in moderating the effect. It is possible that positive valence leads to an interaction with objects in a manner in which basic stimulus features are considered. In contrast, negative valence might lead to a general avoidance response wherein object features are not considered. Whether such processes are moderated by levels of consciousness should also be examined. Moreover, in the present studies, the short presentation durations suggest that, at least for very early perceptual representations, the two levels of valence dissociate. In future studies, longer presentation durations would allow the testing of further hypotheses regarding the time course of these affective evaluations. Future studies could also use 3-D rendered objects to allow a more systematic examination of view-dependent and systematically varied levels of curvature. Thus, we have shown that curved objects are preferred when objects are characteristically neutral or positive but when objects are inherently negative in emotional valence the attractiveness of curvature cannot deceive the threatened perceiver.

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