No difference in flanker effects for sad and happy schematic faces: A parametric study of temporal parameters

Filipp Schmidt & Thomas Schmidt

University of Kaiserslautern, Germany

Abstract

Flanker effects with schematic faces have been reported to be larger for happy than for sad faces, allegedly because sad faces restrict the focus of spatial attention. We report a parametric study that fails to replicate this effect. Participants performed speeded identifications of happy or sad faces accompanied by compatible or incompatible flanker faces. We varied the temporal interval between presentation of central target and flanker faces because differential attentional effects of happy and sad faces should critically depend on this variable. In contradiction to the literature, we found large compatibility effects that were modulated by temporal parameters, but not by the emotional valence of the faces, and not in the way consistent with differential attentional modulation. We conclude that previously reported asymmetries in flanker tasks with schematic faces are not due to changes in attentional scope (mediated by emotion or otherwise), but rather to perceptual low-level differences.

Keywords: Visual attention; emotion; schematic faces; flanker task

Introduction

It is widely known that emotions can influence cognitive processes, e.g., perception, memory, attention, language, planning, and problem solving (for a review on interactions of emotion and cognition from a neuroscientific point of view, see Pessoa, 2008). Recently, researchers have become increasingly interested in the relationship between emotion and a specific component of human cognition, visual attention (for reviews see Compton, 2003; Vuilleumier, 2005).

Visual attention is the cognitive process by which we selectively focus on specific locations, objects, or features of our visual environment, and modulate their processing due to situational or task demands. There is a likely causal relationship between this selection process and emotion: It is evolutionarily advantageous to pay particular attention to environmental stimuli invoking positive affect (being potentially benevolent) or negative affect (being potentially malevolent).

Therefore, one way to investigate the relationship between visual attention and emotion is to study the influence of stimuli with different emotional valences (e.g., pictures of happy and angry/sad faces) on information processing. Using this approach, numerous experimental studies using different paradigms have demonstrated the modulation of different aspects of visual attention by such stimuli. In visual search studies - in which participants search for a negative or positive schematic face in a crowd of same or other distractors - threatening or negative facial expressions have often been reported to be processed more efficiently than positive or neutral expressions (e.g., Eastwood, Smilek, & Merikle, 2001; Fox et al., 2000; Hansen & Hansen, 1988; Horstmann, Scharlau, & Ansorge, 2006; Öhman, Lundqvist, & Esteves, 2001). Although using more controlled face stimuli might reverse this effect into a search advantage for happy faces (Becker, Anderson, Mortensen, Neufeld, & Neel, 2011; see also Becker et al., 2012), all these findings suggest that focal attention is effectively guided by the valence of different emotional stimuli. In line with these results, several studies illustrated that angry or threatening faces impede the disengagement of attention compared to neutral or positive faces (Belopolsky, Devue, & Theeuwes, 2011; Fox et al., 2001; Fox, Russo, & Dutton, 2002; Georgiou et al., 2005). Finally, in the attentional blink paradigm, the use of faces with different emotional valences also results in different identification accuracies and time courses (Maratos, Mogg, & Bradley, 2008; Srivastava & Srinivasan, 2010). In summary, the influence of stimuli's emotional valence on visual attention was tested in a wide range of experimental paradigms and valence was found to modulate different aspects of visual attention (e.g., its engagement and disengagement).

In this paper, we will specifically investigate the relationship between emotional valence and the spatial scope of visual attention. Several researchers have claimed that negative emotions or emotional stimuli tighten the focus of attention, that is, scale down the "spotlight" (Posner, 1980) or "zoom lens" (Eriksen & St. James, 1986; Eriksen & Yeh, 1985) of spatial attention (e.g., Fenske & Eastwood, 2003). At the same time, positive emotions or emotional stimuli are believed to broaden the scope of attention (e.g., Fredrickson, 2003; Fredrickson & Branigan, 2005; Rowe, Hirsh, & Anderson, 2007). These influences of emotion on attentional scope have been tested repeatedly with different methods, stimuli, and experimental paradigms (for reviews see Friedman & Förster, 2010; Srinivasan et al., 2009). A class of stimuli that is used in a great many of these studies is that of schematic faces with different emotional valences.[1]

The Eriksen flanker paradigm (Eriksen & Eriksen, 1974) is a well-established and expedient method for investigating the potential relevance of emotional stimuli for the scope of visuospatial attention. A

---

[1] This is mainly because the use of schematic faces is seen as an elegant way to avoid the variations in physical features (such as luminance or spatial frequency) that are difficult to control in photographs of real faces (Öhman et al., 2001).

particularly interesting flanker study was conducted by Fenske and Eastwood (2003). The authors presented participants with configurations of three schematic face stimuli. The participants' task was to respond to the emotional valence of the central face (i.e., happy or sad) while ignoring the flanking faces. Both flankers were always the same and could be either compatible to the central face (i.e., identical and having the same valence) or incompatible (i.e., non-identical and having the opposite or neutral valence). This design allows for the detection of compatibility effects, in which incompatible configurations typically lead to slower responses than compatible ones. Indeed, Fenske and Eastwood (2003) observed faster responses to compatible configurations, but only when the central face was a happy one. In contrast, when it was a sad one, response times were the same no matter whether it was accompanied by (compatible) sad or (incompatible) happy flanker faces. The authors conclude from these *asymmetric flanker effects* that the valence of schematic faces influences the scope of spatial attention. In particular, they suggest that the effect results from the fact that sad faces constrict the focus of attention more effectively than happy faces (henceforth called the “Fenske-Eastwood hypothesis”). The smaller scope of visual attention induced by sad target faces would withdraw attention from the peripheral flankers and thus diminish their influence. In contrast, the broader scope of visual attention induced by happy target faces would likely increase attention to the flanker positions. As a result, only the response speed to happy faces would be diminished by incompatible flanker information. Fenske and Eastwood's (2003) argument is perfectly in line with the research and theoretical approaches discussed in the preceding paragraphs.

We wanted to replicate and extend the findings of Fenske and Eastwood (2003) by varying temporal parameters and by testing if these would affect the compatibility effects as would be predicted by the Fenske-Eastwood hypothesis. Spatial attention is not an instantaneous phenomenon but unfolds over time and across space (e.g., Posner, 1980; also in flanker paradigms, see Eriksen & Collins, 1969; Eriksen & Rohrbaugh, 1970; for a review see Cave & Bichot, 1999). If schematic faces exert an influence on spatial attention (by means of their emotional valence), the focusing or distribution of the attentional scope should also unfold over time, and the longer a face stimulus precedes subsequent flankers, the more it should modulate (e.g., constrict) the scope of attention.

