Measuring the emotion-specificity of rapid stimulus-driven attraction of attention to fearful faces: evidence from emotion categorization and a comparison with disgusted faces

Shah Khalid · Gernot Horstmann · Thomas Ditye · Ulrich Ansorge

Abstract In the current study, we tested whether a fear advantage—rapid attraction of attention to fearful faces that is more stimulus-driven than to neutral faces—is emotion specific. We used a cueing task with face cues preceding targets. Cues were non-predictive of the target locations. In two experiments, we found enhanced cueing of saccades towards the targets with fearful face cues than with neutral face cues: Saccades towards targets were more efficient with cues and targets at the same position (under valid conditions) than at opposite positions (under invalid conditions), and this cueing effect was stronger with fearful than with neutral face cues. In addition, this cueing effect difference between fearful and neutral faces was absent with inverted faces as cues, indicating that the fear advantage is face-specific. We also show that emotion categorization of the face cues mirrored these effects: Participants were better at categorizing face cues as fearful or neutral with upright than with inverted faces (Experiment 1). Finally, in alternative blocks including disgusted faces instead of fearful faces, we found more similar cueing effects with disgusted faces and neutral faces, and with upright and inverted faces (Experiment 2). Jointly, these results demonstrate that the fear advantage is emotion-specific. Results are discussed in light of evolutionary explanations of the fear advantage.

Introduction

Humans’ facial expression of fear is an important social signal (Whalen, 1998). As a consequence, human visual attention might show a disposition to be rapidly captured and held by a fearful face in a stimulus-driven fashion. In line with this, even if a fearful face is entirely task-irrelevant and presented for just a split second, this fearful face would influence a human’s saccades (Bannerman, Milders, & Sahraie, 2010). However, to date, it is unclear if this rapid stimulus-driven attraction of attention to fearful faces is emotion-specific and to what extent. Therefore, in the present study, we asked the following questions. (1) If a fearful face is presented for just a split second, can participants categorize its emotional expression with above chance accuracy? (2) Is the attentional effect specific to the emotion of fear, or does it generalize to other negative emotion, and in particular to disgust? (3) What is the nature of this attentional effect? Are fearful faces more effective in capturing attention than neutral faces, and do the fearful faces hold attention for a longer time than neutral faces? These were the questions that we addressed in the present study, as we will detail below.

It has been argued that emotional stimuli of high relevance to the inclusive fitness of the organism are capable of capturing attention in a stimulus-driven way (Öhman, Flykt, & Esteves, 2001). According to this view, especially rapid shifts of attention to emotionally significant stimuli would have been highly adaptive during the course of evolution allowing for a quick situation-appropriate reaction, such as to flee from a threatening stimulus or to fight it. Accordingly, if the human attentional system would have adapted to this evolutionary pressure, a disposition towards rapid or more prolonged attraction of attention to threat-related stimuli should be present in humans also.
today. This disposition may have taken the form of an encapsulated processing device—a special-purpose processing device for threat detection that is sensitive to only particular fitting key stimuli that reliably signaled threats in the course of human phylogeny (Fox, Russo, Bowles, & Dutton, 2001). Accordingly threat signals which were around for long periods during human evolution could nowadays still capture or keep attention in a stimulus-driven or automatic way—that is, even when these threat signals are completely irrelevant for a task at hand.

Many attempts of demonstrating stimulus-driven attentional capture by threatening faces used visual search (for a review see Horstmann, 2009). Take the example of visual search experiments in which participants had to search for an emotional “odd-man out” (or singleton) target face, such as the single “threatening” (e.g., sour) or the single smiling face among several emotionally neutral face distractors (Eastwood, Smilek, & Merikle, 2001). In these experiments, participants needed less time to find threatening faces than happy faces, supporting the assumption that threatening faces could capture attention more readily than happy faces. However, because in such experiments all faces were presented for relatively long durations and because the manual response times were relatively high, the participants had plenty of time for the processing of the threatening faces. It is therefore uncertain whether the results of these visual search experiments reflected rapid attraction of attention to threat-related stimuli. In fact, different and even non-attentional processes, such as the difficulty of the visual discrimination between the target and the distractors, contribute to visual search performance with emotional faces (Horstmann & Bauland, 2006). The heterogeneity of the different attentional and non-attentional processes involved might also be a reason why visual search findings on threat advantages for attentional capture are so heterogeneous (Becker, Anderson, Mortensen, Neufeld, & Neel, 2011; Horstmann, Scharlau, & Ansorge, 2006; Savage, Lipp, Craig, Becker, & Horstmann, 2013).

