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Flanker Effects With Faces May Depend on Perceptual as Well as Emotional Differences

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Do threatening or negative faces capture attention? The authors argue that evidence from visual search, spatial cuing, and flanker tasks is equivocal and that perceptual differences may account for effects attributed to emotional categories. Empirically, the authors examine the flanker task. Although they replicate previous results in which a positive face flanked by negative faces suffers more interference than a negative face flanked by positive faces, further results indicate that face perception is not necessary for the flanker-effect asymmetry and that the asymmetry also occurs with nonemotional stimuli. The authors conclude that the flanker-effect asymmetry with affective faces cannot be unambiguously attributed to emotional differences and may well be due to purely perceptual differences between the stimuli.

Keywords: emotion, attention, facial expression

Attentional control is often described in terms of dichotomies: exogenous versus endogenous, top down versus bottom up, concept driven versus data driven, or intentional versus automatic (e.g., Jonides, 1981; Yantis, 1993). These dichotomies strive to capture the assumption that attention can be controlled by the attending subject but that sometimes a stimulus appears to attract attention in itself. For example, an observer may intentionally move his eyes around in a room with the goal of finding his keys, and he may need to do so because it is the only way to succeed. (He may even have his eyes fixated, and his attention may shift "covertly," as is often required in psychological experiments, although this behavior would be quite odd under normal circumstances.) Conversely, salient stimuli, such as a blue towel on green turf, may attract attention although they are not deliberately searched for. Among the features for which an involuntarily attraction of attention has been proposed are the following: new objects that appear abruptly (e.g., Enns, Austen, Di Lollo, Rauschenberger, & Yantis, 2001; Jonides & Yantis, 1988; Rauschenberger, 2003; Yantis, 1993; Yantis & Hillstrom, 1994; Yantis & Jonides, 1984); unique objects in otherwise homogenous surroundings (e.g., Kim & Cave, 1999; Theeuwes, 1992, 1994; Theeuwes & Godijn, 2001); looming objects (i.e., objects that appear to move toward the observer; St. Franconeri & Simons, 2003); expectancy-discrepant (surprising) events (e.g., Horstmann, 2002, 2005; Meyer, Niepel, Rudolph, & Schützwohl, 1991; Schützwohl, 1998; Selz, 1922; Wilcocks, 1928); and negative, angry, or threatening faces (e.g., Eastwood, Smilek, & Merikle, 2001; Fenske & Eastwood, 2003; Fox et al., 2000; Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002; Hansen & Hansen, 1988; Mogg & Bradley, 1999; Öhman, Lundqvist, & Esteves, 2001; Tipples, Atkinson, & Young, 2003; White, 1995).

The present work deals with the attentional effects of affective faces and, in particular, with the hypothesized attention-capturing effects of angry versus happy faces. By the capture of attention, we mean very precisely the involuntary spatial dislocation of attention from its current focus, toward a different spatial location, where the attention-capturing object is located. The position we assume concerning the attention-capturing potential of affective faces, however, is a skeptical one. In fact, we argue that the present evidence for attentional capture by angry faces is not compelling. Then we empirically show that the results from one particular experimental paradigm, the flanker task, are open to alternative accounts.

Experimental Paradigms

Evidence from three experimental paradigms[1] can be connected to the question of whether affective faces capture spatial attention: visual search, spatial cuing, and the flanker task. In visual search, participants are presented with arrays of faces (e.g., Eastwood et al., 2001; Fox et al., 2000; Hansen & Hansen, 1988; Nothdurft, 1993; Öhman et al., 2001; White, 1995). In some of the trials, all

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[1] We are concerned with visuospatial capture of attention—that is, the attraction of attention by a stimulus that is presently not attended to. Eastwood, Smilek, and Merikle (2003) provided evidence that attending to facial components is more difficult with negative than with positive faces and inferred an involuntary shift of attention from local to global stimulus attributes. However, this result does not demonstrate the capture of attention by a stimulus away from the present focus of attention. Also, Fox and coworkers (e.g., Fox et al., 2000, 2001, 2002) have proposed that attention is difficult to disengage from negative stimuli once the stimulus is attended to; this emotion–attention interaction, however, is different from the capturing of attention away from another position.

faces display the same facial expression—for example, happiness. In other experimental trials, one of the faces shows a different expression—for example, anger. The participants' task is to indicate whether the array is expression homogenous or expression heterogeneous. The critical question is how a variation of set size (the number of presented stimuli) influences reaction time (RT). Search is *efficient* if set size has little or no influence on RT (e.g., RT increases by 4 ms for every additional face in the display), and it is *inefficient* if set size has considerable effect on RT (e.g., RT increases by 20 ms or more for every additional face in the display; cf. Wolfe, 1998). If angry faces capture attention, search should be efficient if the odd element in the heterogeneous displays is an angry face surrounded by happy faces but not if the odd element is a happy face surrounded by angry faces. This pattern of results was apparent in some of the studies (e.g., Hansen & Hansen, 1988; White, 1995), but not in others (e.g., Eastwood et al., 2001; Fox et al., 2002; Nothdurft, 1993; Öhman et al., 2001; White, 1995). In some of these studies (e.g., Öhman et al., 2001), RTs with angry target faces were generally lower than with happy targets, independent of set size; however, search efficiency is defined in relation to the slope b of the linear function $y = bx + a$, relating RT y to set size x, not to the intercept a. Apart from the fact that the results concerning search efficiency are mixed, it is important to note that efficient search for angry faces is consistent with a hypothesized attentional capture by angry faces but does not demonstrate attentional capture. If efficient search for an angry face is revealed, this would indicate that the presence of an angry face could be detected preattentively—that is, before attention has been directed to the stimulus. However, this effect cannot be said to be involuntary, because detection was part of the task and thus was intended by the observer (e.g., Yantis, 1993; Yantis & Egeth, 1999).

In the spatial cuing paradigm, participants respond to targets that appear left or right of fixation (e.g., Posner, 1980). The targets are preceded by cues that also appear left or right of fixation. The cues can be valid or invalid—that is, they can appear on the same side as the target or on the opposite side. If cues are mostly valid, such that the observers have an incentive to attend to the cued location first, then valid cues speed up the RT to the targets (induce benefits), whereas invalid cues slow down RT (induce costs). If a similar pattern of costs and benefits is obtained even when cues are invalid on average, such that the observers have no incentive to attend to the cue, involuntary attention capture is revealed. When faces are used as cues that are mostly valid (e.g., Fox et al., 2001), the costs are greater with negative than with positive faces, at least for highly anxious individuals. Because the extra costs for angry faces were incurred in invalid trials exclusively, Fox et al. concluded that negative faces have a stronger potential to hold attention to the cued location than the positive faces. However, because the authors did not find corresponding benefits for angry faces as valid cues, the results do not provide evidence for attentional capture.

Finally, in the flanker paradigm, originally developed by Eriksen and Eriksen (1974), the participants respond to a target stimulus presented at fixation while ignoring flanker stimuli presented on either side of the target. An important discriminating aspect of the flanker paradigm is the complete spatial certainty about the target's and the flankers' positions and a high incentive to attend selectively to the target and ignore the flankers. For this reason, the flanker paradigm tests how effectively the target can be focused on and the flankers can be ignored. The response indicated by the flankers can be congruent, incongruent, or neutral with regard to the response to the target. For example, participants could be instructed to push a left button if the target is a positive face and a right button if the target is a negative face (Fenske & Eastwood, 2003). If the target and the flankers are all positive faces, the response to the target is congruent with the response that would be required by the flankers. If the target is a positive face and the distractors are negative faces, the responses are incongruent. Finally, if the target is a positive face and the flanker is a stimulus to which no response is required, the distractor is neutral with respect to the response to the target.

