PERCEPTUAL CONFORMITY IN FACIAL EMOTION PROCESSING

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The ability to recognize and respond quickly to visual signals of threat is critical for survival. Threatening faces are hypothesized to capture visual attention more rapidly than nonthreatening faces. This experiment tested the perceptual conformity hypothesis, which predicts that attention differences elicited by threatening vs. nonthreatening faces depend on whether the inner facial features follow the curvature of the outer facial surround.

In a pre-experimental study, 38 participants rated the affect of stimuli with and without a facial surround. These ratings determined the stimuli for an experimental flankers task, which was completed by 35 different participants. Flanker displays included compatible and incompatible trials, in which flanker stimuli, if responded to, would or would not have the same response as the centrally-located targets.

The flankers experiment examined a) whether emotionally neutral surround-present and surround-absent stimuli, containing conforming and nonconforming inner lines, generated the flanker-effect asymmetries that have been reported for angry vs. happy faces; and b) whether incompatible flankers with nonconforming inner lines would generate more response interference than those with conforming inner lines, in both surround conditions.

No flanker-effect asymmetry or difference in response interference was obtained for either surround condition. For surround-present trials, reaction times were significantly faster to

targets with conforming inner lines than to those with nonconforming inner lines, and to compatible as opposed to incompatible trials. For surround-absent trials, participants responded faster to compatible trials, and there were no reaction time differences between targets with conforming and nonconforming inner lines.

The results are not consistent with the perceptual conformity hypothesis. One potential reason is that perceptual conformity may not account for the reported attention distribution differences to threatening vs. nonthreatening faces. Some other perceptual feature may explain previously documented flanker-effect asymmetries, or facial affect may override perceptual contributions to these asymmetries. Such interpretations are clouded, however, by the inconclusive and potentially confounded extant literature and the scant evidence for the flanker-effect asymmetry based on facial threat. Assuming the validity of the reported attention differences, future research is needed to elucidate the attributes that consistently elicit such differences for targets that convey specific categories of emotion.

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PREFACE

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1.0 INTRODUCTION

Substantial data suggest that people distribute visual attention differently to faces displaying different emotions. Faces exhibiting signals of threat, for example, are thought to capture visual attention more rapidly than are nonthreatening faces, although investigators offer competing hypotheses to explain differences of this sort. According to one account in the adult facial emotion literature, *facial affect* is responsible for the noted attentional differences. However, an alternative account purports that *perceptual differences* cause attentional deployment differences between threatening and nonthreatening faces.

The facial affect claim has dominated the literature, but increasing evidence consistent with the perceptual differences hypothesis challenges the privileged role of facial affect in the deployment of attention to threat-related stimuli. The quest is ongoing to identify the types of perceptual information that might yield the reported differences in selective visual attention to threatening vs. nonthreatening faces. Some proponents of the perceptual differences account argue that differences in attentional distribution between threatening and nonthreatening faces are based on *perceptual conformity*, or whether the inner facial features conform to the surround of the face (e.g., an upturned mouth follows the contour of the chin). According to this hypothesis, attention is more likely to be distributed to faces with nonconforming inner facial features, such as those in angry faces, than to inner features that conform to the facial surround, such as those in happy faces. A related prediction is that visual attention should be distributed similarly to threatening and nonthreatening faces without a surround. Efforts to explore the role of *perceptual conformity* in the deployment of visual attention have yielded mixed results. Therefore, it is not clear whether the conformity between the inner features and the outer surround can explain the extant data.

The overarching goal of the current investigation was to examine key variables that may influence attentional distribution to facial expressions of emotion. Specifically, the current investigation tested the perceptual differences hypothesis as a potential foundation for explaining the documented differences in the deployment of visual attention to nonthreatening and threatening faces. The text below first provides background information about facial threat and how it is categorized in the facial emotion literature. The next section provides fundamental background information about tasks used in examining attention differences between different categories of facial emotions. Following that section is a review of the evidence consistent with the hypothesis that facial affect influences attentional distribution to emotional faces. After outlining the challenges to the facial affect claim, the text discusses the perceptual differences hypothesis and the role of perceptual conformity in attending to emotional faces. A brief consideration of the literature on face processing in infants provides a broader context within which to consider the findings in the adult facial emotion literature, particularly because the infant literature offers a potential theoretical middle ground from which to address the facial affect and perceptual differences hypotheses. A summary and discussion of the literature leads to the specific aims, research questions, and methods.

2.0 FACIAL EXPRESSIONS OF EMOTION

Facial stimuli have been used frequently to examine the relationship between visual attention and emotion because they are biologically and socially significant, emotional in nature, and have a pivotal role in nonverbal communicative exchanges. Therefore, it is no surprise that a host of investigations have been dedicated to understanding the variables that guide the deployment of attention to different categories of emotional faces (See D. V. Becker, Anderson, Mortensen, Neufeld, & Neel, 2011; Frischen, Eastwood, & Smilek, 2008 for reviews). The current document specifically focuses on reported attentional deployment differences to threatening and nonthreatening faces. Before reviewing the evidence, however, it is critical to supply background information related to facial threat. Explanations are provided below about the categorization of threat in the facial emotion literature and how threat is defined in the context of the current investigation. Following these explanations are descriptions of how threat is depicted in human and schematic facial stimuli.

2.1 CATEGORIZATION OF FACIAL THREAT

The facial affect account of attention distribution hinges on the categorization of facial emotions as threatening or nonthreatening. Faces depicting threat, however, are also categorized as having a negative affective valence (Öhman, Lundqvist, & Esteves, 2001). Therefore, the terms threatening and negative are often interchanged in the literature. In the experimental setting, human and schematic facial depictions of anger are used to represent threat. According to Ekman & Friesen (1975), threatening faces are characterized by furrowed brows and eyes staring directly at vs. away from the observer. Some human angry faces display a closed mouth and lowered mouth corners. Schematic drawings of angry faces contain eyebrows that together create the percept of a “v,” coupled with a downward turned mouth. Data suggest that “v” shaped eyebrows are the most critical feature for categorizing schematic faces as threatening vs. nonthreatening (Lundqvist, Esteves, & Öhman, 1999; Lundqvist & Öhman, 2005). As such, “v” shaped eyebrows are a staple in angry schematic facial stimuli. Nonthreatening faces primarily are those displaying happiness or sadness. Faces thought to show no emotion, also referred to as neutral, are also categorized as nonthreatening (e.g., Hansen & Hansen, 1988).

The various categorizations of threatening and nonthreatening faces have resulted in several terminological differences in studies that compare attention distribution between these categories. Unless referring to specific investigations, the current document uses the term ‘threatening’ to refer specifically to angry faces. The term ‘nonthreatening’ will be paired with the specific emotion in question (e.g., happy, sad), or lack thereof in the case of neutral faces, throughout the remainder of the document (i.e., nonthreatening happy, nonthreatening sad, or neutral). The document now turns to one hypothesis posited to explain the reported differences in the distribution of attention to emotional facial stimuli.

3.0 FACIAL AFFECT INFLUENCES SELECTIVE VISUAL ATTENTION

3.1 THE FACIAL AFFECT CLAIM

Empirical data suggest that visual attention is drawn differently to some categories of facial emotion (e.g., Eastwood, Smilek, & Merikle, 2001; Feldmann-Wüstefeld, Schmidt-Daffy, & Schubo, 2011; Fox & Damjanovic, 2006; Fox et al., 2000; Hansen & Hansen, 1988; Lundqvist & Öhman, 2005; Öhman et al., 2001; Weymar, Low, Öhman, & Hamm, 2011). A dominant hypothesis is that *facial affect* differentially guides visual attention to threatening and nonthreatening facial emotions. Specifically, threat-related faces are hypothesized to influence visual attention more than nonthreatening faces (Eastwood et al., 2001; Fox et al., 2000; Hansen & Hansen, 1988; Vuilleumier & Schwartz, 2001). Empirical support for this claim primarily originates from visual search studies (e.g., Eastwood et al., 2001; Feldmann-Wüstefeld et al., 2011; Fox & Damjanovic, 2006; Fox et al., 2000; Gilboa-Schechtman, Foa, & Amir, 1999; Hansen & Hansen, 1988; Lundqvist & Öhman, 2005; Nothdurft, 1993; Öhman et al., 2001; Weymar et al., 2011). Although other tasks have been used to test the facial affect hypothesis, such as the dot probe task (e.g., Fox, Russo, & Dutton, 2002; Jovev et al., 2012; Mogg & Bradley, 1999; Mogg, Millar, & Bradley, 2000), this text reviews investigations that specifically used visual search and flankers tasks. The flankers task is emphasized because it has also been used to investigate attentional deployment differences between threatening and nonthreatening faces and is the method used in the current investigation. We now turn to an explanation of how data from these tasks relate to visual attention distribution.

3.1.1 The visual search task

In a standard visual search task using facial stimuli, participants search for the presence of a target face (e.g., angry face) among affectively discrepant distracter faces (e.g., happy, sad, neutral faces). Trials vary regarding whether a target is present or absent. Participants make one response during target present trials and a different response to indicate the absence of the target. Search slope efficiencies enable inferences about the attention mechanisms used during the search process. Slope efficiency is measured using a function that reflects the relationship between the number of distracters and the target detection time (Wolfe, Cave, & Franzel, 1989).

Searches are considered efficient if variations in the number of distracters, also called the set size, have relatively little or no effect on response times (RT) to locate facial targets. Efficient searches yield shallow or even flat slopes when RT is plotted against set size (Wolfe et al., 1989) Inefficient searches for affectively discrepant targets are evidenced by increases in RT as set size increases. Slopes for inefficient searches appear linear and steep and represent an estimate of the cost in detection times for increasing numbers of distracters (Wolfe et al., 1989).

3.1.2 Target detection times and attention distribution in visual search

Attention mechanisms in visual search tasks are inferred based on target detection times during the visual search process. It is assumed that visual search is guided by the properties of a stimulus that are detected earliest by the visual system (Cave & Batty, 2006). Therefore, detection times are presumed to provide insight into visual attention deployment and the variables that guide visual attention. One way in which target detection time and attention distribution are linked relates to parallel vs. serial visual processing (e.g., Treisman & Gelade, 1980).

Theoretically, efficient visual searches are suggested to indicate preattentive processing of stimuli in a parallel manner, in which both facial targets and distracters are simultaneously perceived (Wolfe et al., 1989). Detection times in parallel searches are faster than in serial searches. Faster detection of threatening vs. nonthreatening targets, specifically, has been interpreted by some as evidence that facial threat is perceived early and that attention is deployed rapidly because threatening faces “pop out” (Treisman & Gelade, 1980; although see Öhman et al., 2001). This effect is sometimes termed the “face-in-the-crowd” effect (e.g., Hansen & Hansen, 1988; Öhman et al., 2001; Pinkham, Griffin, Baron, Sasson, & Gur, 2010).

Visual attention is also suggested to be deployed serially, or across each stimulus until the presence or absence of a target is determined (e.g., D. V. Becker et al., 2011; Horstmann & Bauland, 2006; Treisman & Gelade, 1980). The link between target detection times and attention distribution in this sense is that the focus of attention is thought to shift from one stimulus to the next in the visual field. Mean RTs for detecting targets during serial searches, therefore, would increase as set size increases (Chen, Liao, & Yeh, 2011). This contrasts with parallel searches in which set size minimally affects detection times.

Another way in which target detection time in visual search is related to visual attention distribution involves stimulus similarity, including both the similarity between the target and the distracters and the similarity among the distracters (Guest & Lamberts, 2011; Horstmann, Becker, Bergmann, & Burghaus, 2010). Highly similar targets and distracters take longer to detect, reducing the likelihood that visual attention is distributed early to the target (Guest & Lamberts, 2011). In contrast, perceptually distinct targets are easier to distinguish from distracters, and as such, may guide attention to the targets faster. The investigations reviewed in this document have homogenous distracters so this aspect of similarity will not be addressed further.

3.1.3 The flankers task

Visual attention distribution between facial emotion categories has also been investigated with a response competition paradigm, known as the flankers task (Eriksen & Eriksen, 1974). In the flankers task, participants focus their attention on a centrally positioned target while ignoring stimuli (flankers) that are located on the right and left sides of the target. Participants are instructed to respond as quickly and as accurately as possible to indicate whether the facial affect of the target is positive or negative. This task measures *response interference* between the target and flankers, defined as the deterioration of performance "…when a dominant response has to be suppressed in order to give the alternate (instructed) response, relative to the condition in which the dominant response and the activated response are the same" (Stins, Tinca Polderman, Boomsma, & de Geus, 2007, p. 389). Response interference is measured by computing RT differences between response-compatible conditions (e.g., positive facial targets and flankers) and response-incompatible conditions (i.e., positive facial target with negative flankers; negative facial target with positive flankers). Participants are typically faster when targets and flankers are compatible, or share the same characteristics (e.g., affective valence), than when the target and flankers are incompatible (e.g., Fenske & Eastwood, 2003). This pattern of results is termed the *flanker compatibility effect* (Fenske & Eastwood, 2003; Horstmann, Borgstedt, & Heumann, 2006).

Flanker compatibility effects also enable investigators to determine whether a *flanker-effect asymmetry* exists between incompatible responses. A flanker-effect asymmetry for emotional faces is evidenced by RT differences when the facial affect of the target and flankers is switched. For example, data consistent with the facial affect account suggest stronger flanker effects for nonthreatening, positive target faces flanked by negative/threatening faces than vice versa (e.g., Horstmann et al., 2006). That is, responses to nonthreatening target faces are influenced more by negative/threatening flankers than responses to threatening targets with nonthreatening flankers (Fenske & Eastwood, 2003). Investigators argue that the difference in RTs between compatible and incompatible conditions suggest that the flankers were not ignored in the incompatible condition (Horstmann et al., 2006).

3.1.4 The flankers task and attention distribution

The flanker effect has been used to draw inferences about selective attention mechanisms. For example, the presence of a flanker compatibility effect is argued to show limitations in the visual system's ability to focus attention (Diedrichsen, Ivry, Cohen, & Danziger, 2000). Another way in which flanker effects are linked to attention distribution relates to the broadening and narrowing of attentional focus (Fenske & Eastwood, 2003). Fenske and Eastwood argue that negative and positive stimuli narrow and broaden the scope of attention, respectively. A narrowing of attention on the target is evidenced by smaller flanker compatibility effects with negative vs. positive targets. In contrast, larger compatibility effects are posited to represent a broadening of attention, in which attention spreads into the periphery.

Attentional capture is yet another way in which flanker effects are linked to attention distribution. Attentional capture refers to "…the involuntary spatial dislocation of attention from its current focus, toward a different spatial location, where the attention-capturing object is located" (Horstmann et al., 2006). While this definition relates specifically to involuntary, bottom-up, stimulus-driven shifts of attention capture, attention can also be distributed based on top-down cognitive processes, such as a set of goals and beliefs (e.g., Pashler, Johnston, & Ruthruff, 2001).

Flanker effects allow investigators to make inferences about the stimulus characteristics in the presumably ignored flanker stimuli that are hypothesized to attract attention (Horstmann et al., 2006). Reported differences in attention distribution between threatening and nonthreatening faces, for example, have often been interpreted in this vein, with claims that threatening flankers orient attention away from nonthreatening targets (Horstmann et al., 2006). Whether facial affect is a source of attentional capture differences between emotion categories remains debatable. Data from the visual search task, for example, suggest that threatening faces guide more efficient searches but that they do not capture attention (Eastwood et al., 2001; Fox et al., 2000; Nothdurft, 1993). Evidence from the flankers task, however, is still in its infancy. As will be discussed later, other explanations have been offered to explain reports of attention distribution differences between threatening and nonthreatening faces. These other explanations may provide more insight into the link between this task and attention distribution.

3.1.5 Summary

One purpose of this section was to briefly introduce the reader to the facial affect claim, which predicts that *facial affect* draws visual attention and is the driving force behind the reported differences in attention distribution between threatening and nonthreatening faces. Secondly, the text described the visual search and flankers tasks and how their measures are presumed to link to visual attention distribution. The next section reviews the evidence consistent with the facial affect claim.

3.2 EVIDENCE CONSISTENT WITH THE FACIAL AFFECT ACCOUNT

3.2.1 Visual search evidence

Numerous visual search studies report that negative (vs. positive) target faces are detected more rapidly amongst neutral and affectively discrepant faces (Calvo, Avero, & Lundqvist, 2006; Eastwood et al., 2001; Fox et al., 2000; Juth, Lundqvist, Karlsson, & Öhman 2005; Lundqvist & Öhman, 2005; Mather & Knight, 2006; Öhman et al., 2001; Pinkham et al., 2010; Smilek, Frischen, Reynolds, Gerritsen, & Eastwood, 2007; Tipples, Atkinson, & Young, 2002). According to the facial affect account, the underlying facial affect is the factor responsible for differential attention distribution between these categories of emotion. In visual search tasks, search asymmetries are frequently reported between threatening and nonthreatening faces (e.g., Horstmann & Bauland, 2006; Horstmann et al., 2010). Search asymmetry refers to a change in search efficiency when targets and distracters change positions (Treisman & Gormican, 1988; Treisman & Souther, 1985).

Reports of faster detection times, specifically to threatening *angry* faces amongst neutral or happy distracter faces, have been coined the "anger-superiority effect" (ASE) (e.g., Horstmann & Bauland, 2006; Purcell & Stewart, 2010). D.V. Becker and colleagues (2011) noted both a strong and a weak version of the ASE. The strong version claims that angry faces are identified at the same rate despite the number of distracter faces in the crowd while the weaker version predicts faster detection of angry compared to happy faces. In general, the ASE has been used as evidence to substantiate the facial affect account of attentional distribution between threatening and nonthreatening faces (e.g., Feldmann-Wüstefeld et al., 2011; Horstmann & Bauland, 2006; Horstmann et al., 2010; Öhman et al., 2001). Hansen and Hansen (1988) reported an ASE in their seminal visual search investigation. They found that participants detected pictures of human angry faces amongst happy distracters more quickly and accurately than happy faces amongst angry distracters. The investigators interpreted these results as indicating that threatening faces do "pop out" of a nonthreatening crowd as argued by others (e.g., Treisman & Gelade, 1980; Treisman & Souther, 1985).

However, Hansen and Hansen's findings were later criticized by Purcell, Stewart, and Skov (1996), who noted perceptual confounds in the stimuli. After Purcell and colleagues (1996) controlled these confounds, the search efficiency for angry faces disappeared, weakening the validity of Hansen and Hansen's findings and raising concern about whether affect *per se* was the factor behind the reported differences in attention distribution. Despite the noted confounds in Hansen and Hansen's investigation (1988), others have found detection advantages with threatening vs. nonthreatening faces using photographs of real humans (e.g., Fox & Damjanovic, 2006; Horstmann & Bauland, 2006).

Since the critical confound surfaced in Hansen and Hansen's study (1988), the overwhelming majority of investigators began to control for potential perceptual confounds noted in photographs of human faces by using drawings of schematic or cartoon-like faces as stimuli (e.g., Calvo et al., 2006; Eastwood et al., 2001; Fox et al., 2000; Hahn, Carlson, Singer,

& Gronlund, 2006; Horstmann, 2007; Horstmann & Bauland, 2006; Horstmann et al., 2006; Juth et al., 2005; Lundqvist & Öhman, 2005; Öhman et al., 2001; Schübo, Gendolla, Meinecke, & Abele, 2006; Tipples et al., 2002). Like the findings reported for human images, some data for schematic drawings show faster detection times to threatening vs. nonthreatening faces (e.g., Feldmann-Wüstefeld et al., 2011; Hahn et al., 2006; Horstmann & Bauland, 2006; Horstmann et al., 2010; Öhman et al., 2001). However, the validity of these data has been a source of debate.

For example, Öhman and colleagues (2001) reported that participants detected schematic angry vs. happy target faces faster despite changes in set size and using neutral and emotional distracters. To determine whether the search advantage for angry faces was caused by the underlying affect, participants viewed inverted faces. Face inversion holds constant the low level properties of a face, such as the luminance, contrast, and spatial frequency, and is presumed to disrupt the configuration and the perception of facial emotion (Farah, Tanaka, & Drain, 1995). In this case, if the reported differences in attentional deployment to angry vs. happy faces were purely based on facial affect the search advantage noted for angry faces would be minimized or eliminated. However, similar detection times would be expected for upright and inverted faces if perceptual differences guide attention.

Surprisingly, attention was distributed similarly for angry faces in the upright and inverted conditions. Öhman et al.'s (2001) interpretation of this finding was that the distribution of attention to the emotion in angry faces was so strong that the effects were also noted for inverted stimuli. Theoretically, this interpretation is not compelling, particularly because it is not yet clear of the source of the inversion effect (Tanaka & Gordon, 2011) or how face inversion influences the processing of facial affect (Horstmann et al., 2010) and because facial inversion data are inconsistent (Mak-Fan, Thompson, & Green, 2011). For example, other data conflict with

Öhman et al. (2001), in finding that the search efficiency for threatening faces was not maintained after inversion (e.g., Eastwood et al., 2001).

Still, others have also questioned the findings and interpretations of Öhman and colleagues' (2001) investigation, arguing that increases in set size produced minimal search efficiency differences between angry and happy targets (D. V. Becker et al., 2011). Furthermore, Horstmann and Bauland (2006) concluded that the searches for angry faces in Öhman et al.'s investigation were inefficient and that only the error data demonstrated search efficiencies for angry target faces. Despite the concerns with Öhman and colleagues' investigation, other studies report faster detections of threatening vs. nonthreatening faces (e.g., Fox et al., 2000; Hahn & Gronlund, 2007).

3.2.2 Flankers task evidence

The facial affect hypothesis has also been investigated using the flankers task. For example, Fenske and Eastwood (2003) used a flankers task in one of the first investigations to examine the hypothesis that facial affect guides the focus of attention. Specifically, they tested the hypothesis that negative faces narrow the focus of attention, subsequently reducing the impact of information from the periphery. The investigators conducted a series of 3 experiments. Two experiments are presented in this section (Experiments 1A and 2) and another experiment (Experiment 1B), which assessed a competing hypothesis, is described later in the text. In Fenske and Eastwood's first experiment (1A), participants viewed positive and negative schematic faces in four conditions: compatible (positive targets/positive flankers; negative target/negative flankers), incompatible affect (positive targets/negative flankers; negative targets/positive flankers), incompatible neutral (positive or negative target/neutral flankers), and no-flanker (only positive or negative target). The no-flanker condition served as a baseline with which to compare the incompatible conditions. Stimuli consisted of a white circle to represent the facial outline, two white dots for eyes, and a white upwards or downwards semi-circular mouth to represent positive and negative affect, respectively (See Figure 1). Neutral flankers had a straight line in the mouth position. The 40 participants were told that they would see either a row of three images or a single image. The task was to identify, as quickly and accurately as possible, the affect of the center image while ignoring the flankers. After viewing a fixation cross, participants responded by pressing one of two computer keys.

Figure 1. Example stimulus used in Experiment 1A (Fenske & Eastwood, 2003)

There were three findings consistent with the hypothesis that facial affect draws visual attention. First, for positive targets, participants responded more quickly in the compatible affect condition than in the other conditions. This finding substantiates previous data showing faster RTs to congruent rather than incongruent conditions. Secondly, the processing of negative targets was not affected by flanker type. Flanker compatibility effect scores were calculated for each participant by subtracting the mean performance level in the compatible condition from the mean performance levels in the incompatible-neutral and incompatible-affect conditions. Reflecting the differences in processing negative and positive targets, the third major result showed that the magnitude of the flanker compatibility effects for negative facial targets was smaller than that for positive facial targets. In general, these results suggested that responses to negative faces were less influenced by peripheral information. However, one qualification of the data is warranted, in relation to the primary measure of interest.

Fenske and Eastwood (2003) were particularly interested in the differences in RTs to positive and negative targets in the incompatible-*neutral* condition. They argued that by using neutral flankers for both positive and negative facial targets, any differences in compatibility effects could be accounted for by facial affect rather than differences in the incompatible flankers. By definition, however, the flanker effect is based on the differences in RTs between response-compatible and response-incompatible conditions. It could be argued that pairing the neutral flankers with positive or negative facial targets created an incompatible response condition; however, it is presumed by the research community in general that flankers without an assigned response, such as the neutral flankers, do not produce any response competition (Horstmann et al., 2006). In any case, while the incompatible-*neutral* conditions do not provide a true measure of the flanker effect, a counterargument is that they serve as critical control conditions for potential confounds. Although Fenske and Eastwood favor the facial affect account to explain their data, there are other plausible explanations of the data. For example, the results could be explained by a perceptual differences account, which will be addressed later in the text.

Experiment 2 tested an alternate explanation of the findings in Experiment 1A, that the results could be explained by a *broadening* of attention to *positive* faces. Fenske and Eastwood (2003) argue that a broadening of attention would result in a greater influence of peripheral information. Specifically, a broadening of attention was proposed to explain the findings in Experiment 1A, which showed that positive targets were more influenced by negative faces in the periphery than negative targets were influenced by peripheral positive faces. In the second experiment, Fenske and Eastwood also aimed to replicate the findings from Experiment 1A with a different group of participants. Participants (n = 48) viewed the stimuli from Experiment 1A with the addition of neutral faces serving as targets. Experiment 2 did not include the no-flanker condition.

Fenske and Eastwood (2003) noted three primary findings consistent with the hypothesis that facial affect is responsible for differences in attentional distribution between negative and positive faces. First, RTs to negative target faces were faster than to positive target faces, indicating that negative target faces were less influenced than positive target faces by peripheral information. Second, responses to negative target faces were less influenced by peripheral information compared to neutral targets. Lastly, peripheral information influenced responses to positive target faces more than to neutral target faces. As in their first experiment, the investigators concluded that negative faces are less susceptible than positive faces to information presented in the periphery. Additionally, they argued that the lesser impact of stimuli in the periphery for negative vs. positive faces, and of neutral vs. positive faces, indicates that negative faces constrict attentional focus and positive faces broaden the focus of attention. Although Fenske and Eastwood's results suggest that facial affect may play a role in guiding selective visual attention, their negative stimuli appear to be "sad," and as such limit the comparisons to results obtained with *threat*-related facial stimuli. This review now turns to a study in which angry faces were used.