A more promising approach has been taken in cueing studies. In these studies a threatening face as an irrelevant cue is presented prior to a target (e.g., Fox, Russo, & Dutton, 2002; Koster, Crombez, van Damme, Verschueren, & De Houwer, 2004). Presenting a single face cue in isolation and at an early point during a trial allows studying attentional capture by this cue and the attentional dwell time on this cue in a form that is relatively uncontaminated by the attentional and non-attentional processes associated with other stimuli presented at alternative locations. The general procedure in these experiments is the following. On each trial of a cueing experiment, participants are presented with a target at one of two (or more) positions. Prior to each target, the cue is either shown at the same position as the target—this is the “valid condition”—or at an alternative position than the target—this is the “invalid condition.” Typically, relative to the invalid condition, the valid cue facilitates searching for the target—a result reflecting the attraction of attention by the cue (Posner, 1980). More precisely, with the cueing procedure it is possible to discriminate between initial attentional capture by a cue and subsequent attentional dwell times on the cue. Stronger initial capture by a threat-related face cue is reflected in facilitation in valid conditions as compared to control conditions (i.e., conditions without a cue or with a valid neutral face cue). In contrast, longer attentional dwell times on a threat-related face cue and delayed disengagement from this cue are reflected in interference in invalid conditions as compared to the control condition.

When threat-related faces were used as non-predictive cues in such experiments—that is, cues that do not predict the most likely target position—, a few studies corroborated that attraction of attention to threat-related stimuli could indeed be rapid and stimulus-driven (Bannerman et al., 2010). Bannerman et al., for example, used two target positions, a non-predictive cue per trial, a short (20 ms) or a long (100 ms) cue-target stimulus-onset asynchrony (SOA), and asked their participants for saccades to the targets in some of their conditions and for manual responses in others. When the authors used an SOA and cue duration of 20 ms and asked their participants for a quick saccade to the target, they found that the participants made faster saccades towards validly than invalidly cued targets although the cue was not predictive of the target position. Crucially, facilitation in valid conditions and interference in invalid conditions were stronger with fearful than with neutral face cues, but only if the faces were presented in a cardinal (or upright) orientation: This “fear advantage,” as we may call the stronger cueing effect of fearful than neutral faces, was eliminated with inverted (upside-down) faces. Importantly, in line with the assumption of a rapid attentional effect of the fearful faces, the fear advantage quickly dissipated and was no longer present with a cue-target SOA of 100 ms.

Is the attraction of attention to fearful faces face-specific or emotion-specific?

The findings of Bannerman et al. (2010) are convincing with respect to an attentional origin of the fear advantage, as the programming of a saccade requires a shift of attention towards the saccade’s landing position in advance of the saccade (Deubel & Schneider, 1996; Hoffman & Subramaniam, 1995; Kowler, Anderson, Dosher, & Blaser, 1995). Also, since humans typically complete two to three saccades per second and (given the appropriate conditions) saccade onset latencies (saccadic reaction times) can be as low as 80–120 ms (Fischer & Weber, 1993) saccades are
very fast responses. The fact that in Bannerman et al. cues as short as 20 ms nonetheless modulated saccade onsets to targets presented directly after the cues also supported the important conclusion that the attentional effect of the fearful faces is due to very rapid shifts of attention.

However, important open questions concerning the emotional origin of this rapid saccade effect remain. One of the open questions is whether participants can actually recognize the emotional meaning of the faces under conditions like that of Bannerman et al. (2010). In general, rapid attraction of attention to threat-related stimuli might be a building-block or a predecessor for an emotion-specific response, but this does not mean that the attraction of attention to a stimulus of only 20 ms length already reflects this emotion-specificity. For once, facial displays differ regarding their visual characteristics, such as their exact luminance (or contrast) and their spectral power. These visual characteristics can also have an emotion-independent impact on the speed of visual processing and, hence, on attention and saccades. Bannerman et al. controlled for perceptual confounds by testing an inverted-face condition (in which the threat advantage was not found). The authors reasoned that face inversion would not alter the visual characteristics but could alter the recognition of the emotional displays. However, this was not tested and the influence of inversion could have also reflected an emotion-unspecific influence. For example, it is possible that the underlying effect is the rapid and stimulus-driven attraction of attention to faces in general (which are undisputedly highly relevant stimuli to which humans have probably adapted). Fearful faces, in turn, may be easier to recognize as faces than neutral faces. This possibility would also be in line with the findings of Bannerman et al. (2010): if such a “face advantage” was responsible for the cueing effects, this effect could have also been present with upright but not inverted faces because face recognition is better for cardinal than inverted faces (Leder & Bruce, 2000).