The typical result (whether obtained with faces or other stimuli) is that RTs with incongruent flankers are longer than with congruent flankers, indicating that the flankers could not be completely ignored. This effect is strongest when the flankers are presented close to the target (Eriksen & Eriksen, 1974). Most important in the present context, the flanker effect is stronger with positive faces than with negative faces as targets (Fenske & Eastwood, 2003). Fenske and Eastwood (2003) interpreted this result as indicating that the negative target stimulus narrows the focus of attention, whereas positive stimuli may broaden the focus. However, the flanker effect (the difference between congruent and incongruent trials) has been used by some researchers interested in involuntary orienting of attention (i.e., attentional capture) as a tool to test whether a nominally irrelevant stimulus presented at a position away from the target could have attracted attention (e.g., Theeuwes & Burger, 1998). Thus, one can also interpret the flanker effect in terms of a threat-capture hypothesis, by assuming that the negative flankers captured attention away from the friendly target, which led to interference between the two incongruent responses.[2] In summary, results from visual search are equivocal as to the question of attention capture by angry faces, and evidence from spatial cuing does not clearly support the hypothesis. However, attention capture is a possible interpretation for the results from the flanker task (though we propose a different attentional account).

Stimulus Adequacy

A test of the hypothesis that negative, angry, or threatening faces capture attention (henceforth referred to as the *threat-capture hypothesis*) depends on the choice of adequate stimuli. First, the stimuli must be relevant to the hypothesis. Thus, in this case, the stimuli must be members of the category of negative, angry, or threatening stimuli. Second, the stimuli should not have other

[2] One might contend that the fact that the neutral flanker interfered as much as the negative flanker with the processing of the positive target speaks against this interpretation. However, this particular result is also difficult to interpret in the framework of Fenske and Eastwood (2003) because, according to the logic of the flanker task, neutral flankers—which do not introduce response competition—should not produce a flanker effect at all, but only filtering costs (Treisman, Kahneman, & Burkell, 1983; see also the *Discussion* section of Experiment 1). Thus, it will be interesting to observe whether the effect is replicated in the present experiments.

characteristics that could independently explain the results. We argue that one can question both requirements for the reviewed studies. In the present section, we discuss the relevance of the stimuli to the hypothesis, and in the next section (Perceptual Differences), we discuss perceptual factors as a possible alternative account.

Most studies on attentional effects of anger expressions have used schematic stimuli (Figure 1 gives an overview of some of the schematic faces used). This has been partially motivated by the demonstration that the photos in the seminal visual search study by Hansen and Hansen (1988) carried a confound (Purcell, Stewart, & Skov, 1996). Obviously, experimental control is better over schematic stimuli than over photos. Some studies have tested relatively complex line drawings of facial expressions that provided redundant cues to facial interpretation (e.g., Öhman et al., 2001), whereas others presented more simple combinations of geometrical shapes—for example, a circle or ellipse for the face outline, dots or small circles for the eyes, curved or straight lines for the mouth, and straight lines of different orientations for eyebrows (e.g., Eastwood et al., 2001; Fenske & Eastwood, 2003; Fox et al., 2000, 2002; Nothdurft, 1993; White, 1995).

A first question that one may ask is whether the stimuli are equivalent members of the common category of negative or threatening stimuli. If so and if the threat-capture hypothesis holds true, they should have similar effects in a test of their attentional effects, despite the differences in their perceptual appearance. At least, obviously better members should show stronger effects than obviously worse members.

Of the relevant paradigms, visual search has been examined most extensively. We have seen, however, that search performance varies widely for different stimuli, with target-present slopes for angry faces being efficient in one study (White, 1995), quite efficient in others (Eastwood et al., 2001; Fox et al., 2000), and very inefficient in the remaining (Nothdurft, 1993; Öhman et al., 2001). The same is true of the relative efficiency of the detection of angry faces. In some studies, angry faces, though they were not searched for efficiently, were detected at least more efficiently than happy faces; the size of this advantage, however, has varied considerably. Moreover, the more simple stimuli tend to be searched for more efficiently, whereas the more elaborate stimuli tend to be searched for inefficiently. Thus, the whole pattern of results does not provide compelling evidence of a category effect but rather suggests that particulars of the stimuli have considerable influence on the hypothesized effect.

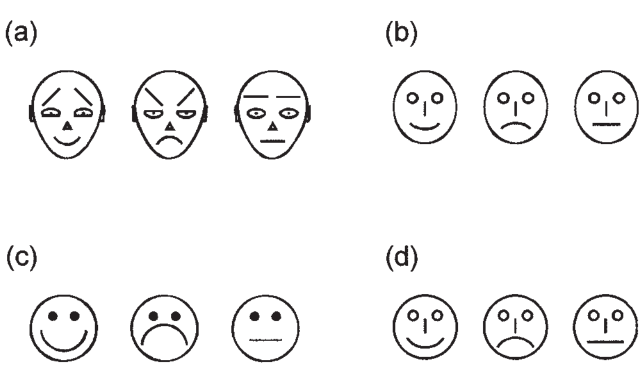

Figure 1. Examples of schematic facial stimuli used in the literature: (a) stimuli from Öhman et al. (2001), (b) from Fox et al. (2000), (c) from Eastwood et al. (2001) and Fenske and Eastwood (2003), and (d) from White (1995). All stimuli are adapted from figures of the respective publications and may thus contain small deviations from the original figures.

One might object that the focusing on categorical perception of an angry face as a gestalt may be misleading and that the presence of particular features may be relevant. Öhman et al. (2001; see also Lundquist, Esteves, & Öhman, 1999, 2004) related their stimuli to tribal art (e.g., ceremonial masks), where similar features can be observed (Aronoff, Barclay, & Stevenson, 1988); however, Öhman et al.'s (2001) stimuli gave one of the weakest indications for a preattentive detection of threat. In many of the other schematic stimuli, the orientation of the curved line inside the circle was the discriminating feature for positive or negative affect. However, the features used to portray negative or angry facial affect, namely the downwardly pointing mouth corners and the diagonally oriented eyebrows, are not considered as features of anger expressions in the literature. Actually, Ekman's (1972) description of the eye region in anger is that of "brows pulled down and inward" and "upper lids appear lowered, tense and squared; lower lids also tensed and raised" (p. 251). With regard to the lower face of anger, Ekman (1972) described two variants, one with the lips pressed against each other, and one with an open mouth, sometimes with visible teeth. In summary, it is not easy to see in what way schematic and real angry faces are similar or exactly what critical features of real faces are represented in the schematic stimuli.

We point out that the schematic facial stimuli actually look like emotional faces (Nothdurft, 1993, explicitly mentioned this point as the rationale for choosing his stimuli). Moreover, that the used faces can be interpreted as emotional faces is sometimes supported by rating studies (Lundquist et al., 2004). However, this evidence does not necessarily mean that the impression of a threatening face is caused by the activation of evolved detectors for facial threat. It could likewise be accounted for by the assumption that the strongly simplified faces are *iconic* signs (cf. Eco, 1968/1988; Maynard Smith & Harper, 1994). Whereas *symbolic* signs (e.g., words) are defined by a completely arbitrary relationship between the sign and its referent, for iconic signs there is a resemblance between sign and referent, which often makes the sign easy to learn and even easy to decode by someone who has not learned the sign (cf. Eco, 1968/1988; many nonverbal means of communication, both evolved and cultural, use this type of sign). That is, the schematic facial expressions may be easily decoded as faces conveying emotions because of the iconic relationship between signal and referent. At the same time, the iconic signs of facial expressions do not really look like real facial expressions because the resemblance is only superficial.