Like Fenske and Eastwood (2003), Horstmann and colleagues (Experiments 1 and 2; 2006) examined facial affect as an explanation for differences in attentional distribution between threatening and nonthreatening faces. The aim of Experiment 1 was to replicate and extend findings of an attentional advantage for threatening faces using stimuli presumed to be more "complex" (Figure 3) than those in prior investigations (Figure 2). The investigators argue that the schematic faces used in some previous studies were flawed because the downwards pointing semi-circle used to represent a negative mouth and the "v" shaped lines used to represent eyebrows did not provide an accurate representation of the prototypical angry face described by Ekman (Ekman, 1972).

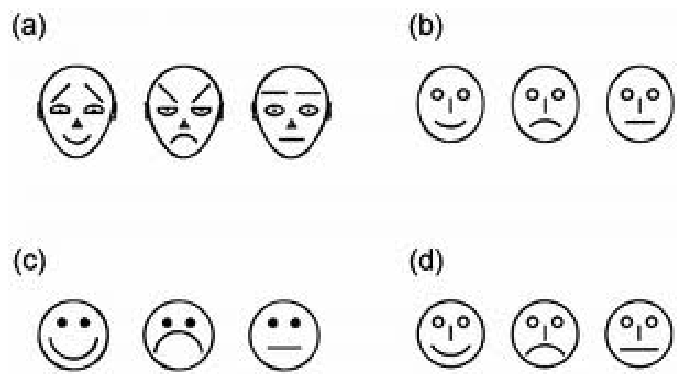


Figure 2. Examples of schematic drawings of facial stimuli used in (a) Öhman et al., 2001, (b) Fox et al., 2000, (c) Eastwood et al., 2001; Fenske & Eastwood, 2003, and (d) White, 1995. Reproduced from Horstmann et al., (2006)

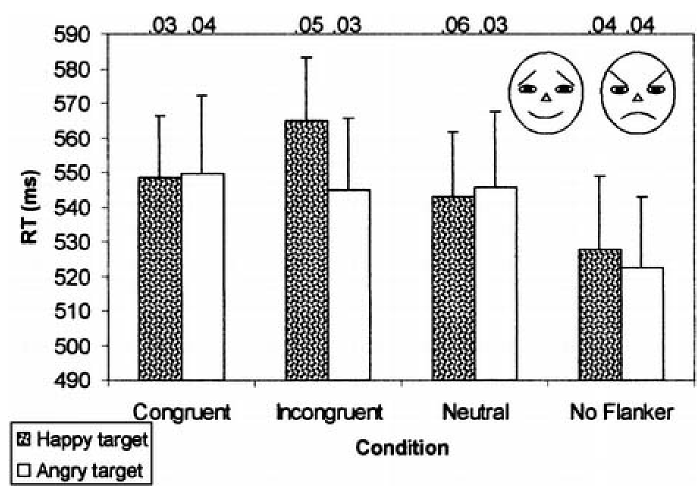


Figure 3. Example of "complex" facial stimuli and results from Experiment 1 (Horstmann et al., 2006)

Participants (n = 12) performed a flankers task in which there were four experimental conditions: congruent (happy targets/happy flankers, angry targets/angry flankers); incongruent (happy target/angry flankers, angry target/happy flankers); neutral (happy or angry target/neutral flankers); and no flanker (only happy or angry target). The target faces were explicitly described to participants as happy, angry, or neutral. Participants were instructed to respond as quickly and accurately as possible by pressing one computer key to indicate a happy target and another key to indicate an angry target while ignoring a pair of flanking faces.

No RT differences occurred between responses to angry targets in the congruent and incongruent conditions. However, participants responded significantly slower to happy targets flanked by angry faces than to happy targets flanked by happy faces. This latter finding corroborates the previously documented flanker-effect asymmetry for angry faces, and in more general terms, 'negative' faces. An analysis of the neutral conditions revealed no significant RT differences when participants responded to angry vs. happy targets flanked by neutral faces. This finding differs from Fenske and Eastwood's (2003) results, in which participants responded faster to positive than to negative targets flanked by neutral faces. Horstmann and colleagues (2006) also did not find RT differences when participants responded to happy and angry targets in the no-flanker condition. Although Fenske and Eastwood also presented their participants with a no-flanker condition, their results are difficult to compare to the results of Horstmann and colleagues (2006) due to differences in facial stimuli and statistical analyses.

Horstmann and associates (2006) argued that their findings of a flanker effect with happy targets and angry flankers provide evidence for the hypothesis that angry faces guide visual attention. That is, angry faces were posited to draw attention away from a happy face no matter whether they served as targets or flankers in the incongruent condition. To explore this finding further, the investigators sought to determine if the same effects would be found after eliminating all but one discriminating facial feature in their schematic faces. This became the focus of their second experiment.

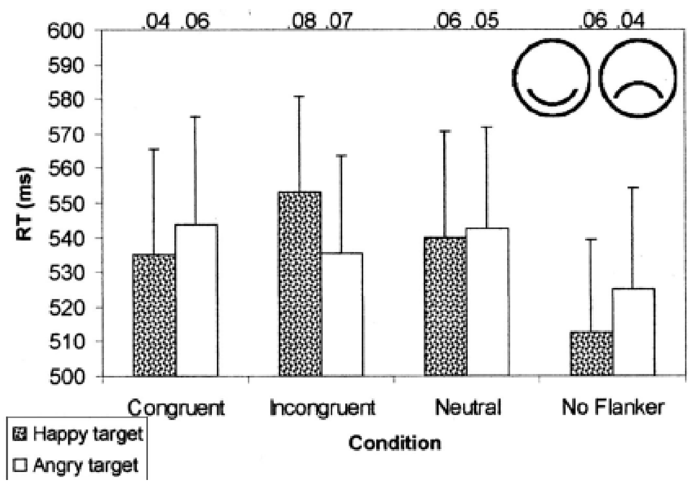


Figure 4. Example of "reduced" facial stimuli and results from Experiment 2 (Horstmann, et al., 2006)

Experiment 2 (n = 12) used the same procedures as the previous experiment. The stimuli differed from those in Experiment 1 in several ways. For example, the stimuli were created with a circle to indicate the outline of a face and a single line in the mouth position, either curved upwards to indicate happiness, curved downwards indicate anger, or displayed horizontally to indicate a neutral expression (Figure 4). Participants responded more accurately to congruent versus incongruent conditions as anticipated. Importantly, for RTs, a significant interaction was noted between target face and congruency. Specifically, there was a significant flanker effect for happy target faces but not for angry target faces. This suggests that happy (or positive) flankers had no influence on participants' responses to angry target faces. The authors interpreted these findings as evidence that flanker effects are strong enough to extend to schematic faces with an outer surround and a single curved line to indicate an emotion.

In general, there are four additional primary areas of concern with this investigation. First, the small sample sizes in both experiments (n =12) may weaken the statistical power of the study. One might counter by arguing that despite the low sample size, the findings from Horstmann and colleagues' (2006) experiments replicate and extend previous findings from investigations using different methods. Specifically, the investigators found a flanker-effect asymmetry consistent with the claim that facial affect guides the distribution of attention to negative vs. positive faces (Experiments 1 and 2). However, the lack of RT differences between happy and angry faces in the neutral condition in Experiment 2 may not have been detectable due to the small sample size.

A second critique involves the instructions given to participants. That is, the experimenters imposed their categorization of the facial affect without a validation process. In Experiments 1 and 2, participants were told that the stimuli with upwards turned mouths represented happiness, downwards turned mouths represented anger, and the straight horizontal line in the mouth area represented a neutral expression. Participants may have identified the facial affect, or lack thereof in the case of neutral faces, differently from the labels provided by the investigators. This concern is primarily emphasized for the neutral trials because data show that sometimes neutral faces are perceived as having emotion (e.g., Somerville, Kim, Johnstone, Alexander, & Whalen, 2004).

The stimuli in Experiment 2 also pose a limitation. For example, the downwards turned mouth might have been perceived as sadness rather than anger. Additionally, the curved lines used to indicate the mouth appear to be larger and more curved than those in Experiment 1. Curvature and size are two attributes that are suggested to influence visual attention (e.g., Wolfe & Horowitz, 2004), therefore it is not clear whether the differences in facial affect, curvature and size differences of the inner lines, or something else may explain the results. The short horizontal line used to indicate the neutral expression may also have been perceived differently than intended. For example, a horizontal line presented in isolation has other connotations, such as “minus” and “negative.” Because the horizontal line was positioned at the mouth level of a face, the potential of these other perceptions may have been reduced. Still, it is questionable whether the neutral stimuli were perceived as intended. A counter to this concern is that the researchers conducted a rating experiment, in which participants used a 7-point scale to rate the emotional valence of each stimulus in Experiments 1-4 (Experiments 3 & 4 are discussed in the next chapter). Although the rating experiment did not provide data on emotion recognition, it revealed two things related to the stimuli used in Experiments 1 and 2: (1) happy faces were rated as more positive than neutral and angry faces and (2) angry faces were rated as more negative than positive and neutral faces.

Lastly, the reported differences in attentional distribution in Experiment 2 could be the result of attention being distributed differently to the incongruent contours between the facial outline and the curvature in the angry mouths. That is, the upward curved mouth in the happy faces has the same contour as the lower portion of the outline of the face (i.e. the chin area). By contrast, the downward turned mouth representing anger does not follow the contour of the lower portion of the facial outline. This concern will be discussed in more detail later in the text.

In summary, the investigations that have been reviewed thus far provide some evidence that is consistent with the hypothesis that facial *affect* guides attention distribution differently between threatening and nonthreatening faces. However, there are several challenges to the validity of the facial affect account that must be considered, to determine whether an alternative account can explain these differences.

3.3 CHALLENGES TO THE VALIDITY OF THE FACIAL AFFECT ACCOUNT

Despite the numerous investigations supporting the facial affect account, the validity of this account has been challenged repeatedly. Three categories of challenges are discussed below: those related to the evidence itself, the nature of the stimuli used to gather the evidence, and the experimental tasks.

3.3.1 The evidence

One of the most critical challenges to the validity of the facial affect account is that not all data corroborate this claim. For example, some findings show faster detection times for happy, rather than threatening faces, as evidenced with schematic faces (e.g., D. V. Becker et al., 2011; Calvo & Nummenmaa, 2008; Horstmann et al., 2010; Juth et al., 2005; Purcell et al., 1996; White, 1995; Williams, Moss, Bradshaw, & Mattingley, 2005) and pictures of human faces (Mermillod, Vermeulen, Lundqvist, & Niedenthal, 2009). Other data suggest that the supposedly efficient searches for angry faces, in particular, are not really efficient (e.g., Horstmann, 2007, 2009). Furthermore, claims that threatening faces pop out amongst other facial emotions are thought by some to be unjustified (e.g., Horstmann et al., 2010). S.I. Becker and colleagues (2011) also contend that reported search asymmetries for angry faces are not due to facial affect, but rather are due to perceptual differences between stimuli from these emotion categories (e.g., the way in which a “U” shaped mouth conforms with the chin in a happy face vs. the nonconforming upside down “U” shaped mouth in a sad face (e.g., Coelho, Cloete, & Wallis, 2010; Horstmann et al., 2010); the exposed teeth in open vs. closed mouth happy or angry faces (D. V. Becker et al., 2011)). Similar concerns have surfaced regarding flanker-effect asymmetries, in which non-emotional and non-face like stimuli (i.e., a circle and a circle with a line through it - “lollipop”) produced similar flanker-effect asymmetries as those noted with emotional faces (Horstmann et al., 2006).

3.3.2 The facial stimuli

As noted by D.V. Becker and colleagues (2011) in their review of the visual search literature, a large portion of the data showing efficient detections for negative faces has been acquired with stimuli that resemble “sad” rather than threatening faces (e.g., Eastwood et al., 2001; Horstmann, 2007, 2009; Horstmann et al., 2010; Suslow, Roestel, Ohrmann, & Arolt, 2003; White, 1995). Fenske and Eastwood (2003) and Horstmann et al.’s (Experiment 2) results, described in the flankers task section, were based on “sad” facial stimuli (Experiments 1A and 2; See Figure 1). Such stimuli contain downwards turned mouths but they do not have the “v” shaped eyebrows typically associated with anger and threat in schematic faces. As a reminder, the “v” shaped eyebrows are the most critical feature for categorizing schematic faces as threatening vs. nonthreatening (Lundqvist et al., 1999). Therefore, investigations that use “sad” facial stimuli are consistent with only a sadness superiority effect (SSE), and must be interpreted as such (D. V. Becker et al., 2011).

Another stimulus-related challenge relates to the use of schematic vs. human faces. Investigations using images of humans have not consistently shown an ASE (e.g., Juth et al., 2005). Furthermore, some studies that used images of humans contain perceptual confounds, which may have altered the results (e.g., Hansen & Hansen, 1988). For example, Hansen and Hansen's (1988) threatening faces contained dark areas that were not present in the nonthreatening stimuli as a result of transforming images from grayscale pictures to black and white. Specifically, the process unintentionally made the angry male face darker and created a black mark in the chin area of the angry female face (Purcell & Stewart, 2010). The ASE effect reported by Hansen and Hansen (1988) was not upheld when Purcell et al. (1996) removed the dark areas. Lastly, it is unknown whether findings acquired for schematic threatening faces will generalize to real-life threatening faces due to the lower ecological validity of the former.

3.3.3 The experimental tasks

3.3.3.1 Visual search

Another challenge relates to the nature of the experimental tasks. In their recent review papers, Frischen et al. (2008) and D. V. Becker et al. (2011) provided guidelines for conducting visual search studies (Table 1). These guidelines were provided for investigations testing the hypothesis that emotional faces are preattentively processed and that they guide attention during visual search. Both groups of investigators argue that studies reporting an ASE have not met many of the criteria presented below, which they deem vital for visual search tasks. As can be noted, however, even these investigators differ on some of the criteria.

Another concern regarding the visual search task relates specifically to findings of faster detection times to threatening faces amongst nonthreatening faces, than vice versa. Horstmann and colleagues (2010) argue that such findings may not reflect how efficiently the target was processed. Instead, they argue that faster detections of negative targets amongst positive faces could simply reflect a faster rejection of the positive distracter faces. Their claim is bolstered by findings showing steeper search slopes with homogeneous negative vs. positive distracter faces (Horstmann, 2007, 2009; Horstmann & Bauland, 2006), which they argue represents a positive face-distracter advantage, rather than a negative face-target advantage.

Another task-related challenge is that the majority of claims in support of the facial affect account are specific to one method, the visual search task. If facial affect drives the differences in attentional distribution between threatening and nonthreatening faces, this effect should be noted across multiple tasks if all other perceptual features are equal. The widespread use of the visual search paradigm has yielded data that have contributed significantly to the understanding of selective visual attention to facial expressions of emotion, but as previously described, the limitations associated with this task are numerous.

Table 1. Examples of suggested criteria to follow when conducting a visual search study

Visual Search Study Criteria	Frischen et al. (2008)	D.V. Becker et al. (2011)	Notes
Vary set size within subjects to calculate slopes to compare search efficiency between stimulus types	✓	✓	
Use more than two set sizes to assess the linearity of the effects	✓	✓	
Hold distracter crowds constant across all targets	✓		D.V. Becker et al. (2011) argue that distracter expressions should appear similar but have some variability to prevent participants from searching for a single distinguishing feature.
Use neutral faces as distracters in target present trials	✓		D.V. Becker et al. (2011) concerned with what constitutes a neutral distracter
Search for specific expressions rather than responding to the presence or absence of affectively discrepant stimuli	✓		D.V. Becker et al. (2011) argue that for their work this is an "unnecessary" criterion because threat relevant stimuli draw attention automatically (p. 3).
Compare slopes for target present vs. target absent trials		✓	
Rule out perceptual features as an explanation of the data		✓	
Present distracters that differ equally from each target (e.g., all targets containing the same number of features; all targets and distracter containing same number of features)		✓	Frischen et al. (2008) mention perceptual features but do not specify this as a definitive criterion of concern when designing visual search studies.

3.3.3.2 Flankers task

The flankers task holds promise for enabling investigators to infer the stimulus features at the heart of the reported attention distribution differences between threatening and nonthreatening faces. However, this task is not without its shortcomings. The first major challenge is that data and subsequent interpretations are based on two assumptions. First, investigators assume that participants' initial fixations start at the centrally located target. The second assumption is that participants adhere to instructions to ignore peripheral flankers by fixating their overt visual attention on the centrally located target throughout all the trials. Such assumptions pose experimental and theoretical concerns.

Experimentally, overt and/or covert visual attention shifts to the periphery leave open the possibility that the flankers become the new central locus of attention. An altered focus of attention could prevent a true measurement of attentional shifts away from the intended target. Thus, data derived from visual fixation locations other than the intended central target may be confounded. The theoretical implication is that the ensuing interpretations may yield invalid models of visual attention and facial emotion processing.

Another challenge facing the flankers task is the scant number of studies that have used this task to examine attention distribution differences between threatening and nonthreatening faces. The current experiments not only add to the extant flankers literature, but they aimed to provide tighter experimental control (e.g., the use of a rating scale to measure perceived affect in stimuli).

3.4 SUMMARY

Data are mixed regarding whether facial affect is responsible for reported differences in deployment of selective visual attention. In addition, a number of challenges leave open the possibility that another factor might explain the data. The next section will describe an alternative explanation of the reported differences in distributing attention to threatening and nonthreatening faces: the perceptual conformity account.

4.0 PERCEPTUAL FACTORS INFLUENCE SELECTIVE VISUAL ATTENTION

Not all data are consistent with the hypothesis that the *affect* perceived in threatening and negative faces accounts for the differences in visual attention processes to this class of stimuli. In fact, a growing number of investigations have led to an alternative explanation of the findings. That is, *perceptual differences* between facial stimuli might instead explain the preferential attention to negative and threatening faces (e.g., D. V. Becker et al., 2011; Calvo & Nummenmaa, 2008; Coelho et al., 2010; Horstmann et al., 2010; Horstmann et al., 2006; Purcell & Stewart, 2010; Purcell et al., 1996).

4.1 PERCEPTUAL FACTORS HYPOTHESIZED TO INFLUENCE SELECTIVE VISUAL ATTENTION

Several arguments have been advanced in the literature to explain the perceptual factors accounting for the differential distribution of attention to positive vs. negative emotional faces. For example, Calvo and Nummenmaa (2008) posit that the visual search differences noted between some facial expressions of emotion could be a result of the visual discriminability between the facial targets and the distracters. They argue that discriminability could determine these differences at three levels of visual processing, each with increasing perceptual complexity: the visual salience, featural, and configural levels. Accounts that focus on these three levels are hypothesized by Calvo and Nummenmaa (2008) to be complementary. According to the *visual saliency account*, only stimulus properties related to the physical saliency of the target are processed in a bottom-up fashion during early stages of visual processing. The low-level stimulus properties are devoid of meaning. Some examples of these elements include luminance, color, and orientation. The *featural account* predicts that attention is drawn differently based on individual facial elements, rather than the emotion that faces may communicate. Varied detection speeds of target faces, for example, may be a result of bottom-up processing of facial features. According to Calvo and Nummenmaa (2008), the *configural account* posits that differences in attentional distribution hinge on the spatial relationships between the features of the face. That is, the detection of some target faces may be facilitated simply because they contain facial configurations that are more visually distinct compared to other faces. However, investigators differ on what constitutes configural processing as it relates to face processing.

Maurer, Le Grand, Mondloch (2002) describe three types of configural processing, the first of which involves the perception of a face based on the *arrangement of its features* (i.e., two eyes positioned above a nose, which is located above a mouth). The second type of configural processing involves *holistic face processing*, in which the features are processed as a gestalt, or as a whole entity. The third type of configural processing reflects Calvo and Nummenmaa's (2008) definition, which involves processing based on *spatial distances among features*. On the other hand, Tanaka and Gordon (2011) make a clear distinction between the terms configural and holistic. They define *configural processing* as the detection of spatial distances between facial features and *holistic processing* as the integration of feature and configural information into a face representation. These varied definitions of configural processing are highlighted in this text because they are integral to one facet of the perceptual differences account that was the focus of the current investigation. That is, differences in attention distribution to threatening and nonthreatening faces may be attributable to *perceptual conformity* differences (Coelho et al., 2010; Horstmann et al., 2006; 2010; Purcell & Stewart, 2010). The next section explains the perceptual conformity account.

4.1.1 The Perceptual Conformity Account: Perceptual conformity influences selective attention

Proponents of the perceptual conformity account argue that attention distribution differences are driven by the relationship between the contour of the inner facial features (i.e., eye brows and curved mouth lines in schematic faces) and the outer facial contour. To elaborate, the internal features of happy faces conform to the curvature of the outer facial contour (i.e., upward turned U-shaped mouth conforms to the upward turned U-shape chin; upside down “v” eyebrows conforms to the upper facial contour), whereas in an angry face, the facial contour and internal facial features do not conform (i.e., “v” shaped eyebrows do not conform to upper facial arch; upside down U-shaped mouth does not conform to the U-shaped chin) (Coelho et al., 2010; Horstmann, 2010; Purcell & Stewart, 2010).

Horstmann et al., (2010) assert a simplicity account, contending that happy expressions have a higher degree of self-similarity than angry expressions, because the mouth curve in the former follows the contour of the facial outline. Therefore, these authors argue, happy faces are perceptually simpler than angry faces. Horstmann and colleagues maintain that distracter rejections in visual search studies may be affected by what they term “self-similarity,” or how similar the features of a face are to the facial outline itself. Specifically, the claim is that reported visual search asymmetries between threatening and nonthreatening faces may be accounted for by the degree of similarity between the mouths and the facial outlines.

Becker, Horstmann, and Remington (2011) offer a similar account, the perceptual grouping account. These investigators contend that reported search asymmetries for angry schematic faces can be explained by a facilitated grouping that occurs when happy faces serve as distracters. They argue that larger numbers of happy distracter faces can be selected and subsequently rejected in parallel while searching for the angry target. The facilitated grouping of happy distracters is a result of the perceptual properties of the search relevant feature (i.e., the mouth line direction) appearing more similar to the lower face outline than it does in angry faces. S.I. Becker and colleagues offer three reasons why happy faces are less perceptually salient and therefore easier to group as distracters. First, they have fewer “local feature contrasts” (p. 1740) (i.e. the conformity of the upward turned mouth with the lower face diminishes the feature contrasts). Second, they do not contain a feature presumed to be distinctive, like the nonconforming mouths in angry faces. Lastly, happy faces have a simpler Gestalt. These investigators extended their argument to include the lines that are used to represent eyebrows in schematic drawings. That is, the eyebrows that are in angry faces are suggested to be more perceptually distinct because they do not conform to the facial outline, compared to the eyebrows found in happy faces, which do conform.

Purcell & Stewart (2010) offer a different hypothesis related to conformity; the *feature surround hypothesis*. They claim that the distinction between happy and angry faces is magnified with increasing distance from the fovea, as visual acuity diminishes. They argue that happy faces become less distinct because the eyebrows and mouths blend with the facial contour, while the nonconforming features in angry faces are relatively more noticeable away from the fovea.

4.1.2 Summary of Perceptual Conformity Account

Overall, these views suggest that there might be various types of perceptual information that attract attention differently for threatening vs. nonthreatening faces. Researchers have initiated efforts to delineate the identity of such perceptual factors. However, much more work is needed to conclude definitively that perceptual differences explain attentional distribution patterns noted between some affective facial expressions.

4.2 EVIDENCE CONSISTENT WITH THE PERCEPTUAL CONFORMITY ACCOUNT

4.2.1 Visual search evidence

Like the facial affect account, data from visual search tasks have provided the overwhelming majority of the empirical evidence consistent with the perceptual differences hypothesis (e.g., D. V. Becker et al., 2011; Calvo & Nummenmaa, 2008; Coelho et al., 2010; Horstmann & Bauland, 2006; Horstmann et al., 2010; Purcell & Stewart, 2010; Purcell et al., 1996). Part of the driving force behind this hypothesis comes from a finding previously discussed. That is, Hansen and Hansen’s (1988) seminal visual search investigation contained a perceptual confound, dark areas in their angry stimuli (Purcell et al., 1996). As a reminder, after controlling this confound, the reported search efficiency for angry faces disappeared (Purcell et al., 1996). The disappearance of the search efficiency prompted theorists to consider factors other than facial affect that might explain the differences in attention distribution to angry vs. happy faces.

For example, Coelho and colleagues (2010) conducted three visual search studies to investigate the hypothesis that perceptual factors guide visual attention distribution. Results of their experiments showed similar distributions of attention to emotional facial stimuli and nonemotional stimuli derived from facial stimuli. Consistent with the perceptual conformity account, the authors argued that inner features of the stimuli that did not conform to the facial outline, or "surround," rendered those stimuli more perceptually distinct than stimuli with conforming features.

In Coelho and colleagues' (2010) first experiment, 20 participants viewed an array of nine stimuli. The experimental stimulus arrays consisted of schematic angry and happy faces amongst distracters of the opposite emotion (i.e., happy target/angry distracters; angry target/happy distracters; See Figure 5a for an example). The control stimulus arrays consisted of circles with conforming or nonconforming features (Figure 5b). The inner features of the control stimuli were created using the conforming and nonconforming eyebrows from the experimental happy and angry faces, respectively. The instructions contained no mention of emotions. Participants used their dominant hand to press the "b" on a keyboard if a discrepant target was present (target present trials) and the "n" if the stimulus display was homogenous (target absent trials). The investigators did not state whether they reversed the response order.