We employed the same experimental paradigm as Fenske and Eastwood (2003) but extended its attributes in the temporal domain. Sample size and number of trials were chosen such that the statistical power was virtually the same as in Fenske and Eastwood’s (2003) original study.[2]

Experiment

General

To explore the potential role of schematic faces for visuospatial attention, we employed a flanker paradigm with happy and sad schematic faces. We replicated Experiment 1A of Fenske and Eastwood (2003), but varied the stimulus-onset asynchrony (SOA) of central target faces and flanking faces in several steps to investigate the time-course of flanker compatibility effects. We employed both negative SOAs (flankers preceding the target) and positive SOAs (target preceding the flankers). First, with *simultaneous flankers and targets*, we expected to replicate the asymmetric flanker effect, because that condition is a close replication of Fenske and Eastwood’s (2003) original study. Second, wi[2]th *flankers preceding the target*, we expected that spatial attention would modulate the time-course of

---

[2] We used G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) to calculate exemplary post-hoc power values for Fenske and Eastwood (2003) and our study. For example, the power to explain a small effect (effect size *f* = 0.1) in our study (set values: error probability = 0.05, sample size = 20, number of groups = 1, repetitions = 120, correlation among measures = 0.5) was 0.835 (sample size = 20, repetitions = 120). This is comparable to Fenske and Eastwood (2003) with a power of 0.842 in Experiment 1A (sample size = 40, repetitions = 36), of 0.539 in Experiment 1B (sample size = 24, repetitions = 36), and of 0.877 in Experiment 2 (sample size = 48, repetitions = 30).

the compatibility effect, changing its overall magnitude and inducing an increase with SOA (Schmidt & Seydell, 2008; Schmidt & Schmidt, 2010; Sumner et al., 2006). In particular, we expected stronger compatibility effects with longer SOAs (a result pattern well known in flanker and response priming paradigms; e.g., Flowers, 1990; Schwarz & Mecklinger, 1995; Vorberg et al., 2003) and larger compatibility effects when flankers were sad rather than happy faces (because sad flankers should be more effective when summoning spatial attention). Third, with the *target preceding the flankers*, we expected that compatibility effects should become smaller with increasing SOA when the target was a sad rather than a happy face, because in that case progressively less attention should be extended to the flankers as the focus of attention constricted around the target.

Methods

Participants. Twenty students from the University of Kaiserslautern, Germany (18 right-handed, 2 left-handed, 13 female, 7 male, ages 21-29), with normal or corrected vision participated in the experiment for payment of € 6 per hour. All of them gave informed consent before the experiment and, after the final session, received an explanation of the experiment. All participants were treated in accordance with the ethical guidelines of the American Psychological Association.

***Apparatus and Stimuli*.** The participants were seated in a dimly lit room in front of a color monitor (1280 x 1024 pixels) with a monitor retrace rate of 85 Hz at a viewing distance of approximately 70 cm. Stimuli were happy and sad schematic faces (diameter of 1.43° of visual angle; 1 cm ≈ 0.82°) in the configuration depicted in Figure 1. They were presented in white (60.00 cd/m^2) against a dark background (13.00 cd/m^2). The gap between faces was about 0.76°. Before onset of the central face, a fixation cross was presented in the middle of the screen (diameter of 0.43°; 60.00 cd/m^2). The schematic faces, their visual angles, and their configuration on the monitor are designed to match those applied by Fenske and Eastwood (2003).

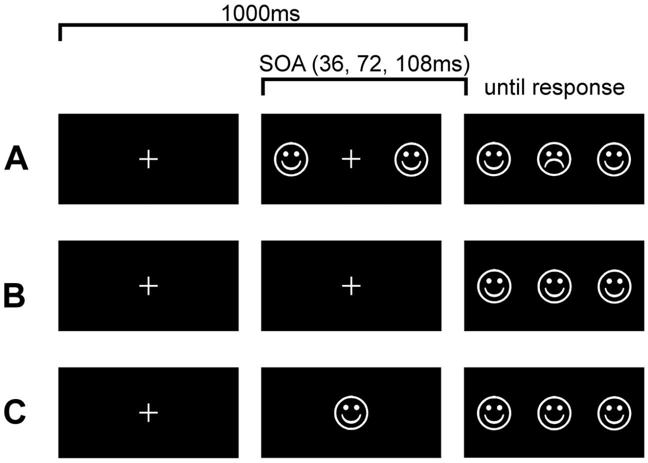

Figure 1. Stimuli and procedure. In each trial, one central and two flanking schematic faces were presented. (A) The flankers precede the central face. (B) Both appear simultaneously. (C) The central face precedes the flankers. Participants always responded to the valence of the central face by a speeded keypress response (e.g., right for happy and left for sad faces). The two flankers always were identical and could either be incompatible (e.g., A) or compatible (e.g., B) with the central face. Note that the face stimuli and fixation cross are not drawn to scale.

***Procedure*.** Each trial started with the presentation of the fixation cross. Depending on the experimental condition, the central target and the two flanking faces were presented simultaneously or with a variable delay. Flankers could either precede or follow the target at SOAs of 0, ±36, ±72, or ±108 ms. Participants were supposed to perform a speeded identification of the target (e.g., by pressing a right button for the happy face and a left button for the sad one) while ignoring the flankers. All stimuli remained on screen until participants finished their response. The target and flanking faces were either compatible or incompatible regarding their emotional valence, that is, a happy target face could be flanked by two happy or two sad faces, respectively (and vice versa for a sad target face).

The time interval from fixation onset to the onset of the final stimulus was constant at 1000 ms; summary feedback on response times and error rates was provided after each block. All stimulus combinations of compatibility, valence of the target face, target-flanker order, and target-flanker SOA occurred equiprobably and pseudo-randomly in a completely crossed repeated-measures design. Half of the participants pressed a right button to indicate a negative face and the left button for a positive one. The other half of participants had the reverse stimulus-response mapping. Participants performed two 1-hour sessions of the task, each consisting of one practice block followed by 60 blocks of 28 trials.

Data treatment and statistical methods. Practice blocks were not analyzed and trials were excluded if response times were shorter than 100 ms or longer than 1000 ms. This criterion eliminated 91 trials (0.14%). The overall error rate was about 8.89% of all trials. Error trials were not included in the response time analyses. Error rates were arcsine transformed to comply with ANOVA requirements and analyzed with the same rationale as the response times.[3] Repeated-measures analyses of variance (ANOVAs) were performed with factors of compatibility (*C*), target-flanker SOA (*S*), and valence of the flanker or target faces (*V*), separately for different temporal target-flanker orders. Results are reported with Huynh-Feldt-corrected *p* values and the effect size partial eta squared (η_p^2). The respective effects are specified by the subscripts of the *F* values (e.g., F_{CxS} for the interaction of compatibility and target-flanker SOA).