In summary, we view two main problems with the stimuli. First, different instantiations of angry or negative stimuli tend to give different results, which thus causes us to question the assumption that a common cause of perceived threat that pertains to the category drives the attentional effects. Second, many of the stimuli are quite dissimilar to prototype facial expressions of anger, and it is thus unclear why they should excite evolved preattentive threat detectors.

Perceptual Differences

Facial expressions of emotion differ from each other—by necessity—in their perceptual appearance. Thus, perceptual differences, both within and between stimulus pairs, may explain both similarities and differences in responses to facial stimuli. Previous experiments sought to control for perceptual factors by either inverting or scrambling the facial stimuli. Inverting a face is quite an efficient means of disturbing holistic face processing (Thompson, 1980) while retaining more basic perceptual differences. Indeed, Eastwood et al. (2001) and Fox et al. (2000) found that inverting the faces eliminated the search asymmetry for upright faces. White (1995) and Öhman et al. (2001), however, found equal slopes for the search of happy and angry faces presented upright or inverted. Apart from the equivocal results, we note that the effects of stimulus inversion on search efficiency are anything but clear. For example, when using silhouettes of elephants, Wolfe (2001) showed that a "dead" (inverted) elephant among "live" (upright) elephants was much more easy to find than vice versa. The cause of this asymmetry is unclear, and it may have something to do with familiarity (Wolfe, 2001), given that the more unfamiliar stimulus stands out of the crowd (possibly because the more familiar items are easier to reject as distractors in serial search). Moreover, other asymmetries in orientation have been reported—for example, objects lit from below were easier to find than objects lit from above (Enns & Rensink, 1990; Kleffner & Ramachandran, 1992). Thus, stimulus inversion not only complicates holistic object processing but may also have other effects as well.

As to the second method, scrambling the face (i.e., rearranging the facial features so that the resulting stimulus no longer resembles a face) has also been used to show that different effects of happy and angry faces are not due to simple feature differences (e.g., Fenske & Eastwood, 2003; Nothdurft, 1993). The drawback of this method is that it destroys the configuration of the components, which may be important for the generation of relational or emergent features (cf. Pomerantz et al., 2003). These features may include, inter alia, curvature discontinuities where the negative mouth is near the face outline (cf. Kristjansson & Tse, 2001), the concave edge that results from the negative mouth in interaction with the face outline (cf. Humphreys & Müller, 2000), apparent T-junctions at the same position, the apparent oval in the lower negative face, and the different distribution of contrast reversals (spatial frequency) in the vertical axis. Put most clearly, this is not to deny that the attentional effects with schematic facial stimuli could be due to face processing or emotional processing in a narrower sense. However, as the paradigms (i.e., visual search, cuing, and flanker task) come from the domain of visual perception research and have been used to uncover effects of perceptual differences, it appears somewhat surprising that researchers interested in the emotion–attention interface have not considered perceptual differences more seriously (with the exception of Tipples, Atkinson, & Young, 2003, whose visual search experiments we do not review here because they did not vary set size). Certainly, an analogous critique can be addressed to visual perception research, where a possible emotional influence is mostly ignored.

Objective of the Present Study

The previous sections focus mostly on the results from the visual search paradigm, simply because of the multitude of experimental studies. In contrast, the flanker paradigm was applied only once to the study of attentional effects of facial expressions, by Fenske and Eastwood (2003). The purpose of the present experiments is to collect more data with this paradigm. We are interested (a) in seeing whether effects supporting attentional capture by threatening faces can be replicated with varied stimuli and (b) in exploring whether the effects can be explained by a perceptual account. Actually, Fenske and Eastwood (2003) conducted one control experiment to rebut a perceptual interpretation, using a scrambled face condition. However, as substantiated before, this control condition only tests whether isolated elements foster the examined effects. Therefore, we included a novel control condition, which left part of the original stimulus configuration intact while eliminating the perception of the stimulus as a face.

Experiments 1 and 2 seek to replicate the flanker-effect asymmetry, with Experiment 1 using stimuli similar to Öhman et al.'s (2001) and Experiment 2 using strongly reduced stimuli to identify a possible critical region of the stimuli. Experiment 3 provides the novel control condition. It tests stimuli that contain features of strongly schematized happy and angry faces, but, in addition to that, adds features that eliminate (or reduce) the impression of a happy or an angry face. The resulting stimuli are not easily interpreted as positive or negative facial expressions. In fact, the stimuli resemble the letters *X* and *O*, respectively, and are evidently members of a nonemotional category. The rationale of this experiment is as follows. If the flanker-effect asymmetry for positive and negative faces is due to the processing of facial affect, an *X* versus *O* discrimination should not lead to a flanker-effect asymmetry. However, if we obtain a flanker-effect asymmetry with this stimulus pair, we can cast serious doubts on a face-processing explanation. Experiment 4 explores a general hypothesis about the mechanism leading to the flanker-effect asymmetry. More precisely, we reason that if a flanker-effect asymmetry is due to perceptual differences between the stimuli, it should then be possible to obtain a flanker-effect asymmetry with other stimuli that do not resemble faces and do not even share features with schematic faces. Experiment 5 complements Experiments 1–4 by providing ratings of the valence of the stimuli.

Experiment 1

Experiment 1 tested the flanker effect for positive, negative, and neutral faces with relatively complex schematic stimuli that resembled the stimuli used by Öhman et al. (2001). That is, the stimuli were ovals with eyes, eyebrows, nose, and mouth (ears were omitted). Emotions were portrayed on three dimension: eyes, eyebrows, and mouth (see Figure 2). The main relevance of the experiment within the present series was to test whether the flanker-effect asymmetry (e.g., Fenske & Eastwood, 2003), which had been found previously with rather simple stimuli, could also be found with more complex stimuli.

Method

Participants. Six men and 6 women with a mean age of 25 ($SD = 5.4$) years participated in the experiment. Most of them were students, who were either paid or received course credits.

Apparatus. A microcomputer, equipped with an Intel 80486/100MHz processor, a keyboard, and a 14-in. (35.56-cm) black-and-white CRT monitor, was used for stimulus presentation and response registration.

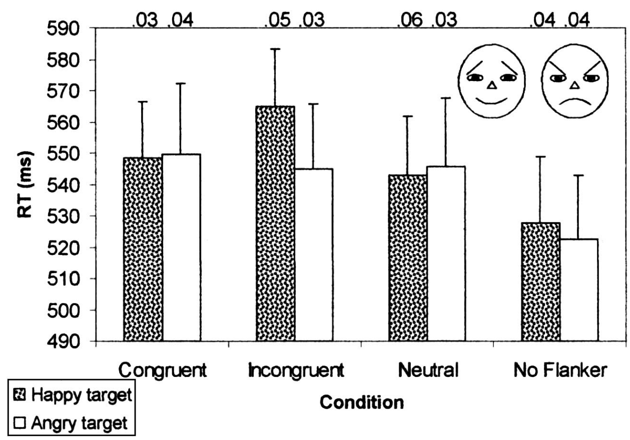

Figure 2. Results from Experiment 1. The category axis codes for the flanker condition: Flankers could have been congruent, incongruent, neutral, or absent (control). The dependent variable was average RT (ms). The numbers on the top of the figure above the bars report the average error rates in the respective condition. Error bars represent standard errors of the means.

