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Simple geometric shapes are implicitly associated with affective value

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Abstract

Growing evidence suggests that the underlying geometry of a visual image is an effective mechanism for conveying the affective meaning of a scene or object. Indeed, even very simple context-free geometric shapes have been shown to signal emotion. Specifically, downward-pointing V's are perceived as threatening and curvilinear forms are perceived as pleasant. As these shapes are thought to be primitive cues for decoding emotion, we sought to assess whether they are evaluated as affective even without extended cognitive processing. Using an Implicit Association Test to examine associations between three shapes (downward- and upward-pointing triangles, circles) and pleasant, unpleasant, and neutral scenes, in two studies we found that participants were faster to categorize downward-pointing triangles as unpleasant compared to neutral or pleasant. These findings were specific to downward-pointing shapes containing an acute angle. The present findings support the hypothesis that simple geometric forms convey emotion and that this perception does not require explicit judgment.

Keywords

Emotion perception; Implicit cognition; IAT; Threat

Introduction

Efficient recognition of salient stimuli that signal threat or benefit to the individual is crucial for survival. Consistent with this premise, potential cues of threat and reward have been shown to receive preferential processing (Gable and Harmon-Jones 2008; Öhman and Mineka 2001). Moreover, in addition to stimuli with clear contextual import for one's own immediate survival, Lorenz (1943) suggested that the configural aspects of the human infant's head and facial features evoked adult care for the infant, a suggestion that has received a great deal of support from Zebrowitz and her associates (1997). This work, as well as that of Darwin (1872/1998) and Ekman (1973) outlining precise feature changes

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associated with universal emotional expressions, suggests that identification of biologically-meaningful stimuli can be reduced to very simple stimulus properties. Indeed, pioneering work by ethologists such as Tinbergen demonstrated that even in animals well down the phylogenetic hierarchy there exist mechanisms for prioritized responding to very primitive survival-relevant cues (Eibl-Eibesfeldt 1989). Following this work, we have hypothesized the presence of simple underlying features, common across a number of threat or avoidance and attachment or reward-related signals, which permit the affective value of the stimulus to be extracted quickly without the need for thorough processing of the entire object or scene. Extending previous research supporting this hypothesis, and consistent with our contention that this is a deeply engrained mechanism for signaling affect, the aim of the present study was to determine whether simple geometric features convey emotion even when processed implicitly.

The search for such elemental stimulus properties has revealed that the geometry of the display is a critical factor in conveying emotional meaning. Everyday objects containing non-representational images of sharp angles are less well liked and activate neural regions such as the amygdala that are implicated in response to threat more than similar items containing curves (Bar and Neta 2006, 2007). Similarly, abstract angular geometric patterns tend to be associated with threat and curvilinear forms tend to be associated with pleasantness or happiness, a phenomenon evident in a wide array of naturalistic displays such as those found in the facial features of tribal masks (Aronoff et al. 1988), patterns of physical movement by “bad” or “good” characters in ballet (Aronoff et al. 1992), preference for infant and “babyish” adult faces (Zebrowitz 1997), and the configural layout formed by the human subjects in seventieth century Dutch paintings (Aronoff 2006). Importantly for the evolutionary argument, such geometric forms are also prominent in facial expressions of emotion, with angry faces containing more angles (e.g., eyebrows pointing down and in) and happy faces containing more roundedness (e.g., cheeks expanding outward and the shape of the mouth during a smile). The contrasting configural pattern associated with angry and happy emotion was most strongly demonstrated in the work of Bassili (1978), who used a point light technique (i.e., luminescent dots placed on the subject’s face in a dark room) to show that the overall pattern of muscle movements in happy faces forms a rounded configuration whereas in angry faces the muscles tend to pull down and into form a V shape.

To clarify the precise underlying features that are perceived in these configural affective stimuli, in a set of experimental studies we stripped away all contextual information and constructed an array of models containing the simple geometric forms (e.g., literally a “V” or a circle) that appeared to convey emotion in natural environments. In brief, semantic differential ratings reveal that downward V forms are rated as more “bad” and circles and curvilinear forms are rated as more “good” (Aronoff et al. 1992; Larson et al. 2007). Further assessment of the downward V shape indicates that attentionally and neurally it functions much like standard contextual threat stimuli. Compared to the same shape inverted, downward-pointing V’s are detected more rapidly in a field of distracters (Larson et al. 2007; LoBue and Larson 2010; Watson et al. in press), interfere with valence-based judgments of neighboring target stimuli as is typical of contextual affective distracters (Watson et al. 2011), and recruit the amygdala, insula, subgenual anterior cingulate cortex and other brain regions involved in perception of threat and negative emotion (Larson et al.

2009). Thus, while just a simple shape, the downward V form effectively recruits neural circuitry implicated in affect and affective perception.