Results and Discussion

Response times and error rates. First, when flankers were presented before the target, responses were faster and produced less errors in compatible trials compared to incompatible ones [response times, *RTs*: $F_C(1,19) = 75.09$, $p < .001$, $\eta_p^2 = .798$; errors: $F_C(1,19) = 56.29$, $p < .001$, $\eta_p^2 = .748$] (Figure 2A). This effect increased with the target-flanker SOA [RTs: $F_{CxS}(2,38) = 14.52$, $p < .001$, $\eta_p^2 = .433$; errors: $F_{CxS}(2,38) = 6.32$, $p = .004$, $\eta_p^2 = .250$] but was not significantly different for happy and sad flanker faces [RTs: $F_{CxV}(1,19) = 0.01$, $p = .922$, $\eta_p^2 = .001$; $F_{CxSxV}(2,38) = 0.35$, $p = .671$, $\eta_p^2 = .018$; errors: $F_{CxV}(1,19) = 1.70$, $p = .208$, $\eta_p^2 = .082$; $F_{CxSxV}(2,38) = 0.30$, $p = .725$, $\eta_p^2 = .016$].[4]

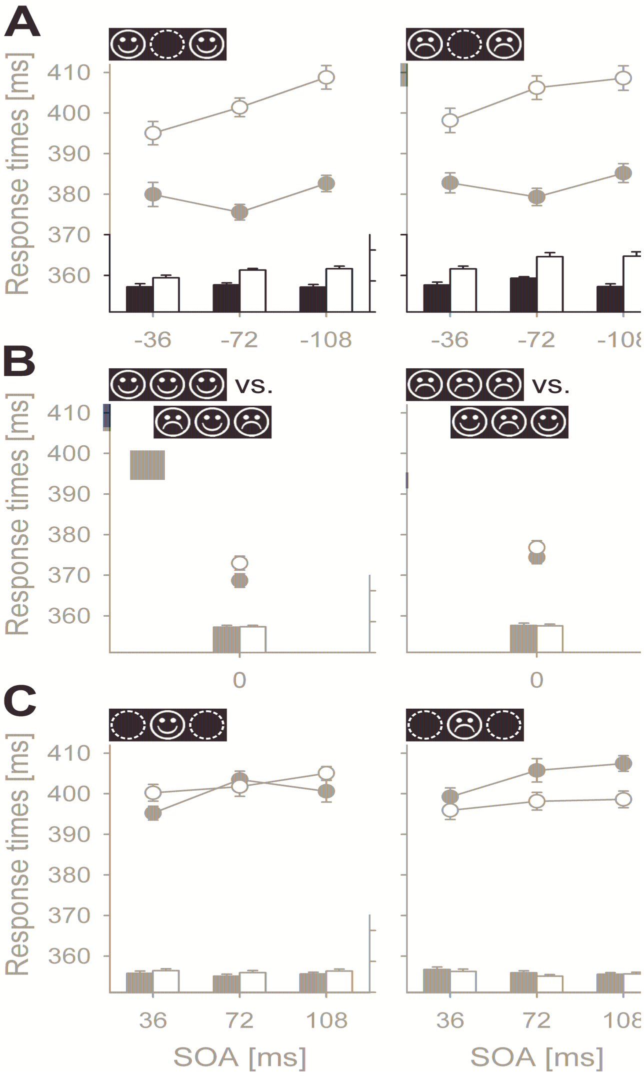

Figure 2. Results. Response times and error rates in compatible (black) and incompatible trials (white) as a function of target-flanker SOA. The

---

[3] Just like response times, error rates can represent motor response conflicts in flanker and response priming tasks. Specifically, participants tend to produce more errors in incompatible trials; this compatibility effect usually increases with the SOA between flanker (prime) and central (target) stimuli (e.g., Schmidt, Haberkamp, & Schmidt, 2011; Vorberg et al., 2003).

[4] Indeed, we strongly suppose that the Eriksen flanker effect and the response priming effect are merely two variants of the same effect, differing only in whether targets and distractors are presented at the same or neighboring locations. Both effects have been shown to involve a processing conflict at the motor stage, to have similar time-courses with respect to stimulus onset asynchrony, and to be dissociable from visual awareness of the primes or flankers. In our lab, we use them interchangeably. From this background, it is a puzzle to us that most studies of the Eriksen effect confine themselves to a flanker-target SOA of 0 ms, where the effect is smallest.

compatibility effect is defined by the differences between responses in compatible and incompatible trials. (A) Flankers preceding the target. (B) Simultaneous flankers and targets. (C) Target preceding the flankers. Left and right panels show data for first-occurring happy and sad faces, respectively. Error bars denote the standard error of the mean corrected for between-subjects variance (Bakeman & McArthur, 1996; Loftus & Masson, 1994).

Second, when target and flanker faces were presented simultaneously, as in Fenske and Eastwood's (2003) original study, the compatibility effect in response times was small but significant [$F_C(1,19) = 4.77$, $p = .042$, $\eta_p^2 = .201$]; however, there was no interaction with target valence [$F_{CxV}(1,19) = 1.62$, $p = .218$, $\eta_p^2 = .079$] and no effects in the error rates [$F_C(1,19) = 0.07$, $p = .933$, $\eta_p^2 < .001$; $F_{CxV}(1,19) = 0.22$, $p = .642$, $\eta_p^2 = .012$] (Figure 2B). Numerically, though, the compatibility effect was slightly larger for the happy than for the sad target faces, consistent with Fenske and Eastwood's (2003) results.

Third, when the target preceded the flankers, we observed a small compatibility effect in response times that interacted with SOA [$F_C(1,19) = 4.76$, $p = .042$, $\eta_p^2 = .200$; $F_{CxS}(2,38) = 3.52$, $p = .042$, $\eta_p^2 = .156$] but did not depend on the valence of the target face [$F_{CxV}(1,19) = 1.98$, $p = .176$, $\eta_p^2 = .094$; $F_{CxSxV}(2,38) = 0.07$, $p = .973$, $\eta_p^2 = .003$] (Figure 2C). Unexpectedly, this effect was negative, with faster responses in incompatible than in compatible trials. We refrain from further interpretations because the main effect is so small (only 2 ms), its interactions are all nonsignificant, and it is discernible in only three of the participants. No effects were observed in error rates [$F_C(1,19) = 0.56$, $p = .465$, $\eta_p^2 = .028$; $F_{CxS}(2,38) = 0.49$, $p = .616$, $\eta_p^2 = .025$; $F_{CxV}(1,19) = 1.69$, $p = .209$, $\eta_p^2 = .082$; $F_{CxSxV}(2,38) = 0.92$, $p = .408$, $\eta_p^2 = .046$].

It might be argued that the current study cannot provide definite evidence supporting or contradicting the Fenske-Eastwood hypothesis because the basic flanker asymmetry of previous studies was not replicated. Indeed, even though we presented the same target and flanker faces with the same size and configuration as those by Fenske and Eastwood (2003), compatibility effects were not depending on face valence. In the search for an explanation of this result, we took a closer look at the individual data of our participants. Surprisingly, most of the participants showed marked flanker asymmetries. However, the difference of compatibility effects between happy and sad faces was not always in the direction reported by Fenske and Eastwood (2003) but varied strongly between participants.