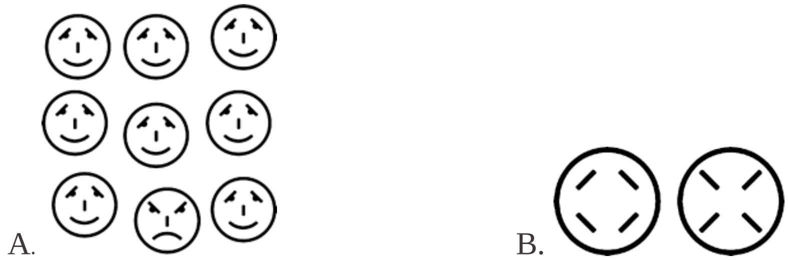


Figure 5. Examples of stimuli from Coelho et al. (2010) Experiment 1 – A) An example of a-9-item stimulus array using angry target/happy distracter faces; B) Control stimuli (left – conforming/happy; right – nonconforming/angry)

Data for Experiment 1 showed significant main effects for target presence, stimulus type, and emotional valence (See Figure 6). Specifically, participants responded significantly faster to target present vs. target absent trials, to abstract control vs. schematic experimental trials, and to nonconforming/angry faces (collapsed across both experimental and control stimuli) vs. conforming/happy faces. The significant stimulus type x emotional valence interaction reflected faster responses to nonconforming abstract stimuli than to nonconforming schematic angry faces when averaged across the target presence conditions. Participants' faster responses to the abstract control stimuli compared to the schematic experimental faces surprised the investigators. They argued that their data fell in line with others showing greater threat advantages for less complex stimuli (e.g., Horstmann & Bauland, 2006; Horstmann et al., 2006). Overall, however, the similar pattern of responses between abstract stimuli and schematic faces leaves open the possibility that a factor other than facial emotion played a role in guiding attention.

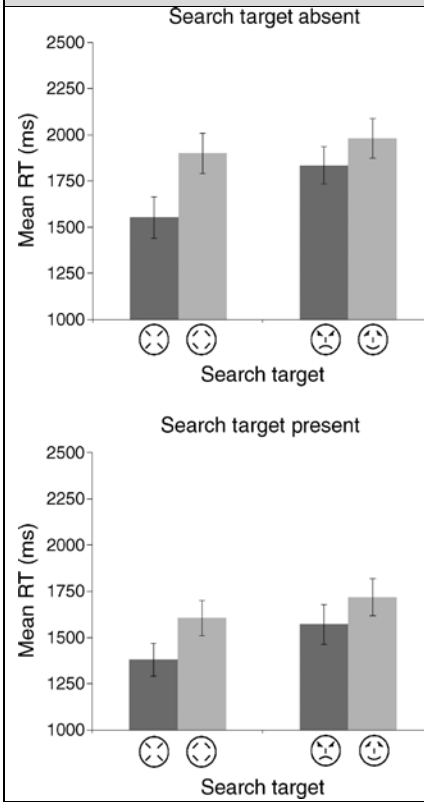
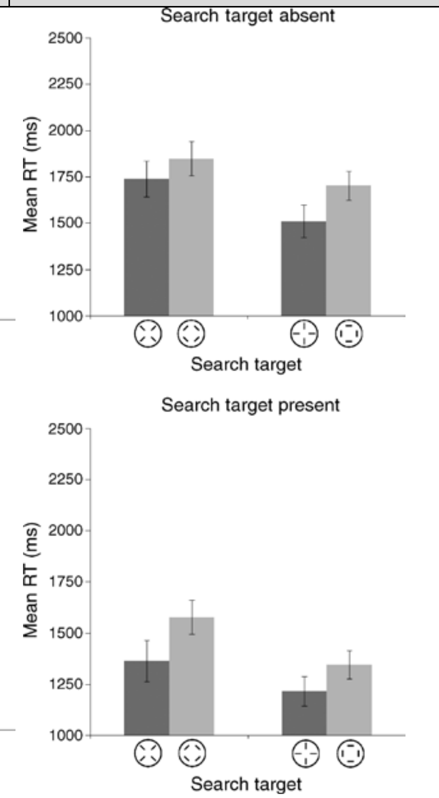
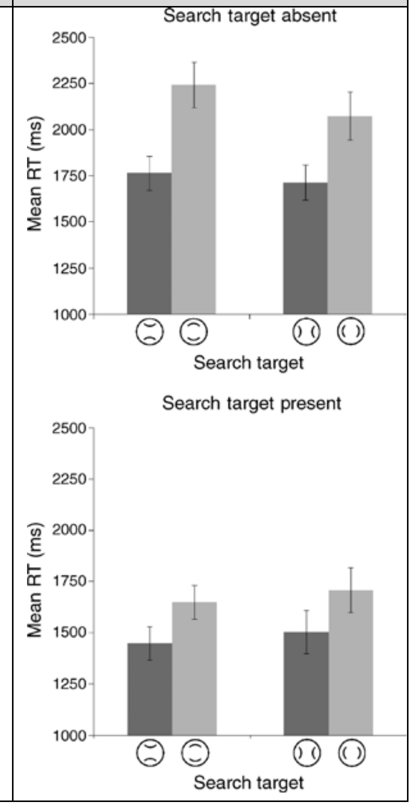
EXPERIMENT 1	EXPERIMENT 2	EXPERIMENT 3
		

Figure 6. Results from Experiments 1, 2, and 3 (Coelho et al., 2010)

There are several positive aspects of this investigation. For example, the control stimuli in this experiment appear to be well thought out and designed. The control stimuli included features derived from the experimental angry and happy faces to strengthen cross stimuli comparisons. Additionally, the investigators conducted an affect ratings study to test the perceived affect of the experimental and control stimuli. Participants other than those in the main experiments rated how negative or positive the stimuli appeared using an 8-point Likert scale (1 = Negative; 8 = Positive). The investigators selected two separate participant groups to rate the face (n = 14) and non-face (n = 20) stimuli, to avoid priming a face percept for the non-face stimuli. The inclusion of separate participant groups, however, may have introduced a new issue, that the groups had different thresholds for rating the stimuli.

Two other notes of caution must be considered when interpreting the data from this investigation's Experiment 1. First, the control stimuli may have generated unintended connotations, which in turn could have influenced RTs. For example, the "angry" abstract control stimuli resemble a railroad crossing street sign, which may generate ideas of slowing down or stopping. These same stimuli may have primed the letter "X," which can have negative connotations. These confounds are plausible, because the "angry" control stimuli resembling an "X" were rated more negative than the "happy" control stimuli (resembling a diamond) were rated positive. A second limitation of the control stimuli is that they may have primed the percept of a face. In the study's within-subject design, all participants in Experiment 1 viewed stimuli in both the emotional (faces) and control (abstract) conditions.

Coelho et al.'s (2010) second experiment addressed the within-subject design limitation by including 15 new participants who viewed stimuli all presumed to be devoid of emotional content. Additionally, the control stimuli used in the previous experiment (See Figure 7a-upright condition) were rotated by 45 degrees to prevent the perception of a face (See Figure 7b- rotated condition). Importantly, there were no differences in affect ratings for the two types of newly rotated stimuli. The stimuli previously used in Experiment 1 (upright stimuli) served as the control condition for the new rotated stimuli. The procedure used in Experiment 2 was similar to that in Experiment 1 except that the trials were randomized for presentation instead of being counterbalanced by stimulus type.

Figure 7. Examples of stimuli in Experiment 2 (Coelho et al., 2010). A) Upright Condition (“diamond” and “X”), B) Rotated Condition (“square” and “cross”)

Unlike the previous experiment, data from Experiment 2 yielded a significant three-way interaction (target presence x stimulus type x emotional valence). Specifically, the rotated stimuli (See Figure 7b - the “square” and the “cross”) in the target absent condition produced larger effects than the upright stimuli (See Figure 7a - the “diamond” and the “X”) in the target present condition. The significant main effects indicated faster responses to target present vs. target absent trials, “angry” nonconforming control stimuli vs. “happy” conforming control stimuli, and rotated vs. upright stimuli.

The investigators’ concerns regarding the stimuli in Experiment 1 being perceived as “face-like” was addressed by rotating the stimuli in this experiment. The finding of faster RTs to the newly rotated stimuli (the “square” and “cross”) versus the upright stimuli led the investigators to two conclusions. First, the faster RTs to nonconforming angry vs. conforming happy abstract stimuli in Experiment 1 were not attributed to participants’ perceiving the stimuli as “face-like.” Second, the investigators argued that their data challenge a suspected limitation in Experiment 1. They contend that the “V” shaped eyebrow configuration typically associated with threat in schematic faces, which was represented as the “X” in their stimuli, may not actually relate to threat. Rather, they hypothesize that the varied orientations of the lines inside the surround may drive the differences in detection times. Specifically, their data showed faster detections for stimuli containing inner lines perpendicular to the surround (nonconforming) versus lines that were more conforming ("square" and "diamond").

One concern discussed in relation to the previous experiment remains likely. That is, top-down processing of the rotated stimuli may have generated other connotations, such as the letters "O," a square (i.e., Figure 7b, on left; Coelho et al., 2010), and a lowercase letter "t" (Figure 7b-above, on right). The lines in the "t"-shaped stimuli also resemble a cross (Coelho et al., 2010), a plus, the face of a clock, and the cardinal directions on a compass. The finding that rotated stimuli yielded faster RTs than did upright stimuli is consistent with the possibility that the rotated stimuli generated stronger unintended connotations. It is also possible that participants did not generate such unintended connotations, in which case purely perceptual differences may have accounted for the findings.

A final control experiment (Experiment 3; Coelho et al., 2010) with 15 participants sought to replicate and extend the findings in Experiment 2. Participants viewed circles that either contained the conforming or nonconforming mouths from the face stimuli in Experiment 1 (Figure 8). The investigators chose to use mouths as the inner facial feature of interest, for two reasons. First, the conformity and nonconformity of the upwards (happy) and downwards (angry) turned mouths, respectively, allowed them to test the perceptual conformity hypothesis in explaining attention distribution differences. Secondly, other data show differences in RTs with these stimuli (e.g., Horstmann et al., 2006). The procedures were the same as those used in Experiments 1 and 2.

As in the previous experiments, participants responded faster to target present than target absent trials and to nonconforming/angry stimuli than conforming/happy stimuli. RTs did not differ based on the rotation of the stimuli. The investigators reported three significant two-way interactions, two of which are relevant to this text. The rotation x valence and a rotation x target presence interactions demonstrated that irrespective of target presence and its rotation, participants consistently responded faster to angry configurations.

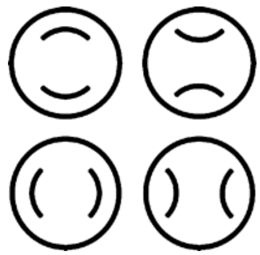


Figure 8. Stimuli used in Experiment 3 (Coelho et al., 2010). Top left – Conforming upright; Top right – Nonconforming upright; Bottom left – Conforming rotated; Bottom right – Nonconforming rotated

Collectively, the results were interpreted to suggest that the previously reported preferential distribution of attention to negative faces is also manifest in nonemotional and nonfacial stimuli. One finding that was consistent across the three experiments relates to conformity. That is, participants responded faster to stimuli with nonconforming inner features, whether emotional or nonemotional, than to those with conforming features. This finding suggests that the conformity of the inner features with the surround, rather than affect, may play a critical role in how fast stimuli are detected (Coelho et al., 2010). Notwithstanding the previously described limitations, the findings bring into question the claim that facial affect is the factor driving the differential distribution of attention to angry vs. happy faces.

As just highlighted, Coelho and colleagues' (2010) data are consistent with the perceptual conformity account in that differences in detection times appear to stem from the conformity of the internal facial features relative to the stimulus surround. Specifically, inner features that do not conform to the surround vs. conforming features are hypothesized to account for attention distribution differences. The preference to attend to the nonconforming inner features has been corroborated in other investigations, as well, such as that of Purcell and Stewart (2010).

Purcell and Stewart (2010) also tested the perceptual conformity hypothesis (conforming vs. nonconforming facial features/surrounds) and whether it underlies the differences in attentional distribution to happy and angry faces. These authors contend that happy faces are more difficult to detect than angry faces because of their conforming nature. In their investigation, angry and happy schematic faces were created using the features from Öhman and colleagues' stimuli (2001). Purcell and Stewart created affect-neutral faces with the same facial features as Öhman and colleagues' stimuli. However, in Purcell and Stewart's investigation, the configurations of the inner features were organized to prevent the stimuli from being perceived as emotional (See "Affect Neutral Faces" - Figure 9). These affect-neutral stimuli maintained the same conforming vs. nonconforming relationships with the stimulus surround as did the emotional faces.

Purcell and Stewart (2010) tested their hypotheses in four studies, three of which are described below (Experiments 2-4). The remaining experiment (Experiment 1) was an affect rating study. In Experiment 2, half of Purcell and Stewart's 34 participants viewed a nine item array of affect-neutral faces while the remaining half viewed emotional faces. Participants completed a go/no-go task, pressing the number "0" if they viewed a discrepant face (in an array of neutral faces) but making no response to a homogenous array.

The investigators predicted similar RTs between nonconforming affect neutral stimuli and angry faces. They also predicted that conforming affect neutral faces and happy faces would contain a perceptual disadvantage; the blurring of the inner conforming features would make these stimuli less conspicuous compared to stimuli with nonconforming features.

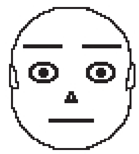
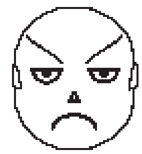
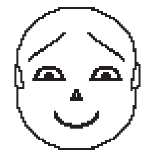
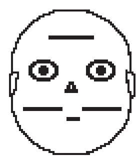
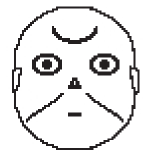
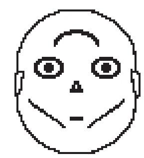
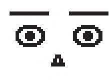
	Distracter Stimuli	Nonconforming Features	Conforming Features
Emotional Faces (Experiments 2, 3)	 Distracter Neutral	 Angry	 Happy
Affect Neutral Faces-Reorganized Features (Experiments 2 & 3)	 Distracter Neutral	 Nonconforming Affect Neutral	 Conforming Affect Neutral
Surround-Absent Faces	 Surround-Absent Neutral	 Surround-Absent Angry	 Surround-Absent Happy

Figure 9. Example stimuli (Purcell & Stewart, 2010). The labels within the cells were provided by the author of this text to facilitate interpretation

The variables of interest included feature organization (emotional faces vs. affect-neutral faces), feature conformation (nonconforming vs. conforming), and retinal position. Results related to retinal position will not be described, as they are not relevant to this text. The main effect of feature conformation was significant, showing faster responses to nonconforming vs. conforming features which fell in line with other data (e.g., Coelho et al., 2010).

The methods in Experiment 3 paralleled those in Experiment 2, with the exception of the addition of a four-item stimulus display. Once again, nonconforming stimuli elicited faster responses than conforming feature stimuli. There was a significant interaction between feature conformation and retinal position, again indicating that conforming/happy stimuli took longer to detect than nonconforming/angry stimuli with increasing distance from the fovea, as was noted in the second experiment. Also as in the second experiment, the feature organization x feature conformation interaction was not significant. The findings involving the number of stimuli in the display are not discussed here, as they are not relevant to the focus of the current text.

Stronger evidence consistent with the perceptual conformity account would come from data showing similar RTs, and presumed distributions of attention, to positive and negative faces *without* facial surrounds. That is, attention differences should be eliminated with surround-absent stimuli because there is no surround with which the inner features can conform. Purcell and Stewart (2010) argued that such a finding would indicate that the inner features of happy faces without surrounds were just as noticeable as those in angry faces without surrounds. Using this rationale, Purcell and Stewart (2010) assessed the role of the facial surround to test the perceptual conformity hypothesis in their fourth experiment.

One group of participants (n = 36) viewed upright arrays while a second group of participants (n = 33) viewed inverted, surround-absent, happy and angry faces. The stimulus arrays consisted of four or nine items. Half of the stimuli in the four item array were arranged in a "+" configuration (i.e., stimuli placed at 0°, 90°, 180°, and 270°) while the remaining half were arranged in an "x" configuration (i.e., stimuli placed at 45°, 135°, 225°, 315°). The "+" and "x" configurations were created to prevent participants from "blurring" the features since they did not have surrounds. Examples of the stimuli are in Figure 10.

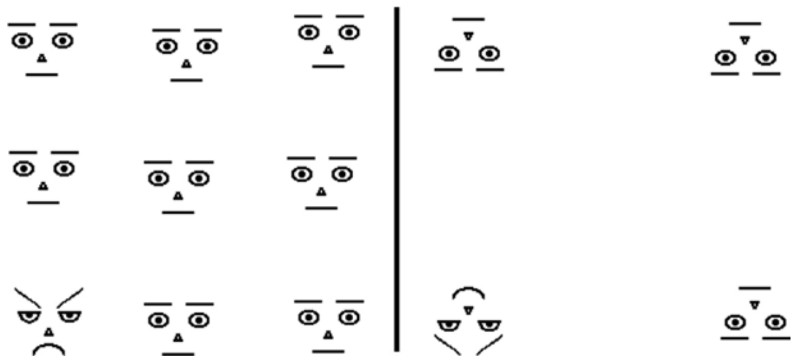


Figure 10. Example stimuli from Experiment 4 (Purcell & Stewart, 2010); Left - Example of a 9-item array using surround-absent angry target/neutral distracter faces; Right - Example of an "X" configuration with a 4-item array using inverted, surround-absent happy

Despite the removal of the facial surround, participants detected the targets with "angry" facial features faster than targets with "happy" features. This critical finding does not support the investigators' prediction of similar attention distribution between these two types of stimuli. Although the main effect of orientation (upright vs. inverted) in Experiment 3 was not significant, a feature conformation x orientation interaction was observed, indicating faster detections of inverted angry faces than upright angry faces. As a reminder, facial inversion is suggested to prevent the perception of emotion. Therefore, this finding may suggest that participants processed the stimulus based on perceptual features, rather than affect.

These data are particularly interesting, for several reasons. On one hand these data appear to corroborate and extend the perceptual conformity account, which was previously based on other findings using surround-*present* stimuli. One the other hand, the theoretical and experimental validity of such findings is based on an underlying assumption: that physically removing the facial surround would also eliminate the activation of a mental representation of the surround. Given that the facial features remained visible, it is tenable that participants generated their own mental representations of the facial surrounds, or that processing these face-like features activated a stored facial gestalt. The demonstration of more efficient searches for surround-absent angry vs. happy faces does not definitively invalidate the perceptual differences hypothesis. However, this finding does raise doubt about whether participants distributed attention based on conformity differences between the inner features and the "eliminated" facial surround, their own mentally activated facial surround, or a different unknown perceptual factor.

Some potential limitations must be considered when interpreting the results from this experiment. First, the stimuli in Figure 9 not only varied in eyebrow and mouth directions, but the shapes of the eyes differed between distracter, nonconforming, and conforming features. Second, the angry and happy face stimuli extend higher vertically than the neutral faces, which could be a confound in trials containing happy or angry targets and neutral distracters. Third, the eyebrows in the angry and happy faces are slightly longer than those in the neutral faces. It is unknown if and how these differences might have contributed to the observed findings and whether or not these differences serve as perceptual features that may drive attention differences. Fourth, the elements of the stimuli are not held constant across stimulus types. For example, the affect neutral stimuli contain an additional perceptual element (i.e., a short horizontal line) that is not present in the other types of stimuli. Another potential limitation stems from the validation of the experimental stimuli. While the investigators are commended for obtaining affect ratings, participants viewed only faces during the rating study. It is possible that the ratings may have differed if non-face control stimuli had been included. Overall, however, Purcell and Stewart's (2010) data are consistent with a growing number of findings suggesting a perceptual differences hypothesis to explain attentional distribution to threatening vs. nonthreatening faces.

4.2.2 Flankers task evidence

The flankers task (Eriksen & Eriksen, 1974) is another method with which the perceptual differences hypothesis has been tested. To date, there are two investigations that have examined the perceptual differences hypothesis using the flankers task, and the findings are mixed (Fenske & Eastwood, 2003; Horstmann, et al., 2006). Fenske and Eastwood (Experiment 1B) concluded that facial affect caused the differences in attentional distribution between their “positive” and “negative” scrambled faces. Horstmann and colleagues counter this claim with findings consistent with the perceptual differences account. These two investigations are now reviewed in detail.

Fenske and Eastwood (2003) conducted a series of three experiments, two of which have already been described. As a reminder, the investigators concluded that the flanker-effect asymmetry observed between positive and negative target faces was due to a broadening and narrowing of attention based on the underlying facial affect. To test an alternative explanation of the data, the perceptual differences hypothesis, Fenske and Eastwood (Experiment 1B) presented faces with scrambled features, a process presumed to prevent the processing of emotion.

The scrambled faces contained the mouth and eye features used in a previous experiment (Figure 11). The mouth was rotated clockwise or counterclockwise 90 degrees and centered in the facial outline. The dots representing the eyes were lowered and positioned along the central horizontal axis. The investigators reasoned that if perceptual factors accounted for the differences in the flanker-effect asymmetry effect observed for angry faces in Experiment 1A, then the same, or similar, findings should occur for scrambled stimuli devoid of emotion. The procedure used in this experiment (1B) was the same as in Experiment 1A.

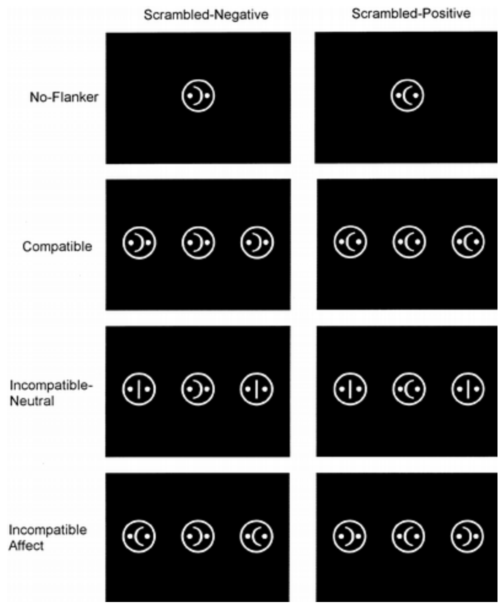


Figure 11. Example of stimuli used in Experiment 1B (Fenske & Eastwood, 2003)

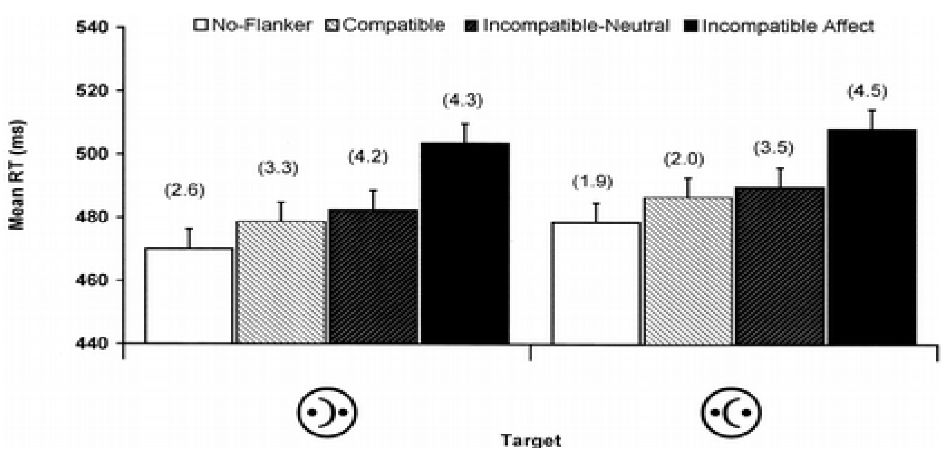


Figure 12. Results from Experiment 1B (Fenske & Eastwood, 2003)

As expected, participants (n = 40) responded faster in the compatible condition (for both types of targets) than in either of the incompatible conditions (incompatible neutral and incompatible affect), which defines the flanker compatibility effect (Figure 12). However, the pattern of results differed between the *scrambled* stimuli (Experiment 1B) and the *facial* stimuli (Experiment 1A). For the scrambled stimuli, the magnitude of the flanker compatibility effect did not differ between either type of targets (scrambled negative or scrambled positive). That is, all targets in the scrambled condition were equally influenced by information in the periphery. This contrasts with the findings in Experiment 1A (facial stimuli), in which the magnitude of the flanker compatibility effect differed according to the identity of the target. In general, responses to negative target faces were less influenced by flankers than were responses to positive target faces. Emotional categorization was presumed to be disrupted with the scrambling of the features in Experiment 1B. Therefore, the investigators argued that the differences in results between facial and scrambled stimuli were due to facial affect.

Fenske and Eastwood (2003) are applauded for examining an alternative hypothesis for their original findings. However, their data are difficult to interpret in the context of the perceptual conformity account, because the mouths in the scrambled faces conform to the surround on one side (the arched side) but not the other side (the opened side). Also, faces have been scrambled numerous ways in the literature. Although scrambling is intended to alter the global configuration of faces while retaining facial features, there are limited data to demonstrate that scrambling actually disrupts emotion processing. Furthermore, there are no guidelines for what kind of scrambling is sufficient to disrupt emotional processing, creating concerns about studies that use this process.

Horstmann and colleagues (2006, Experiment 3) also used the flankers task to test the perceptual differences hypothesis presenting the curved mouths that were extracted from positive and negative faces in a way presumed to distort a face percept (Figure 13). They reasoned that if facial affect caused the flanker-effect asymmetry in their previous experiments, the effect should not be substantiated with abstract stimuli. However, if a flanker-effect asymmetry was found for abstract stimuli that were devoid of emotion, the affect account may not be valid.