Although these initial studies suggest that the V-shaped and circular forms are effective signals of emotion in a visual display, the data thus far demonstrating that these shapes are subjectively perceived as affective rely on explicit self-report ratings, which may be subject to demand characteristics and other potential confounds. Therefore, additional research supporting the notion that these shapes are subjectively perceived as affective is needed. Of more theoretical significance, given our hypothesis that these shapes represent very basic, and perhaps evolutionarily adapted signs of biological relevance, it is important to demonstrate that this affective perception occurs without extended cognitive processing and without relying on introspective awareness necessary for explicit self-report (Greenwald and Banaji 1995). Thus, we sought to show that this process operates at an implicit, rather than overt/explicit level through two experiments using the Implicit Association Test (IAT; Greenwald et al. 1998).

The IAT has been widely used as an indirect measure of the strength of putatively automatic associations between an attribute dimension (e.g., pleasant and unpleasant) and target stimuli (e.g., puppies and snakes). In a typical IAT participants are presented with an exemplar of either of the two attributes or two targets and asked to categorize that stimulus as a function of the super-ordinate attribute and target categories (e.g., does a particular stimulus fit the category of unpleasant and/or snakes). The task is structured such that in one block of trials putatively compatible attribute-target pairs are categorized using the same response button (e.g., pleasant and puppy). In a separate block the attribute-target pairings are switched so that the same button press response is required for categorizing supposedly incompatible pairs (e.g., pleasant and snake). The assumption is that participants' reaction times will be faster when categorizing strongly related attributes and targets. The IAT has been used as an indirect assessment of attitudes and associations in a wide variety of domains, particularly in the study of social attitudes (Karpinski and Hilton 2001), personality (Greenwald and Farnham 2000), and clinical psychology (Ellwart et al. 2006). Here we apply this robustly replicated attitude task to a more basic cognitive process, that of affective perception.

Experiments 1a and 1b: Assessing affective associations with the V shape

To test the notion that simple shapes possess inherent affective meaning we conducted two separate IAT experiments. In the first experiment we examined whether downward-pointing triangles and circles are more readily associated with threat-related unpleasant and pleasant images, respectively. The second experiment was designed to provide a stronger test of the downward-V/unpleasant association by comparing these stimuli with the identical triangle inverted (pointing up) and neutral images. This comparison is more conservative since the exact same shape is being compared and these two forms are less distal in terms of explicit affective ratings than are the downward V and the circle (Larson et al. 2007). We predicted that people would be faster at categorizing downward pointing Vs when paired with unpleasant (Experiment 1a) or neutral (Experiment 1b) stimuli. Support for these predictions would further bolster the hypothesis that simple geometric configurations convey affect and that this process does not require explicit evaluation.

Experiment 1a method

Participants and procedure—Eighty-seven right-handed undergraduates (32 M, 55 F) participated in an IAT experiment for course credit. The IAT protocol in this experiment was designed to test whether downward-pointing triangles and circles (target categories) were more readily associated with threat-related unpleasant and pleasant scenes (attribute categories), respectively. Six stimuli representing each shape and scene type were used. The shape stimuli were simple line drawings (see Fig. 1). The downward-pointing Vs and circles were matched in size and complexity (e.g., if a given downward V stimulus contained two overlapping shapes of a particular size, the identical configuration was created using circles). In both studies triangles were used for the majority of the stimuli rather than an actual “V” to avoid the confound of V being a letter and thus having linguistic meaning. Furthermore, this allowed for a closer comparison with a circle in that both are closed figures. The unpleasant and pleasant images were selected from the International Affective Picture System (IAPS; Center for the Study of Emotion and Attention 1999) based on published norms (Lang et al. 1999). The six unpleasant images contained threat-related content such as guns aimed at the viewer, snakes or snarling dogs (IAPS pictures 1050, 1120, 1300, 6230, 6250, 6510). The pleasant images included appetitive stimuli such as food or money and other positively-valenced content such as puppies and fireworks (IAPs pictures 1710, 5460, 5480, 7230, 7502, 8501).

For each trial in the IAT task, super-ordinate category labels for the attribute and target categories were presented in the upper left and right corner of the screen (e.g., pleasant and unpleasant). Stimuli depicting one of the four categories (pleasant, unpleasant, circle, downward triangle) were presented in the center of the screen and participants were instructed to press a key indicating whether that central stimulus belonged to the super-ordinate category on the left (press the “e” key) or the right (the “i” key). Reaction times for categorizing circles and downward Vs with pleasant and unpleasant images are assumed to reflect the degree of association between the categories (Greenwald et al. 2003). Stimulus presentation terminated with the button press. If an error was made in classification participants were given feedback (a red X) and instructed to change their answer before proceeding to the next trial. Each trial was separated by 500 ms.