To quantify these results, we calculated the individual difference score *D* by subtracting the compatibility effects obtained with sad faces from those with happy faces, using only data from the 0-ms SOA. Consequently, positive values of *D* describe a flanker asymmetry as reported by Fenske and Eastwood (2003) (i.e., happy faces produce stronger compatibility effects compared to sad faces) while negative values of *D* describe a flanker asymmetry in the opposite direction (i.e., happy faces produce weaker compatibility effects compared to sad faces). The resulting mean value for response times, $M_D = 1.36$, strongly varied between participants ($SD_D = 16.52$; range = [-36.07; 35.72]; 95% CI [-6.37; 9.09]).

Discussion. Overall, we did not replicate the findings of Fenske and Eastwood (2003) although we exactly reproduced their stimulus details and configuration. First, when presenting target and flanker faces simultaneously, we observed a compatibility effect that was much smaller than originally reported and did not depend on target face valence. When flankers preceded the targets, compatibility effects were much larger, as expected from the known time-course of Eriksen and response priming effects. However, response times and error rates showed no indication that flanker valence modulated the compatibility effect. Note that the failed replication with simultaneous presentation of targets and flankers was not due to a general lack of power in our design, as is attested by the power analysis described in footnote 4 and the finding of strong and increasing compatibility effects when flankers preceded the target. Clearly, our measurements are precise enough to capture the time course of the compatibility effect. Finally, a detailed inspection of the individual data shows a very high variability in the compatibility effects between participants when target and flankers were presented simultaneously.

General discussion

We tested for a specific prediction following from the notion that schematic faces with different emotional valence are opposed in their influence on the scope of visual attention, such that sad faces tend to narrow the "spotlight" of attention whereas happy faces tend to widen it (the Fenske-Eastwood hypothesis). Most importantly, flanker compatibility effects for sad as compared to happy target faces (1) should generally be smaller, and (2) should increase more slowly with increasing SOA between response-irrelevant distractors and response-relevant targets.

We obtained large flanker compatibility effects that were modulated by the SOA between central and flanker faces. These results are in accordance with earlier research in flanker experiments (e.g., Eriksen & Eriksen, 1974; Flowers, 1990; Schwarz & Mecklinger, 1995) and correspond to findings in the closely related response priming paradigm (e.g., Schmidt et al., 2011; Vorberg et al., 2003). If a response-relevant target stimulus is preceded by response-compatible or -incompatible stimuli, the difference between response times (and error rates) in both cases strongly depends on the duration of the time interval between stimulus presentations: The longer the first stimulus has time to direct the motor response, the larger the compatibility effect (Fig. 2A). In contrast, if the response-relevant target appears simultaneously or even before the other stimulus, usually no effect or only a very small one occurs (Fig. 2B, C). [5]

With respect to the results and the validity of the spatial attention hypothesis by Fenske and Eastwood (2003), our experiment provides two major results. First, we did not replicate the basic flanker asymmetry (i.e., different compatibility effects for happy and sad faces) when presenting central and flanker faces simultaneously. This is surprising because we exactly replicated the corresponding stimulus configurations from Fenske and Eastwood's (2003) Experiment 1A in an experiment with statistical power very similar to the original study. In fact, the only major difference between their study and ours was that we varied the SOA between central and flanker faces on a trial-to-trial basis, which is a standard technique in many experiments on selective attention. Moreover, we found the effect to be subject to strong inter-individual differences, with some participants showing an asymmetry in the direction originally reported and some showing an effect in the opposite direction. Second, we found no evidence that happy and sad faces modulate the scope of visuospatial attention differently. Compatibility effects induced by happy and sad faces were not modulated by the SOA between central and flanker faces in the fashion predicted by Fenske and Eastwood (2003). Together, these findings strongly suggest that the schematic faces used by Fenske, Eastwood, and others do not modulate the scope or "spotlight" of visuospatial attention according to their emotional valence.

Probably, the most disconcerting aspect of our data is the absence of any solid evidence that the asymmetric flanker effect for schematic emotional faces even exists.

---

[5] Note that Fenske and Eastwood (2003) allowed their participants a very small amount of training. In their Experiment 1A, each person performed 14 practice trials followed by 12 blocks of 24 trials. This contrasts with two 1-hour sessions with 28 practice trials followed by 60 blocks of 28 trials in our experiment. Indeed, the response time in Fenske and Eastwood's study (averaging about 550 ms in Exp. 1A, and about 600 ms in Exp. 2) is 150-200 ms slower than the average performance in our experiment. To rule out the possibility that training plays a major role in the size or time-course of the compatibility effect, we investigated the modulation of compatibility effects by central face valence over the course of our experiment. An ANOVA for SOA = 0 revealed no significant interaction of the factors compatibility, valence of the central face, and number of trials (T; in six blocks of 280 successive trials each, approximating the length of Experiment 1A of Fenske and Eastwood, 2003) [$F_{CxVxT}(5,95) = 1.92$, $p = .098$, $\eta^2_p = .091$]. This was also the case when we contrasted the findings in the first 280 trials with the average results in all the following ones [$F_{CxVxT}(1,19) = 2.40$, $p = .138$, $\eta^2_p = .111$].

Our experiment contains Fenske and Eastwood's (2003) original stimulus conditions as a special case, and there is only sparse, nonsignificant evidence for the purported effect. In addition, our experiment extends the parameter space of the original study to settings where the basic compatibility effect becomes much larger, increasing the chances of finding a possible modulation as well as for sufficient time to re-allocate spatial attention. Moreover, a supplementary experiment varying the SOA as well as the spatial distance between flankers and targets shows large compatibility effects modulated by both temporal and spatial parameters, but no Fenske-Eastwood effect, and instead several effects that contradict the Fenske-Eastwood hypothesis (Appendix A). In other words, after searching extensively for the most amenable conditions, we simply find no evidence for the effect.

Could this failure to replicate be due to a lack of statistical power? Several arguments speak against this possibility. First, power in the 0-ms conditions was matched to the original Fenske and Eastwood (2003) study. Second, the same amount of power was available for every single parametric variation. Third, we found effects that demonstrate the flanker compatibility effect to be sensitive to changes in time parameters, yet none of them in the direction of the Fenske-Eastwood hypothesis. Because our study resolves effects that are much smaller than the one reported by Fenske and Eastwood (2003) and also by Horstmann et al. (2006), we simply cannot imagine how a 20-ms or even a 10-ms asymmetry effect could have failed to be detected by our design.[6]

We conclude that even if emotional stimuli alter the scope of attention, schematic faces do not have a sufficient emotional impact to do so. This may be due to a lack in ecological validity, a drawback of schematic face stimuli that has long been discussed in the field but never led to a disqualification of these stimuli for research in emotion and cognition (a possible alternative might be to use standardized sets of real-world face pictures; Goeleven et al., 2008; Pinkham, Griffin, Baron, Sasson, & Gur, 2010). Also, schematic face stimuli may lack motivational intensity, which was shown to influence visual attention independent of emotional valence (Gable & Harmon-Jones, 2008, 2010a, b, c).