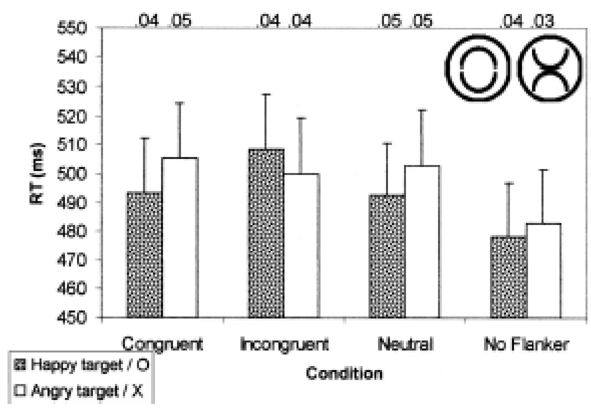


Figure 13. Examples of stimuli from Experiment 3 (Horstmann et al., 2006)

The procedures in this experiment paralleled those of Experiment 2 (described previously). A second aim of Experiment 3 was to examine whether attentional processing is influenced by knowing that the stimulus is a face. To maintain consistency between experiments, half of the participants in Experiment 3 (n = 12) received descriptions of the stimuli as faces displaying happiness, anger, or no emotion (neutral). The remaining participants received instructions to label the stimuli as the letters “X” and “O” (See Figure 13). The investigators created the stimuli for Experiment 3 by inverting and then superimposing the upwards and downwards curved lines in the positive and negative faces from Experiment 2, respectively. The

"X" stimuli were created using the curved lines that indicated anger in Experiments 1 and 2, whereas the "O" stimuli used the curved lines that indicated happiness. A single circle represented the neutral condition.

The first significant finding was a congruency effect. Participants responded faster to congruent trials than to incongruent trials, a finding that is expected in the flankers task. Secondly, a significant congruency x target face interaction indicated faster responses to congruent vs. incongruent happy (O) trials. No such differences existed between congruent vs. incongruent angry (X) targets. The observed flanker-effect asymmetry replicated the effect for affective facial stimuli from Horstmann and colleagues' Experiment 1.

One interpretation of the asymmetry with angry (X) scrambled targets is reminiscent of the perceptual conformation account, in that the "X" and "O" differ in their conformity with the surround (Purcell & Stewart, 2010). Therefore, it is tenable that the perceptual differences could be the driving factors causing the asymmetry. Regarding whether attentional distribution is influenced by knowing that a stimulus represents a face, participants responded similarly to the *face* and *letter* (X, O) instruction conditions. The investigators interpreted this finding as evidence that the flanker-effect asymmetry may not hinge on top-down knowledge of the stimuli, but rather on the stimulus differences. They acknowledge that the null findings may cause some to question statistical power, but they argue that the lack of differences when responding to facial and letter instructions suggests that the flanker-effect asymmetry does not rely on higher order cognition.

Overall, there are several areas of concern with this experiment, the first of which involves the instructions given to the participants. Instructing the participants to think of the stimuli as angry, happy, or neutral faces, or as the letters "X" and "O" does not eliminate the possibility that different meanings were assigned to these stimuli. For example, the letters "X" and "O" are frequently used in combination to represent kisses and hugs, while the letter "X" can be linked to negative connotations, such as being incorrect (e.g., an incorrect response) or inappropriate (e.g., an X-rated movie). This possibility is underscored by the results of Experiment 5, in which participants rated stimuli from Experiments 1-4 on a 7-point scale. Participants rated the "X" stimuli as more negative than the "O" stimuli. The investigators admitted their surprise at this finding, and conceded that although the "X" and "O" stimuli were derived from schematic emotional faces, they may have primed an emotional connotation. The negative connotations conjured by the "X" may have been similar to the negative affect in the *facial* stimuli, potentially explaining the null differences between the two. Lastly, the letters "X" and "O" differ in their graphemic/phonologic congruity. Specifically, faster responses to the letter "O" may be due to the congruity between the letter "O" and the phoneme "O," whereas there is no such congruity with the letter "X." Along those lines, a second limitation in this study is that the control stimulus, a plain circle, may also have generated the letter/phoneme "O," particularly for participants in the letter instruction condition.

Horstmann et al. (2006) recognized that the stimuli in Experiment 3 might have been perceived as emotional. With this in mind, Experiment 4 tested whether the flanker-effect asymmetry could be obtained with stimuli that did not appear to be faces and that were also devoid of emotion. The stimuli consisted of a circle or a circle with a vertical line (i.e., a lollipop) going through the bottom half (Treisman & Souther, 1985). Triangles served as neutral stimuli. The investigators state that the instructions did not reference any emotional content and that participants received the "same" instructions as in previous experiments, though it is unclear how the circle and lollipop stimuli were described and in general what instructions the participants received in Experiment 4. It is assumed that participants pressed one response key to the circle stimuli and another to the lollipop stimuli.

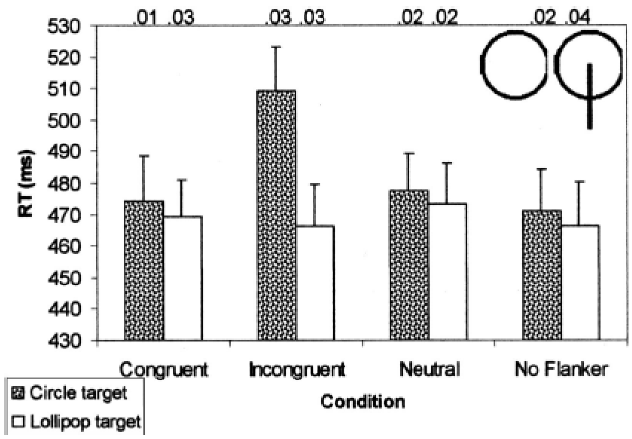


Figure 14. Example stimuli from Experiment 4 (Horstmann et al., 2006)

The primary analysis indicated a significant target (circle vs. lollipop) x congruency (congruent vs. incongruent) interaction (Figure 14). There was a flanker-effect asymmetry evidenced by faster RTs to lollipop than to circle targets when the targets and distracters were switched. The investigators argued that the flanker-effect asymmetry can be generated by nonfacial, nonemotional stimuli. They further concluded that perceptual factors can explain the observed flanker-effect asymmetry. It is premature to conclude that the perceptual *conformity* account, per se, might explain the flanker-effect asymmetry. While the line in the lollipop does not conform to the surround, the circle stimuli do not contain conforming features with which to make a comparison. However, a broader perceptual differences explanation is consistent with the data in this experiment.

The authors suggest that perceptual differences could explain the data in the first 3 experiments, but did not definitively rule out the potential role of facial affect. Because the same stimuli have been used in investigations which reported visual search asymmetry, the investigators tentatively hypothesized that stimuli exhibiting efficiencies in visual search tasks may also induce a flanker-effect asymmetry. More studies are needed to test this hypothesis.

4.3 CHALLENGES TO THE VALIDITY OF THE PERCEPTUAL CONFORMITY ACCOUNT

The challenges to the validity of the perceptual conformity hypothesis are discussed in terms of the categories introduced in the facial affect section: those related to the evidence itself, the nature of the stimuli used to gather the evidence, and the experimental tasks.

4.3.1 The evidence

The primary data-related challenge for the perceptual conformity hypothesis is that facial affect could explain the differences in attention distribution between threatening and nonthreatening faces. The details of this alternate hypothesis have already been described. Another challenge stems from Purcell & Stewart's (2010) investigations. They noted faster detection times to surround-absent angry vs. surround-absent positive faces. This finding particularly challenges the perceptual conformity account, which predicts that such attention differences should have been eliminated with the removal of a facial surround (if mental representations of the facial surround were not activated, as discussed previously).

4.3.2 The facial stimuli

The perceptual account faces three stimulus-related challenges. First, it is very difficult to create stimuli that are devoid of meaning. Therefore, the possibility of participants' top-down knowledge generating unintended connotations, and subsequently influencing attention distribution, is likely. For example, Horstmann and colleagues (2006) instructed participants to think of their stimuli as the letters "O" and "X." However, this may not have prevented participants from generating other connotations, which may have influenced their perception of the stimuli. The second challenge is that some facial stimulus contrast conditions differ by multiple features. For example, Purcell and Stewart (2010) used three different eye shapes for their neutral, positive, and negative stimuli. To improve internal validity, the only features that should differ across stimuli are those that are relevant to the research questions. The last stimulus-related challenge is that some data are based on control stimuli that are only assumed to be nonemotional. To ensure that stimuli are perceived as intended, it is critical to validate the perceived affect.

4.3.3 The experimental tasks

As identified in the facial affect section of this document, the majority of findings stem from the visual search task. While much has been gained by using this task, the visual search task also has limitations. Data consistent with the perceptual conformity account have started to emerge from other tasks, but these investigations are scant and contain confounds of their own. To strengthen the validity of the perceptual differences account, converging evidence from different approaches is vital.

4.4 SUMMARY

The perceptual differences account holds promise for explaining the extant findings of differential distribution of attention to positive and negative faces. The data are mounting to suggest that the conformity of the inner facial features with the outer facial surround may explain differences in visual attention distribution between threatening and nonthreatening faces. However, much more research is needed to determine the validity of this account.

5.0 A DEVELOPMENTAL PERSPECTIVE ON FACE PROCESSING

The facial affect and perceptual differences hypotheses are most frequently presented as opposing views in the adult facial emotion literature. However, theories on the development of infant face processing may offer a conceptual framework for reconsidering whether these factors should be considered as such. The next section introduces the widely reported face preference in newborns, and discusses three hypotheses posited to explain this preference. A two-process theory of infant face recognition is described next and is offered as a potential middle ground for informing the theoretical debate in the adult facial emotion literature. The chapter closes by discussing the theoretical implications of considering both perceptual properties and facial emotion as factors driving visual attention differences in the adult literature.

5.1 FACE PREFERENCE IN NEWBORNS AND HYPOTHESIZED MECHANISMS

It is well established that soon after birth, newborns exhibit a preference for looking at faces over non-face-like patterns (e.g., Johnson, Dziurawiec, Ellis, & Morton, 1991; Valenza, Simion, Cassia, & Umiltà, 1996). Morton and Johnson (1991) argue that a face preference is necessary to establish a bond with adult caregivers and to bias the visual system so that the cortical circuitry is adequately specialized for faces later in development. Other researchers posit that newborns prefer to look at faces because of the stimulus category. For example, Johnson (2011) argues that early foveations of facial stimuli result in the newborn face preference. As babies orient their attention to faces over time, their increased visual attention to faces is thought to influence the evolving cortex. The influence on the cortex is particularly evident in areas that are sensitive to facial stimuli. Much controversy has surfaced, however, regarding the mechanism(s) that underlie face preferences in infants. Three hypotheses are briefly described below.

First, the *sensory hypothesis* is grounded in the assumption that infants exhibit a visual preference for specific categories of stimuli based on their properties during the early stages of visual processing (Morton & Johnson, 1991). A sensory mechanism is thought to pass on information about properties of the stimulus to a decision-making system. This system decides where and for how long an infant fixates on a given stimulus. It is argued that the system's bias for faces and face-like stimuli is a result of the increased visibility of faces vs. other entities, to the infant's sensory mechanism (Johnson, 2011). Face properties are passed to a system which prefers faces and face-like stimuli over other objects (e.g., Johnson et al., 1991).

Second, the *non-face structural preferences* argument claims that the infant face preference is related to the visual system's response to several non-specific attentional biases, which are simply maximized with facial stimuli (e.g., Sugita, 2009). That is, in addition to faces, infants also exhibit preferences for other properties of visual stimuli (e.g., Farroni, Valenza, Simion, & Umiltà, 2000; Macchi Cassia, Turati, & Simion, 2004; Simion, Valenza, Macchi Cassia, Turati, & Umiltà, 2002). One example includes the "top-heavy" bias, also called an up-down asymmetry (Macchi Cassia et al., 2004; Simion et al., 2002; Turati, 2004). This bias refers to the presence of more elements in the upper vs. lower portion of a visual stimulus. Simion and colleagues (2002) concluded that the top-heavy bias was a perceptual property guiding newborns' face preference after their data showed that newborns exhibited significantly longer fixation times to stimuli with top-heavy vs. bottom-heavy configurations. The top-heavy bias has been reported using pictures of schematic (Turati, Simion, Milani, & Umiltà, 2002) and human faces (Macchi Cassia et al., 2004).

Congruency is another non-specific attentional bias hypothesized to drive newborns' preferences for face and face-like stimuli (Macchi Cassia, Valenza, Simion, & Leo, 2008). Macchi Cassia and colleagues (2008) define congruency in terms of the relationship between the number of features located in the widest portion of a face (the upper half) and a single feature, the mouth, located in the narrowest portion (the lower half). Using the top-heavy bias as a guide, they argued that newborns exhibit a face preference due to the congruency between the number of elements in the upper and lower half of a face. Evidence consistent with this view comes from findings showing that, when viewing non-face configurations, infants directed their attention to congruent (greater number of elements in widest part of stimulus; smaller number of elements in narrowest part) vs. incongruent patterns (greater number in narrowest part; smaller number in widest part) (Macchi Cassia, Valenza, Pividori, & Simion, 2002). In general, the *non-face structural preferences* argument claims that newborns' attention to face-like stimuli is not due to the face being a face, but rather to a preference to attend to perceptual properties in a face.

Johnson (2011) casts doubt on the *non-face structural preferences* account, however, explaining that only a specific complex combination of different attentional biases would yield an optimal facial stimulus that results in newborns attending to it. Based on a series of investigations that examined such biases, he concluded that the ideal stimulus would have to be "…an up-down asymmetrical pattern with more elements or features in the upper half, but only when it is within a congruently shaped bounded object or area such as an oval" (p. 6).

A third account also weakens the non-face structural preference argument. That is, newborns are thought to possess *complex face representations at birth*. For example, minutes after birth newborn babies prefer to orient their attention to schematic vs. scrambled faces (e.g., Johnson et al., 1991). Other evidence consistent with this claim includes findings of infant face preferences for upright vs. inverted faces (e.g., Slater, Quinn, Hayes, & Brown, 2000), attractive vs. unattractive faces (e.g., Quinn, Kelly, Lee, Pascalis, & Slater, 2008; Slater et al., 2000; Slater, Von der Schulenburg, Brown, & Badenoch, 1998), and faces with direct vs. averted eye gazes (Farroni, Csibra, Simion, & Johnson, 2002). Based on these findings, infant facial emotion investigators typically agree that babies have some level of facial information available to them at or soon after birth that causes them to attend preferentially to this class of stimuli. However, the reasons behind infant face preferences continue to be debated.

The next section addresses another debate, about the types of facial information available to infants during early development. A brief discussion introduces two types of information thought to guide infant face processing, the first of which is perceptual and the second, emotional.

5.2 INFANT PROCESSING OF PERCEPTUAL INFORMATION IN FACES

As stated in previous chapters, proponents of the perceptual differences hypothesis in the adult facial emotion literature claim that perceptual factors account for differences in attentional deployment across various emotion categories (e.g., Coelho et al., 2010; Horstmann et al., 2010; Purcell & Stewart, 2010; Purcell et al., 1996). Although based on facial recognition, data from the infant facial emotion literature show that newborns also rely on perceptual information from faces (e.g., Bartrip, Morton, & de Schonen, 2001; Farroni et al., 2000; Gava, Valenza, Turati, & de Schonen, 2008; Turati, Macchi Cassia, Simion, & Leo, 2006; Turati et al., 2002; Turati, Valenza, Leo, & Simion, 2005). For example, Turati, Cassia, Simion, and Leo (2006) found that one-to-three day old infants not only used the configurations of the facial features to aid face recognition, but were also sensitive to the relation between the inner and outer facial features. Also consistent with the roles of inner and outer perceptual features are findings that infants as young as four days old can discriminate their mothers' faces from strangers' faces, although removal of the outer facial elements hampers their recognition (Bartrip et al., 2001; Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995). This finding led many to argue that infants rely on the outer facial elements (e.g., ears, hairline, chin), and their configurations, more than the inner elements (e.g., eyes, nose, mouth) during face recognition (Campbell & Tuck, 1995; Campbell, Walker, & Baron-Cohen, 1995; Want, Pascalis, Coleman, & Blades, 2003). This finding contrasts with the adult literature, which shows an increased number of fixations and fixation durations to inner facial features (e.g., Barton, Radcliffe, Cherkasova, Edelman, & Intriligator, 2006; Vassallo, Cooper, & Douglas, 2009). Notwithstanding the differences in adult and infant literatures, the processing of information from facial features suggests that perceptual properties play a role in face processing.

5.3 INFANT PROCESSING OF EMOTIONAL INFORMATION IN FACES

Evidence also shows that the ability to process facial emotions emerges soon after birth (e.g., Barrera & Maurer, 1981; Walker-Andrews, 1997). Some facial emotions are recognized earlier in development, such happy and sad faces, as opposed to those displaying disgust and fear (e.g., Boyatzis, Chazan, & Ting, 1993; Gosselin & Larocque, 2000). Others' facial emotions drive infants' attentional biases similarly to reports in the adult literature. For example, infants as young as seven months old exhibit an attentional bias towards threatening vs. nonthreatening faces (e.g., Leppänen, Moulson, Vogel-Farley, & Nelson, 2007; Peltola, Leppänen, Palokangas, & Hietanen, 2008). Two mechanisms have been posited to explain this infant capacity to process facial emotion.

The first argument is evolutionarily based, in that the human brain is thought to have developed specialized modules for face processing (e.g., Kanwisher, McDermott, & Chun, 1997; Kanwisher & Yovel, 2006; Öhman & Mineka, 2001; Öhman & Wiens, 2004; Reddy & Kanwisher, 2007). Modules are defined as domain-specific cognitive systems that are rapid and automatic, and whose purpose is to address recurrently encountered problems in the environment (Sander, Grafman, & Zalla, 2003). An evolved fear module, for example, has been critical to mammalian evolution (Öhman & Mineka, 2001). Specifically, it is argued that humans are more likely to fear potentially dangerous situations that once threatened the survival of our ancestors.

The second purported mechanism of facial emotion processing was inferred from a series of investigations conducted by Ekman and his associates (Ekman & Friesen, 1971; Ekman, Friesen, & Ellsworth, 1972; Ekman et al., 1987). This group found that a small set of facial emotions, coined the 'basic emotions,' was recognized cross-culturally. The claimed universality of some facial expressions has been taken to indicate that these expressions are innate and prewired (Johnson, 2011; although see Russell, 1994). Darwin was a firm supporter of this claim years ago, even though this view was not widely held (see Ekman, 2006). Some facial emotion investigators currently involved in research concur, at some level, with Darwin's original claims (e.g., Morton & Johnson, 1991; Sugita, 2009).

In brief, it appears that babies rely on both perceptual and emotional information to facilitate face processing. One critical question, then, is whether this dependence on both types of information might explain conflicting data in the adult facial emotion literature regarding the factors guiding visual attention. That is, it is possible that the empirical differences reported in the adult literature are a reflection of attentional guidance based on both perceptual and emotional factors. The idea that data consistent with only one account may not completely rule out the other account is not new (Horstmann et al., 2006; Juth et al., 2005). This discussion is tabled temporarily to consider another important theory in the infant facial emotion literature, the two-process theory of face recognition.

5.4 TWO-PROCESS THEORY OF FACE RECOGNITION

The two-process theory of face recognition (Morton & Johnson, 1991) proposes two mechanisms in the development of infant face recognition. Morton and Johnson claim that babies possess an innate subcortical system comprised of a coarse face template of structural information about the visual characteristics of conspecifics (e.g., the facial features and their configurations). It is claimed that infants use this innate system, called CONSPEC, to identify a face as a face. Morton and Johnson add that the structural information about faces biases babies to exhibit a face vs. non-face visual preference. Evidence consistent with the processing of configural information early in life comes from Le Grand, Mondloch, Maurer, and Brent (2001). They found that even after having surgery to correct bilateral congenital cataracts, infants who were deprived of visual input within the first six of months showed permanent impairments in processing configural information from faces.

The second system is a specialized cortical circuitry for face processing that develops as a result of having more frequent exposure to faces during social interactions. This system, called CONLERN, gathers and obtains information about the properties of faces and is based on learning through experience. For example, the ability to recognize facial emotions at lower intensities is more developed in adulthood than during infancy (e.g., Herba, Landau, Russell, Ecker, & Phillips, 2006; Thomas, De Bellis, Graham, & LaBar, 2007). Another example is evident in young infants' inability to differentiate human and monkey faces, a skill that develops around 9 months of age (Pascalis, de Haan, & Nelson, 2002).

5.5 A POTENTIAL MIDDLE GROUND: PERCEPTUAL AND EMOTIONAL INFORMATION IN FACE PROCESSING

Current knowledge about the use of perceptual and emotional information during infancy informs the equivocal findings from adult studies that have examined the facial affect and perceptual differences hypotheses. Infants' utilization of both perceptual and emotional information in face processing suggests that this information may also be readily available in adulthood, albeit significantly more developed. The evidence consistent with the facial affect hypothesis, then, may be explained by the CONSPEC mechanism and evolutionary-based theories, which suggest that face representations are innate and are preferred more than other visual stimuli by the visual system. On the other hand, evidence that infants use perceptual information in face processing may help to explain data in the adult literature that are consistent with the perceptual differences hypothesis. According to Johnson (2011) face processing is a "…subtle interweaving of nature and nurture" (p. 11). In this sense, nature may refer to the early face preference reported in infants while nurture refers to the learning aspect that occurs throughout development as a result of increased exposure to faces in the environment. Johnson continues that considering these two elements as independent processes will only augment the polarized debate that has plagued the literature in the past. As argued by some investigators (Horstmann et al., 2006; Juth et al., 2005), both perceptual and emotional factors may drive visual attention processes.

This theoretical middle ground suggests that facial affect may guide visual attention in some circumstances and the same may hold true for the perceptual differences in other circumstances. In many or most cases, though, these factors most likely interact in ways that remain to be determined in future research.

6.0 OVERALL SUMMARY AND DISCUSSION

The ability to recognize and respond quickly to signals of danger and threat in the visual field is critical for survival, particularly when these signals are socially relevant. The first approach to understanding the differential distribution of visual attention between threatening and nonthreatening faces has been to consider facial affect. However, not all evidence is consistent with the idea that facial affect drives the attention differences between threatening and nonthreatening faces. Challenges facing the facial affect hypothesis have been described previously. In general, however, the combination of inconsistent results, flawed stimuli, and the lack of converging evidence consistent with this claim have left open an alternative explanation.

In particular, accumulating data from the perceptual differences account raise empirical challenges to the validity of the facial affect account and the theoretical foundations upon which this account's predictions are grounded. The *perceptual conformity account* has been offered to explain reports of attention differences between facial stimuli that represent different emotion categories. Initial efforts have been made to examine the hypothesis that attention is differentially influenced by angry vs. happy faces because of perceptual conformity differences between the inner facial features and the outer facial surround. Coelho et al. (2010) suggest that attention is oriented to angry faces more than to happy faces because of an interaction between the nonconforming inner features and the facial surround. Purcell and Stewart (2010) argue that rather than angry faces being easier to detect, it is happy faces that are more difficult to identify because of a “destructive interaction” (p. 2126) between the surround and the conforming nature of happy facial features. It is important to note that neither perceptual explanation considers the role of facial affect.

The facial affect and perceptual conformity accounts appear to compete as explanations of factors that generate attention distribution differences to different facial emotions. However, the infant face perception literature may offer an alternative theoretical framework from which to consider these accounts. In particular, reports that newborns rely on perceptual *and* emotional information during face processing are important for understanding related claims in the adult facial emotion literature. Most data suggest that both perceptual and facial emotion processing skills are refined with age. It is plausible that the conflicting findings in the adult literature represent the importance of both perceptual and emotional processing, as asserted by some adult facial emotion researchers (e.g., Horstmann et al., 2006; Juth et al., 2005). Whether or when both factors are used in face processing simultaneously, however, remain unknown. Continued research efforts to identify the stimulus properties underlying attention distribution differences within each account, while controlling for the influence of the other factor, will help guide future hypotheses and predictions about how the factors might interact. The current investigation adds to the literature by testing the validity of the perceptual conformity account in explaining differential distribution of attention to threatening and nonthreatening faces.

Understanding of attention distribution differences to varied facial emotion categories has been advanced with data from numerous visual search studies, but as described previously this task has many limitations. The flankers task has been used less frequently in assessing attention distribution to emotional faces, but its measures of response interference between targets and flankers enable investigators to infer what stimulus features cause attention differences between threatening and nonthreatening faces. The current investigation, therefore, used the flankers task. Several steps were taken to strengthen the experimental control of this work.

For example, a pre-experimental affect ratings study evaluated the perceived affect of the experimental stimuli. This ratings study was similar to Coelho and colleagues' (2010) investigation (Discussed in Section 4.2.1) in that participants used a Likert scale to rate how negative or positive the stimuli appear. Second, in the flanker task itself, the inclusion of fillers with and without outer surrounds was anticipated to decrease the chances of participants generating a face percept. Third, to maximize the likelihood that overt visual attention initially was oriented to the centrally placed target, a high contrast fixation cue was used to focus attention to the target location at the start of each trial.

In closing, the primary aim of the current investigation was to test one aspect of the perceptual conformity hypothesis. Specifically, the current study tested whether *perceptual conformity* differences between the inner features of a stimulus with that of the outer surround would generate the differences in attention distribution that have been attributed to the processing of facial threat. The secondary aim was to determine whether perceptual conformity would generate differences in the amount of response interference between target stimuli and flankers.