The IAT consisted of a series of five blocks ordered as follows: (1) attribute categorization (unpleasant vs. pleasant), (2) target categorization (downward V vs. circle), (3) compatible combined attribute/target categorization (unpleasant/downward V vs. pleasant/circle), (4) reversed attribute categorization (pleasant vs. unpleasant), and (5) incompatible attribute/target categorization (pleasant/downward V vs. unpleasant/circle). Blocks 3 and 5 provided the critical test of strength of association, with Block 3 containing the compatible pairings (e.g., unpleasant/downward V) and Block 5 containing the incompatible pairings (e.g., unpleasant/circle). The order of the pairings was counterbalanced such that 43 participants completed the paradigm in this order, and for the remaining 44 participants, Block 3 contained the incompatible pairings and Block 5 the compatible pairings.

Blocks 1, 2, and 4 consisted of 24 trials (12 of each shape or scene, each stimulus presented twice). Seventy-two stimuli were presented in blocks 3 and 5, eighteen of each of the four stimulus types (downward V, circle, unpleasant and pleasant scenes). Each stimulus was repeated three times during Blocks 3 and 5.

Data reduction—Only the critical Blocks 3 and 5 were included in statistical analysis. Following previously established guidelines (Greenwald et al. 2003) trials on which errors were included, and RTs of greater than 10,000 ms were excluded from analyses. The recommended exclusion of participants with RTs less than 300 ms on more than 10% of trials was assessed; however, no participants met this criterion. Mean reaction time (RT) was calculated for the compatible and incompatible blocks (Blocks 3 and 5).[1] Previous data indicate that RTs for the categories within a block are relative to one another and cannot be meaningfully interpreted individually (Brendl et al. 2001). Thus, mean RTs for Blocks 3 and 5, the compatible and incompatible blocks, were calculated across all four conditions in each block. A paired *t*-test was calculated comparing compatible and incompatible blocks. There were no effects for gender so it was not included as a factor in the analyses presented here.

Experiment 1b method

Experiment 1b was designed to determine if the key component in the negative perception of the V (the element producing the perception of threat) is the downward-pointing acute angle. Thus, we sought to examine whether the downward-pointing V was more readily categorized as unpleasant than the identical shape inverted (pointing upward). The stimuli and procedures used were identical to Experiment 1 except that upward triangles replaced the circles (see Fig. 1) and neutral images (selected from the IAPS) replaced the pleasant images. Neutral images were selected because the upward V falls between the downward V and circle on bipolar pleasantness ratings (i.e., more neutral). The neutral pictures included everyday household objects (e.g., stool, basket) (IAPS pictures 7000, 7010, 7025, 7050, 7090, 7100). As before, the protocol consisted of five blocks with Blocks 3 and 5 being the critical blocks cross-categorizing the shapes and the scenes. Fifty-seven right-handed undergraduates (15 M, 42 F) participated in this experiment in exchange for course credit. Twenty-eight of the participants followed these category assignments: Block 3: unpleasant/ downward V vs. neutral/upward V (compatible pairings); Block 5: unpleasant/upward V vs. neutral/downward V (incompatible pairings). For the remaining 27 individuals the order was reversed. Data reduction procedures were identical to Experiment 1a.

Results and discussion

As described above, for Experiment 1a we compared categorization of downward Vs and circles paired with unpleasant and neutral images. We predicted faster RTs for downward V/ unpleasant and circle/pleasant pairings than downward V/pleasant and circle/unpleasant pairings. To test this prediction, a paired *t*-test was calculated comparing the compatible (downward V/unpleasant, circle/pleasant) and incompatible (downward V/pleasant, circle/ unpleasant) blocks. RTs were significantly faster for compatible (M = 725.27, SE = 14.85)

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[1] Greenwald et al. (2003) recommend using a *D* statistic that involves computing the difference between the compatible and incompatible blocks and dividing by the pooled variance across the two blocks. This statistic was calculated and yields identical results for the compatible compared to incompatible blocks in the present studies. For ease of interpretation the mean RTs are presented here.

than incompatible (M = 858.11, SE = 20.37) trials, *t*(86) = 9.38, $p < .001$, *d* = .80 (see top panel of Fig. 2).

In Experiment 1b we predicted that downward V/unpleasant and upward V/neutral pairings would lead to faster categorization RTs than the downward V/neutral and upward V/unpleasant pairings. Using the same analytic procedures as Experiment 1a, we again found that RTs were faster for compatible (unpleasant/downward V, neutral/upward V; M = 780.79, SE = 22.71) compared to incompatible trials (M = 872.64, SE = 34.11), *t*(56) = 4.70, $p < .001$, *d* = .42 (see bottom panel of Fig. 2).