How, then, can we explain the previously reported asymmetric compatibility effects of positive and negative schematic faces? Horstmann, Borgstedt, and Heumann (2006) point out that dissimilar responses to positive, neutral, and negative facial stimuli may be governed by the differences in their perceptual attributes rather than the differences in their emotional meaning. A common experimental approach to disentangle these two possibilities is the comparison of responses to regular faces with those to inverted or scrambled ones – which admittedly produced equivocal results (Horstmann et al., 2006). In their attempt to demonstrate the potential importance of purely perceptual differences, Horstmann et al. employed a number of different stimuli in four flanker experiments comparable to those by Fenske and Eastwood (2003). In their most conclusive experiment, they contrasted two completely non-emotional stimuli (a circle and a circle with a line intersecting its base) and obtained similar asymmetric compatibility effects as with schematic faces (see Experiment 4 in Horstmann et al., 2006).[7] This result indicates that perceptual factors may be sufficient to explain the observed asymmetries in flanker com[6]patibility effects. An increasing number of studies stresses the same point with respect to studies using the visual search paradigm (e.g., Becker et al., 2011; Coelho, Cloete, & Wallis, 2010; Mak-Fan, Thompson, & Green, 2011; Purcell & Stewart, 2010). Horstmann et al. (2006) suggest specific perceptual feature candidates that may be crucial in producing asymmetries in flanker or visual search

---

[6] Note that Horstmann et al.'s (2006) paper does not contain any exact replication of Fenske and Eastwood's (2003) effect, either. The stimuli in their Experiment 1 differed in the shape of the mouth, the eyebrows, and the eyes themselves, more approximating a naturalistic sketch of a human face rather than a stylized smiley face. Even so, the authors concluded that it were isolated features of the stimulus, not the holistic expression, that determined the flanker asymmetry.

[7] Power to explain a small effect (f = 0.1) was 0.801 (sample size = 20, repetitions = 108).

experiments. First, spatial frequency distributions are different in happy and sad faces; second, in the sad face compared to the happy face the interaction of face outline and mouth leads to curvature discontinuities and a concave edge (Humphreys & Müller, 2000; Kristjánsson & Tse, 2001; Stein & Sterzer, 2012).

Horstmann et al. (2006) surmise that there may be no experimental silver bullet to solve the problem of confounding affective valence and perceptual attributes of emotional stimuli. For an even more general call to caution see the insightful discussion and conclusion in Becker et al. (2011). Nevertheless, we believe that it is possible to avoid this confound by inventive experimental methods. For example, a promising way to tackle the problem may be *fear conditioning* (or *emotional learning*) paradigms, where physically identical face stimuli are emotionally charged negatively or positively through combination with aversive or non-aversive stimulation (e.g., Batty, Cave, & Pauli, 2005; Milders, Sahraie, Logan, & Donnellon, 2006; Notebaert, Crombez, Van Damme, De Houwer, & Theeuwes, 2011, Pischek-Simpson, Boschen, Neumann, & Waters, 2009; Yates, Ashwin, & Fox, 2010). By using this approach, researchers can be sure that the obtained effects are really due to different emotional valences (or levels of arousal) associated with the stimuli and not due to their different perceptual attributes.

Acknowledgments

We thank Shanley Allen, Anke Haberkamp, Neiloufar Family, and Kirstin Bergstroem for helpful comments on earlier versions of the manuscript. We also want to thank Gernot Horstmann, two anonymous reviewers, and the editor for valuable suggestions. This research was supported by Schm1671/1-5 of the German Research Foundation to T.S.

Author note

Filipp Schmidt, Thomas Schmidt, University of Kaiserslautern, Faculty of Social Sciences, Experimental Psychology. Correspondence may be sent to either author (filipp.schmidt@sowi.uni-kl.de, thomas.schmidt@sowi.uni-kl.de).

References

Bakeman, R., & McArthur, D. (1996). Picturing repeated measures: Comments on Loftus, Morrison, and others. *Behavior Research Methods, Instruments, & Computers, 28,* 584-589. doi:10.3758/LB.36.2.75

Batty, M. J., Cave, K. R., & Pauli, P. (2005). Abstract stimuli associated with threat through conditioning cannot be detected preattentively. *Emotion, 5,* 418-430. doi:10.1037/1528-3542.5.4.418

Becker, D. V., Anderson, U. S., Mortensen, C. R., Neufeld, S. L., & Neel, R. (2011). The Face in the Crowd Effect Unconfounded: Happy Faces, Not Angry Faces, Are More Efficiently Detected in Single- and Multiple-Target Visual Search Tasks. *Journal of Experimental Psychology: General, 140*, 637-659. doi: 10.1037/a0024060

Becker, D. V., Neel, R., Srinivasan, N., Neufeld, S., Kumar, D., & Fouse, S. (2012) The Vividness of Happiness in Dynamic Facial Displays of Emotion. *PLoS ONE, 7(1)*:

e26551. doi:10.1371/journal.pone.0026551

Belopolsky, A. V., Devue, C., & Theeuwes, J. (2011). Angry faces hold the eyes. *Visual Cognition, 19,* 17-36. doi:10.1080/13506285.2010.536186

Cave, K. R., & Bichot, N. P. (1999). Visuospatial attention: Beyond a spotlight model. *Psychonomic Bulletin & Review, 6,* 204-223.

Coelho, C. M., Cloete, S., & Wallis, G. (2010). The face-in-the-crowd effect: When angry faces are just cross(es). *Journal of Vision, 10,* 1-14.

Compton, R. J. (2003). The Interface Between Emotion and Attention: A Review of Evidence from Psychology and Neuroscience. *Behavioral and Cognitive Neuroscience Reviews, 2,* 115-129. doi:10.1177/1534582303002002003

Eastwood, J. D., Smilek, D., & Merikle, P. M. (2001). Differential attentional guidance by unattended faces expressing positive and negative emotion. *Perception & Psychophysics, 63,* 1004-1013. doi:10.3758/BF03194519

Eriksen, C. W., & Collins, J. F. (1969). Temporal course of selective attention. *Journal of Experimental Psychology, 80,* 264-261.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16,* 143-149.

Eriksen, C. W., & Rohrbaugh, J. W. (1970). Some factors determining fficiency of selective attention. *American Journal of Psychology, 83,* 330-342.

Eriksen, C. W., & St. James, J. D. (1986). Visual attention within and around the field of focal attention: A zoom lens model. *Attention & Psychophysics, 40,* 225-240.

Eriksen, C. W., & Yeh, Y. (1985). Allocation of attention in the visual field. *Journal of Experimental Psychology: Human Perception and Performance, 11,* 583-597.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analyis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175-191.

Fenske, M. J., & Eastwood, J. D. (2003). Modulation of focused attention by faces expressing emotion: Evidence from flanker tasks. *Emotion, 3,* 327-343. doi:10.1037/1528-3542.3.4.327

Flowers, J. H. (1990). Priming effects in perceptual classification. *Perception and Psychophysics, 47,* 135-148.