The flankers experiment tested the perceptual conformity hypothesis using nonemotional, surround-present abstract stimuli with "mouths" similar to those used in schematic drawings of faces. According to the perceptual conformity account, incompatible flankers should generate the expected flanker-effect asymmetry that has been reported for threatening and nonthreatening faces. Specifically, a significant flanker effect was predicted with targets with conforming features in the incompatible condition but no such flanker effect should be generated with targets with nonconforming features in the incompatible condition. In addition, incompatible flankers were predicted to generate more response interference to targets with conforming inner features than to target stimuli with nonconforming inner features. To address this prediction the outer surrounds from the stimuli were removed. According to the perceptual conformity account, removal of the outer surround should yield similar flanker effects and similar amounts of response interference for targets with conforming and nonconforming features, because there is no surround with which the features can interact. Finding a flanker-effect asymmetry with surround-absent stimuli would raise questions about the validity of the perceptual conformity account. Because potential priming of a facial "outline" was a limitation in Purcell and Stewart's (2010) investigation, the current investigation incorporated four steps to minimize this possibility. First, participants responded to surround-*absent* stimuli first. Second, the curves representing the "mouths" were not placed in a typical face configuration. Third, the stimuli contained more than one "mouth." Lastly, the filler stimuli consisted of various shapes, such as triangles and squares, which were administered with a variety of inner designs. The "mouths" used in the experimental stimuli were placed in the other shapes. In addition to decreasing the priming of a facial outline, these four steps were implemented to decrease the elicitation of stored facial feature representations and to disguise the experiment's overall purpose.

7.0 SPECIFIC AIMS & RESEARCH QUESTIONS

The primary aim of the current investigation was to examine whether perceptual conformity differences may underlie the reported differences in attention distribution between threatening and nonthreatening facial stimuli. The specific aims and research questions are listed below. The potential outcomes and interpretations are found in Appendix A.

Specific Aim 1: to compare the pattern of results between surround-present and surround-absent conditions to assess whether perceptual conformity may play a role in the reported flanker-effect asymmetries for angry vs. happy faces

Research Question 1 - (Surround-Present Condition)
Do surround-present, incompatible flankers generate the expected flanker-effect asymmetry that has been reported for angry vs. happy faces in healthy adults?

Research Question 2 – (Surround-Absent Condition)
Do surround-absent, incompatible flankers generate the expected flanker-effect asymmetry that has been reported for angry vs. happy faces in healthy adults?

Specific Aim 2: to determine if conforming and nonconforming stimuli elicit different amounts of flanker response interference in the incompatible condition

Research Question 3 – (Surround-Present Condition)
Do surround-present, incompatible flankers produce more response interference when targets have conforming inner features than when targets have nonconforming inner features?

Research Question 4 – (Surround-Absent Condition)
Do surround-absent, incompatible flankers produce more response interference when targets have conforming inner features than when targets have nonconforming inner features?

8.0 SIGNIFICANCE

The current investigation aimed to contribute to the understanding of visual attention deployment mechanisms and the factors posited to guide attention to facial stimuli that convey different emotions. Specifically, this research investigated the proposed contribution of perceptual differences in guiding visual attention, a competing hypothesis to the debated facial affect hypothesis. The theoretical implications of the investigations have been mentioned throughout the text.

Clinically, the significance of this research rests in the numerous reports of impaired facial emotion processing in a variety of patient populations. Some examples include individuals with autism (e.g., Best, Minshew, & Strauss, 2010; Calder, Rhodes, Johnson, & Haxby, 2011; Dundas, Best, Minshew, & Strauss, 2012; Dundas, Gastgeb, & Strauss, 2012; Gastgeb, Wilkinson, Minshew, & Strauss, 2011; Strauss et al., 2011), traumatic brain injuries .(Callahan, Ueda, Sakata, Plamondon, & Murai, 2011; Dal Monte et al., 2012; McDonald, Li, et al., 2011), cerebrovascular accidents (e.g., Nijboer & Jellema, 2012; Paradiso, Anderson, Boles Ponto, Tranel, & Robinson, 2011), and schizophrenia (e.g., Kohler, Walker, Martin, Healey, & Moberg, 2010; Lee, Gosselin, Wynn, & Green, 2011). Despite the well documented occurrence of deficits in these groups, there remains a paucity of evidence-based rehabilitation efforts to address facial emotion processing deficits. This work sought to advance an enhanced understanding of normal facial emotion processing, which may provide a basis for comparison with abnormal processing in clinical populations. This, in turn, may foster further investigations and may also facilitate the development of appropriate intervention strategies to address facial emotion processing deficits.

9.0 METHOD

9.1 PRE-EXPERIMENTAL AFFECT RATING TASK

In a pre-experimental affect rating study, participants rated the perceived affect of a set of potential surround-present and surround-absent experimental stimuli. An *a priori* concern was that viewing surround-present stimuli first may prime a mental representation of a facial surround when subsequently administered the surround-absent stimuli. To address this concern, participants rated the surround-absent stimuli first. In addition, all verbal and written material related to the experiment (e.g., phone/email script, recruitment fliers, title of the experiment) avoided references to faces. Instead, participants were informed that the experiment was related to how people perceived different shapes. Participants were debriefed about the true purposes of the experiment at its completion.

9.1.1 Pre-experimental affect rating task participant recruitment

Participants were recruited via e-mail, posted fliers, and word of mouth.

9.1.2 Pre-experimental affect rating task participant characteristics

A total of 40 individuals accessed an online survey; however one participant failed to complete all of the screening questions and another participant rated all the stimuli with the same value. These two participants were excluded from data analysis. The remaining 38 participants ranged in age from 20-25 years old (M = 21.9, SD = 1.90). Participants reported having normal or corrected-to-normal vision, at least a high school degree or equivalent, and no history of psychiatric or neurological involvement, head injury, learning disability or substance abuse based on an online eligibility questionnaire (see Appendix B).

9.1.3 Pre-experimental affect rating task description

Participants used an 8-point Likert scale (Likert, 1932) with the endpoints labeled (1 = “positive,” 8 = “negative”) to rate the main variable of interest, perceived stimulus affect. Participants in Coelho et al.’s (2010) investigation used a similar 8-point scale to rate perceived affective valence. Unlike Coelho et al.’s investigation, the endpoint labels in the current investigation were reversed for half of the participants. In each rating trial, one stimulus appeared at the top of the computer screen with the rating scale located below it (See Figure 15).

9.1.4 Pre-experimental affect rating task instructions

Before the first trial, participants read the following instructions:

You are about to see a series of designs. Below each design is an 8-point scale with the labels "POSITIVE" or "NEGATIVE" on either end.

If you think the picture is positive then choose a rating somewhere on the [left / right] side of the scale that says "POSITIVE."

If you think the picture is negative then choose a rating somewhere on the [left / right] side of the scale that says "NEGATIVE."

If you think a picture is neither positive nor negative then choose a rating towards the middle of the scale.

To make your judgments you will click the box under the number. There are no right or wrong answers for this task. You may begin the survey by pressing the spacebar.

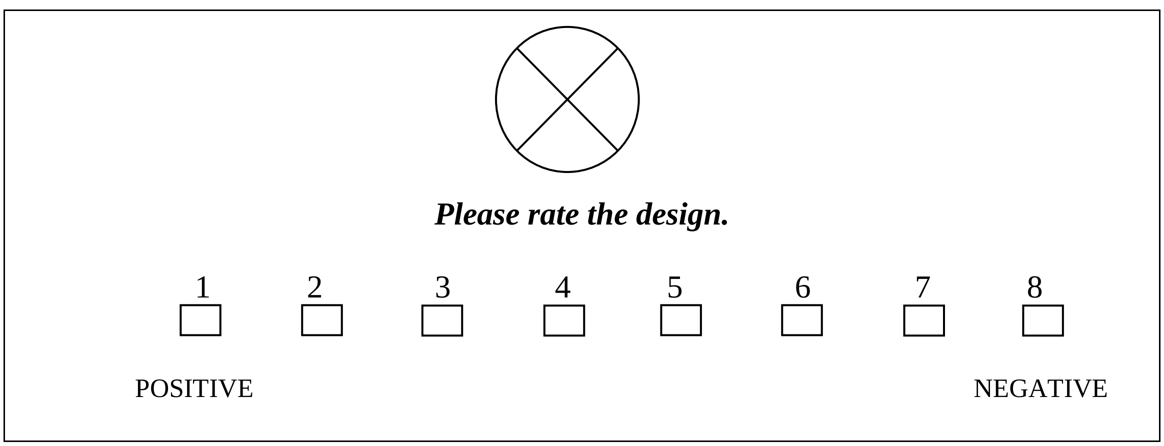


Figure 15. Pre-experimental affect rating task sample stimulus item

9.1.5 Pre-experimental affect rating task administration

All trials were administered and data were collected using an online survey (Survey Monkey). Participants provided subjective affect ratings for 69 potential stimuli for the flankers experiment, 32 of which were experimental (16 surround-absent / 16 surround-present) (see Appendix C for example of experimental stimuli).

9.1.6 Pre-experimental affect rating task stimuli

All stimuli were presented in black font and displayed on a white background. Within each of two blocks of trials (surround-absent; surround-present), the stimuli were pseudo-randomly distributed based on the following criteria: (a) each stimulus was administered only once, (b) no more than three experimental or filler stimuli occurred consecutively, (c) no more than three stimuli with conforming or nonconforming features occurred consecutively, (d) two fillers began and four fillers ended each block.

9.1.6.1 Experimental stimuli

The potential experimental stimuli for the flankers task, which were subjected to the pre-experimental affect ratings task, were created by extracting the curved "mouths" from schematic faces and presenting them with or without an outer facial surround (See Appendix C). Two mouths appeared in each potential experimental stimulus to decrease the chances of participants generating a face percept. Surround-absent potential stimuli were identical to the surround-present potential stimuli, except the outer circle that forms the facial surround was removed. In addition to revalidating some of Coelho et al.'s (2010) stimuli, participants rated a new set of potential stimuli to increase the chances of obtaining appropriate ones for the flankers experiment.

9.1.6.2 Filler stimuli

Fillers for the ratings task were included to disguise the overall purpose of the experiment and to decrease the chances of participants generating the percept of facial features. The potential flankers experiment stimuli were expected to be perceived as having minimal affect so the fillers were designed to generate more positive (e.g., a circle with a check mark) and negative affect ratings (e.g., a circle with an "x"). Fillers took various shapes, such as circles, triangles, and squares. To further disguise the purpose of the experiment, the inner lines of some of the fillers contained "nonfeatures" (e.g., an "x," a zig-zag line, a check mark) while others contained the same "mouth" inner features as those in the experimental stimuli (See Appendix D).

9.1.7 Pre-experimental affect rating task experimental procedures

Testing required one session of approximately 30 minutes and was completed online. Formal informed consent was not required because no identifying information linked participants to their responses. Participants accessed the survey via an e-mailed link. After completing the online eligibility screening (see Appendix B) and the pre-experimental affect rating task, participants read a debriefing about the true purpose of the experiment followed by a thank you message. After data collection the principal investigator (PI) randomly selected three participants to receive a $20 gift card to a store of their choice.

9.2 FLANKERS TASK EXPERIMENT

The flankers task experiment consisted of a flankers task and the Visual Form Discrimination test, both of which are described below.

9.2.1 Flankers task participant recruitment

Participant recruitment procedures paralleled those in the pre-experimental affect rating task.

9.2.2 Flankers task power and sample size calculations

When attempting to calculate sample size using previous data it was noted that effect sizes, and the necessary data to calculate them, were not reported for any flankers experiments in the literature most relevant to the current study. Thus, two steps were taken to estimate sample size. First, the PI identified the investigations in the flanker literature most similar to the current study. The maximum sample that was used to detect a 2-way interaction using stimuli and variables similar to those in the current investigation was 24 participants (Horstmann et al., 2006; experiment 3). This number, therefore, served as the minimum for the sample size. Second, a range of reported effect sizes in related visual search studies was used as a guide for determining significance for potential 2-way interactions with variables similar to those in the current investigation (i.e., Target Conformity and Flanker Compatibility). Based on this second step, and being conservative because of the differences in tasks, variables, and stimuli, the following parameters were entered in the G*Power program (version 3.1.3; Faul, Erdfelder, Buchner, & Lang, 2009): effect size = .59, α = .05, power = .80. The *a priori* power analysis recommended a sample size of 33. Considering the aforementioned factors, 35 individuals were recruited for the current study (M = 16, F = 19).

9.2.3 Flankers task participant recruitment

Participant recruitment procedures paralleled those for the pre-experimental affect ratings task.

9.2.4 Flankers task participant characteristics

Participants ranged in age from 18-25 years old (*M* = 20.9 years old, *SD* = 1.9). All participants reported having at least a high school diploma or equivalent with no history of neurological or psychiatric disorders, learning disabilities, traumatic brain injuries, or substance abuse via an eligibility questionnaire (see Appendix E). Participants also reported normal or corrected-to-normal vision.

9.2.5 Flankers task design and experimental conditions

The flankers task used a 2 x 2, within-subjects experimental design. The factors of interest are Target Conformity and Flanker Compatibility (see Table 2).

Table 2. Flankers Task Experiment: Flankers task experimental design, investigating RTs and accuracy to target conformity and flanker compatibility

		Flanker Compatibility	
		COMPATIBLE	INCOMPATIBLE
Target Conformity	CONFORMING	Conforming Target Compatible Flankers	Conforming Target Incompatible Flankers
	NONCONFORMING	Nonconforming Target Compatible Flankers	Nonconforming Target Incompatible Flankers

9.2.6 Flankers task description

Each trial began with a 1,000 ms red fixation cross, to direct participants' overt attention to the center of the screen and to indicate the start of a trial. At the offset of the fixation, a flanker display was presented. Each display contained a centrally placed experimental or filler target with flankers positioned horizontally to the right and left sides of the target. The targets were also centered on the computer monitor. Targets and flankers were 2 cm wide, 1.9 cm in height, and subtended 1.7° of visual angle in height and width. The targets and flankers were separated by 1 cm, or .086°, which is within the range of previously documented studies (Fenske & Eastwood, 2003; Horstmann et al., 2006). The flanker display remained on the screen until the participant responded. A 2000 ms inter-trial interval followed the offset of participants' responses. Figure 16 illustrates the temporal structure of the trials.

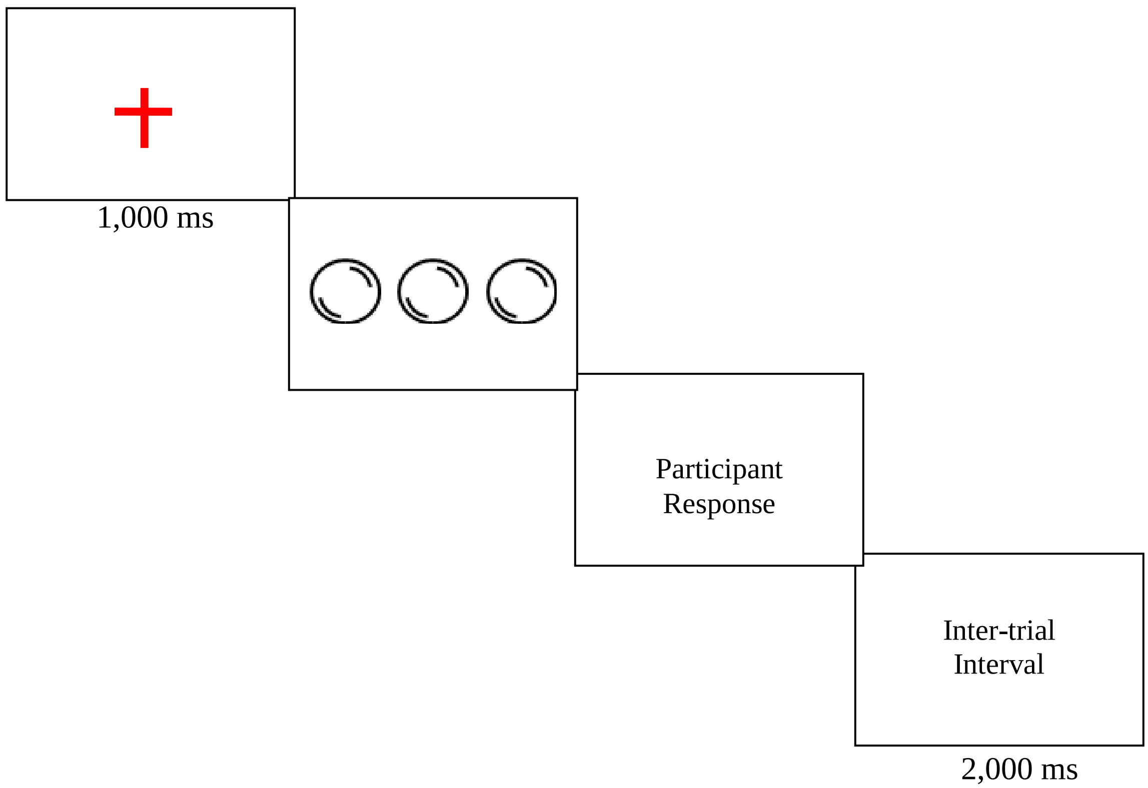


Figure 16. Temporal structure of flankers experiment task trials

There were four blocks each of surround-absent and surround-present stimuli. Within each surround condition four different block orders were created using an online random number generator (Random Number Generator). The numbers 1-4, indicating the number of blocks within each surround condition, were placed in the random number generator, producing the four block orders noted in Table 3.

Table 3. Experimental protocol for flankers task experiment

ORDER 1	ORDER 2	ORDER 3	ORDER 4
Consent Form	Consent Form	Consent Form	Consent Form
Eligibility Questionnaire	Eligibility Questionnaire	Eligibility Questionnaire	Eligibility Questionnaire
Vision Screening	Vision Screening	Vision Screening	Vision Screening
Flankers task Surround-Absent (SA) (Practice Trials)	Flankers task Surround-Absent (SA) (Practice Trials)	Flankers task Surround-Absent (SA) (Practice Trials)	Flankers task Surround-Absent (SA) (Practice Trials)
Flankers Task SA (Experimental Trials) SA BLOCK 3	Flankers Task SA (Experimental Trials) SA BLOCK 1	Flankers Task SA (Experimental Trials) SA BLOCK 4	Flankers Task SA (Experimental Trials) SA BLOCK 2
SA BLOCK 4	SA BLOCK 3	SA BLOCK 3	SA BLOCK 1
SA BLOCK 1	SA BLOCK 2	SA BLOCK 1	SA BLOCK 3
SA BLOCK 2	SA BLOCK 4	SA BLOCK 2	SA BLOCK 4
Visual Form Discrimination	Visual Form Discrimination	Visual Form Discrimination	Visual Form Discrimination
Flankers task Surround-Present (SP) (Practice Trials)	Flankers task Surround-Present (SP) (Practice Trials)	Flankers task Surround-Present (SP) (Practice Trials)	Flankers task Surround-Present (SP) (Practice Trials)
Flankers Task SP (Experimental Trials) SP BLOCK 2	Flankers Task SP (Experimental Trials) SP BLOCK 4	Flankers Task SP (Experimental Trials) SP BLOCK 1	Flankers Task SP (Experimental Trials) SP BLOCK 3
SP BLOCK 4	SP BLOCK 2	SP BLOCK 3	SP BLOCK 1
SP BLOCK 1	SP BLOCK 3	SP BLOCK 4	SP BLOCK 2
SP BLOCK 3	SP BLOCK 1	SP BLOCK 2	SP BLOCK 4
Participant Debriefing & Payment	Participant Debriefing & Payment	Participant Debriefing & Payment	Participant Debriefing & Payment

Note. Orders 1-4 determined via online random number generator.

9.2.7 Flankers task stimuli

The flankers task consisted of 200 trials, (96 experimental, 104 fillers). The 96 experimental trials comprised 8 targets, presented 12 times each. These 8 targets reflected the factorial design: 2 levels of target conformity (conforming vs. nonconforming), 2 levels of flanker compatibility (compatible vs. incompatible), and 2 levels of surround presence (present vs. absent). Prior to the experiment, there was concern that some experimental trials would need to be excluded, reducing the dataset for statistical analysis. To maximize the likelihood that there would be at least 6 valid responses for each target an E-prime (Schneider, Eschman, & Zuccolotto, 2002) computer script was written to re-administer incorrect trials.

Participants completed 8 blocks of 25 trials each. Each block contained 12 target and 13 filler trials, which were distributed into blocks based on the following conditions: (a) no more than three target or filler trials occurred consecutively, (b) no more than three right or left arrow responses occurred consecutively, (c) no more than three conforming or nonconforming targets occurred consecutively, (d) no more than three compatible or incompatible flanker displays occurred consecutively, (e) each of the 8 targets were administered twice in each block, (f) one filler began each block and four fillers ended each block, and (g) the first 4 blocks contained surround-absent trials and next 4 contained surround-present trials.

9.2.7.1 Flankers task targets

Surround-present targets were represented as circle "surrounds" containing 2 curved inner lines. The inner lines represented the "mouths" from schematic drawings of faces. Surround-absent targets consisted of only the same "mouths," without the outer surround. The targets were selected based on the results of the affect rating study (see Section 10.1).

9.2.7.2 Flankers task fillers

The outer surrounds in the surround-present fillers were circles, triangles, or squares. The surround-absent fillers were identical to the surround-present fillers, except with the surrounds removed. Fillers also were selected based on the findings from the affect rating study (see Section 10.1).

9.2.8 Flankers task administration

9.2.8.1 Flankers task administration overview

Stimulus presentation and data collection were completed using E-prime software (Schneider et al., 2002) on a Dell Inspiron 5150 notebook computer with a 12” monitor. Participants sat approximately 65cm from the monitor.

A separate set of instructions and practice trials was completed before each block of surround-absent and surround-present trials. The 16 practice trials consisted of 2 presentations each of the 4 possible experimental conditions (conforming-compatible, conforming-incompatible, nonconforming-compatible, and nonconforming-incompatible) and 8 fillers. During practice trials only, participants received visual feedback regarding their accuracy. The word ‘Correct’ or ‘Incorrect’ appeared after each response. The PI provided spoken feedback about RTs when asked (e.g., “Am I responding fast enough?”). The PI encouraged participants to respond as quickly and as accurately as possible.

9.2.8.2 Flankers task instructions

Participants received instructions for, and responded to, surround-absent trials (Appendix F) before receiving instructions for the surround-present trials (see Appendix G). For both surround conditions, spoken instructions indicated that participants would complete a computer task, and that they would respond by pressing the right or left arrow keys using their right index finger. The downward pointing arrow served as the resting spot between responses.

Participants were told that they would see a red fixation cross in the center of the computer monitor, replaced by a row of designs. The PI emphasized the need for participants to look only at the center design for all trials. The instructions stated that in some trials, a single left or right pointing arrow would be positioned directly below the center design, indicating how they should respond on the keyboard (i.e., press the right arrow key when the center design has a right arrow; press the left arrow key when the center design has a left arrow). Trials containing arrows served as fillers. Experimental trials did not have arrows. Accordingly, participants were told that when there were no arrows, one of two designs would let them know whether to press the right or left arrow key. Target conformity distinguished the two designs. One design had conforming lines and the other had nonconforming lines. However, there was no explicit mention of conformity. Rather, participants were given as much time as needed to learn which arrow key corresponded to which design. Additionally, participants learned the surround-absent designs (Blocks 1-4) independent of the surround-present designs (Blocks 5-8).

Instructions also stated that participants would complete practice trials first followed by the experimental “computer task.” Before starting the computer task, participants read specific instructions on the computer screen.

9.2.9 Flankers task accuracy scoring

In addition to collecting RTs, each response to the target was scored as correct or incorrect. This was done so that RTs could be analyzed using only correct responses and so that the data could be evaluated for a speed-accuracy tradeoff.

9.3 VISUAL FORM DISCRIMINATION

As a descriptive measure of visual perceptual skills, participants in the flankers experiment also completed the Visual Form Discrimination (VFD) test (Benton et al., 1994). This task was used to assess participants' baseline visual perceptual skills, to aid in the interpretation of the flankers data. Specifically, the test assesses discrimination of complex visual patterns that differ in subtle ways.

The VFD was included in this study for several other reasons. First, although limited reliability evidence is available (Franzen, 2000), the VFD is relatively well normed and its validity is well documented. Benton's normative data on 85 healthy participants ranging in age from 19-74 showed no effect of gender, age, or education (Benton et al., 1994). Campo and Morales (2003) also gathered normative data on 379 healthy Spanish-speaking participants ranging in age from 18-59. In addition, the validity of the VFD for identifying visual perceptual impairments has been documented in several patient populations, such as individuals with Alzheimer's disease, aphasia, Parkinson's disease, and closed head injuries (Campo & Morales, 2003). The other reason for administering the VFD was to help disguise the purpose of the flankers experiment. All verbal and written material related the pre-experimental affect ratings task and the flankers experiment (e.g., phone/email script, recruitment fliers, title of the experiment) avoided references to faces. Instead, participants were informed that the experiment was related to how people perceive different shapes. Similarly, the instructions for the VFD explicitly mentioned “shapes” and the designs in the stimuli resembled those in the flankers task.

9.3.1 VFD description

A single target design appeared at the top of a page while four additional designs (one target and three distracters) were simultaneously presented on a page below. There was no time limit to complete the task.

9.3.2 VFD stimuli

VFD targets consisted of two large geometric designs (e.g., a large triangle and a large square) with a smaller peripheral design (e.g., a smaller square placed on the right). In the three distracters, one aspect of the target is varied. For example, the small peripheral design is repositioned or rotated in one case. Another distracter presents a distortion of one of the large geometric shapes. In the last distracter, the large geometric design is rotated. Targets and distracters appear in black ink on a white background.

9.3.3 VFD administration

9.3.3.1 Overview of VFD administration

Participants sat at a table, with a three ring binder containing the laminated stimuli placed at midline. Participants viewed 2 practice and 14 experimental trials. The PI manually documented all responses.

9.3.3.2 VFD instructions

Participants were asked to identify which of the four bottom designs matched the top target design by pointing or by stating the number of the design.

9.3.3.3 VFD scoring

Scoring procedures followed those described by Benton et al. (1994). Specifically, correct answers received two points, incorrect answers involving the peripheral shape received one point, and errors involving the large geometric shapes received no points.