These two studies demonstrate robust associations between unpleasantness and downward Vs, when contrasted with both pleasant and neutral stimuli. In the context of our previous work these data provide additional support for our hypothesis that the downward-pointing V shape holds affective meaning. The results from Experiment 1a are also consistent with previous research indicating preference for curvilinear forms. Overall, these studies highlight the affective potency of these simple, context free shapes, in this case using an indirect assessment of subjective perceptions.

Experiments 2a and 2b: Addressing possible alternative explanations

While the findings from Experiments 1a and 1b indicate stronger associations between pleasantness/unpleasantness and specific shapes, methodological studies on the IAT technique have suggested that the effects may be largely driven by the semantic category labels rather than the exemplar stimuli themselves (De Houwer 2001; Karpinski and Hilton 2001). Thus, the use of the term “downward” as a category label may be driving the increased association between downward Vs and unpleasantness. Indeed, “downward” and “upward” have been shown to carry affective valence (Eder and Rothermund 2008). In addition, it may also be possible that unpleasantness is associated with downwardness in general. Previous work has suggested that verticality is linked with affect such that downwardness is seen as more negative (Meier and Robinson 2004). To address these possibilities we used a two-pronged approach. First, in Experiment 2 we replaced the terms “upward” and “downward” with other category labels, “A” and “V” respectively, that may carry less affective weight. Replicating the first two experiments, we predicted that “V” would be more strongly associated with the downward-compared to upward-V shape.

To address the specificity of the acute angle in conveying negative affect, in Experiment 2b we presented the participants shapes identical to those used in Experiment 1b, but with the acute angle replaced by a curve. Thus, the same value-laden category labels were used and the shapes still pointed up and down, but the exemplar stimuli lacked the acute angle that we hypothesized was responsible for the unpleasant-downward association. If downwardness in general is associated with unpleasantness we should replicate the association between “downward” and “unpleasant” as there was in Experiments 1a and 1b. However, a failure to find such a difference would suggest that the effect does not generalize to all downward-pointing stimuli and further support the notion that acute angle in the downward-V shape is critical for judgments of unpleasantness.

Method

In Experiment 2a we tested whether category labels other than “upward” and “downward” would also lead to a significant association between the downward V shapes and unpleasantness. With the exception of the category labels, this experiment was identical to Experiment 1b, which required categorization of “unpleasant” and “neutral” with the downward and upward-pointing Vs. In this experiment the terms “A” and “V” replaced “upward” and “downward,” respectively. Again, the protocol consisted of five blocks with Blocks 3 and 5 being the critical blocks cross-categorizing the shapes and the scenes. Forty-five undergraduates (20 M, 25 F) participated in this experiment. Twenty-three of the participants in Experiment 2a followed these category assignments: Block 3: unpleasant/V vs. neutral/A (compatible pairings); Block 5: unpleasant/A vs. neutral/V (incompatible pairings). For the remaining 22 participants the Blocks were reversed. Across all subjects, four trials were dropped because RTs were faster than 300 ms.

Experiment 2b was also a direct replication of Experiment 1b in which “unpleasant” and “neutral” were categorized with upward- and downward-pointing shapes. In Experiment 2b these category labels were retained, but the shape stimuli were different. The upward and downward pointing shapes used in Experiment 1b were modified such that the point was replaced with a curve (see Fig. 3). The shape stimuli were otherwise identical. Forty-eight undergraduate students (21 M, 27 F) completed the paradigm. Half of the participants first categorized “unpleasant” with “downward” in Block 3 and “unpleasant” with “upward” in Block 5. The order was reversed for the remaining half. For both experiments data reduction procedures were identical to Experiments 1a and 1b.

Results and discussion

Experiment 2a: Altering category level labels—“A” and “V”—Overall, using the category labels, “A” and “V” resulted in the same pattern of reaction times as using the labels “upward” and “downward.” Mean RTs were significantly faster for compatible (V/unpleasant, A/neutral; M = 768.61, SE = 18.26) than incompatible (M = 827.89, SE = 20.54) trials, $t(44) = 2.87$, $p = .006$, $d = .45$ (see Fig. 4, top panel).

Experiment 2b: Downward and upward curvilinear forms paired with unpleasant and neutral images—Replacing the shapes containing acute angles with the same shapes with curved ends eliminated the significant association between “downward” and “unpleasant.” The paired t test comparing compatible (M = 779.11, SE = 21.27) and incompatible (M = 802.03, SE = 24.59) trials did not yield a significant difference, $t(47) = 1.07$, $p = .29$, $d = .14$ (see bottom panel of Fig. 4). Thus, there was no evidence for the hypothesis that downward-pointing stimuli in general are associated with unpleasantness. This finding suggests that the acute angle is critical to conveying unpleasant affect.