Fox, E., Lester, V., Russo, R., Bowles, R. J., Pichler, A., & Dutton, K. (2000). Facial expressions of emotion: Are angry faces detected more efficiently? *Cognition and Emotion, 14,* 61-92. doi:10.1080/026999300378996

Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do threatening stimuli draw or hold attention in subclinical anxiety? *Journal of Experimental Psychology: General, 130,* 681-700. doi:10.1037//0096-3445.130.4.681

Fox, E., Russo, R., & Dutton, K. (2002). Attentional Bias for Threat: Evidence for Delayed Disengagement from Emotional Faces. *Cognition and Emotion, 16,* 355-379. doi:10.1080/02699930143000527

Fredrickson, B. L. (2003). The value of positive emotions. A*merican Scientist, 91,* 330-335.

Fredrickson, B. L., & Branigan, C. (2005). Positive emotions broaden the scope of attention and thought-action repertoires. *Cognition and Emotion, 19,* 313-332. doi:10.1080/02699930441000238

Friedman, R. S., & Förster, J. (2010). Implicit affective cues and attentional tuning: an integrative review. *Psychological Bulletin, 136,* 875-893. doi:10.1037/a0020495

Gable, P. A., & Harmon-Jones, E. (2008). Approach-motivated positive affect reduces breadth of attention. *Psychological Science, 19,* 476–482. doi:10.1111/j.1467-9280.2008.02112.x

Gable, P., & Harmon-Jones, E. (2010a). The motivational dimensional model of affect: Implications for breadth of attention, memory, and cognitive categorization. *Cognition and Emotion, 24,* 322-337. doi:10.1080/02699930903378305

Gable, P., & Harmon-Jones, E. (2010b). The blues broaden, but the nasty narrows: Attentional consequences of negative affects low and high in motivational intensity. *Psychological Science, 21,* 211–215. doi:10.1177/0956797609359622

Gable, P. A., & Harmon-Jones, E. (2010c). Late positive potential to appetitive stimuli and local attentional bias. *Emotion, 10,* 441–446. doi:10.1037/a0018425

Georgiou, G. A., Bleakley, C., Hayward, J., Russo, R., Dutton, K., Eltiti, S., & Fox, E. (2005). Focusing on fear: Attentional disengagement from emotional faces. *Visual cognition, 12,* 145-158. doi:10.1080/13506280444000076

Goeleven, E., De Raedt, R., Leyman, L., & Verschuere, B. (2008). The Karolinska directed emotional faces: a validation study. *Cognition and Emotion, 22,* 1094-1118. doi:10.1080/02699930701626582

Hansen, C. H., & Hansen, R. D. (1988). Finding the face in the crowd: An anger superiority effect. *Journal of Personality and Social Psychology, 54,* 917-924.

Horstmann, G., Borgstedt, K., & Heumann, M. (2006). Flanker effects with faces may depend on perceptual rather than emotional differences. *Emotion, 6,* 28-39. doi:10.1037/1528-3542.6.1.28

Horstmann, G., Scharlau, I., & Ansorge, U. (2006). More efficient rejection of happy than angry face distractors in visual search. *Psychonomic Bulletin and Review, 13,* 1067-73. doi:10.3758/BF03213927

Humphreys, G. W., & Müller, H. (2000). A search asymmetry reversed by figure-ground assignment. *Psychological Science, 11,* 196-201.

Kristjánsson, Á., & Tse, P. U. (2001). Curvature discontinuities are cues for rapid shape analysis. *Perception & Psychophysics, 63,* 390-403.

Lingnau, A., & Vorberg, D. (2005). The time course of response inhibition in masked priming. *Perception & Psychophysics, 67,* 545-557.

Loftus, G. R., & Masson, M. E. J. (1994). Using confidence intervals in within-subject designs. *Psychonomic Bulletin & Review, 1,* 476-490.

Mak-Fan, K. M., Thompson, W. F., & Green, R. E. A. (2011). Visual search for

schematic emotional faces risks perceptual confound. *Cognition & Emotion, 25,* 573-584. doi:10.1080/02699931.2010.500159

Maratos, F. A., Mogg, K., & Bradley, B. P. (2008). Identification of angry faces in the attentional blink. *Cognition and Emotion, 22,* 1340-1352. doi:10.1080/02699930701774218

Milders, M., Sahraie, A., Logan, S., & Donnellon, N. (2006). Awareness of Faces Is Modulated by Their Emotional Meaning. *Emotion, 6,* 10-17. doi:10.1037/1528-3542.6.1.10

Notebaert, L., Crombez, G., Van Damme, S., De Houwer, J., & Theeuwes, J. (2011). Signals of threat do not capture, but prioritize, attention: A conditioning approach. *Emotion, 11,* 81–89. doi:10.1037/a0021286

Öhman, A., Lundqvist, D., & Esteves, F. (2001). The face in the crowd revisited: A threat advantage with schematic stimuli. J*ournal of Personality and Social Psychology, 80,* 381-396. doi:10.1037/0022-3514.80.3.381

Pessoa, L. (2008). On the relationship between emotion and cognition. *Nature Reviews Neuroscience, 9,* 148-158.

Pinkham, A. E., Griffin, M., Baron, R., Sasson, N. J., & Gur, R. C. (2010). The Face in the Crowd Effect: Anger Superiority When Using Real Faces and Multiple Identities. *Emotion, 10,* 141-146. doi:10.1037/a0017387

Pischek-Simpson, L. K., Boschen, M. J., Neumann, D. L., & Waters, A. M. (2009). The development of an attentional bias for angry faces following Pavlovian fear conditioning. *Behaviour Research & Therapy, 47,* 322-330. doi:10.1016/j.brat.2009.01.007

Posner, M. (1980). Orienting of attention. *The Quarterly Journal of Experimental Psychology, 32,* 3-25.

Purcell, D. G., & Stewart, A. L. (2010). Still another confounded face in the crowd. *Attention, Perception, & Psychophysics, 72,* 2115-2127. doi:10.3758/APP.72.8.2115

Rowe, G., Hirsh, J. B., & Anderson, A. K. (2007). Positive affect increases the breadth of attentional selection. *Proceedings of the National Academy of Sciences, 104,* 383-388. doi:10.1073/pnas.0605198104

Schmidt, F., Haberkamp, A., & Schmidt, T. (2011). Dos and don'ts in response priming research. *Advances in Cognitive Psychology, 7 (special issue)*, 120-131.

Schmidt, F., & Schmidt, T. (2010). Feature-based attention to unconscious shapes and colors. *Attention, Perception & Psychophysics, 72,* 1480-1494.

Schmidt, T., & Seydell, A. (2008). Visual attention amplifies response priming of pointing movements to color targets. *Perception & Psychophysics, 70,* 443-455. doi:10.3758/PP.70.3.443

Schmitz, T. W., De Rosa, E., & Anderson, A. K. (2009). Opposing influences of affective state valence on visual cortical encoding. *The Journal of Neuroscience*, 29, 7199-7207. doi:10.1523/JNEUROSCI.5387-08.2009

Schwarz, W., & Mecklinger, A. (1995). Relationship between flanker Identifiability and compatibility effect. *Perception & Psychophysics, 57,* 1045-1052.