In the current study, we therefore took the following measures. In addition to testing the effects of face cues on saccades, we tested whether the inversion of the face cues affected the categorization of the emotional expressions as fearful vs. neutral. This is an important question because in order to track down the effect of inversion to an emotion-specific fear advantage it needs to be confirmed that the inversion indeed decreases the categorization of the faces’ emotion. Experiment 1 of the present study, therefore, studied whether participants were able to reliably discriminate between the emotional expressions of 20-ms long fearful and neutral faces and whether this ability was lower for inverted than for cardinal faces. In addition, we carefully equated the luminance/contrast and the spectral power of different emotional face cues to rule out these visual confounds.

Is the attraction of attention to fearful faces fear-specific or threat-specific?

A second open question concerning the emotion-specificity of the rapid cueing effect on saccades is the following: Even if rapid attraction of attention to a fearful face would be related to emotions, it is unclear whether this “fear advantage” would extend to a different threat-related emotion, such as the emotion of disgust. Disgust is a response towards potentially infectious, contaminated, toxic, or obnoxious stimuli that also generalizes to the social domain (Chapman & Anderson, 2012; Rozin, Haidt, & McCauley, 1993). Similar to fear (Whalen, 1998), disgust, thus, also informs about potential dangers or threats in the environment. This was also the reason why in the current study disgust rather than anger was used for the comparison of different threatening expressions. Facial expressions of anger are different from fearful expressions in one important respect. Fear signals the presence of danger to other members of the family or the group, while anger signals the intention to attack (Fridlund, 1994, Horstmann, 2003). In other words, a fearful expression is not threatening in itself and rather refers to some threat in the environment, anger itself is threatening. According to Whalen (1998) this is an important difference that could boost the human interest in fearful as compared to angry faces (see also Boll, Gamer, Kalisch, & Büchel, 2011; N’Diaye, Sander, & Vuilleumier, 2009). Disgust, on the other hand, is similar to fear in that it refers to a challenge to inclusive fitness in the environment. Because both the facial displays of disgust and fear would be very similar in this respect, and because both would potentially fit to the requirements for a fitness-increasing disposition to attract attention, we compared fearful and disgusted faces.

Despite joint relations of fear and disgust to inclusive fitness threats in the environment, a number of studies indicated differences in the processing of threat vs. disgust (Chapman, Johannes, Poppenk, Moscovitch, & Anderson, 2013; Davis et al., 2011; Krusemark & Li, 2011; Susskind et al., 2008; Vermeulen, Godefroid, & Mermillod, 2009). So far, it is not certain if these processing differences extend to the rapid effects that the two emotions have on attention (Carretié, Ruiz-Padial, López-Martín, & Albert, 2011; Cisler & Olatunji, 2010; Cisler, Olatunji, Lohr, & Williams, 2009; van Hooff, Devue, Vieweg, & Theeuwes, 2013; Vogt, Lozo, Koster, & De Houwer, 2011). For example, in favor of a general threat advantage for more attention capture by both fear and disgust, Cisler and Olatunji (2010) found that disengagement of attention from fear and disgust stimuli was similarly delayed (only in participants with elevated contamination fear). In the corresponding study, more disengagement of attention took the form of faster responses to invalidly cued targets.
individuals’ responses do not sufficiently isolate the early phase of rapid stimulus-driven face cueing effects on saccades. In addition, it is possible that rapid attraction of attention extends to other threat-related stimuli or may even be stronger for these stimuli, but this is likewise not entirely certain, as studies with relatively long-lasting pictures and slow manual responses do not sufficiently isolate the early phase of rapid attentional effects. Experiment 2 therefore tested whether rapid stimulus-driven face cueing effects on saccades are restricted to fearful face cues or whether they generalize to disgusted face cues.

Experiment 1

In Experiment 1 we wanted to replicate the fear advantage of attention to irrelevant 20-ms fearful face cues as compared to neutral face cues that was observed with saccades (Bannerman et al., 2010), but we also tested whether this fear advantage is accompanied by the participants’ categorization of the different emotional expressions. We tested whether the participants were able to reliably discriminate between the neutral and the fearful expressions of the briefly presented face cues.

In each trial, participants had two tasks—that is, they performed under dual-task conditions: Participants first made a quick saccade toward a validly or invalidly cued target and subsequently categorized the emotional expression of the face cue that they had just seen as wearing a fearful or neutral expression. These were our expectations. With respect to the saccades, with upright face cues, we expected that participants were better able to categorize the emotional expressions of the face cues under upright than under inverted conditions.

Method

Participants

Twenty-four students (13 female) with a mean age of 22.0 years participated. Measurement by the German version of State-Trait Anxiety Inventory (STAI; Laux, Glanzmann, Schaffner, & Spielberger, 1981) showed that all participants had normal state \( (M = 36.5, SD = 6.1) \) and trait \( (M = 38.6, SD = 7.4) \) anxiety levels. In this and the following experiment, all participants gave their informed consent, had normal or corrected to normal vision, and were naïve with respect to the hypotheses.