Overall, these two experiments address possible confounds in the primary effects demonstrated in Experiments 1a and 1b. While these confounds were addressed as directly as possible, it is still possible that the effects observed in Experiments 2a and 2b are due to category-level effects, particularly if the participants recoded the category labels to facilitate efficient categorization (Gast and Rothermund 2010; Rothermund et al. 2009). For example, in Experiment 2a, the participants may have recoded the labels “A” and “V” as “upward” and “downward.” However, despite these concerns, the replication of the unpleasant-V association using less affectively charged category labels and the failure to replicate this association using non-pointed stimuli suggest that the effect is likely to due the affective and perceptual properties of the exemplar stimuli themselves.

General discussion

The aim of the present work was to use the IAT as a tool to assess affective perception, specifically the degree to which simple configural properties can serve as the basis for extracting affective meaning from a visual image. The results of the first two experiments show that implicit processing of very simple geometric shapes elicits the same perception of affective value as does a more explicit rating process. The robust effect indicating faster responses for compatible compared to incompatible trials indicates a strong bias for downward V shapes to be associated with unpleasantness and for circles to be perceived as pleasant. The tendency for classifying the V shape as unpleasant held even when subjected to a more stringent comparison with the identical shape inverted. Experiment 2a demonstrated that this effect held true even when attempting to minimize the semantic value judgments embedded in the category-level terms used. Most notably, there was no association with downward-pointing shapes and unpleasantness when the exemplar shapes categorized were curved rather than pointed. This finding suggests that the perception of the downward-pointing shapes as unpleasant depends on the shapes containing a pointed, acute angle. It should be noted that some studies have shown that the context of the face is crucial for the rapid detection of affective angry schematic faces (e.g., Schubö et al. 2006; Tipples et al. 2002). These studies differed from ours in the exact nature of the stimulus presentation, either in also including the curvilinear feature of the mouth, or by not including the actual acute angle. These conflicting findings clearly call for further specification of both the exact perceptual features of the simple shapes that result in rapid capture of attention and the role of other contextual cues that moderate the affective potency of these shapes. However, in general, previous self-report, attention, and neuroimaging studies in this line of work demonstrated that these primitive, context-free geometric forms convey affect associated with perception of threat and pleasantness. Here we extend support for the configural hypothesis of affect perception to the domain of implicit cognition.

Implicit evaluation of these simple geometric shapes as affective provides important support for our hypothesis that underlying geometry is a mechanism facilitating rapid and efficient recognition of biologically-relevant stimuli. LeDoux (1996) and others (Öhman and Mineka 2001) have argued that detection of potential threat is so important for evolutionary fitness that this process should occur even with minimal sensory and cognitive processing. Implicit or “indirect” measures such as the IAT putatively allow for assessment of attitudes and stimulus evaluation under conditions that minimize direct and extensive cognitive engagement. At the level of sensation, the IAT technique does not limit sensory input; however, the stimuli themselves are completely non-contextual and carry far less incoming sensory information than a typical affective image. Thus, the combination of these rudimentary sensory inputs and the IAT paradigm make it possible to examine affective evaluation of the downward V and curvilinear forms under conditions that minimize contextual sensory input and explicit cognitive processing. Together with our earlier work, the present data highlight that emotion can be effectively and implicitly communicated based on primitive geometric forms that are embedded in many common affective cues.

In considering the neural basis of such implicit evaluative processes, the amygdala has been repeatedly implicated in studies of implicit emotional learning and memory (Phelps and LeDoux 2005) and implicit attitudes (Stanley et al. 2008). Considered in this context, the current data and our previous finding that downward-pointing V shapes activate the amygdala (Larson et al. 2009) suggest that evaluation of these simple shapes rely on similar neural circuitry previously implicated in implicit processing of affective stimuli. It is yet to be determined whether the downward acute angle and curvilinear forms themselves directly evoke an attitude or affective response, perhaps through direct projections from sensory brain regions to the amygdala, or whether these forms are determined to be affective via top-down memory associations. Regardless, a growing body of work suggests that recognition of affectively meaningful signals in the environment does not necessarily rely on extensive contextual information and that simple underlying geometry may serve as an organizing principle for detecting some types of affective stimuli.