Response keys were two adjacent keys on the lower row of the keyboard (arrow left and arrow down). ERTS (BeriSoft Cooperation, Frankfurt am Main, Germany) was used for event scheduling and RT measurement.

Stimuli. The stimuli were an angry, a friendly, and a neutral face (see Figure 2; the neutral face had a straight rather than a curved line as the mouth), which were designed with commercial graphics software and stored as 112 × 142 pixel bitmaps. Each stimulus subtended 1.2° of visual angle in height and 1.0° in width (viewing distance was 110 cm). The target stimulus was always presented at the center of the screen, whereas the flankers, when present, were shown in the immediately adjacent positions, with their center positioned at 1.2° eccentricity. The fixation cross subtended about 0.1°. The stimuli were presented as black on a white background. Figure 3 shows the temporal and spatial arrangement of the stimuli.

Procedure. The experiment was divided into eight blocks, each comprising six repetitions of eight stimulus configurations resulting from the orthogonal combination of the target face condition (friendly or angry) with the flanker condition (friendly, angry, neutral, or no flanker face). The experimental blocks were preceded by a 24-trial practice block with the same design. Between the blocks, participants were allowed to pause.

Each trial began with the 1,000-ms presentation of the fixation cross, which was immediately followed by the stimulus display. RTs were measured from the beginning of the stimulus display. False responses were signaled with a 100-ms warning tone. The next trial began only after a response had been made. Half of the participants had to respond with the left response key to the friendly target face and with the right response key to the angry target face, whereas for the other half the mapping was reversed.

Written instructions were used to explain the task and the stimuli. Participants were carefully instructed on all aspects of the task. The instructions urged the participants to react quickly to the target face and to ignore the flanker faces as much as possible because the flanker faces could often impair performance. The faces were described as angry, happy, or neutral expressions. Both speed and accuracy were emphasized.

Results

RTs shorter than 200 ms or longer than 1,000 ms (less than 2%) and false responses (3.9%) were excluded from the analysis. Figure 2 shows the mean correct RTs for the eight conditions. The main analysis concerned the RTs from the congruent and the incongruent flanker conditions to test the central hypothesis of a stronger flanker effect with angry faces than with happy faces as flankers. A 2 (target face: happy vs. angry) × 2 (congruency: congruent vs. incongruent) ANOVA revealed a significant Target Face × Congruency interaction effect only, $F(1, 11) = 6.1$, $p < .05$. The main effects for target face and congruency were both not significant, Fs < 2.1, ps $> .17$. The Target Face × Congruency interaction reflected virtually no flanker effect (i.e., incongruent–congruent difference) for the angry face target (545 ms vs. 550 ms), $t(11) < 1$, but a significant flanker effect for friendly face target (565 ms vs. 549 ms), $t(11) = 2.9$, $p < .05$.

A corresponding error analysis revealed the same pattern of results, although the Target Face × Congruency interaction was only marginally significant, $F(1, 11) = 4.2$, $p = .06$. The two main effects were not significant, Fs < 3.1, ps $> .10$. Participants made fewer errors in the congruent than in the incongruent condition with the friendly face as the target (3.0% vs. 6.3%), $t(11) = 3.6$, $p < .01$, whereas there was no difference in errors with the angry face as the target (3.0% vs. 3.6%), $t(11) < 1$. Thus, there was no indication of a speed–accuracy trade-off.

The second analysis used the RTs from the neutral and the no-flanker conditions to test whether participants responded to happy and angry faces equally quickly and whether the presentation of the flankers per se induced an RT cost. A 2 (target face: happy vs. angry) × 2 (flanker presence: neutral flanker vs. no flanker) ANOVA revealed a significant flanker presence effect only, $F(1, 11) = 14.3$, $p < .01$. The main effect for target face and the interaction were both not significant, Fs < 1. The flanker presence effect resulted from 19-ms longer RTs with flankers. A corresponding error analysis revealed no significant main effects or interactions, Fs < 1.

Discussion

Trials with friendly targets and angry flankers caused a more pronounced flanker effect than trials with angry targets and friendly flankers, thus replicating the results of a similar experiment by Fenske and Eastwood (2003). This could be explained by the hypothesis that angry faces attract attention: When the target is friendly and the flankers are angry, the flankers attract more attention away from the target, thereby producing conflict with respect to the required response (Eriksen & Eriksen, 1974). In contrast, when the angry face is the target and happy faces serve as flankers, attention is attracted to the target and away from the flankers, thereby reducing possible conflicts that would result from attending to the flankers.

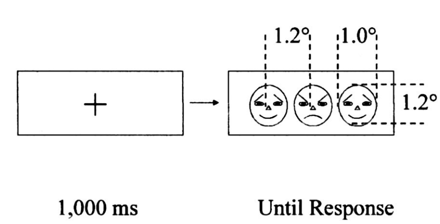

Figure 3. Temporal and spatial structure of a trial in Experiment 1.

This effect is also compatible with a different explanation: that the negative face as the target suffers less distraction because it constricts the focus of attention, whereas the positive face as the target suffers more distraction in incongruent trials because it dilates the focus of attention (Fenske & Eastwood, 2003). We note that Fenske and Eastwood used a different comparison to test their hypothesis: They compared the congruent with the neutral flanker condition. We regard this procedure as problematic because it violates the underlying logic of the flanker task. Incongruent flankers have an effect on RTs mainly because they specify the alternative response to that required by the target (Eriksen & Eriksen, 1974). Neutral flankers do not—by definition—specify a response and thus cannot create response competition. One might note that our results replicate the contrast in Fenske and Eastwood's Experiment 1 for compatible and incompatible flankers but not the contrast for congruent and neutral flankers.

The analysis of the RTs from the neutral and the no-flanker conditions reveals costs introduced by the mere presentation of flankers, as indicated by a 19-ms RT increase in the presence of the flankers. Thus, the mere presence of flankers slowed the response to the target even if the flankers did not specify any response in the current task. This can be explained by filtering costs (Treisman, Kahneman, & Burkell, 1983), because the mere presence of several objects imposes the requirement to be selective and filter out the irrelevant distractor stimuli. Filter costs may also explain why the RTs appeared to be longer in the congruent flanker condition than in the no-flanker condition.

Experiment 2

Experiment 2 used the same design as before, but with more reduced stimuli (see Figure 4) than in Experiment 1 and in Fenske and Eastwood (2003)—that is, a circle with an upward-pointing curved line (happy), a downward-pointing curved line (angry), and a straight line (neutral). With this variation, we tested whether the flanker-effect asymmetry depends on the redundancy of the facial stimuli used in Experiment 1 or can be obtained with only one discriminating feature.