Apparatus

Visual stimuli were presented on a 19-inch, color CRT monitor (Sony Multiscan G400) with a refresh rate of 120 Hz. Accurate timing of the display was verified by measurement with an oscilloscope.

The participants sat at a distance of 64 cm from the screen in a quiet, dimly lit room, with their heads resting in a chin rest to ensure a constant viewing distance and a straight-ahead gaze direction. Eye movements were recorded via the SR Research Ltd. Eye-Link 1000 eye tracker. Gaze position was sampled at a rate of 1000 Hz. Monocular tracking was used with a gaze-position error below 0.5°. After calibration and reading of the instructions the participants pressed the spacebar with their index finger of the dominant hand to start the experiment. The participant started each trial by pressing the spacebar again. In this way participants could take breaks at their convenience by simply not pressing the space bar. Also, the self-paced start of the trials allowed for an optimal preparation for the task at hand—that is, preparation of a quick saccade to the target (a plus sign, see below).

Stimuli

Face stimuli were grayscale images of the same five male and five female individuals, and wore neutral or fearful emotional expressions. These images were selected from the Karolinska Directed Emotional Faces (KDEF) database (Lundqvist, Flykt, & Öhman, 1998). Using Matlab functions, all face images were equated for luminance/contrast.
(root mean square, $M = 77.87$, $SD = 0.03$) and spectral power (amplitude $M = 91.19$, $SD = 1.90$). All of the face images were also cropped behind a white oval layer so that only the face features were presented. The resultant male and female face images wore neutral and fearful expressions (see Fig. 1).

The face images subtended a visual angle of $7.5^\circ$ horizontally and $11.2^\circ$ vertically. They were used as cues. A plus sign of $1.5^\circ \times 1.5^\circ$ was used as a target. In each trial, the face cue and the target were presented in a sequence and with an eccentricity of $9.2^\circ$ on either the left or right side of the screen center. Presentation of the stimuli was against a uniform white background.

**Procedure**

We adopted the procedure of Bannerman et al. (2010). See Fig. 2 for an example sequence of events in a trial. Each trial began with a central fixation for 1 s. Next a blank screen was presented for 200 ms. The blank screen was supposed to speed up saccade initiation (Bannerman et al., 2010; Fischer & Weber, 1993) because the offset of the fixation cross at fixation and prior to the onset of the target creates a temporal gap between the stimuli that is known to allow disengagement of attention from fixation and the temporal gap also increases the predictability of the point in time at which the target is presented. Jointly, these factors facilitate the onset of the saccade (Saslow, 1967; for a review see Jin & Reeves, 2009). After the blank, a face cue was shown at either the left or the right position for 20 ms. In the final display, the target was shown unpredictably at either the left or right position for 1 s. The inter-stimulus interval between cue and target was zero and the stimulus-onset asynchrony was, thus, 20 ms. Participants were instructed to saccade toward the target as quickly and as accurately as possible, disregarding the prior face cue for their saccades. They were also informed that cue and target positions were uncorrelated.

The experiment consisted of a saccade-task practice phase followed by dual-task blocks. During practice, participants had to keep their eyes at fixation and then to conduct a saccade to the target as quickly as possible. In the dual-task blocks the procedure was the same. However, after each saccade, participants had to categorize the face cue as wearing either a neutral or a fearful expression. Keys (‘D’) and (‘K’) on the keyboard (covered and marked) were used for the manual categorization of the emotions. The mapping of the keys to neutral vs. fearful faces was counter-balanced across participants.

In the dual-task blocks, two with upright and two with inverted faces, fearful faces were presented in half of the trials, and neutral faces were presented in the other half of the trials. Each dual-task block consisted of 40 repetitions of each combination of emotion type (fearful vs. neutral face) and validity (valid vs. invalid cue), for a total of 160 trials. Within each block, the different conditions were realized equally often and presented in a pseudo-random sequence, with the two constraints that no particular face cue was repeated in immediately succeeding trials and that no condition (emotion, validity, face gender, side of presentation) was repeated more than five times in a row. Two practice blocks with upright and with inverted faces preceded the dual-task blocks. The whole experiment took approximately 1 h.

**Results**

Saccadic errors were defined as saccades to the opposite side of the target. Saccadic reaction times (onset times) were calculated as the differences between the onset of the target and that of the saccade. For saccade onset latency (or saccadic reaction time), the algorithm used established thresholds of gaze displacement (>0.1°), velocity (>300°/s), and acceleration (>8000°/s²). Data from two participants were discarded due to average saccadic error rates exceeding 50% of the trials, including saccades not starting within 2° of the screen center, or conducting no saccade towards one of the two positions at all. Of the remaining 22 participants, the trials in which no saccade started within 2° of the screen center, or conducting no saccade was made towards either side, or in which eye blinks occurred were discarded (4.7%). The remaining data were analyzed in the following way.