9.3.4 Experimental procedures for flankers task and VFD

Testing occurred in a single session and lasted approximately one hour with a break provided if requested. Written consent was obtained according to procedures approved by the University of Pittsburgh's Institutional Review Board. The PI conducted the screening and experimental protocols in a quiet room. First, participants completed the previously described eligibility questionnaire (Appendix E). Visual acuity was assessed next using the Reduced Snellen eye chart. Using one eye at a time, participants reported the identities of different sized letters on the chart located approximately 16 inches away from their eyes. This screening indicated that all participants had at least 20/20 vision. Following the eye exam participants completed half of the flankers task, specifically the four blocks containing the surround-absent stimuli. The VFD was administered next, in order to give participants a break from the computer. Following the VFD, participants viewed the four blocks of surround-present stimuli from the flankers task. The experiment concluded with participants receiving a written debriefing, the PI answering questions, and each participant receiving $15.

10.0 RESULTS

The aim of this investigation was to test the perceptual conformity hypothesis, one version of the perceptual differences hypothesis predicted to account for the documented differences in the deployment of visual attention to threatening and nonthreatening faces. In a pre-experimental task, ratings of perceived affect were obtained to identify potential stimuli for the flankers task. The flankers experiment addressed four research questions. Questions 1 and 2 asked whether incompatible flankers would generate the expected flanker-effect asymmetry, like that reported for angry and happy faces:

Question 1: in the surround-present condition, and

Question 2: in the surround-absent condition.

A flanker-effect asymmetry in the current experiment would suggest differential deployment of attention based on the perceptual conformity of the target and flankers when switched in the incompatible condition (i.e., targets with conforming inner lines and flankers with nonconforming inner lines vs. targets with nonconforming inner lines and flankers with conforming inner lines). For surround-present stimuli, the perceptual conformity account predicts a flanker-effect asymmetry manifested as significant RT differences in the incompatible condition when targets have conforming inner lines ("mouths") but no such differences when the targets have nonconforming lines. For surround-absent stimuli, the perceptual conformity account predicts the absence of a flanker-effect asymmetry. Instead, the removal of the outer surround is predicted to yield similar RTs when target and flankers are switched in the incompatible condition. This latter prediction hinges on the elimination of the relationship between the outer surround and the inner lines because the lines have nothing with which to conform.

Questions 3 and 4 asked whether incompatible flankers would produce more response interference for targets with conforming than with nonconforming inner features:

Question 3: in the surround-present condition, and

Question 4: in the surround-absent condition.

Questions 3 and 4 were motivated by two factors. First, prior data show that the magnitude of flanker compatibility effects is based on physical differences between the target and flankers (e.g., color, size, spatial proximity; see Fenske & Eastwood, 2003). If perceptual differences account for variations in visual attention deployment to emotional faces, conforming and nonconforming stimuli should elicit different amounts of flanker interference in the incompatible condition. This difference is central to Horstmann et al.'s (2010) simplicity account and S.I. Becker and colleagues' (2011) perceptual grouping account (see Section 4.1.1), for example. Second, these questions enable comparisons with the broader facial emotion literature. Extrapolating from this literature, the prediction for the current study was that for targets with incompatible flankers, significantly more response interference would occur with conforming inner lines ("mouths") than with nonconforming inner lines. Such a finding in the current investigation would suggest that the flanker compatibility effects, if found, are due to differences in perceptual conformity.

The novelty of the current investigation is the inclusion of stimuli *without* an outer surround because, according to the perceptual conformity hypothesis, different amounts of response interference are predicted for stimuli with and without an outer surround. Specifically, surround-present stimuli in the incompatible condition were predicted to generate more response interference to targets with conforming inner features than to targets with nonconforming inner features. This finding would suggest that the nonconforming nature of the inner lines with the outer surround caused the differences in interference between the target and flankers. However, no such differences were predicted for surround-absent stimuli when targets have conforming inner features compared to nonconforming inner lines in the incompatible condition. This finding would be consistent with the perceptual conformity hypothesis, in that the removal of the surround would eliminate the interaction between the inner lines and the outer surround and therefore, the amount of response interference generated. Visual attention deployment was, therefore, predicted to be distributed in a similar manner in both types of surround-absent stimuli.

10.1 PRE-EXPERIMENTAL AFFECT RATING TASK

All ratings were transformed to a common scale prior to analysis to account for the reversed endpoint labels for half of the participants (see Section 9.1.3). Individual affect ratings that deviated from the group mean for any particular stimulus by more than 2 scale points were designated as outliers. Outliers so defined constituted 4.2% of the data and were excluded from further data analysis.

To be included in the flankers task, experimental and filler stimuli had to meet two rating criteria: (a) mean ratings fell within the criterion range of ≥ 4 and ≤ 5, and (b) at least 70% of the individual participants' ratings fell within that criterion range. A total of 2 experimental stimulus pairs were desired for use in the flankers task study, one to contain conforming "mouth" features and the other to contain nonconforming "mouth" features. The "mouth" features in both of these stimulus pairs were placed in the same positions in each of the Target Conformity conditions, with and without facial surrounds. In sum, the desired stimulus pairs were:

Experimental stimulus pair 1-

a) surround-present stimulus with *conforming* "mouth" features and

b) the same as 1a with the surround removed

Experimental stimulus pair 2 -

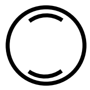
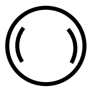
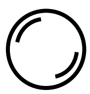
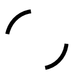
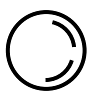
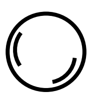
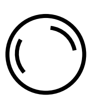
a) surround-present stimulus with *nonconforming* "mouth" features

b) the same as 2a with the surround removed

The mean affect ratings for six of the potential experimental stimuli fell outside of the ≥ 4 and ≤ 5 criterion range. These stimuli were therefore excluded. Stimuli that were part of a corresponding pair (i.e., surround-present vs. surround absent) with any of the six excluded stimuli were also excluded. In all, 22 rated experimental stimuli were entered into the data analysis (11 corresponding pairs). Tables 4 and 5 illustrate the analyzed stimulus pairs, and identify with an asterisk those that were selected for the flankers task.

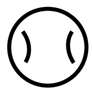
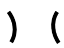
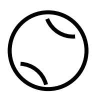
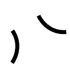
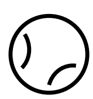
Eleven paired, two-tailed sample *t*-tests were used to assess differences in mean affect ratings for corresponding stimulus pairs (see Tables 4 and 5). Results showed that affect ratings did not differ between paired stimuli with and without a surround. Ultimately, the two stimulus pairs selected for the flankers task were those for which mean ratings most closely approximated “neutral” (score = 4.5) and for which the highest percentages of responses fell within the criterion range.

Table 4. Mean (*M*), standard deviation (*SD*), percentage of responses in 4-5 criterion range, range of affect ratings, paired t-test (*t*), p-value (*p*), and Cohen's d (*d*) of affect rating scores for surround-present and surround-absent stimulus pairs with "conforming" features

STIMULUS PAIRS		*M (SD)*	% OF RESPONSES IN 4-5 CRITERION RANGE	RANGE OF AFFECT RATINGS	TEST STATISTICS
Surround-Present Conforming A		4.41 (1.21)	56.7% (n=20)	2-7	*t*(34) = 1.14 *p* = .263 *d* = .10
Surround-Absent Conforming A		4.28 (1.32)	63.9% (n=23)	2-7	
Surround-Present Conforming B		4.33 (.86)	75.0% (n=27)	3-6	*t(34)*= .32 *p* = .751 *d* = .08
Surround-Absent Conforming B		4.41 (1.24)	65.7% (n=23)	2-7	
Surround-Present Conforming C		4.32 (.85)	75.7% (n=28)	3-6	*t(34)* = .68 *p* = .499 *d* = .01
Surround-Absent Conforming C		4.31 (1.10)	69.4% (n=25)	2-7	
Surround-Present Conforming D		4.10 (.67)	80.6% (n=29)	3-5	*t*(34) = .68 *p* = .501 *d* = .18
Surround-Absent Conforming D		4.25 (1.0)	66.7% (n=24)	2-6	
Surround-Present Conforming E		4.12 (1.00)	63.2% (n=24)	2-6	*t(34)* = .28 *p* = .782 *d* = .10
Surround-Absent Conforming E		4.23 (1.11)	60.0% (n=21)	2-6	
*Surround-Present Conforming F		4.00 (.63)	80.5% (n=29)	3-5	*t(34)* = .27 *p* = .786 *d* = .20
*Surround-Absent Conforming F		4.15 (.89)	73.6% (n=25)	2-6	

*Stimuli selected for use in experimental flankers task

Table 5. Mean (*M*), standard deviation (*SD*), percentage of responses in 4-5 criterion range, range of affect ratings, paired t-test (*t*), p-value (*p*), and Cohen's d (*d*) of affect rating scores for surround-present and surround-absent stimulus pairs with "nonconforming" features

STIMULUS PAIRS		*M* (SD)	% OF RESPONSES IN 4-5 CRITERION RANGE	RANGE OF AFFECT RATINGS	TEST STATISTICS
Surround-Present Nonconforming A		4.08 (.84)	75.0% (n=27)	2-6	*t(34)* = .88 *p* = .386 *d* = .16
Surround-Absent Nonconforming A		4.25 (1.30)	55.5% (n=20)	2-7	
Surround-Present Nonconforming B		4.17 (.85)	77.8% (n=28)	2-6	*t(34)* = .78 *p* = .439 *d* = .19
Surround-Absent Nonconforming B		4.37 (1.21)	57.1% (n=20)	3-7	
Surround-Present Nonconforming C		4.11 (.65)	84.2% (n=32)	3-6	*t(34)* = 2.02 *p* = .051 *d* = .43
Surround-Absent Nonconforming C		4.51 (1.15)	65.7% (n=23)	3-7	
*Surround-Present Nonconforming D		4.03 (.80)	81.1% (n=30)	2-6	*t(34)* = 1.28 *p* = .211 *d* = .26
*Surround-Absent Nonconforming D		4.25 (.91)	75.0% (n=27)	2-6	
Surround-Present Nonconforming E		4.00 (.48)	88.9% (n=32)	3-5	*t(34)* = .36 *p* = .721 *d* = 0
Surround-Absent Nonconforming E		4.00 (1.0)	62.2% (n=23)	2-6	

*Stimuli selected for use in experimental flankers task

10.2 FLANKERS TASK

10.2.1 Data preparation

Prior to data analysis, data were excluded for incorrect responses (2.3%) and for RTs faster than 100 ms or, on an individual basis, greater than 3 SDs above that participant's mean RT (10.2%).

Shapiro-Wilk's test of normality showed non-normal RT distributions for each of the experimental conditions (all $ps < .001$). Thus, a logarithmic transformation was applied to approximate a normal RT distribution. Each analysis described in the results sections below exhibited the same pattern of results for logarithmically transformed and non-logarithmically transformed RT. Thus, the non-logarithmically transformed data are presented hereafter, for ease of interpretation. The critical significance level was set at $\alpha = 0.05$. Descriptive data for the eight experimental conditions are shown in Tables 6 and 7.

Table 6. Cell means (*M*) RT (milliseconds), standard deviations (SD), and ranges for the experimental conditions, Target Conformity and Flanker Compatibility, in surround-present and surround-absent trials from the flankers task

	Flanker Compatibility	
Target Conformity	**Compatible**	**Incompatible**
***Surround-Present**		
Conforming		
M (SD)	690.19 (161.85)	707.14 (164.66)
Range	354-1677	378-1778
Nonconforming		
M (SD)	700.72 (151.55)	733.64 (168.29)
Range	394-1209	405-1450
****Surround-Absent**		
Conforming		
M (SD)	702.68 (160.17)	731.68 (164.66)
Range	342-1341	421-1671
Nonconforming		
M (SD)	699.94 (175.45)	726.51 (161.95)
Range	353-1338	360-1323

*Total of 288 trials were compared across each condition
**Total of 231 trials were compared across each condition

Table 7. Marginal means (*M*) RT (milliseconds), standard deviations (SD), and ranges for the experimental conditions, Target Conformity and Flanker Compatibility, in surround-present and surround-absent trials from the flankers task

	*Surround-Present	**Surround-Absent
Target Conformity		
Conforming		
M (SD)	698.73 (140.90)	717.18 (143.71)
Range	393-1257	426-1221
Nonconforming		
M (SD)	716.41 (140.50)	713.22 (148.79)
Range	403-1207	391-1158
Flanker Compatibility		
Compatible		
M (SD)	695.10 (133.65)	701.31 (147.71)
Range	446-1181	374-1140
Incompatible		
M (SD)	720.04 (144.79)	729.09 (145.39)
Range	391-1358	406-1225

*A total of 288 trials were compared across each condition
**A total of 231 trials were compared across each condition

10.2.2 Accuracy / Error analysis

Accuracy data for each experimental condition are presented in Table 8. Accuracy ranged from 90% to 99%. Responses were at ceiling with the exception of surround-absent trials with conforming targets and compatible flankers.

Table 8. Mean accuracy and standard deviations (SD) for experimental conditions in the flankers task

	Surround-Present	**Surround-Absent**
Conforming Compatible M (*SD*)	.99 (.09)	.90 (.31)
Conforming Incompatible M (*SD*)	.98 (.12)	.98 (.14)
Nonconforming Compatible M (*SD*)	.99 (.11)	.99 (.09)
Nonconforming Incompatible M (*SD*)	.98 (.14)	.97 (.17)

10.2.3 Research questions 1 & 2

The purpose of research questions 1 and 2 was to assess whether surround-present (Research Question 1) and surround-absent (Research Question 2), abstract stimuli, containing conforming and nonconforming inner lines, generated the expected flanker-effect asymmetries that have been reported for angry vs. happy faces in healthy adults. The flanker-effect asymmetry is represented as RT differences when the conformity of the target and flankers is switched.

10.2.3.1 Research question 1- Surround-present condition

A 2 (Target Conformity: conforming vs. nonconforming) x 2 (Flanker Compatible: compatible vs. incompatible) within-subjects Analysis of Variance (ANOVA) yielded significant main effects for Target Conformity ($F(1,287) = 6.32$, $p = .012$, $\eta^2 = .02$) and Flanker Compatibility

($F(1,287) = 12.91$, $p < .001$, $\eta^2 = .04$). Participants responded significantly faster to surround-present conforming targets compared to nonconforming targets and to surround-present compatible trials than to incompatible trials (see Table 6). The Flanker Compatibility results replicate and extend previous findings, consistent with a basic flanker compatibility effect (Fenske & Eastwood, 2003; Horstmann et al., 2006). There was no significant interaction ($F(1,287) = 1.60$, $p = .207$. $\eta^2 = .01$).

10.2.3.2 Research question 2 – Surround-absent condition

Another 2 (Target Conformity: conforming vs. nonconforming) x 2 (Flanker Compatible: compatible vs. incompatible) within-subjects ANOVA indicated a significant main effect for Flanker Compatibility ($F(1, 230) = 15.15$, $p < .001$, $\eta^{2\,=}$ .06), showing faster RTs to surround-absent compatible versus incompatible trials (see Table 6). There were no significant difference between RTs to targets with conforming vs. nonconforming inner lines ($F(1, 230) = .32$, $p = .575$, $\eta^{2\,=}$ .00) and no significant interaction effects ($F(1, 230) = .03$, $p = .868$, $\eta^{2\,=}$ .00).

10.2.4 Research questions 3 & 4

Research Questions 3 and 4 asked whether surround-present (Research Question 3) and surround-absent (Research Question 4), incompatible flankers produced more response interference when targets have conforming inner lines than when targets have nonconforming inner lines.

10.2.4.1 Overview of RT proportion calculations

To take into account potential variations in inter-individual response speeds, RT proportion scores were calculated to determine the magnitude of flanker interference separately for the surround-present and surround-absent conditions. These scores were computed within participant by first subtracting RTs in the compatible condition from RTs in the incompatible condition for each item, producing a difference score. Each difference score was then divided by the incompatible condition RT for that specific item. The calculations were computed independently for conforming and nonconforming stimuli in both the surround-present and surround-absent conditions. For example, in both surround conditions, the calculation for the conforming stimuli was ((Conforming Incompatible RT – Conforming Compatible RT) / Conforming Incompatible RT) and for nonconforming stimuli it was ((Nonconforming Incompatible RT – Nonconforming Compatible RT) / Nonconforming Incompatible RT). The calculations produced four proportion scores for the following conditions: (1) surround-present conforming, (2) surround-present nonconforming, (3) surround-absent conforming, and (4) surround-absent nonconforming. Table 9 provides descriptive data for these scores.

Table 9. RT proportion scores, Mean (M) and standard deviations (SD) for surround-present and surround-absent conditions

RT Proportion Scores*	**Surround-Present**	**Surround-Absent**
Conformity		
Conforming		
M (SD)	.01 (.01)	.03 (.07)
Range	-.17 - .17	-.17 - .16
Nonconforming		
M (SD)	.02 (.01)	.03 (.08)
Range	-.10 - .09	-.08 - .16

Note. RT proportion scores = ((Incompatible RT –Compatible RT) / Incompatible RT)) for conforming and nonconforming trials in surround-present and surround-absent conditions

*The RT proportion scores cannot be computed directly from the mean RT data in other Tables because these scores were calculated with different denominators for each participant.

10.2.4.2 Research question 3 - RT proportion scores for surround-present stimuli

A paired samples *t*-test, contrasting the amount of response interference in the incompatible condition when surround-present targets had conforming (M = .01, SD = .01) vs. nonconforming (M = .02, SD = .01) inner lines, showed no significant differences ($t(34) = -1.43$, p = .163).

10.2.4.3 Research question 4 - RT proportion scores for surround-absent stimuli

A second paired samples *t*-test, contrasting the amount of response interference in the incompatible condition when surround-absent targets had conforming (M = .03, SD = .07) vs. nonconforming (M = .03, SD = .08) inner lines, again showed no significant differences ($t(34)$ = -.164, p = .871).

10.2.5 Speed-accuracy analysis

Participants responded with high accuracy for each of the eight experimental conditions (see Table 8). A paired samples *t*-test, comparing the average RTs for correct (M = 717.00, SD = 169.89) and incorrect responses (M = 782.31, SD = 116.62) showed no indication of a speed accuracy trade-off ($t(7) = -1.68$, $p = .137$).

10.3 VISUAL FORM DISCRIMINATION (VFD) PERFORMANCE

The maximum number of points in the VFD is 32 with the cutoff off for normal performance at 25. Performance in the current study ranged between 25 and 32, with participants showing high levels of accuracy, overall (M = 31.20, SD = 1.51).

11.0 DISCUSSION

Several hypotheses exist to explain reported differences in visual attention deployment between threatening and nonthreatening faces. The facial affect claim predicts that facial affect underlies such differences (e.g., Feldmann-Wüstefeld et al., 2011; Fenske & Eastwood, 2003; Horstmann, 2007; Horstmann & Bauland, 2006; Horstmann et al., 2006; Purcell & Stewart, 2010). Other researchers posit an alternative explanation related to the perceptual differences between threatening and nonthreatening faces (e.g., D. V. Becker et al., 2011; Calvo & Nummenmaa, 2008; Coelho et al., 2010; Horstmann et al., 2010; Horstmann et al., 2006; Purcell & Stewart, 2010; Purcell et al., 1996). While there are multiple perceptual differences hypotheses, the current investigation tested a prediction of the perceptual conformity hypothesis (e.g., Coelho et al., 2010; Horstmann et al., 2010; Horstmann et al., 2006; Purcell & Stewart, 2010).

The perceptual conformity hypothesis claims that the documented differences in attention deployment between threatening and nonthreatening faces are driven by whether the inner facial features conform to the surround of the face (e.g., an upturned mouth follows the contour of the chin while a downturned mouth does not). This hypothesis was tested with nonemotional abstract stimuli, some with and some without an outer facial surround. If the perceptual conformity hypothesis is valid then the pattern of results should differ for stimuli with and without the outer surround. The results of the current investigation are not consistent with this prediction, suggesting that perceptual conformity may not drive the previously reported differences in visual attention deployment between threatening and nonthreatening faces.

The second hypothesis in this study related to whether incompatible flankers would produce more response interference when targets had conforming vs. nonconforming inner lines. The magnitude of flanker effects is posited to reflect the physical differences between the target and flankers (e.g., Fenske & Eastwood, 2003). If perceptual conformity constitutes one such physical difference, then flankers with conforming and nonconforming inner lines should elicit different amounts of interference in the incompatible condition when an outer surround is present. When the outer surround is eliminated, such differences were predicted to disappear. This was not the case for the current investigation. Instead, the data demonstrated non-significantly different amounts of response interference from incompatible flankers when surround-present targets had conforming and nonconforming inner lines. Results from the surround-absent condition are clouded because the predicted differences in the surround-present condition were not upheld. Overall, the findings of this study raise questions about the perceptual conformity hypothesis and leave open alternative explanations regarding the factors that are predicted to guide the deployment of visual attention to different categories of facial emotions.

The current study's findings also may reflect methodologic factors, as elaborated below. The results must be considered in light of broader issues plaguing the facial emotion and visual attention literatures, as well. For example, the evidence used to argue that threat-related stimuli draw attention more rapidly than nonthreatening stimuli is weakened due to conflicting findings (e.g., Calvo & Nummenmaa, 2008; Coelho et al., 2010; Horstmann et al., 2010; Juth et al., 2005) and possible methodological confounds previously described. Additionally, the evidence used to bolster support for the flanker-effect asymmetry between threatening and nonthreatening faces remains scant (e.g., Fenske & Eastwood, 2003; Horstmann et al., 2006). The limited number of investigations reporting the flanker-effect asymmetry makes it difficult to draw firm conclusions about its reliability. In light of the current study's findings, in which no flanker-effect asymmetry occurred for nonemotional abstract stimuli, it could be questioned whether the flanker-effect asymmetry is a robust finding. Collectively, these critical issues could undermine the validity of previously documented visual attention differences between threatening and nonthreatening faces.

These issues will be addressed in greater detail throughout the remainder of the document after the interpretations of the primary findings are provided and compared with data from the extant literature. The implications of the current data will also be described along with the investigation's strengths and limitations. The chapter closes with considerations of how the current study's findings might inform future research efforts.

11.1 FLANKER-EFFECT ASYMMETRY

The first aim in the current investigation was to compare the patterns of results between surround-present and surround-absent conditions to infer whether perceptual conformity played a role in reported flanker-effect asymmetries for angry vs. happy faces.

11.1.1 Surround-present condition

As expected the flanker *compatibility* effect was evidenced by faster responses to compatible vs. incompatible trials, a finding that is consistent with the flanker studies reviewed thus far (i.e., Fenske & Eastwood, 2003; Horstmann et al., 2006). The flanker compatibility effect suggests that flankers, which are presumed to be ignored, were processed at some level in the periphery (e.g., Eriksen & Eriksen, 1974; Fenske & Eastwood, 2003; Horstmann et al., 2006). However, contrary to prediction, there was no indication of a flanker-effect asymmetry for the surround-present condition. That is, participants responded similarly in the incompatible conditions when targets had conforming and nonconforming inner lines. Thus, the findings from the current study do not square with expectations based on the perceptual conformity hypothesis.

One possibility to explain the lack of a flanker-effect asymmetry is that visual attention was equally deployed to surround-present nonconforming and conforming flankers in the incompatible condition. It is plausible that the visual system did not detect any distinguishing stimulus properties that would render flankers or targets more readily available in one conformity condition than in the other. This argument is consistent with findings suggesting that distinguishing stimulus properties may be ultimately responsible for driving the reported differences in attention deployment (e.g., D. V. Becker et al., 2011; Hansen & Hansen, 1988; Horstmann et al., 2006). Examples of such distinguishing stimulus properties include the presence vs. absence of a discriminative perceptual feature, such as the line in the lollipop stimuli of Horstmann et al.'s study (2006; see Figure 14), the black blotch in the angry faces of Hansen and Hansen's (1988) stimuli, or the visibility of exposed teeth in smiling faces (e.g., D. V. Becker et al., 2011; Juth et al., 2005). In the current study, no discriminative perceptual feature differentiated the surround-present conforming and nonconforming flankers in the incompatible condition. Without a distinguishing feature to influence visual attention, attention was more likely to be equally deployed from the target to the periphery. However, this argument does not account for findings from other studies in which attentional differences were noted using stimuli that may also have lacked a distinguishing stimulus property.

Differences in the degree of perceptual saliency between the experimental target and flankers might also account for the noted flanker-effect asymmetry in other studies and the failure to find this effect in the current study. One such perceptual salience difference relates to the size of the stimulus elements, which has been documented to be a guiding attribute of visual attention (e.g., Treisman & Gormican, 1988; Wolfe & Horowitz, 2004). The inner stimulus elements in the current study and in Horstmann and colleagues' (2006) investigation differed in size. As a reminder, Horstmann et al. created their stimuli by inverting and then superimposing the upwards and downwards curved lines in the positive and negative faces from their second experiment (see Figure 13). The curved lines making up the 'Xs' and 'Os' constituted the majority of the space inside the surround, thus appearing to be very large within the surround. With larger inner stimulus elements, the degree of perceptual saliency difference between the target and flankers may also have been greater compared to the degree of difference in the current stimuli with smaller inner elements. Specific to Horstmann et al.'s stimuli, the larger inner elements may have represented a greater degree of perceived 'nonconformity' for the "X" flankers in the incompatible condition compared to the degree of perceived 'conformity' with the "O" flankers in the incompatible condition. With a larger degree of perceptual salience difference between the target and fillers, as is hypothesized for Horstmann et al.'s stimuli, visual attention may have been more easily directed by the nonconforming flankers in the incompatible condition, yielding a flanker-effect asymmetry. Conversely, the smaller degree of perceptual saliency difference between the target and flankers in this study may not have influenced visual attention differentially.