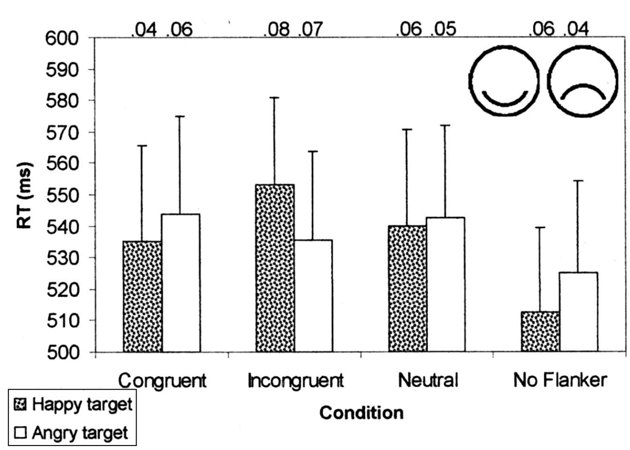

Figure 4. Results from Experiment 2. The category axis codes for the flanker condition: Flankers could have been congruent, incongruent, neutral, or absent (control). The dependent variable was average RT (ms). The numbers on the top of the figure above the bars report the average error rates in the respective condition. Error bars represent standard errors of the means.

Method

Participants. Participants were 8 women and 4 men from the same participant pool as in Experiment 1. Their mean age was 29 (SD = 10.5) years.

Apparatus, stimuli, and procedure. These were the same as in Experiment 1, with the only exception being that we used different stimuli (see Figure 4; the neutral face had a straight line as the mouth). Each stimulus subtended 1° of visual angle in diameter.

Results and Discussion

RTs shorter than 200 ms or longer than 1,000 ms (less than 5%) and false responses (5.9%) were excluded from the analysis. Figure 4 shows the mean correct RTs for the eight conditions. The main analysis concerned the RTs from the congruent and the incongruent flanker conditions. A 2 (target face: happy vs. angry) × 2 (congruency: congruent vs. incongruent) ANOVA revealed a significant Target Face × Congruency interaction effect only, $F(1, 11) = 14.2, p < .01$. The main effects for target face and congruency were both not significant, $Fs < 1$.

The Target Face × Congruency interaction reflected virtually no flanker effect (i.e., incongruent–congruent difference) for the angry face (535 ms vs. 544 ms), $t(11) = 1.3, p > .10$ (one-tailed) but a significant flanker effect for friendly faces (553 ms vs. 535 ms), $t(11) = 1.8, p < .05$ (one-tailed). A corresponding error analysis revealed a main effect for congruency, $F(1, 11) = 9.5$, $p < .01$, reflecting 2.4% more errors in the incongruent condition than in the congruent condition. The other main effect and the interaction were not significant, $F < 2.3, p > .10$.

The second ANOVA of the RTs from the neutral flanker and the no-flanker condition with the variables target face (happy vs. angry) and flanker presence (neutral flanker vs. no flanker) revealed a significant flanker presence effect only, $F(1, 11) = 13.9$, $p < .01$. The main effect for target face and the interaction were both not significant, $F < 1$. The flanker presence effect resulted in 22-ms longer RTs with flankers. A corresponding error analysis revealed no significant main effects or interactions, Fs < 1. Experiment 2 almost perfectly replicated the results pattern of Experiment 1 with different stimuli, indicating that reducing the schematic face to a circle with a curved line is sufficient to produce the effect.

Experiment 3

Experiment 2 showed that highly redundant stimuli are not necessary to obtain a stronger flanker effect with angry faces as compared to friendly faces as flankers. Rather, a stimulus consisting of a circle indicating the face outline plus a curved line indicating the mouth was sufficient to obtain the effect. Experiment 3 was a control experiment to test the possibility that the flanker-effect asymmetry is due to certain—more primitive—features of the stimuli used rather than to the—more complex—facialness of the stimuli. The traditional approach to disturb face processing is to use stimulus inversion (e.g., White, 1995) or feature scrambling (e.g., Fenske & Eastwood, 2003), neither of which is without problems, as detailed in the introduction. Experiment 3 used a novel approach. The basic idea behind Experiment 3 was to present stimuli that contained some of the features that made up the positive and the negative faces in Experiment 2 but, at the same time, to distort the perception of the stimulus as a positive or negative face. We did this by superimposing the inverted stimulus on the positive and the negative face, respectively, such that each stimulus consisted of a circle-shaped outline and two horizontally oriented curves near to the chin and the forehead (see Figure 5). The effect of this procedure was that the immediate impression of a face was strongly reduced (if not completely eliminated), and the resultant stimuli looked more akin to the letters *O* and *X*, respectively. Note that the construction of the stimuli implies a guess about what aspect (or aspects) of the stimuli in Experiment 2 constituted the critical difference (or differences) between the stimuli. In particular, we assume that the critical difference was in the lower part of the face and that the upper part of the face was not that important.[3]

The stimuli in Experiment 1 and 2 were portrayed as faces in the instructions. To keep constant as many factors as possible, we decided to use corresponding instructions for some of the participants in Experiment 3. In fact, it appeared to us that, with some good will, one could interpret the additional shapes as eyebrows that were consistent with the iconic facial expression (e.g., Öhman et al., 2001)—that is, with the nasal parts of the brows drawn down in an angry face and pushed up in a friendly face. We instructed the rest of the participants to respond to stimuli that looked like the letters *X* and *O*. In addition to providing a control for side conditions of the flanker-effect asymmetry, the instructional manipulation enabled us test the importance of the instructions for the phenomenon. In particular, we were interested in noting whether the enhanced flanker effect for angry faces depended on whether a facial (or emotional) interpretation of the stimuli was suggested by the instruction or whether it depended entirely on the stimulus configuration.

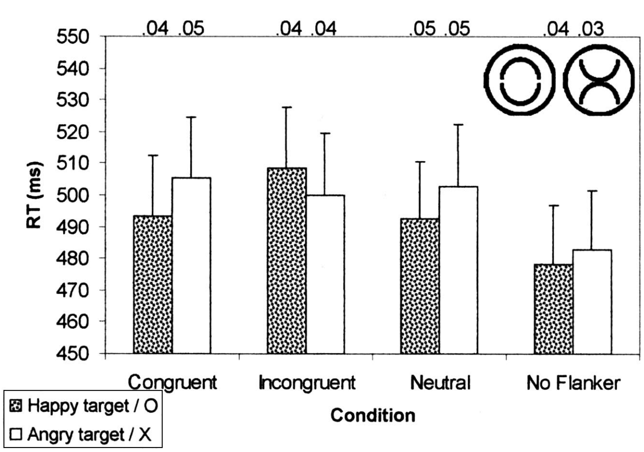

Figure 5. Results from Experiment 3. The category axis codes for the flanker condition: Flankers could have been congruent, incongruent, neutral, or absent (control). The dependent variable was average RT (ms). The numbers on the top of the figure above the bars report the average error rates in the respective condition. Error bars represent standard errors of the means.

Method

Participants. Eight men and 16 women with a mean age of 26 (*SD* = 7.9) years from the same participant pool as before participated in the experiment. Twelve participants each received the face instruction and the letter instruction.

Apparatus, stimuli, and procedure. These were the same except for two modifications. First, we used different stimuli (see Figure 5 for the two target stimuli; the neutral stimulus was an empty circle). The new stimuli were slightly larger than in Experiment 2, subtending 2.2° of visual angle each. Second, we presented the stimuli with different instructions. The *face instruction* designated the stimuli as angry, happy, or neutral, as before. In contrast, the *letter instruction* designated the stimuli as circles containing the letters *X* or *O* or nothing. We kept all other aspects of the instructions constant.