For all following analyses, an alpha level of significance of .05 was chosen, and, unless otherwise noted, Bonferroni corrections for multiple comparisons were applied. In the case of significant multi-way interactions, degrees of freedom were Greenhouse-Geisser corrected where Mauchly tests indicated a violation of the sphericity assumption.

**Emotion categorization**

An analysis of the percentages of correct judgments showed that participants performed significantly above chance level (50%) when discriminating upright faces, both in the validly cued condition ($M = 55.6\%$, $SD = 7.2$), $t(21) = 3.67$, $p < .01$, and in the invalidly cued condition ($M = 59.3\%$, $SD = 11.2$), $t(21) = 3.89$, $p < .01$, as well as when discriminating inverted faces, this time only in the invalidly cued condition ($M = 54.7\%$, $SD = 6.5$), $t(21) = 3.40$, $p < .01$, but not in the validly cued condition ($M = 52.6\%$, $SD = 7.0$), $t(21) = 1.71$, $p = .10$. Importantly, it was much easier for the participants to discriminate the emotions of upright faces ($M = 57.5\%$, $SD = 8.3$) than those of inverted faces ($M = 53.6\%$, $SD = 6.2$), $t(21) = 2.86$, $p = .01$. 

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**Fig. 1** Upper panel set of female neutral, fearful, and disgusted faces. Lower panel set of male neutral, fearful, and disgusted faces. Neutral and fearful faces were used in Experiments 1 and 2. Disgusted faces were only used in Experiment 2. Stimuli are not drawn to scale.
Saccadic error rates (SERs)

As illustrated in the saccadic error rates (SERs) in Fig. 3, we found that SERs were higher in invalidly than validly cued trials, and that this validity effect was stronger with fearful faces than with neutral faces in the blocks with upright face cues. This impression was corroborated by formal analysis.

A repeated measures analysis of variance (ANOVA), with the within-participant variables face orientation (upright vs. inverted), face emotion (neutral vs. fearful), and cue validity (valid vs. invalid) led to the following results. We found a significant main effect of cue validity, $F(1, 21) = 19.74$, $p < .001$, partial $\eta^2 = 0.49$. Performance was more accurate in the validly cued condition ($M = 0.3\%$) than in the invalidly cued condition ($M = 14.6\%$). We also found a significant two-way interaction of face orientation and face emotion, $F(1, 21) = 7.84$, $p < .01$, partial $\eta^2 = 0.27$: for the fearful faces, upright ($M = 8.3\%$) and inverted faces ($M = 6.5\%$) differed significantly from one another, $t(21) = 2.08, p < .05$, but for the neutral faces this was not the case (upright: $M = 6.9\%$; inverted: $M = 8.1\%$), $t(21) = 1.10, p = .28$. Importantly, the three-way interaction of face orientation, face emotion, and cue validity was also significant, $F(1, 21) = 8.70$, $p < .01$, partial $\eta^2 = 0.29$ (see follow-up analyses below). No other significant effects or interactions were found, all $F$s $< 1.00$.

To understand the three-way interaction, follow-up ANOVAs were conducted, split for upright vs. inverted faces. The ANOVA for the upright faces, with the repeated-measures variables face emotion and cue validity, showed a tendency toward a significant main effect of emotion, $F(1, 21) = 3.46, p < .07$, partial $\eta^2 = 0.14$. Performance was more accurate with neutral ($M = 6.9\%$) than fearful ($M = 8.3\%$) faces. The effect of cue validity
Importantly, in line with Bannerman et al. (2010) the two-way interaction of face emotion and cue validity was significant, $F(1, 21) = 4.24$, $p < .05$, partial $\eta^2 = 0.17$. Mean validity effects were stronger in the case of fearful faces [valid: $M = 0.1\%$ vs. invalid: $M = 16.5\%$, $t(21) = 4.57$, $p < .001$] than in the case of neutral faces [valid: $M = 0.1\%$ vs. invalid: $M = 13.6\%$, $t(21) = 4.14$, $p < .001$]. [This was also reflected in more errors under upright fearful than inverted fearful face conditions, $t(21) = 2.23$, $p < .04$ (uncorrected for multiple testing), but no such difference was found in upright vs. inverted neutral face conditions, $t(21) < 1.00$, $p > .34$ (uncorrected for multiple testing).] An analogous ANOVA of the validly cued condition did not show any significant effect or interaction, all $Fs < 2.02$.