Srinivasan, N., Srivastava, P., Lohani, M, & Baijal, S. (2009). Focused and distributed attention. *Progress in Brain Research, 176,* 87-99. doi:10.1016/S0079-6123(09)17606-9

Srivastava, P., & Srinivasan, N. (2010). Time course of visual attention with emotional faces. *Attention, Perception, & Psychophysics, 72,* 369-377. doi:10.3758/APP.72.2.369

Stein, T., & Sterzer, P. (2012). Not Just Another Face in The Crowd: Detecting Emotional Schematic Faces During Continuous Flash Suppression. *Emotion, 12,* 988-996. doi:10.1037/a0026944

Stevens, J. (1996). *Applied multivariate statistics for the social sciences (3rd edition)*. Hillsdale, NJ: Erlbaum.

Sumner, P., Tsai, P.-C., Yu, K., & Nachev, P. (2006). Attentional modulation of sensorimotor processes in the absence of perceptual awareness. *Proceedings of the National Academy of Sciences USA*, *103,* 10520-10525.

Vorberg, D., Mattler, U., Heinecke, A., Schmidt, T., & Schwarzbach, J. (2003). Different time courses for visual perception and action priming. *Proceedings of the National Academy of Sciences USA, 100,* 6275-6280.

Vuilleumier, P. (2005). How brains beware: neural mechanisms of emotional attention. *Trends in Cognitive Sciences, 9,* 585-594. doi:10.1016/j.tics.2005.10.011

Yates, A., Ashwin, C., & Fox, E. (2010). Does Emotion Processing Require Attention? The Effects of Fear Conditioning and Perceptual Load. *Emotion, 10,* 822-830. doi:10.1037/a0020325

Appendix: Supplementary Experiment

We varied the spatial distance between central and flanker faces in three steps (near: 0.66°, medium: 1.07°, far: 1.48°; constant retinal eccentricity: 1.97°, cf. Lingnau & Vorberg, 2005) to measure the gradient of spatial attention (Eriksen & St. James, 1986). Twenty new students from our university (3 left-handed, 7 male, ages 21-29) responded to the flankers preceded by a central face that should attract attention and modulate its spatial scope. The Fenske-Eastwood hypothesis predicts compatibility effects to decrease with central-flanker distance more quickly for sad central faces (narrow scope) than for happy ones (wide scope; cf. Rowe et al., 2007; Schmitz, de Rosa, & Anderson, 2009).[7]

Simultaneous presentation (SOA = 0 ms) yielded strong compatibility effects [RTs: $F_{C}(1,19) = 31.26$, $p < .001$; errors: $F_{C}(1,19) = 35.37$, $p < .001$] that were not modulated by valence or distance [RTs: $F_{CxV}(1,19) = 0.50$, $p = .489$; $F_{CxD}(2,38) = 0.19$, $p = .828$; $F_{CxDxV}(2,38) = 1.43$, $p = .252$; errors: $F_{CxV}(1,19) = 1.17$, $p = .293$; $F_{CxD}(2,38) = 0.47$, $p = .630$; $F_{CxDxV}(2,38) = 1.47$, $p = .243$]. For SOAs > 0 ms, we obtained strong compatibility effects that increased with SOA [RTs: $F_{C}(1,19) = 95.72$, $p < .001$; $F_{CxS}(2,38) = 58.91$, $p < .001$; errors: $F_{C}(1,19) = 105.95$, $p < .001$; $F_{CxS}(2,38) = 30.55$, $p < .001$] but were not modulated by valence [RTs: $F_{CxV}(1,19) = 0.27$, $p = .608$; errors: $F_{CxV}(1,19) = 0.02$, $p = .969$]. Two effects contradicted predictions by the Fenske-Eastwood hypothesis. Compared to sad central faces, compatibility effects for happy central faces increased more slowly with SOA instead of more quickly [RTs: $F_{CxSxV}(2,38) = 5.87$, $p = .008$; errors: $F_{CxSxV}(2,38) = 4.82$, $p = .017$] and decreased more quickly with distance instead of more slowly [RTs: $F_{CxSxV}(2,38) = 5.87$, $p = .008$; errors: $F_{CxSxV}(2,38) = 4.82$, $p = .017$]. Generally, the compatibility effect decreased with increasing distance, showing that the basic experimental manipulation was successful [RTs: $F_{CxD}(2,38) = 3.99$, $p = .028$]. There was high variability in the compatibility effects between participants (near condition: $M_{D} = 1.45$; $SD_{D} = 41.34$; range = [-74.60; 79.62]; 95% CI [-17.90; 20.80]). The experiment fails to replicate the Fenske-Eastwood effect.

Appendix: Figures

Here, we present two supplementary figures illustrating the stimuli and procedure (Fig. A1, see p.1) and the results (Fig. A2, see p.2) for the experiment reported in the appendix of Schmidt and Schmidt (2013). As in our main experiment, we fail to replicate the Fenske-Eastwood effect when investigating not only the temporal but also the spatial domain.