Results

RTs shorter than 200 ms or longer than 1,000 ms (less than 1%) and false responses (4%) were excluded from the analysis. Figure 5 shows the mean correct RTs for the eight conditions. We analyzed the RTs by means of a 2 (target face: happy vs. angry) × 2 (congruency: congruent vs. incongruent) × 2 (instructions: face vs. letter) ANOVA, which revealed a significant congruency effect, $F(1, 22) = 4.7$, $p < .05$, reflecting a 5-ms disadvantage for the incongruent trials, and a significant Congruency × Face interaction, $F(1, 22) = 10.9$, $p < .01$, reflecting longer RTs with incongruent than with congruent flankers with happy faces (or *O* stimuli) as targets (508 ms vs. 493 ms), $t(23) = 3.5$, $p < .05$, but no differences with angry faces (or *X* stimuli) as targets (500 ms vs. 505 ms), $t(23) = 1.58$, $p = .12$ (two-tailed; note that we could not interpret these as marginally significant results, because the difference contradicts the hypothesis).

Apart from this, the analysis revealed only a marginally significant Instruction × Congruency effect, $F(1, 22) = 3.4$, $p = .08$, indicating that the overall congruency effect (congruent minus incongruent flankers) was smaller with the face instruction than with the letter instruction (0 ms vs. 9 ms), which is not theoretically significant. No other main effects or interactions were significant, Fs < 1. A corresponding error analysis revealed no significant effects whatsoever, Fs < 1.

As before, a second analysis of the RTs concerned the effect of neutral versus absent flankers. The 2 (target face: happy vs. angry) × 2 (flankers: neutral vs. absent) × 2 (instructions: face vs. letter) ANOVA revealed a significant congruency effect, $F(1, 22) = 41.7$, $p < .001$, reflecting an 18-ms slowing with neutral flankers relative to the no-flanker condition, and a marginally significant target-face effect, $F(1, 22) = 3.2$, $p = .09$, reflecting a 7-ms RT advantage for the happy face. A corresponding error analysis revealed no significant effects, Fs < 1.

[3] One might think that it is also possible to predict a complete reduction of the flanker-effect asymmetry with these stimuli, because the two curved lines that render the mouth are now present in both stimuli. However, on the basis of the previous literature, differential effects between positive and negative faces disappear with inversion. As revealed by an unpublished flanker experiment from our lab, this is also true for the Experiment 2 stimuli.

Discussion

The results from Experiment 3 challenge the assumption that the flanker-effect asymmetry obtained with positive and negative faces is due to their facial aspects (or their facial valence; but see Experiment 5 for evidence that the *X*/angry face stimulus was rated as more negatively valenced than the *O*/happy face stimulus)—although the stimuli used in Experiment 3 do not immediately give rise to the impression of a face, we obtained results very similar to those in Experiment 2. Of course, we cannot ignore the fact that the flanker-effect asymmetries in Experiments 2 and 3 were due to different causes. For example, one might argue that the flanker-effect asymmetry in Experiment 2 was due to facial threat, whereas the asymmetry in Experiment 3 was due to other factors. The problems with this account are that it is not parsimonious (two different explanations are given for the same phenomenon in two stimuli that have a common feature) and that it is unfounded (no independent evidence is available that different factors are at work in the two experiments). A second finding from the experiment is a null result: The instructional manipulation had no influence on the flanker-effect asymmetry. This result suggests that the flanker-effect asymmetry as examined in the present experiments does not depend strongly on the top-down established interpretation of the stimuli but is more associated with stimulus-bound differences.

Experiment 4

Experiment 3 revealed a flanker-effect asymmetry with stimuli that possessed features of schematic emotional faces but did not lend themselves easily to a particular facial perception. This result suggests that physical properties may be as important for the flanker-effect asymmetry as the interpretability of the stimulus as a face. However, Experiment 3 was limited in that one could contend that the *X* and *O* stimuli shared features with stimuli that are normally considered as schematic emotional faces and that this similarity had primed a certain emotional content. Therefore, it is still possible to argue that the flanker-effect asymmetry in Experiment 3 was due to a threatening flanker capturing attention away from the target or to the negative and the positive target face, which narrowed or dilated, respectively, the aperture of the focus of attention (Fenske & Eastwood, 2003). In fact, although there have been reports that perceptual factors modulate the strength of the flanker effect (Cohen & Shoup, 1993), no researcher prior to Fenske and Eastwood (2003) appears to have used the present *asymmetry design*. We therefore do not know whether we can obtain a flanker-effect asymmetry at all with nonemotional stimuli that do not plausibly prime emotional contents.

Thus, the purpose of Experiment 4 was to test whether a flanker-effect asymmetry is the hallmark of emotional processing or whether we can also obtain it with completely nonemotional stimuli. The targets used in Experiment 4 had no similarity with faces and did not appear to be emotional in other ways, either. They were borrowed from the classical study of Treisman and Souther (1985) on search asymmetries: a circle and a lollipop (a circle with a line intersecting its base). The selection of the stimuli was inspired by the idea that both the occasional findings of a search asymmetry with schematic faces and the flanker-effect asymmetry may be due to a similar perceptual difference between the positive and the negative stimuli. Thus, if it is a general rule that a stimulus pair that exhibits a search asymmetry also exhibits a flanker-effect asymmetry, the classical example for a search asymmetry should also exhibit a flanker-effect asymmetry.

Method

Participants. Four men and 8 women with a mean age of 28 (SD = 3.9) years from the same participant pool as before participated in the experiment.

Apparatus, stimuli, and procedure. These were the same as before, except for the stimuli used and the instructions. The new stimuli were a circle, a circle with a vertical line intersecting the circumference at 180°, and a triangle. The size of the circles was the same as in Experiment 2 (1°), and the base and hypotenuse of the triangle also subtended 1°. The two circles were the response-relevant stimuli, whereas the triangle was the neutral stimulus. Participants were instructed in the same way as in the previous experiments, but emotional meaning was not attached to the stimuli.

Results

RTs shorter than 200 ms or longer than 1,000 ms (less than 1%) and false responses (2.3%) were excluded from the analysis. Figure 6 shows the mean correct RTs for the eight conditions. The main analysis concerned the RTs from the congruent and the incongruent flanker conditions. A 2 (target circle: plain circle vs. circle plus line) × 2 (congruency: congruent vs. incongruent) ANOVA revealed a significant Target Circle × Congruency interaction effect, $F(1, 11) = 29.9$, $p < .001$. The main effects for both target circle and congruency were also significant: congruency, $F(1, 11) = 16.4$, $p < .01$; target circle, $F(1, 11) = 15.6$, $p < .01$. The Target Circle × Congruency interaction revealed a 35-ms flanker effect for the plain circle stimulus as the target, $t(11) = 5.2$, $p < .001$, but a −3-ms flanker effect for the circle plus line stimulus, $t(11) < 1$. A corresponding error analysis revealed a marginally significant main effect for stimulus, $F(1, 11) = 3.3$, $p = .10$, reflecting 1.1% more errors with the circle plus line, and a marginally significant interaction, $F(1, 11) = 3.8$, $p = .08$,

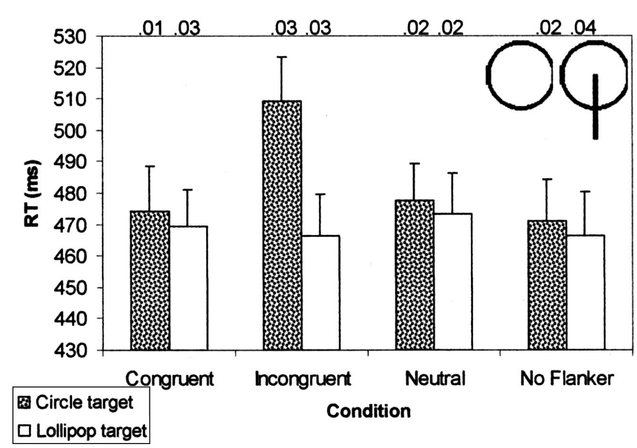

Figure 6. Results from Experiment 4. The category axis codes for the flanker condition: Flankers were congruent, incongruent, neutral, or absent (control). The dependent variable was average RT (ms). The numbers on the top of the figure above the bars report the average error rates in the respective condition. Error bars represent standard errors of the means.

indicating fewer errors in the congruent than in the incongruent condition for the plain circle stimulus (2.8% vs. 0.9%) but virtually no difference for the circle plus line stimulus (2.6% vs. 3.1%). The main effect for congruency was not significant, $F < 1$.