**Saccadic reaction times**

Mean correct saccadic reaction times (SRTs) for each participant and condition were calculated. Trials with SRTs faster than 80 ms or slower than 3 standard deviations from the individual mean correct SRTs (cf. Bannerman et al., 2010) were discarded (4.8%).

The same ANOVA, with the within-participant variables face orientation (upright vs. inverted), face emotion (neutral vs. fearful), and cue validity (valid vs. invalid) was run. It showed a significant main effect of cue validity, $F(1, 21) = 48.09$, $p < .001$, partial $\eta^2 = 0.70$. Saccades were faster in the validly cued condition ($M = 178\ ms$) than in the invalidly cued condition ($M = 243\ ms$). Furthermore, we found a significant main effect of face orientation, $F(1, 21) = 12.54$, $p < .01$, partial $\eta^2 = 0.37$. Performance was better in the inverted face condition ($M = 202\ ms$) than in the upright face condition ($M = 219\ ms$). The main effect of face emotion and the interactions were not significant, all $Fs < 1.00$.

**Discussion**

In the current experiment, we found a fear advantage based on rapid stimulus-driven attraction by fearful faces, only with the upright faces and only in the invalid conditions.
The results of Bannerman et al. (2010) were, thus, conceptually replicated in the present experiment. Different from Bannerman et al., however, this effect was found in the SERs and not in the SRTs. This difference can be explained by a more liberal response criterion of the participants in the current study than in the previous study of Bannerman et al. On this account, derived from the general concept of a speed-accuracy trade-off, participants in the current study admitted more errors to decrease their SRTs, and as a consequence, the difference between the validity effects was reflected in an increased SER for upright fearful faces as compared to upright neutral faces. As in the study of Bannerman et al., this capture effect difference between the fearful and the neutral faces was absent with inverted faces, demonstrating that the fear advantage was face-specific.

Interestingly, the stronger attraction of attention to the upright fearful faces was selectively present only in the invalid conditions. This can be explained by longer attentional dwelling on the fearful faces, or put otherwise, a longer time to disengage attention from the fearful than from the neutral faces (Bannerman et al., 2010). With the inverted faces, if anything, this pattern reversed, and more errors were made with neutral than with fearful face cues. We can only speculate about the cause of this unexpected finding. First of all, higher error rates for all inverted faces might be expected on the basis of an explanation of all cueing effects in terms of human interest in ambiguity. According to Whalen (1998) humans devote more attention to fearful faces than many other emotional expressions because a fearful face is an ambiguous source of information about a threat somewhere in the environment. Applying this logic to all cues, inverted face cues might have simply attracted more attention because of their lower familiarity and, thus, higher ambiguity. This would not explain, however, that the error rates were higher for inverted neutral than inverted fearful faces. This latter fact could have to do with the emotion-discrimination task. It is possible that the inverted fearful faces were slightly easier to see than the inverted neutral faces, such that participants were less likely to erroneously look at inverted fearful faces at a position away from the target. If this was the case, it would explain the results with inverted neutral faces.

Also, from the non-significant results in the valid conditions it looks as if rapid attentional capture was not stronger for fearful than neutral faces. Although this is a possibility, we want to point out that lacking performance differences in the valid conditions could have likewise reflected a floor effect.

Even more important, we found evidence that the fear advantage deserves its label because it could be based on emotion recognition. In the categorization task, our participants were able to successfully discriminate between the facial emotions, and more so with cardinal than with inverted face orientations. This measurement, which was lacking in previous studies, provides evidence for an important precondition of the supposed emotion-specific mechanism: These results show that face inversion indeed changed the ability of the participants to recognize facial emotion under conditions of severely restricted visibility.

Furthermore, our emotion categorization task indicated higher recognition of cue emotions in invalid than valid conditions. This was probably due to more backward masking of face cues by target crosses at face cue positions in valid than invalid conditions. Critically, a recognition-dependent contribution of the different facial emotions to the cueing effect could, thus, have been higher in invalid than valid conditions, just as it was observed in the present experiment.