A similar argument about perceptual saliency differences can be made for the stimuli in Horstmann et al.'s (2006) fourth experiment, in which a flanker-effect asymmetry was noted using circle and lollipop targets (see Figure 14). The investigators acknowledged that the flanker-effect asymmetry for these stimuli could have stemmed from participants using a discriminative perceptual feature in the lollipop stimuli that was absent in the circle stimuli (i.e., the vertical line at the bottom half of the lollipop). It is convincing that such a distinct perceptual feature, like the line in the lollipop, is difficult to ignore when presented in a flanker. Therefore, attentional mechanisms might have been deployed differently to the circle and lollipop flankers compared to the flankers in the current investigation in which the same perceptual features were always present.

11.1.2 Surround-absent condition

Consistent with the *a priori* prediction, there was no indication of a flanker-effect asymmetry for the surround-absent condition. This result would have provided strong evidence consistent with the perceptual conformity account if a flanker-effect asymmetry was noted in the surround-*present* condition. Since no such effect was found with surround-present stimuli an alternative interpretation is needed.

One such interpretation might be related to the larger issues that have been previously mentioned. For example, the extant results that suggest differences in attentional capture to threatening vs. nonthreatening stimuli remain debatable and inconsistent. The lingering empirical inconsistencies in studies using surround-present stimuli, therefore, limit interpretations in this study. If perceptual conformity does play a role in the reported attention differences, then removing the outer surround in the current study should have reduced any relationship between the inner features and the outer surround. Specifically, the conforming features in the surround-absent condition may have become as available to the visual system as the features in the nonconforming stimuli since the features were no longer bound by the outer surround. It is not possible to compare the current findings to others because this is the first flanker investigation to use surround-absent stimuli.

11.2 RESPONSE INTERFERENCE

The second aim of the current investigation was to test whether surround-present and surround-absent, incompatible flankers produced more response interference when targets had conforming inner features than when targets had nonconforming inner features.

11.2.1 Surround-present condition

The prediction did not hold that incompatible flankers would generate more response interference to targets with conforming inner features. This lack of effect mirrors Fenske and Eastwood's (2003) data for abstract stimuli presumed to be devoid of emotion (see their Experiment 1B). Beyond possible methodological reasons for this outcome, as described in depth in Section 11.3, below, there are three potential explanations for the failure to find response interference differences. First, given the mixed findings in the literature, it could be questioned whether the prediction itself was sound. Second, until more conclusive data corroborate attentional differences for threatening vs. nonthreatening stimuli, it may be premature to try to determine the factors, such as perceptual conformity, that may underlie these presumed differences. Finally, it is possible that perceptual conformity, as operationalized in this study, is not a feature that generates differences in response interference.

11.2.2 Surround-absent condition

Again, the outcomes from the surround-absent condition appear to fall in line with the *a priori* prediction, i.e., that in the incompatible condition, there would be no difference in the amount of response interference for targets with conforming vs. nonconforming inner lines. This finding would be consistent with the perceptual conformity hypothesis, in that the removal of the surround should eliminate the relationship between the inner features and surround and therefore any difference in the amount of response interference. However, this interpretation would depend on predicted differences in the surround-present condition. Since these differences did not occur, it is not possible to attribute the surround-absent findings to perceptual conformity. When considering an explanation as to why these differences did not occur, the issues described in the previous sections again are likely to be important (e.g., the question of whether attention differences between threatening vs. nonthreatening faces are reliable). Again, it is impossible to compare these findings with other investigations that only used surround-present conditions.

11.3 EXPLANATIONS FOR OUTCOME DIFFERENCES ACROSS INVESTIGATIONS

Several potential explanations have already been provided to account for the outcome differences between prior flanker studies and the current study. However, other possible explanations remain.

11.3.1 Variability of the data

In light of the large degree of variability in the RT data, the question arises whether the failure to uphold predictions may be due in part to a reduced power to detect significant effects. In the conditions most relevant to the flanker-effect asymmetry, the surround-present conforming and nonconforming trials (see Table 7), the standard deviations were 20% of their respective condition means. By contrast, the same ratios of standard deviations to means for Fenske and Eastwood (2003) were substantially smaller, on the order of 3% to 4%. Horstmann et al. (2006) did not provide numerical data for means or standard errors. Despite the increased variability in the current dataset, the direction of differences in RT means for surround-present, incompatible, conforming and nonconforming trials is opposite that expected. Thus, reduced power does not explain the failure to obtain a flanker-effect asymmetry in the current study. For the flanker interference data (Table 9), the degree of RT variability is even higher, with standard deviations representing 100% and 50% of the condition means for the surround-present conforming and nonconforming conditions, respectively. Again, though, the direction of differences in the data was opposite of that predicted, so reduced power is not solely responsible for the unexpected results.

11.3.2 Fillers vs. no fillers

To disguise the purpose of the current experiment, fillers constituted half of the administered items. However, there were no fillers in Horstmann et al.'s (2006) and Fenske and Eastwood's (2003) studies. As a reminder, the fillers in each flanker display in the current study contained arrows pointing left or right to maintain the same response mapping for experimental and filler stimuli.

Because arrows indicate a direction, it is possible that the requirements needed to process the stimulus elements, and then to choose a response, differed between filler and experimental trials. For example, the arrows might have served as a visual cue, generating an implicit priority for responses to fillers relative to the experimental trials. To assess this possibility a follow-up analysis was conducted to examine possible differences in RTs to filler vs. experimental items. The data were consistent with this explanation in that participants responded significantly faster to fillers than to experimental trials ($p < .001$). This finding falls in line with results from a modified version of the flanker task in which a cuing paradigm is implemented to study attentional selection (Posner, 1980; Posner & Cohen, 1984). In these modified flanker investigations either a central or peripheral cue is administered prior to presenting the target stimuli. This cue is intended to prompt overt visual attention deployment from a central target to the location of the cue. Evidence from these studies shows that participants respond more quickly to cued than to uncued trials (e.g., Klemen, Verbruggen, Skelton, & Chambers, 2011; Paquet & Lortie, 1990). The explanation for this finding is that selective attention has been facilitated by the cue.

In the current study, despite instructions to focus overt visual attention on the center target, the arrows may have elicited overt and/or covert visual attention shifts to the periphery.

This possibility can be evaluated in resource models of visual attention which will be explained in greater detail later (Section 11.4.1). In brief, the arrows could have directed attentional resources away from the centrally located target towards the peripheral location to which the arrow pointed. Each time participants viewed an arrow in a filler trial vs. an experimental item without an arrow, the task demands may have been re-evaluated. As such, the processing resources required to complete the task may also have been adjusted. If true, the allocation of attentional resources might have been based on the nature or type of trial (i.e., trials with arrows vs. no arrows). When arrows were present, they might have directed attentional resources away from the central target towards the periphery. When arrows were not present, more attentional resources might have been allocated to target. In this case, and with the periphery presumably ignored, one could argue that a stronger flanker-effect asymmetry might be noted. However, this explanation hinges on two critical assumptions. The first is that the absence of an arrow in the experimental trials reduced attention shifts to the periphery. If this assumption is invalid, then a true flanker-effect asymmetry may not have been detected. The second assumption is that there was some feature in the periphery that *could* elicit attention shifts from the central targets. That is, if perceptual conformity as operationalized in this study does not influence visual attention deployment, then there would be no reason for attention to shift from the central target to the periphery.

This line of reasoning might explain why a flanker-effect asymmetry was noted in Horstmann et al. (2006) and Fenske and Eastwood's (2003) experiments and not in the current study. Specifically, the differences in outcomes might be explained by the cross-investigational differences in the allocation of attentional resources to the target and the periphery. It is presumed that significantly more attentional resources were allocated to the targets in the other studies, because the stimuli contained no directional cues. In contrast, the failure to detect a flanker-effect asymmetry in the current study may have stemmed from visual attention being disproportionately allocated to the periphery. Although the flanker-effect asymmetry is based on the experimental compatible and incompatible conditions and not on the fillers, it is unknown if and how the arrow cues in the filler trials might have altered task demands and/or affected the amount of attentional resources that typically would have been influenced by the experimental nonconforming flankers in the incompatible condition. The possibility that the attentional demands might have differed between the current study and other flanker studies might be tested by adding a divided attention demand to a portion of the stimuli or tasks used in prior investigations.

11.3.3 Repetitions of experimental variables

Previous flanker studies and the current study also differed in the number of times each stimulus of interest was administered. The experimental stimuli in the current study were administered 12 times and no flanker-effect asymmetry was obtained for surround-present stimuli. Fenske and Eastwood (2003) and Horstmann et al. (2006) used 24 and 34 repetitions of their experimental trials, respectively, and found flanker-effect asymmetries. It is unknown if the flanker-effect asymmetry might have been noted in the current study if more repetitions been administered. It is plausible that the effect might be present with more repetitions because the stimulus-response mapping would have occurred already. The attentional system would no longer have been needed for learning the task and could instead be diverted as occurs typically with attentional shifting in flanker tasks. Future studies could test this hypothesis by using a similar number of repetitions as those in Fenske & Eastwood (2003) or Horstmann et al.’s (2006) studies.

11.3.4 Stimulus probability and expectancy

Stimulus probability may provide another potential explanation of the difference in outcomes between the current study and those that reported a flanker-effect asymmetry. The flanker-effect asymmetry is assumed to be based on nonstrategic attention allocation. However, upon close consideration, it appears that an unintended, high-probability pattern in the sequencing of stimuli may have induced a strategic allocation of attention in the current study.

To explain, a disproportionately high percentage (69%) of fillers with arrows pointing in one direction (e.g., left arrow) were followed by trials that required the opposite response (e.g., right arrow response) relative to trials requiring the same response (e.g., left arrow). These differences in probability could have therefore elicited a strategic allocation of attention (Posner, 1980; Posner, Davidson, & Snyder, 1980; Posner, Nissen & Ogden, 1978), invoking preparatory activity that influenced the information-processing system to perform more efficiently on pairs of filler-experimental trials that differed in response (Gehring, Gratton, Coles, & Donchin, 1992). Preparatory activity is suggested to accomplish cognitive operations before what typically might be accomplished when a stimulus appears. Therefore, the absence of a flanker-effect asymmetry in the current study may have resulted because some of the processing operations that are typical in flanker tasks may not have occurred. Specifically, attention may not have been influenced by the flankers if the information processing system was prepared for a trial prior to its onset. If such preparatory activity occurred, that could account for the lack of differences in attention deployment to incompatible conforming and nonconforming flankers.

The variability in the current dataset is consistent with the probability that, over the course of the experiment, participants implicitly or explicitly began to expect that trials with an arrow pointing in one direction would be followed by trials that required the opposite response.

When the expectancy was met, RT benefits would have accrued, but when the expectancy was not met, RT costs would have occurred. Overall, this would yield larger RT variability than in experiments with sequential responses that were not so predictable.

The influence of stimulus probability and expectations on attention deployment has been previously documented (Browning & Harmer, 2012; Itti & Baldi, 2009; Kok, Jehee, & de Lange, 2012). According to Browning and Harmer (2012), people detect, recognize, and respond to stimuli that are expected more readily than those that are not expected. These authors argue that expectations help people process information that conforms to previously formed beliefs. Again, the possibility of a strategic allocation of attention related to stimulus probability and expectancy could have played a role in the absence of a flanker-effect asymmetry in the current investigation. This potential confound can be addressed in future studies by ensuring that relevant probabilities are better controlled.

11.3.5 Order of presentation of surround-present and surround-absent stimuli

The order of presentation of the surround-present and surround-absent stimuli might also have contributed to the differences in findings between the current investigation and the other flanker studies that have reported a flanker-effect asymmetry. In the current study, it was thought that if participants saw the surround-present trials first, they might generate mental representations of an outer surround when viewing the surround-absent trials. Therefore, participants always saw the surround-absent items before the surround-present trials. What must be considered, then, are the potential implications of this stimulus presentation order on visual attention deployment.

One consideration relates to the perception of the flanker display elements as single vs. multiple entities. The presence of an outer surround in any stimulus indicates a border and cues the percept of a single entity. The flanker displays for the surround-present stimuli consisted of three individual elements, each circumscribed by an outer surround (see Figure 16 for an example). There was no such perceptual boundary in the surround-absent conditions. The elimination of the outer surrounds might have caused the six lines (2 curved lines within each element) to be grouped in a manner that was not intended, thereby affecting the locus of visual attention. If this notion is correct, the outer surround in the surround-present trials might have focused attentional resources more on the central target compared to the targets in surround-absent trials. Without an outer surround, visual attention distribution was more likely to shift from the target to the periphery, enhancing flanker processing. Related to the current investigation, this explanation is consistent with the finding that participants responded faster to targets with conforming vs. nonconforming inner lines in the surround-present condition but not in the surround-absent condition. In addition, a *post-hoc* paired samples *t*-test showed significantly faster responses to surround-present (M = 710.53, SD = 160.01) vs. surround-absent (M = 724.56, SD = 181.17) stimuli ($t(1429) = 2.25$, $p = .025$). The overall slowed responses to surround-absent stimuli might also imply that participants required more time to determine the elements constituting the target. In the current study, the center of the target and the center of the flankers were separated by distances used in previous studies (e.g., Fenske & Eastwood, 2003; Horstmann et al., 2006). However, those studies did not include surround-absent trials. Therefore, it is possible that the center of the target and flankers in surround-absent flanker displays needs to be placed at greater distances to ensure they are perceived as intended. If implemented, future investigators must also keep in mind the documented impact of flanker eccentricity on response interference. Specifically, flanker interference decreases significantly when flankers are positioned farther away from the center of the target (e.g., Eriksen & Eriksen, 1974; Rowe, Hirsh, & Anderson, 2007; Zeef, Sonke, Kok, Buiten, & Kenemans, 1996).

11.4 THEORETICAL INTERPRETATIONS

This section considers how the findings of the current study might be explained by current models of visual attention and addresses theoretical implications of the results for the perceptual conformity hypothesis. As the attention literature is vast, the next section focuses specifically on a small selection of theoretical models most relevant to the aims of the study.

11.4.1 Theoretical interpretations according to models of visual attention

Despite the absence of a flanker-effect asymmetry for surround-present stimuli and the limited interpretations afforded by the surround-absent stimuli, the expected flanker *compatibility* effect was noted for both surround conditions. The flanker compatibility effect was evidenced by faster responses to compatible versus incompatible trials, a finding that is consistent with other data (e.g., Fenske & Eastwood, 2003; Horstmann et al., 2006). The flanker compatibility effect suggests that flankers, which are presumed to be ignored, were processed from the periphery (Eriksen & Eriksen, 1974; Fenske & Eastwood, 2003; Horstmann et al., 2006).

One explanation for the flanker compatibility effect is that it reflects a failure of selective attention resulting in the flankers receiving attentional processing (Chastain, Cheal, & Lyon, 1996; Paquet & Lortie, 1990; Schmidt & Dark, 1998; Yantis & Johnston, 1990). Schmidt and Dark (1998) associated the failure of selective attention to participants' intentions. They contended that intention cannot define attention. That is, a person's intention to direct overt visual attention exclusively to targets is not adequate to successfully restrict visual attention to those targets. Therefore, the flanker compatibility effect is thought to reflect limitations in the ability to focus attention on the target, as intended (e.g., Diedrichsen et al., 2000; Eriksen & Eriksen, 1974).

The flanker compatibility effects, and other findings in the current study, might also be explained by Kahneman's (1973) resource allocation theory. The major assumption of this theory is that human cognitive activity is fueled by a limited capacity processor. This processor contains resources that are allocated to various mental operations as needed. The allocation of resources is based on several factors including the task demands, performance criteria, and level of arousal or alertness. Therefore, some processes may require more resources than others, to optimize performance on a task. When the total necessary resource capacity exceeds that which is available, performance declines on tasks supported by those processes (Hula, 2011). As was mentioned previously, the failure to find a flanker-effect asymmetry in the current study may have resulted from differences in the amount of attentional resources available to be influenced by the nonconforming flankers in the incompatible condition. There are two ways in which the current study's findings might be explained by this model.

First, the current study likely had different attentional demands than other studies, the implications of which were described in Section 11.3.1. Second, it is possible that more attentional resources were needed to focus attention on the targets because there was always competing information in the periphery. In studies that had a "no-flanker" condition (i.e., Fenske & Eastwood, 2003; Horstmann et al., 2006), for example, the available supply of resources could be more completely dedicated to the target. Consistent with this concept are data showing that people respond faster to a single target compared to a target with flanking stimuli (e.g., Horstmann et al., 2006). Overall, it is likely that attentional resources were more divided in the current study compared to others. If so, then there may have been insufficient attentional resources in both surround conditions to be disproportionately drawn to the flankers.[1] This interpretation is offered cautiously, however, due to the relatively low percentage (i.e., 25%) of "no-flanker" trials that were administered in other studies (Fenske & Eastwood, 2003; Horstmann et al., 2006).

The resource allocation theory is typically tested by having participants perform two tasks simultaneously (Hula, 2011). Various aspects of the tasks are manipulated, such as the task's priority and/or difficulty. The trading of resources between the tasks is inferred by monitoring declines in performance on one task when the difficulty or priority of the other task has been increased (Hula, 2011). Participants in the current investigation completed a single flanker task. However, one might argue that having different task instructions, which varied based on the stimulus type (i.e., filler vs. experimental), might be similar to having different tasks. If this is true, then the allocation of resources might have been driven by stimulus type and the processing demands associated with each.

11.4.2 Theoretical interpretations for the perceptual conformity hypothesis

One theoretical implication of the current study's findings is the possibility that visual attention is deployed to perceptual properties of stimuli other than those represented in this work. As reviewed in Section 5.2, data from the infant facial emotion literature show that newborns rely

[1] Attentional resources were probably more divided in the surround-absent condition, which likely required resources for an extra step, compared to the surround-present condition: determining, without an outer boundary, which elements of the display constituted the target as a single entity.

on perceptual information to process faces. For example, infants are sensitive to the relation between the inner and outer facial features and they rely on the outer facial elements (e.g., ears, hairline, chin), and their configurations, more than the inner elements (e.g., eyes, nose, mouth) during face recognition (Campbell & Tuck, 1995; Campbell et al., 1995; Campbell et al., 1999; Want et al., 2003). Although adults tend to fixate inner facial features more than outer features (e.g., Barton et al., 2006; Vassallo et al., 2009), the broader notion that perceptual properties guide attention deployment to emotional faces during infancy makes it more conceivable that some perceptual properties might be at play when adults attend to emotional faces.

Another possibility, as suggested by Horstmann and colleagues (2001), is that the differences in visual attention deployment to emotional (threatening and nonthreatening) and nonemotional (perceptually different) stimuli may reflect involvement from both facial affect *and* perceptual conformity factors. The mixed findings from investigations testing the facial affect claim (Section 3.1), for example, suggest that the underlying affect may not be the sole factor in such differences, if it is important at all. The findings of the current study may be consistent with the possibility that previously documented flanker-effect asymmetries were based on specific types of perceptual properties (e.g., the presence or absence of a single feature, as in the lollipop vs. circle stimuli in Horstmann et al.'s experiment 4). Considering the current study's findings a logical follow-up question would be, what types of nonconformity, or other perceptual attributes, might generate a flanker-effect asymmetry?

Wolfe and Horowitz (2004) categorized the attributes hypothesized to guide the deployment of visual attention according to the amount of evidence supporting each. One attribute that is relevant to the current work, and that was discussed above, is that of size. Wolfe and Horowitz also identified curvature as a probable attribute that influences visual attention deployment (e.g., left vs. right). They argued that "If the curves are part of the bounding contour of an object, this becomes concavity and convexity with possible preference for concavities" (p. 5). A closer inspection of the inner lines used in the current study compared to those used in Horstmann et al.'s (2006) investigation shows differences in the degree of curvature, which might also have contributed to the differences in findings. Specifically, the inner lines in Horstmann and colleagues' investigation appear to have a greater degree of curvature in relation to the outer surround compared to that in the current study. Thus, visual attention may have been shifted more readily in the incompatible condition by nonconforming flankers possessing a greater degree of curvature, in Horstmann et al.'s study, than by nonconforming flankers with lesser degrees of curvature, as in the current work.

It is acknowledged that visual search studies differ from flanker studies in many ways. Nevertheless, the attributes that yield asymmetries in visual search studies can provide a starting point for future work to test other types of perceptual properties that might yield flanker-effect asymmetries. If perceptual properties *and* facial affect influence the deployment of visual attention, then future research is needed to delineate (a) the types of perceptual properties that influence visual attention to emotional faces, (b) how both factors in combination yield differences in attentional deployment, and (c) the situations in which one factor has a greater influence than the other.

11.5 FUTURE CLINICAL IMPLICATIONS

The joint study of visual attention and facial emotion has the potential to provide a more in-depth understanding of impaired facial emotion processing and threat-related biases that have been documented in various patient populations. Impairments in facial emotion processing have been documented in individuals with autism (e.g., Best et al., 2010; Calder et al., 2011; Dundas, Best, et al., 2012; Dundas, Gastgeb, et al., 2012; Gastgeb et al., 2011; Strauss et al., 2011), traumatic brain injuries (e.g., Callahan et al., 2011; Dal Monte et al., 2012; McDonald, Li, et al., 2011; McDonald, Rushby, et al., 2011), cerebrovascular accidents (e.g., Nijboer & Jellema, 2012; Paradiso et al., 2011), and schizophrenia (e.g., Kohler et al., 2010; Lee et al., 2011). Specific to the current investigation, threat-related biases have also been documented in many of these clinical populations, including individuals with anxiety disorders (e.g., Eldar, Yankelevitch, Lamy, & Bar-Haim, 2010; Mogg, Philippot, & Bradley, 2004), autism spectrum disorders (Ashwin, Wheelwright, & Baron-Cohen, 2006; Krysko & Rutherford, 2009), and right hemisphere stroke (Vuilleumier & Schwartz, 2001). The development of appropriate treatment strategies, therefore, may rely on sound theories of facial emotion processing *and* visual attention.

The findings from the current investigation do not have immediate clinical implications for patients with disordered facial emotion processing. However, two potential future clinical implications are offered based on the current findings and limitations.

Data from the current study suggest that perceptual conformity may not play a role in the distribution of visual attention between threatening and nonthreatening faces. If this conclusion is valid, future treatment might primarily focus on facilitating facial affect recognition, including stimulus characteristics or strategies to improve the identification, discrimination, and/or further processing of the basic facial emotions related to facial threat (Section 5.3). On the other hand, given the limitations of this study previously described, it is possible that another type or degree of perceptual conformity may be a key factor in the reported attention distribution differences between threatening and nonthreatening faces. If so, then clinical intervention in the future might primarily focus on manipulating types and degrees of perceptual conformity to capitalize on its influence on facial emotion processing. Until the role of perceptual conformity in visual attention distribution to threatening and nonthreatening faces is elucidated, the theoretical implications that have been previously discussed can be used to gain a better understanding of the reported visual attention differences to threatening vs. nonthreatening faces.

11.6 STRENGTHS AND LIMITATIONS

This study had a number of strengths. In particular, a novel condition without a facial surround was included to test the perceptual conformity hypothesis. In addition, several steps were taken to carefully implement the affect rating and experimental studies, including the critical task of disguising the emotional nature of the experiment. To decrease the possibility of participants generating a face percept, this study (1) used various shapes as the outer surround for the fillers (e.g., triangle, square); (2) used "nonfeatures" in some of the fillers (e.g., a hyphen, a lightening streak); (3) positioned the two curved inner lines in the experimental stimuli, representing "mouths" from schematic facial drawings, away from a typical mouth location; and (4) included surround-absent fillers.

This study also addressed a confound plaguing prior investigations that have reported differences in visual attention deployment based on perceptual differences: the failure to validate the perceived affect of stimuli presumed to be devoid of emotion. By implementing a separate affect ratings study, it was possible to select carefully the stimuli perceived as most neutral, emotionally. Coelho and colleagues (2010) used a similar affect ratings study. However, the current study differed from theirs in that the endpoint labels in the Likert scale (Likert, 1932) in the current study were reversed for half of the participants. This step is important in decreasing the likelihood of a response bias to a specific portion of the scale.

Another assumption that is neglected in the literature is that all participants have intact baseline visual perceptual skills. The current study, and those studies reviewed in this text, recruited cognitively intact participants. This participant eligibility requirement reduces the chance that participants had impairments of visual perception. Still, the current investigation objectively assessed this assumption by including the Visual Form Discrimination test (Benton et al., 1994). As expected, no participants exhibited deficits in processing visual perceptual information on this test. However, if a self-reported intact cognitive status is false and underlying visual perceptual deficits go undocumented, the data and subsequent interpretations could be weakened.

Future studies should, however, consider the current investigation's potential limitations. For example, the higher probability of fillers being followed by a trial requiring the opposite response may have elicited unintended expectations and a strategic allocation of attention. The higher probability could have altered the natural way in which attention is typically deployed into the periphery, invalidating the measurement of flanker interference. Another limitation is whether the surround-absent stimuli were perceptually grouped in the intended way. As noted previously, to control for this potential confound in future studies, the distance between the surround-absent flanker display elements could be increased so that they are perceptually grouped as individual components like those in the surround-present condition. However, this may be problematic because changes in flanker eccentricity alter the amount of flanker interference (Eriksen & Eriksen, 1974; Rowe et al., 2007; Zeef et al., 1996). An alternative approach might be to instruct participants explicitly about the elements of the surround-absent stimuli that make up single vs. multiple entities. Whether this approach is valid might be explored by testing whether stimuli that are perceptually grouped like the elements of the surround-absent stimuli prime RTs to the surround-absent stimuli more than other possible perceptual groupings do.

Other possible limitations that have been previously described comprise (a) the inclusion of fillers that contained a potential visual cue (i.e., an arrow), (b) the use of different instructions for fillers and experimental stimuli, (c) the order of presentation for the experimental stimuli (i.e., the surround-absent stimuli were administered before the surround-present stimuli), and (d) the limited number of presentations of experimental trials.