The second ANOVA of the RTs from the neutral flanker and the no-flanker conditions with the variables target face (happy vs. angry) and flanker presence (neutral flanker vs. no flanker) revealed no significant effects whatsoever, $F(1, 11) < 2.9$, $ps > .10$. A corresponding error analysis revealed no significant main effects or interactions, $Fs < 2.4$, $ps > .10$.

Discussion

Experiment 4 found a flanker-effect asymmetry with a stimulus pair that did not have any particular resemblance with emotional stimuli. Thus, the experiment indicates that the flanker-effect asymmetry is not a hallmark of the processing of emotional stimuli. More precisely, although we cannot exclude the possibility that emotional factors rather than perceptual factors drove the flanker-effect asymmetry in Experiments 1–3, Experiment 4 indicates that, in principle, perceptual factors are sufficient to explain the asymmetry. Moreover, the results are in line with the suspicion that stimuli that exhibit a search asymmetry would also exhibit a flanker-effect asymmetry.

The overall pattern of results has an aspect distinct from the previous experiments: Whereas Experiments 1–3 all revealed filtering costs in comparison to the no-flanker condition, these were virtually absent in Experiment 4. A possible explanation is that the neutral stimulus in Experiment 4 was so easy to discriminate from the two targets that the filtering operation did not impose any detectable costs.

How could we explain the flanker-effect asymmetry? Remember that there is no compelling reason to assume that the circle and circle plus line stimuli unconditionally capture attention or change the focus of attention. We may derive an explanation from theories on conditional automaticity (e.g., Bargh, 1989; Folk, Leber, & Egeth, 2002; Folk, Remington, & Johnston, 1992), assuming that intentions (as introduced by requirements and affordances of the task) can have nonintended and deleterious side effects. According to this account, participants might have used the presence versus absence of the line for the discrimination between the two stimuli (or responses). Because the presence of the line is highly available (Treisman & Souther, 1985), it would activate the correct response when appearing with the target but the wrong response when appearing with the flankers.

In summary, whatever the details of the flanker-effect asymmetry are (which future experiments must uncover), emotional valence is not an indispensable part of the phenomenon. Indeed, all stimulus pairs tested in Experiments 1–4 were perceptually different from each other, which suggests that perceptual differences are a more constant factor in producing the effect.

Experiment 5

In interpreting Experiment 4, we assumed that the plain circle, the circle plus line, and the triangle would not be considered as emotional stimuli. To provide an empirical test for this assumption, we conducted a rating experiment.

Method

Participants. Thirty-six students of an introductory course in psychology volunteered for the experiment.

Apparatus, stimuli, and procedure. The stimuli tested were the positive, neutral, and negative stimuli from Experiments 1–3. The stimuli were printed on a two-page questionnaire. Stimuli were printed one below the other at the left side of a questionnaire page, with stimuli belonging to a single experiment grouped together. To the right of each stimulus, there was a 7-point rating scale ranging from −3 (*negative*) to 3 (*positive*). The zero point of the scale was labeled *neutral*. Participants were asked to circle the scale point that best fitted the emotional valence of that stimulus.

Results

One data point was missing and was therefore replaced by the group mean. The results are shown in Figure 7. For a combined analysis of the ratings, the stimulus factor was established as the more interference-suffering target (positive faces, *O*, or plain circle), the neutral flanker (neutral faces, circle, or triangle), and the less interference-suffering target (negative faces, *X*, or circle plus line). A 4 (experiment) × 3 (stimulus) ANOVA revealed significant main effects for experiment, $F(3, 102) = 5.2$, $p < .01$, and stimulus $F(2, 68) = 237.8$, $p < .001$, as well as a significant Experiment × Stimulus interaction, $F(6, 204) = 51.1$, $p < .001$. Follow-up one-way ANOVAs revealed significant main effects for stimulus with the stimuli of Experiment 1, $F(2, 70) = 171.6$, $p < .001$; Experiment 2, $F(2, 70) = 170.7$, $p < .001$; and Experiment 3, $F(2, 70) = 40.8$, $p < .001$, but not for Experiment 4, $F(2, 70)$ 1.2, $p > .10$.

Discussion

The analysis of the ratings supports the assumption that whereas the stimuli of Experiment 1 and 2 could be considered as emotional (or valenced), the stimuli used in Experiment 4 did not differ in emotional valence. Somewhat surprising (at least to us) is the fact that the stimuli used in Experiment 3 were perceived as valenced: In particular, the *X* stimulus received remarkably nega-

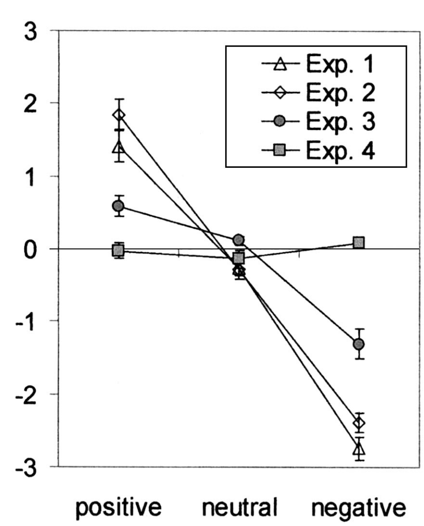

Figure 7. Results from Experiment 5. See the text for more information.

tive ratings. However, the most important result is that the nonfacial stimuli from Experiment 4 were indeed nonvalenced.

One may see the relatively high difference in rated valence for the *X*/*O* stimuli as casting new light on the previous experiments. In particular, we may summarize the results from Experiments 1–3 by noting that every experiment with stimuli that were independently found to convey affect also showed significantly reduced flanker compatibility effects with a negative target and positive flankers than vice versa. We come back to this point in the General Discussion.

General Discussion

We conducted four experiments and one rating study concerning differences in emotional faces in their ability to involuntarily attract attention in a flanker task. Experiments 1 and 2 obtained the flanker-effect asymmetry predicted by the threat-detection hypothesis: Angry faces as flankers revealed a pronounced incongruence effect, whereas friendly faces as flankers produced a weak (or absent) incongruence effect only. Experiment 2 suggested that redundant facelike stimuli are not necessary to obtain the flanker-effect asymmetry but that a curved line (as the mouth) within a circle is sufficient. Experiment 3 indicated that the interpretation of the stimuli as facial expressions with emotional meaning is not a necessary condition for the flanker-effect asymmetry. Finally, Experiment 4 revealed a flanker-effect asymmetry with stimuli completely unlike faces or other emotional stimuli.