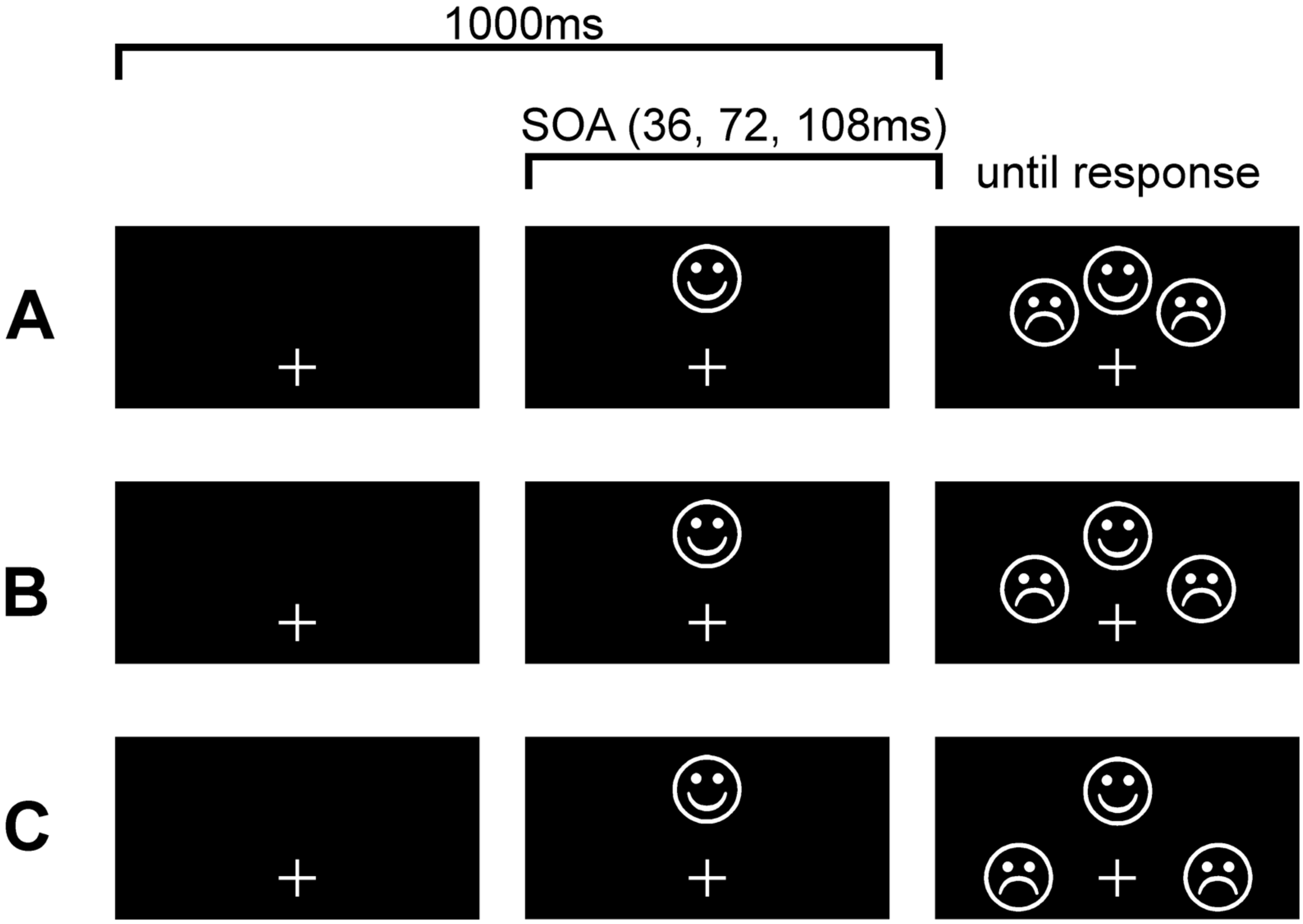

Figure A1. Stimuli and procedure. In each trial, one central face and two flanking schematic faces were presented. The central face preceded the flankers with varying SOAs, or all faces were presented simultaneously (as depicted in the rightmost panels). Participants always responded to the valence of the flanking faces by a speeded keypress response (e.g., right for happy and left for sad faces). The two flankers were always identical and could either be compatible or incompatible (see above) with the central face. The distance between central and flanking faces was either (A) near, (B) medium, or (C) far. Note that the face stimuli and fixation cross are not drawn to scale.

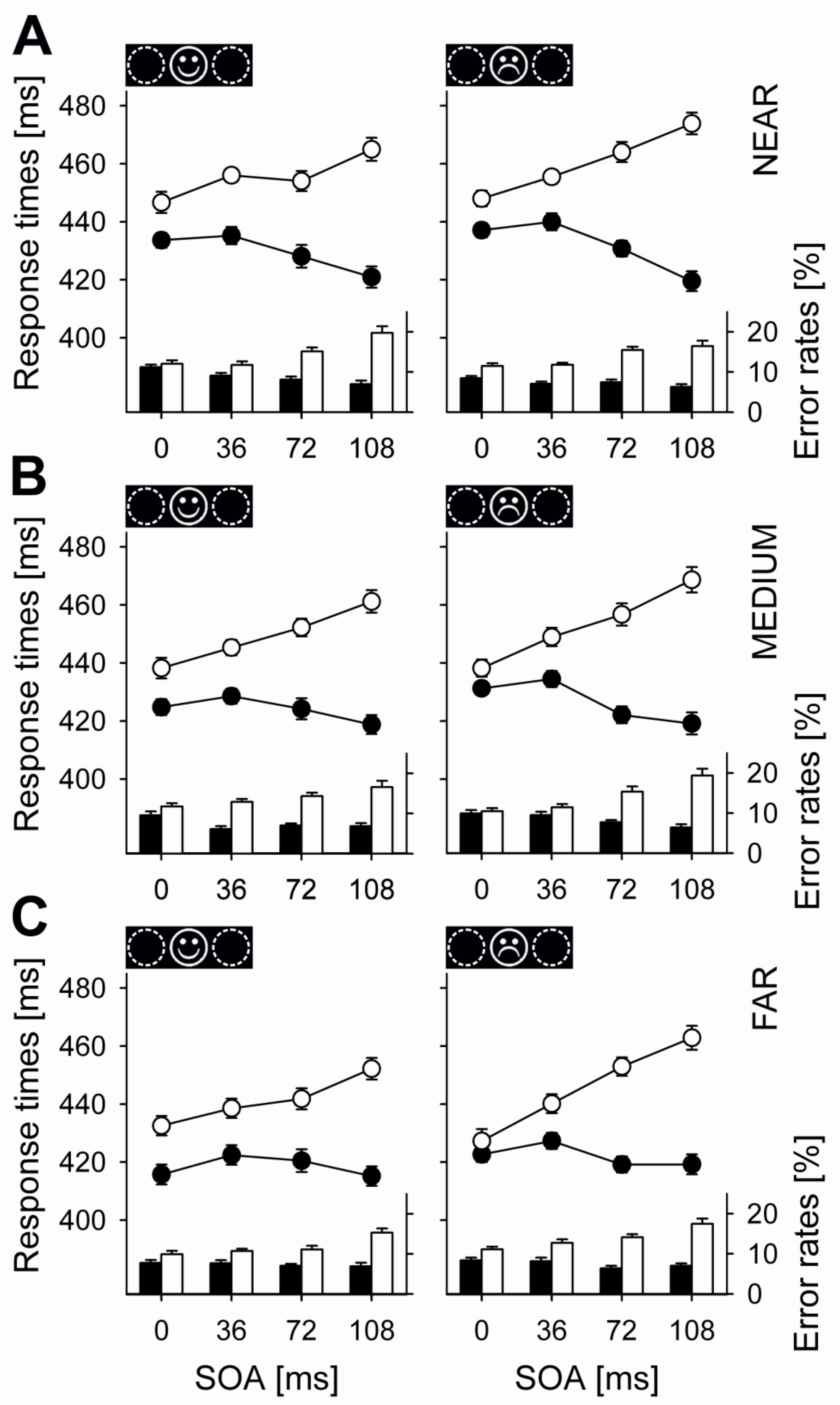

Figure A2. Results. Response times and error rates in compatible (black) and incompatible trials (white) as a function of central-flanker SOA. The compatibility effect is defined by the differences between responses in compatible and incompatible trials. Left and right panels depict the separate results for happy and sad central faces, respectively, for (A) near, (B) medium, and (C) far distance between central and flanker faces. Error bars denote the standard error of the mean corrected for between-subjects variance (Bakeman & McArthur, 1996; Loftus & Masson, 1994).