### Experiment 2

To test whether the fear advantage reflected a fear-specific effect or whether it would also extend to other threat-related facial expressions, we next tested two different negative facial emotional expressions—fearful faces and disgusted faces—and compared their cueing or validity effects to that of neutral faces. To that end, we again used the 20-ms-SOA condition of Bannerman et al. (2010). Within participants and between blocks, we either compared the cueing effect of a fearful face with that of a neutral face, or we compared the cueing effect of a disgusted face with that of a neutral face. With this procedure, the blocks with the fearful faces were exact replications of the protocol of Bannerman et al. Again, we carefully equated all facial expressions in terms of their spectral powers and their luminance/contrasts. This was done to use facial emotional expressions that were as similar as possible to one another with respect to some of their most prominent visual low-level characteristics. In addition, to test whether the expected cueing effect differences were face-specific, we also again used blocks with inverted faces. To note, in Experiment 2, we did not include a cue categorization task as a secondary task. This was done to demonstrate that the rapid cueing effect of the fearful faces indeed reflected stimulus-driven attention rather than attention to task-relevant cues (i.e., relevant for the emotional categorization, as could have been the case in Experiment 1).
These were our expectations. In the block with upright fearful face cues, we expected to replicate the findings of Bannerman et al. (2010) (and of the present Experiment 1)—that is, a stronger cueing effect with fearful than with neutral faces. Disgust is also a negative emotion and signals a negative or dangerous state in the environment. Accordingly, we might also see a general threat advantage in the block with upright disgusted face cues. However, clearly the facial expression of disgust is different from that of fear, and, therefore, we might also see less or more of a threat advantage with disgusted face cues (as compared to neutral face cues). Finally, a fear-specific attraction of attention was expected to lead to a stronger cueing effect with fearful than with neutral faces, but in this case, there should not be a difference between the cueing effects of disgusted and neutral face cues. Also, any emotion-specific effect, be it a threat-advantage or a fear-advantage should not be present with inverted faces as cues.

Method

Participants

Twenty-four students (12 female) with a mean age of 22.8 years participated. Measurement by the German version of STAI showed that all participants had normal state \( M = 35.4, SD = 7.3 \) and trait \( M = 38.1, SD = 8.7 \) anxiety levels.

Apparatus, stimuli, and procedure

These were the same as in Experiment 1 with the following exceptions. First, participants were not asked to discriminate the emotional expressions of the faces. Second we included blocks with five disgusted faces. Like the fearful and neutral faces, these were taken from the KDEF database and subsequently equated for spectral power and luminance/contrast with the neutral and fearful faces.

The experiment consisted of 4 blocks; two with upright faces and two with inverted faces. In two blocks, one with upright, the other one with inverted faces, fearful faces were presented in half of the trials, and neutral faces were presented in the other half of the trials. These blocks were an exact replication of the short-SOA conditions of Bannerman et al. (2010). In two further blocks, again, one with upright, the other one with inverted faces, disgusted faces were presented in half of the trials and neutral faces were presented in the other half of trials.

The sequence of the four blocks was counter-balanced across participants. Each block consisted of 40 repetitions of each combination of block-specific emotion type (fearful vs. neutral; or disgusted vs. neutral) and validity (valid vs. invalid cue), for a total of 160 trials. Additionally, 20 training trials for each upright and inverted condition were included at the beginning of the respective blocks.

Results

Data from four participants were discarded due to the same criteria as in Experiment 1. Out of the remaining twenty participants, another 4.8 % of the trials were eliminated due to not properly held fixation prior to the targets, blinks, and no saccades to the target at all (see Experiment 1).

Saccadic error rates (SERs)

Saccadic errors were defined as in Experiment 1—that is, as saccades to the opposite side of the target. As shown in Fig. 4, we found higher SERs in invalidly than validly cued trials, and, importantly, this validity effect was strongest in the blocks with upright fearful face cues. This was confirmed by formal analyses (see below).

SERs of the fearful face cues

Since we were aiming for a replication of the results of Experiment 1 and of Bannerman et al. (2010), a first analysis of variance (ANOVA), with the within-participant variables face orientation (upright vs. inverted), face emotion (neutral vs. fearful), and validity (valid vs. invalid) concerned the fearful-face cue condition only.

This ANOVA led to the following results. The main effect of cue validity was significant, \( F(1, 19) = 18.77, p < .001, \eta^2 = 0.50 \). Performance was more accurate in the validly cued condition \( M = 0.1 \) % than in the invalidly cued condition \( M = 6.4 \) %. We also found a significant two-way interaction of face orientation and face emotion, \( F(1, 19) = 6.12, p < .02, \eta^2 = 0.24 \). Mean SERs of different emotions differed significantly in the upright face condition [neutral: \( M = 2.0 \) % vs. fearful: \( M = 3.8 \) %, \( t(19) = 2.69, p < .01 \], but not in the inverted face condition [neutral: \( M = 3.6 \) % vs. fearful: \( M = 3.4 \) %, \( t(19) = 0.36, p > .71 \)]. Importantly, the three-way interaction of face orientation, face emotion, and cue validity was also significant, \( F(1, 19) = 5.96, p < .02, \eta^2 = 0.24 \). No other significant effect or interaction was found, all \( F_s < 1.00 \).