11.7 CONCLUSIONS

The question of which factors drive differences in attentional deployment to threatening and nonthreatening faces remains unresolved. Assuming the validity of these differences, future research is needed to tease apart the roles of emotional vs. perceptual properties, or some combination, and to identify the attributes that consistently elicit such differences for targets that convey specific categories of emotion.

The findings of the current study did not fall in line with the predictions of the perceptual conformity hypothesis, at least for the specific type and degree of perceptual attribute that was investigated. The failure to find the predicted flanker-effect asymmetry in the surround-present condition limits the interpretations and conclusions that can be drawn from the data. It is likely that methodological differences account for the difference in findings between this study and prior studies that did demonstrate flanker-asymmetry effects. Examples of such factors include potential differences in perceptual saliency, the use of fillers vs. no fillers, the number of repetitions of each experimental target, and the inclusion of surround-absent stimuli. Other potential methodological considerations involve the effect of stimulus probabilities and expectancy, the potential perception of flanker displays as containing single (i.e., surround-present) vs. multiple (i.e., surround-absent) entities, and the order of presentation of the surround-absent vs. surround-present stimuli.

A broader issue concerns the scarcity of studies documenting a flanker-effect asymmetry between threatening and nonthreatening stimuli, making it difficult to discern the reliability of this effect. Together with the mixed findings on whether threatening and nonthreatening faces influence visual attention differently, cautious interpretations of the extant literature are warranted.

APPENDIX A

RESEARCH QUESTIONS, HYPOTHESES, POTENTIAL OUTCOMES, AND INTERPRETATIONS

RESEARCH QUESTION 1 - (Surround-Present Condition) - Do surround-present, incompatible flankers generate the expected flanker-effect asymmetry that has been reported for angry vs. happy faces in healthy adults?

Hypotheses	Potential Outcomes	Potential Interpretations
H_o: No flanker effect differences will be found in the surround-present, incompatible flanker condition when targets have conforming and nonconforming inner features. H_1: Flanker effect differences will be found in the surround-present incompatible flanker condition when targets have conforming and nonconforming inner features.	Incompatible flankers generate expected flanker-effect asymmetry; significant flanker effect for targets with conforming features in the incompatible condition but no such effect for targets with nonconforming features ***(Predicted Outcome)***	1. The flanker-effect asymmetry is attributed to the perceptual conformity of the inner features with the outer surround 2. Participants may have generated and assigned unintended meanings to the targets with conforming features or perceived them as affective. However, the affective ratings study is intended to quantify subjective affect of the stimuli.
	Incompatible flankers generate unexpected flanker-effect asymmetry; significant flanker effect for targets with nonconforming features in the incompatible condition but no such flanker effect for targets with conforming features in the incompatible condition	1. Conforming inner features do not "blur" with the outer surround, as hypothesized by Purcell and Stewart (2010). 2. Conforming features are not perceptually simpler, and therefore less conspicuous, than are nonconforming features, as hypothesized by Horstmann et al. (2010).
	No flanker-effect differences will be found with targets with conforming and nonconforming features in the incompatible condition	1. Perceptual conformity may not play a role in attention distribution differences. 2. Conforming and nonconforming features guide visual attention distribution in the same manner.

		3. A null finding could also be the result of low power. An *a priori* power analysis was conducted to determine an adequate sample size to achieve sufficient power (see Section 9.2.2 for details).

RESEARCH QUESTION 2 – (Surround-Absent Condition) - Do surround-absent, incompatible flankers generate the expected flanker-effect asymmetry that has been reported for angry vs. happy faces in healthy adults?

Hypotheses	Potential Outcomes	Potential Interpretations
H_o: No flanker effect differences will be found in the surround-absent, incompatible flanker conditions when targets have conforming and nonconforming inner features. H_1: Flanker effect differences will be found in the surround-absent, incompatible flanker conditions when targets have conforming and nonconforming inner features.	No significant flanker effect differences will be found between targets with conforming and nonconforming features in the incompatible condition ***(Predicted Outcome)***	1. This finding would be consistent with the perceptual conformity hypothesis, in that the removal of the surround would eliminate the relationship between inner features and surround. 2. Surround-absent conforming and nonconforming inner features guide visual attention distribution in the same manner. 3. As stated previously, low power might result in a null finding. However, steps were taken to ensure sufficient power (via *a priori* power analysis)
	Significant flanker effect differences found between targets with conforming and nonconforming features in the incompatible condition	1. Perceptual conformity may not play a role in visual attention differences 2. This finding could also be consistent with the claim that attention distribution differences stem from underlying facial affect. 3. Participants may have generated and assigned unintended meanings to the stimuli, despite attempts to minimize this possibility.

RESEARCH QUESTION 3 – (Surround-Present Condition) Do surround-present, incompatible flankers produce more response interference when targets have conforming vs. nonconforming inner features?

Hypotheses	Potential Outcomes	Potential Interpretations
H_o: No differences in the amount of response interference when targets have conforming inner features than when targets have nonconforming inner features in the incompatible condition. H_1: The amount of flanker response interference will differ when targets have conforming inner features than when targets have nonconforming inner features in the incompatible condition.	Incompatible flankers generate more response interference to targets with conforming inner features than to targets with nonconforming inner features. ***(Predicted Outcome)***	1. This finding suggests that the nonconforming nature of the inner features with the outer surround caused the differences in the amount of interference between the target and flankers 2. It is possible that participants may have generated and assigned unintended meanings to the stimuli with conforming features or perceived them as affective, however the affect ratings study is intended to address this potential confound.
	Incompatible flankers generate more response interference to targets with nonconforming inner features than to targets with conforming inner features.	1. Conforming inner features do not "blur" with the outer surround, as hypothesized by Purcell and Stewart (2010) 2. Conforming features are not perceptually simpler, and therefore less conspicuous, than are nonconforming features, as hypothesized by Horstmann et al. (2010). 3. Participants may have generated and assigned unintended meanings to the stimuli with conforming features or perceived them as affective.
	Incompatible flankers generate equal amounts of response interference to targets with nonconforming and conforming inner features	1. Perceptual conformity may not play a role in attention distribution differences. 2. Conforming and nonconforming features guide visual attention distribution in the same manner. 3. A null finding could also be the result of low power. An *a priori* power analysis was conducted to determine an adequate sample size to achieve sufficient power (see Section 9.2.2 for details).

RESEARCH QUESTION 4 – (Surround-Absent Condition) Do surround-absent, incompatible flankers produce more response interference when targets have conforming vs. nonconforming inner features?

Hypotheses	Potential Outcomes	Potential Interpretations
H_o: No differences in flanker response interference in the surround-absent condition when targets have conforming inner features than when targets have nonconforming inner features in the incompatible condition. H_1: Flanker response interference differences will be found in the surround-absent condition when targets have conforming inner features than when targets have nonconforming inner features in the incompatible condition.	No differences in the amount of response interference between targets with conforming and nonconforming flankers ***(Predicted Outcome)***	1. This finding would be consistent with the perceptual conformity hypothesis, in that the removal of the surround would eliminate the relationship between inner features and surround and therefore the amount of response interference generated. 2. Surround-absent conforming and nonconforming inner features guide visual attention distribution in the same manner.
	Differences in the amount of response interference between targets with conforming and nonconforming flankers	1. Perceptual conformity may not play a role in visual attention differences 2. This finding could also be consistent with the claim that attention distribution differences stem from underlying facial affect.

APPENDIX B

ONLINE ELIGIBILITY QUESTIONNAIRE FOR PRE-EXPERIMENTAL AFFECT RATING TASK

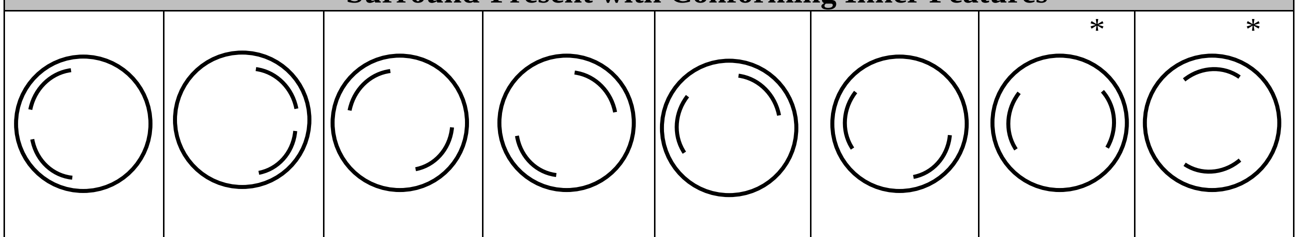
Thank you for taking the time to complete the research survey. To determine your eligibility you will first answer some questions related to your age, education, and medical history. Please press next to continue.
What is your age? □ Less than 18 □ 18 □ 19 □ 20 □ 21 □ 22 □ 23 □ 24 □ 25 □ 26 □ 27 □ 28 □ 29 □ 30 □ Over 30
What is the highest level of school you have completed or the highest degree you have received? If you are currently enrolled, please mark the previous level of school or highest degree received. □ 8th Grade □ High School, No Diploma □ High School Degree or equivalent (For example – GED) □ Some college but no degree □ Associate Degree □ Bachelor Degree □ Master's Degree □ Professional Degree

□ Doctorate
What is your gender? □ Female □ Male
Do you have any visual impairments that have not already been corrected (for example with contacts, glasses, or Lasik)? □ Yes, I have a visual impairment □ No, I do not have a visual impairment / My vision is corrected to normal
Do you or have you ever had any of the following: □ Neurological Disorder □ Psychiatric Disorder □ Brain Injury □ Learning Disability □ Substance Abuse □ None of the above
Thank you for completing the eligibility portion.

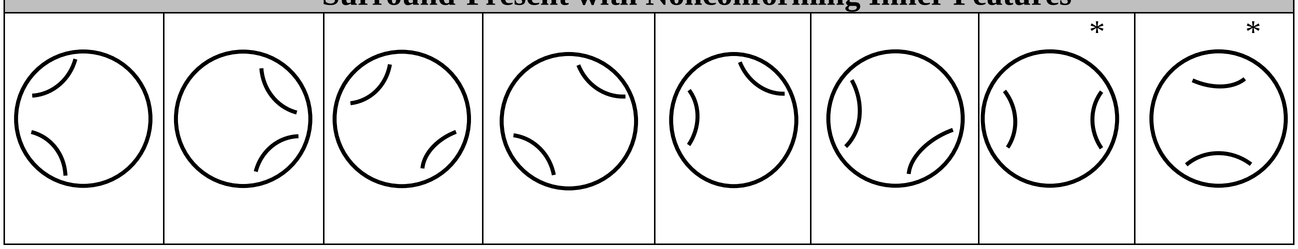
APPENDIX C

EXAMPLE EXPERIMENTAL SURROUND-PRESENT AND SURROUND-ABSENT STIMULI IN THE PRE-EXPERIMENTAL AFFECT RATING TASK

Surround-Present with Conforming Inner Features

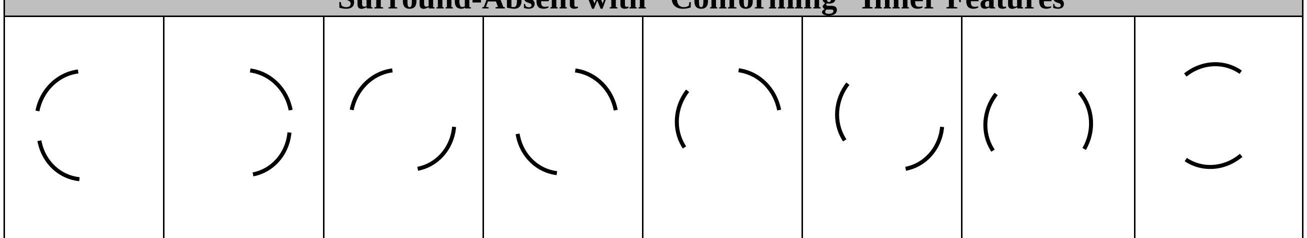


Surround-Present with Nonconforming Inner Features

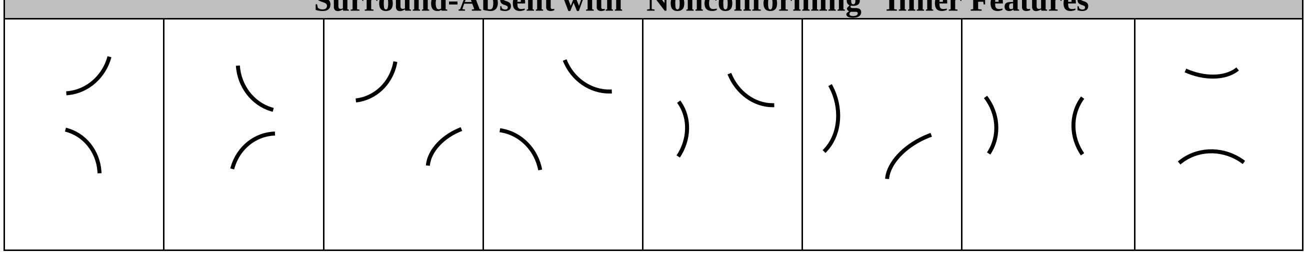


*Stimuli similar in appearance to those used in Coelho et al.’s (2010) investigation (Experiment 3)

Surround-Absent with “Conforming” Inner Features



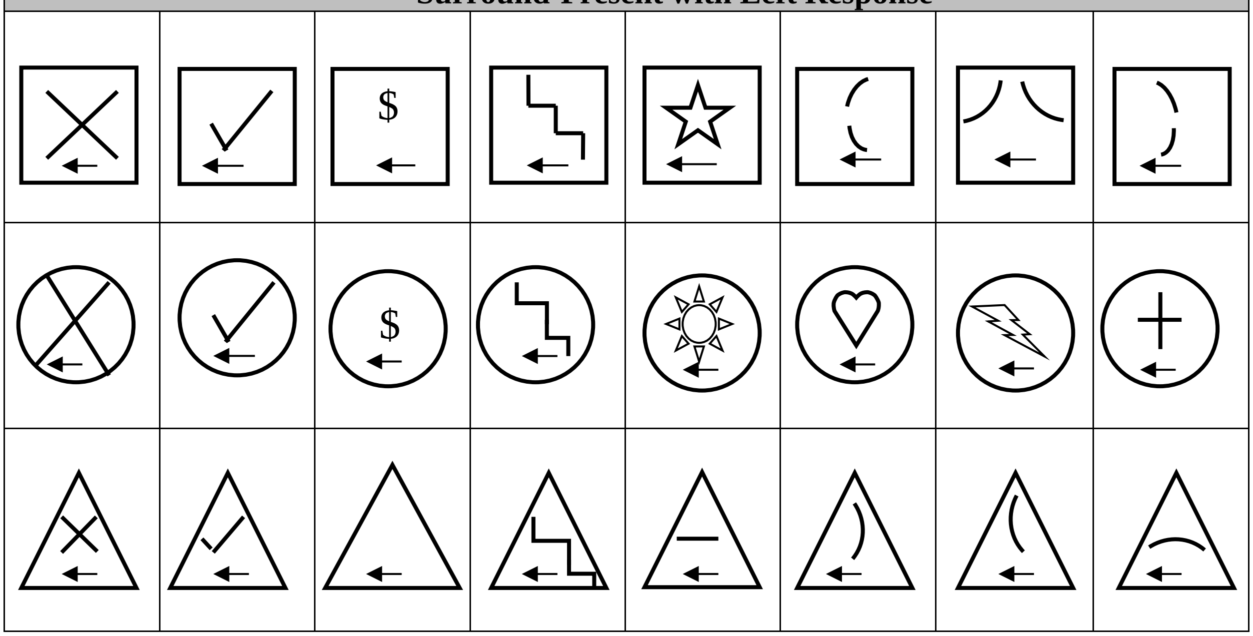
Surround-Absent with “Nonconforming” Inner Features



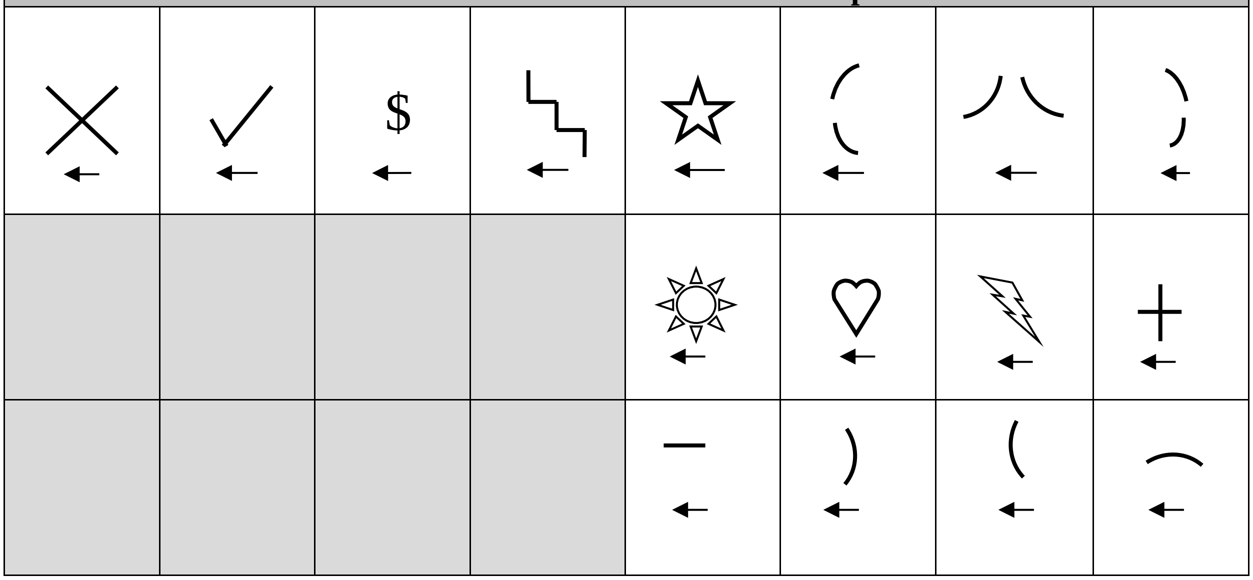
APPENDIX D

EXAMPLE FILLER STIMULI IN THE PRE-EXPERIMENTAL AFFECT RATING TASK

Surround-Present with Left Response



Surround-Absent with Left Response



Note – These filler stimuli also appeared with right pointing arrows.

APPENDIX E

PARTICIPANT SCREENING QUESTIONNAIRE FOR THE FLANKER EXPERIMENT

DEMOGRAPHIC INFORMATION

Date of Birth: ____________

Age: _____________

Gender (Please Circle) Male Female

EDUCATION

Highest Degree Earned _______ High School Degree or Equivalent

_______ Undergraduate Degree

_______Graduate or Advanced Degree

MEDICAL HISTORY

Do you have a history of any of the following: *(Please circle)*

Y N Neurological Disorder

Y N Psychiatric Disorder

Y N Traumatic Brain Injury

Y N Learning Disability

Y N Substance Abuse (i.e. alcohol, drugs)

Referral: Subject Pool Word of Mouth Email Flyer Other________________________
Vision Screening Results: ____
Screening Status: OK Not Eligible ____

APPENDIX F

FLANKERS TASK INSTRUCTIONS FOR SURROUND-ABSENT TRIALS

You are going to use the computer for this task. First, you will see a red cross in the center of the screen. This cross is to warn you that something else is about to appear in the same location. Keep looking at the cross when you see it. After the cross disappears you will see a row of designs. It is very important that you only look at the designs in the center of the screen for the entire task. The center designs will be in the same location as the cross. Please ignore the other designs on the right and left sides of the center design.

Your task is to look at the designs in the center of the screen and use the right and left arrow keys on the computer to indicate which designs you see. Some of these designs will have right and left arrows to help you decide which keys to press, but other designs will not have arrows.

Here is an example of a design that has an arrow [EXAMPLE 1]. You will notice that the arrow points to the right, so you would press the right arrow on the keyboard. Here's another example of a design with a left pointing arrow [EXAMPLE 2], so you would press the left arrow.

The next two designs do not have arrows so you will have to commit them to memory. Each time you see this design [EXAMPLE 3] in the center of the screen you will press the [RIGHT] arrow key on the keyboard. Each time you see this design [EXAMPLE 4] you will press the [LEFT] arrow. Take a moment to look at both of these designs and their appropriate arrow keys. We'll practice to make sure you remember which arrow to use.

Now, just a few notes before we start. When you respond please use only your index finger on your right hand. You will keep that finger on the down arrow key between your responses. It is also very important that you respond as quickly and as accurately as possible.

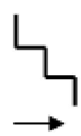
Ok, let's try a few practice items on the computer to get you comfortable with which arrow corresponds to which design. As a reminder, you will press the [RIGHT] key when you see this design [EXAMPLE 3] in the center of the screen, and the [LEFT] key when you see this design [EXAMPLE 4] in the center of the screen. For the designs with an arrow, you will press the computer key that corresponds to the direction of the arrow. Please place your index finger on the down arrow. Please remember to look only at the designs in the center of the screen, and to respond as quickly and accurately as possible. Are you ready?

[SURROUND-ABSENT COMPUTER PRACTICE TRIALS ADMINISTERED]

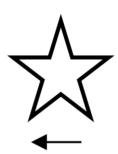
Okay, let's move on to the real thing. You'll see 4 sets of designs like those you saw during the practice portion. Each set will have around 25 items. But if you look anywhere on the screen except the center, some of the designs may need to be shown again. You will be able to take breaks in between each set of designs. If you need a break before then please let me know. Also, if you need to be reminded which arrow key to press with a specific design; you can let me know at the end of each section. As a reminder, please ignore the designs on either side of the center design. Also, please respond as quickly and as accurately as possible. Do you have any questions before you start?

EXAMPLES 1-4

EXAMPLE 1 – PRESS THE **RIGHT** ARROW WHEN YOU SEE A DESIGN WITH A RIGHT ARROW

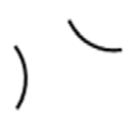


EXAMPLE 2 – PRESS THE **LEFT** ARROW WHEN YOU SEE A DESIGN WITH A LEFT ARROW



EXAMPLE 3 - PRESS THE **RIGHT** ARROW WHEN YOU SEE THIS DESIGN:

EXAMPLE 4 - PRESS THE **LEFT** ARROW WHEN YOU SEE THIS DESIGN:



APPENDIX G

FLANKERS TASK INSTRUCTIONS FOR SURROUND-PRESENT TRIALS

You are going to use the computer again for the next task. This task is very similar to the one you completed earlier. However, the designs may appear a little different to you. As a reminder you will first see a cross in the center of the screen. This cross is to warn you that something else is about to appear in the same location. Keep looking at the cross when you see it. After the cross disappears you will see a row of designs. Look only at the designs in the center of the screen for the entire task. The center designs will be in the same location as the cross. Please ignore the other designs on the right and left sides of the center design.

Just like in the last computer task, you are to look at the designs in the <u>center</u> of the screen and use the right and left arrow keys on the computer to indicate which designs you see. Once again, some of these designs will have right and left arrows to help you decide which keys to press, but other designs will not have arrows.

Here is an example of a design that has an arrow pointing to the right [EXAMPLE 1] so you would press the right arrow on the keyboard. And in this example [EXAMPLE 2] you would press the left arrow on the keyboard since the arrow is pointing left.

The next two designs do not have arrows so you will have to commit them to memory. Each time you see this design [EXAMPLE 3] in the center of the screen you will press the [RIGHT] arrow key on the keyboard. Each time you see this design [EXAMPLE 4] you will press the [LEFT] arrow. Take a moment to look at both of these designs and their appropriate arrow keys.
We'll also practice to make sure you remember which arrow to use.

The way in which you respond is just like the last computer task. Please use only your index finger on your right hand. Remember to keep that finger on the down arrow key between your responses. It is also very important that you respond as quickly and as accurately as possible.

We'll do some new practice items on the computer to get you comfortable with which arrow corresponds to which design. As a reminder, you will press the [RIGHT] key when you see this design [EXAMPLE 3] in the center of the screen, and the [LEFT] key when you see this design [EXAMPLE 4] in the center of the screen. For the designs with an arrow, you will press the computer key that corresponds to the direction of the arrow. Please place your index finger on the down arrow. Please remember to look only at the designs in the center of the screen, and to respond as quickly and accurately as possible. Are you ready?

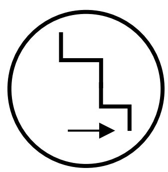
[SURROUND-PRESENT COMPUTER PRACTICE TRIALS]

Okay, let's move on to the real thing. You'll see 4 sets of designs like those you saw during the practice portion. Each set will have around 25 items. But if you look anywhere on the screen except the center, some of the designs may need to be shown again. You will be able to take breaks in between each set of designs. If you need a break before then let me know. Also, if you need to be reminded which arrow key to press with a specific design; you can let me know at the end of each section.

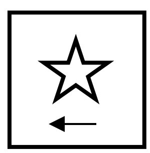
As a reminder, please ignore the designs on either side of the center design. Also, please respond as quickly and as accurately as possible. Do you have any questions before you start?

EXAMPLES 1-4

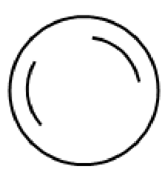
EXAMPLE 1 - PRESS THE **RIGHT** ARROW WHEN YOU SEE THIS DESIGN:



EXAMPLE 2 - PRESS THE **LEFT** ARROW WHEN YOU SEE THIS DESIGN:



EXAMPLE 3 – PRESS THE **RIGHT** ARROW WHEN YOU SEE A DESIGN WITH A RIGHT ARROW



EXAMPLE 4 – PRESS THE **LEFT** ARROW WHEN YOU SEE A DESIGN WITH A LEFT ARROW

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