The present results replicate and extend the corpus of evidence that schematic facial expressions of anger and happiness have differential effects in three attention research paradigms: visual search, spatial cuing, and the flanker task (e.g., Eastwood et al., 2001, 2003; Fenske & Eastwood, 2003; Fox et al., 2000, 2002; Hansen & Hansen, 1988; Nothdurft, 1993; Öhman et al., 2001; White, 1995). Of these, the flanker paradigm is of particular interest, because any influence of the flankers on the response to the targets is clearly involuntary: Observers should intend to focus exclusively on the centrally presented target and ignore the flankers as much as possible (Eriksen & Eriksen, 1974). In this regard, the flanker paradigm, in which there is spatial certainty about the position of the target, is superior to the visual search task, in which every stimulus is a potential target and participants have to search for it (see Yantis, 1993, for a summary of arguments concerning the conditions necessary to prove nonintentionality in search tasks).

Experiments 3 and 4, however, cast doubts on the assumption that the flanker-effect asymmetry for happy and angry faces is caused by perceived facial emotionality or facial threat. In fact, we obtained the flanker-effect asymmetry with ambiguous stimuli, whether participants were given a facial or a nonfacial meaning (Experiment 3), and with completely nonemotional stimuli (Experiment 4). Together, these experiments show that the flanker-effect asymmetry cannot be unambiguously attributed to the stimuli's categories of facial expressions or of emotional stimuli. Rather, it is evident that perceptual differences between the stimuli may also account for the flanker-effect asymmetry.

In Experiment 3 we introduced a new procedure for testing a perceptual alternative account. Previous studies have scrambled (e.g., Fenske & Eastwood, 2003) or inverted (e.g., Eastwood et al., 2001) the faces to show that the component parts, when differently arranged, are not sufficient to cause the attention effects. In Experiment 3, schematic happy and angry faces were superimposed with an inverted copy, which virtually eliminated the impression of a face but left intact the lower half of each stimulus. The advantage of this technique is that some of the emergent features (cf. Pomerantz et al., 2003) of schematic faces are maintained (i.e., those in the lower half of the face), but the facial perception of the stimuli is disrupted. The results were clear cut: A flanker-effect asymmetry was revealed for the stimuli that shared perceptual features with the schematic angry and happy faces. This result suggests that the flanker-effect asymmetry found in Experiment 2 might have been due to factors that originated in the very stimuli and were not necessarily bound to the perception of facial expressions of emotion. This interpretation is fostered by the null effect of the instructional manipulation: The flanker-effect asymmetry did not differ depending on whether the stimuli were introduced as faces or as letters. Even when we acknowledge that null effects always raise concerns about statistical power, the ineffectiveness of the instructional manipulation suggests that higher order cognitive–emotional factors, or sets, are not very important aspects of the flanker-effect asymmetry.

Experiment 5 revealed important information about the stimuli in Experiment 3: The nonfacial stimulus that shared features with a negative face was rated more negative than the nonfacial stimulus that shared features with a positive face. We might interpret this as evidence that the flanker-effect asymmetry, although it is not restricted to facial stimuli, is closely linked to the perceived valence of the presented stimuli. Experiment 4, however, demonstrated that differences in emotional valence are not a necessary condition for the flanker-effect asymmetry. Thus, we found a simple dissociation of valence and the flanker-effect asymmetry. Future studies may reveal a double dissociation between valence and the flanker-effect asymmetry (that a difference in valence is also not a sufficient condition for the effect) or, alternatively, reveal that emotional valence is an independent factor for the effect.

Experiment 4 countered the concern that similarity to faces and emotional valence are the crucial factors for the flanker-effect asymmetry and revealed that the flanker-effect asymmetry is not the hallmark of the processing of emotional stimuli. We chose the stimuli for Experiment 4, the plain circle and the circle plus line stimuli, because they exhibit a search asymmetry (Treisman & Souther, 1985), which is sometimes also found for schematic faces similar to those used in Experiment 1 and 2. A flanker-effect asymmetry may arise in a way similar to a search asymmetry. More precisely, we assume that the search asymmetry stems from the fact that one stimulus of a stimulus pair is characterized by the presence of a basic perceptual feature, whereas the other is characterized by the feature's absence (Treisman & Gormican, 1988). The search asymmetry then reflects the fact that the presence of a basic perceptual feature can be detected better than its absence. By analogy, the flanker-effect asymmetry may result from the fact that, in their attempt to choose the correct response, the participants use a discriminative perceptual feature, which identifies one stimulus (i.e., the less interference-prone target) by its presence but the other stimulus (i.e., the more interference-prone target) by its absence, which has the unbidden side effect that the basic feature is difficult to ignore when presented with the flanker. The identity of this feature, however, remains obscure. Possible candidates include curvature discontinuities between the face outline and the mouth in the negative face (Kristjansson & Tse, 2001), the concave edge that results from the negative mouth in interaction with the face outline (Humphreys & Müller, 2000), and the different distribution of contrast reversals (spatial frequency) in the vertical axis. We hope that future research will bring some clarity about the details of the flanker-effect asymmetry in general and for emotional faces in particular.

Against this preliminary account, some may object that Öhman et al. (2001) did not find a search asymmetry (i.e., flatter search slopes for angry faces). A possible explanation for this fact is that, in the present paradigm, the stimuli were presented near the fovea, where acuity is relatively good, whereas in the visual search task, some of the stimuli were presented with a higher retinal eccentricity, where acuity is less good. This is a disadvantage for high-detail stimuli, such as those in Öhman et al. (2001) and the present Experiment 1. Note, however, that the stimuli in Experiment 1 were only similar to Öhman et al.'s (but not exact replicas), such that we cannot exclude differences in the stimuli used.

We have regarded the flanker paradigm as a means to examine attentional capture of negative or threatening faces (see also Theeuwes & Burger, 1998). Fenske and Eastwood (2003), in their original investigation of flanker effects with faces, however, used the same task to examine a different hypothesis, that negative stimuli narrow the focus of attention relative to positive stimuli. From our results, we cannot exclude the possibility that the observed effects were due to a change in the width of the focus of attention. Moreover, Lavie (1995) has argued that selectivity of attention in the flanker task is modulated by perceptual load imposed by the target, which is a function, for example, of the target's complexity. Future research may examine the details of the flanker-effect asymmetry.

In summary, we started with the question of whether negative, angry, or threatening faces capture attention. A review of the literature revealed that a precondition for attentional capture, that the assumed attention-capturing stimulus feature is preattentively available, is not supported by the relevant search experiments. We also pointed out the potential problems with the confound between perceptual differences and emotional differences. Empirically, we tested in the flanker paradigm whether a results pattern that is compatible with attentional capture by negative or threatening faces could also be explained by perceptual differences. The results indicate that the flanker-effect asymmetry with emotional faces, similar to previous results from the visual-search experiments, can be explained by perceptual differences and thus does not provide unequivocal support for the threat-capture hypothesis.

Does that mean that there is no place for emotion in a theory of attention? Although we are skeptical about the notion that emotion affects attention before attention has been directed to the emotional stimulus, as presupposed by threat capture, this does not imply that emotion cannot affect attention after attention has been directed to the emotional stimulus. Fox and coworkers (e.g., Fox et al., 2000, 2001, 2002) have suggested that it is more difficult to disengage attention from a threatening than from a benign stimulus. Fenske and Eastwood's (2003) hypothesis of an attention-focusing effect of negative stimulus information is also an example of a postattentive emotion–attention interaction. Although tests of these hypotheses also have to deal with the confound between the emotional content and perceptual stimulus features, we look forward to further studies that clearly address the hypothesized postattentive effects of emotion on attention.

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