Currently there is substantial debate regarding the psychological mechanism underlying the IAT effect. While extant data supports the initial contention that the IAT reflects semantic associations (Greenwald et al. 2002), other findings also support more recent hypothesized mechanisms, such as perceptual similarity (Mierke and Klauer 2003) and salience asymmetry (Rothermund and Wentura 2004). Despite debate over the exact processes underlying the IAT effect, several relevant points are generally agreed upon. First, slower reaction times in the putatively incompatible block is clearly a function of the same response key being assigned to two categories that do not have strong associations (Mierke and Klauer 2001). Thus, the present findings are consistent with the notion that downward V's and circles are more strongly associated with unpleasant and pleasant valence, respectively. Second, while recently some of the underlying assumptions of implicit psychological measures have been questioned (Witterbrink and Schwarz 2007), it does seem generally agreed upon that as a performance-based discrimination task that does not require explicit verbal report the IAT can reasonably be called an “indirect” measure of associations between concepts (Gawronski et al. 2007). Such indirect measures are thought to recruit relatively automatic cognitive processes (Wilson et al. 2000). Therefore, the present data suggest that perception of these simple geometric shapes as affective is not restricted to direct, explicit judgments.

One possible alternative explanation for the present findings is that the V shape is not judged more negatively because of the downward-pointing acute angle specifically, but rather because of it’s connotation of downward verticality. Previous work has indicated that verticality conveys affective meaning, such that stimuli placed in an upward position are regarded more positively, whereas those placed lower in the visual field are evaluated more negatively (Meier and Robinson 2004). Thus, the affective value of the downward V stimulus may in part be due to its association with downwardness. However, this model cannot completely account for the full pattern of findings from the work on affect and geometric shapes. According to the geometry hypothesis the most pleasant shapes are circular or curvilinear, rather than upward pointing. Indeed, our ratings data from Larson et al. (2007) clearly support that position, as do many studies indicating the relationship between pleasantness and more curved abstract stimuli (Bar and Neta 2006) and more rounded contextual stimuli, such as faces (e.g., Zebrowitz 1997). However, our data from these studies and the present ones also clearly demonstrate that downward pointing Vs are perceived as more unpleasant than upward pointing Vs. Thus, it is likely that both the verticality and the geometry perspectives are useful models for understanding how simple cues can signal affective valence.

Returning to the primary theoretical question at hand, these IAT findings provide further support for the hypothesis that specific configural features of visual images can convey emotion. Although angular objects and forms are generally less preferred (Bar and Neta 2006) and rated as more aversive (Aronoff et al. 1992), these findings clearly indicate that not only are sharp angles indicative of threat or unpleasantness, but that the orientation of the angle is crucial. Downward-pointing V's were more readily identified as unpleasant than upward-pointing Vs. This finding, coupled with a growing body of research highlighting that the downward-pointing V is associated with increased perception of threat (Aronoff et al. 1992; Larson et al. 2007), attentional bias (Larson et al. 2007; Watson et al. in press), and recruitment of threat-detection regions in the brain (Larson et al. 2009), further underscores the precedence granted to downward acute angles. The fact that the orientation of the angle is critical to eliciting perception of threat supports the hypothesis that the effect is not produced simply by a learned "sharpness" of some angular forms. Furthermore, as the IAT and other indirect measures are thought to tap somewhat automatic, schema-driven processes, the present data support the assertion that evaluation of the V shape as threatening is deeply engrained, perhaps through evolutionary mechanisms, although these associations may also be a result of early learning.

The observed link between circles and pleasantness is also in keeping with previous reports examining both contextual (Aronoff et al. 1988, 1992, 2006) and abstract (Bar and Neta 2006) objects and scenes, as well as explicit ratings of circles and other simple context-free curvilinear forms (Aronoff et al. 1992; Larson et al. 2007). The basis for the preference for curved or rounded contours is robustly demonstrated by a long line of research demonstrating preference for a babyface (Sternglanz et al. 1977; Zebrowitz 1997), and that more juvenile facial features increase bonding and attachment (Hildebrandt and Fitzgerald 1983). Numerous of the identified characteristics of a babyface, a seemingly oversized protruding head, a round face, large round eyes, and large pupils (Hildebrandt and Fitzgerald 1979; Lorenz 1943; Sternglanz et al. 1977; Zebrowitz and Montepare 1992), contain curvilinear or rounded components. Even among infants, babies with more pronounced roundness of facial features tend to be preferred by adults (Hildebrandt and Fitzgerald 1979). Consistent with the configural hypothesis of emotion presented here, adults possessing a babyface are perceived as being more warm, honest, and kind (Berry and McArthur 1985; Zebrowitz and Montepare 1992). Overall, babyish features tend to be preferred, viewed as pleasant, and elicit caregiving (Lorenz 1943; Zebrowitz 1997). Notably, such simple perceptual features may affect behavior. For example, cuteness has been shown to increase carefulness (Sherman et al. 2009).

On a broader theoretical note, we have hypothesized that evolution has helped shape the association between these shapes and specific affects; however, this is clearly difficult to test. Our emphasis on evolution stems from observations that these simple shapes are embedded in stimuli that were clearly relevant to survival in our evolutionary past, such as fangs and the flared hood of a cobra. Furthermore, as demonstrated by the studies of the silver fox (vulpes vulpes) reducing the threat potential of a species through domestication has been shown to result in morphological changes as would be expected based on the configural hypothesis (Trut 2005). One of the hallmark changes resulting from successive generations of domestication of the silver fox has been a distinct change in their physical and morphological features, such that their skulls are broader and less angular, their noses shorter and less pointed, their pointed ears now flop and their tails are curved rather than straight. Despite this consistent evidence, there are also examples that may indicate that the association between threat and the V shape is learned, such as the arrowhead. Thus, it is fair to speculate that both evolutionary and culturally learned factors influence the affective connotations of these shapes.

Synthesizing these various lines of research suggests that the underlying geometry of salient contextual cues may signal a variety of emotions, including threat, pleasantness or happiness, and affiliation. Furthermore, our data suggest that the emotional value of this geometry is maintained even after removal of the contextual information. The present work bolsters previous explicit ratings data and indicates that the affective connotations of these shapes are recruited even through indirect assessment. In sum, these relatively primitive signals, and the perceptual mechanisms facilitating their detection, are posited to have been honed over the course of evolution to facilitate efficient recognition of stimuli that affect our well-being for better or worse.

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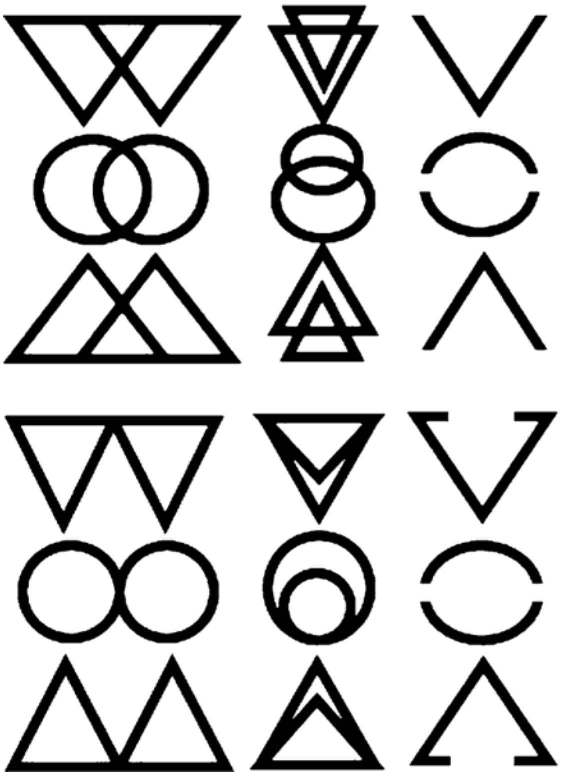


Fig. 1.

Shapes presented in Experiments 1a and 1b. Experiment 1a used the *downward*-pointing *triangles* and *circles*. Experiment 1b included *downward*- and *upward*-pointing *triangles*. This figure depicts the six matched sets of stimuli. Please note that the stimuli are not to scale as the size has been modified for display purposes

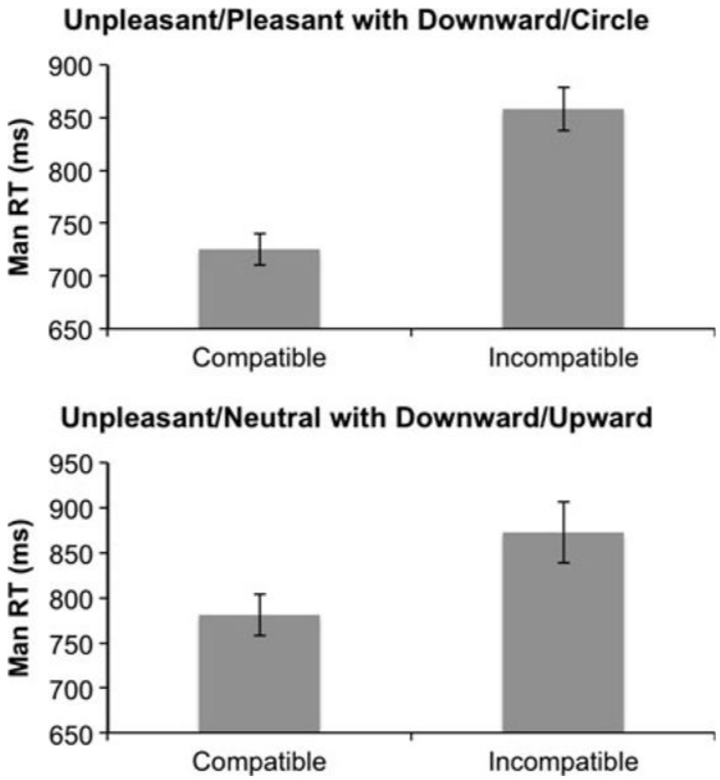


Fig. 2.

Mean RT for compatible and incompatible blocks for Experiment 1a (*top panel*) and Experiment 1b (*bottom panel*). For Experiment 1a compatible trials included unpleasant/downward and pleasant/circle, and incompatible trials paired unpleasant/circle and pleasant/downward. For Experiment 1b the compatible trials paired unpleasant/downward and neutral/upward and the incompatible trials paired unpleasant/upward and neutral/downward. *Error bars* represent standard error. Please not that the scale for the *y*-axes is different for the two graphs

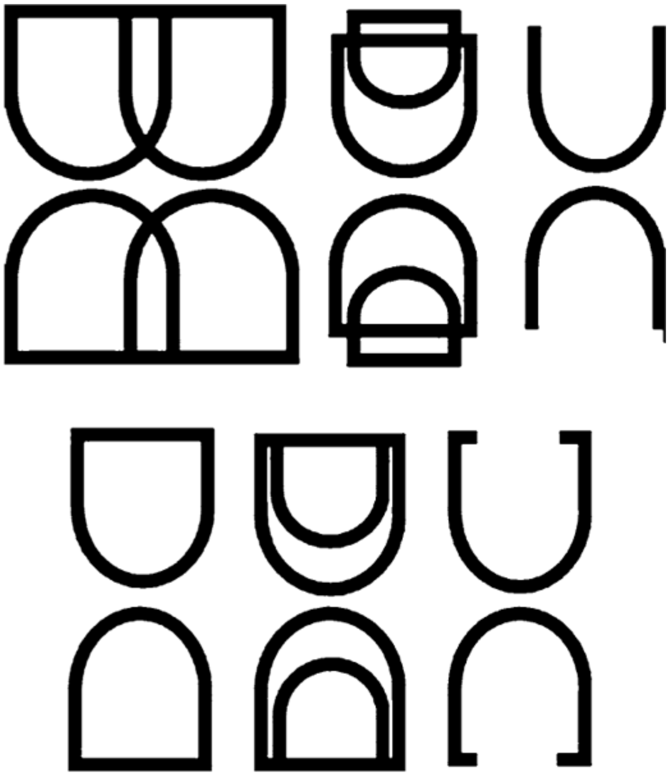
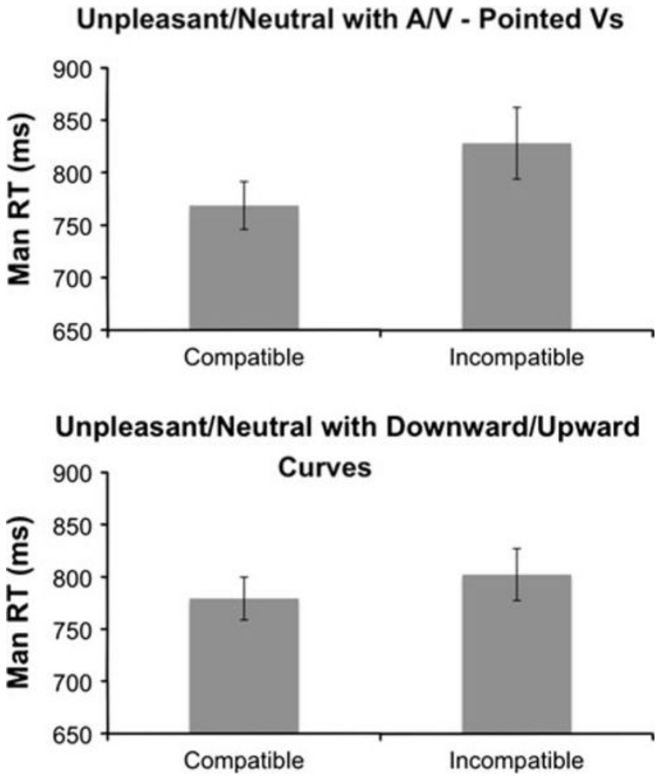


Fig. 3.

Shapes presented in Experiment 3. Shape stimuli were identical to those presented in Experiment 1b, but contained curves rather than pointed V shapes. Please note that the stimuli are not to scale as the size has been modified for display purposes



Unpleasant/Neutral with A/V - Pointed Vs

Unpleasant/Neutral with Downward/Upward Curves

Fig. 4.

Mean RT for compatible and incompatible blocks for Experiment 2a (*top panel*) and Experiment 2b (*bottom panel*). For Experiment 2a the compatible trials paired unpleasant/V and neutral/A and the incompatible trials paired unpleasant/A and neutral/V. For Experiment 2b, compatible trials paired unpleasant/downward and neutral/upward and the incompatible trials paired unpleasant/upward and neutral/downward. *Error bars* represent standard error