To understand the three-way interaction, follow-up ANOVAs were conducted, split for upright vs. inverted faces. In the follow-up ANOVA of the upright fearful-face block, with the repeated-measures variables face emotion and cue validity, we found a significant main effect of emotion, \( F(1, 19) = 7.25, p < .01, \eta^2 = 0.28 \). Performance was more accurate in the neutral face condition \( M = 2.1 \) % than in the fearful face condition.
The effect of cue validity was also significant, $F(1, 19) = 19.07, p < .001$, partial $\eta^2 = 0.50$. Performance was more accurate in the valid ($M = 0.0\%$) than in the invalid ($M = 5.9\%$) condition. Importantly, the two-way interaction of face emotion and cue validity was also significant, $F(1, 19) = 7.25, p < .01$, partial $\eta^2 = 0.28$. Mean validity effects (SER in invalid minus SER in valid condition) differed less in the case of neutral face cues [valid: $M = 0.0\%$ vs. invalid: $M = 4.1\%$, $t(19) = 3.83, p < .001$] than in the case of fearful face cues [valid: $M = 0.0\%$ vs. invalid: $M = 7.6\%$, $t(19) = 4.19, p < .0001$]. Further, paired-sample $t$ test showed significantly less errors in the invalid neutral ($M = 4.1\%$) than in the invalid fearful ($M = 7.9\%$) conditions, $t(19) = 2.69, p < .01$. An analogous ANOVA of the inverted face condition, with the repeated-measures variables of face emotion and validity showed only a significant effect of validity, $F(1, 19) = 14.76, p < .001$, partial $\eta^2 = 0.44$. Performance was more accurate in the valid condition ($M = 0.1\%$) than in the invalid condition ($M = 6.9\%$). No other significant effect or interaction was found in both of the follow-up ANOVAs reported above, all $F$s < 1.00.

To explore whether the interaction concerned the valid or the invalid conditions, we also conducted follow-up ANOVAs, split for validly vs. invalidly cued conditions. The ANOVA for the invalidly cued condition, with the repeated-measures variables of face orientation and face emotion, showed only a significant two-way interaction of our variables, $F(1, 19) = 6.13, p < .03$, partial $\eta^2 = 0.24$. Means reflected significant differences in the case of upright faces [fearful: $M = 7.6\%$ vs. neutral: $M = 4.1\%$, $t(19) = 2.69, p < .02$], but not in the case of inverted faces [fearful: $M = 6.6\%$ vs. neutral: $M = 7.1\%$, $t(19) = 0.37, p = .71$]. An analogous ANOVA of the validly cued condition did not show any significant effect or interaction, all $F$s < 2.12.
SERs of the disgusted face cues

An ANOVA of the SERs of the disgusted face-cue condition, with the within-participant variables face orientation (upright vs. inverted), face emotion (neutral vs. disgusted), and validity (valid vs. invalid) revealed a significant main effect of validity, $F(1, 19) = 13.70, p < .001$, partial $\eta^2 = 0.42$. Performance was more accurate in the valid condition ($M = 0.1\%$) than in the invalid condition ($M = 4.9\%$). Also, the two-way interaction of face emotion and cue validity tended towards significance, $F(1, 19) = 4.17, p < .06$, partial $\eta^2 = 0.18$. Across face orientations, mean SERs between valid and invalid conditions differed less in the case of neutral faces [valid: $M = 0.1\%$ vs. invalid: $M = 4.3\%$, $t(19) = 3.39, p < .003$], and more in the case of disgusted faces [valid: $M = 0.1\%$ vs. invalid: $M = 5.6\%$, $t(19) = 3.76, p < .001$]. No other significant main effect or interaction was found, all $Fs < 1.00$.

Comparison of the fearful and disgusted face cues

To compare the fearful and disgusted face cues, we also conducted an ANOVA of SERs, with the within-participant variables face orientation (upright vs. inverted), negative emotion (disgusted vs. fearful), and cue validity (valid vs. invalid). Here, the main effect of cue validity was significant, $F(1, 19) = 16.62, p < .001$, partial $\eta^2 = 0.47$. Performance was more accurate in the validly cued condition ($M = 0.1\%$) than in the invalidly cued condition ($M = 6.4\%$). We also found a significant main effect of negative emotion, $F(1, 19) = 4.75, p < .05$, partial $\eta^2 = 0.20$. Performance was more accurate in the disgusted condition ($M = 2.8\%$) than in the fearful condition ($M = 3.6\%$). Furthermore, we found a tendency towards a two-way interaction of negative emotion and cue validity, $F(1, 19) = 3.82, p = .07$, partial $\eta^2 = 0.17$. Across face orientations, mean SERs between valid and invalid conditions differed less in the case of disgusted faces [valid: $M = 0.1\%$ vs. invalid: $M = 5.6\%$, $t(19) = 3.76, p < .001$], and more in the case of fearful faces [valid: $M = 0.1\%$ vs. invalid: $M = 7.1\%$, $t(19) = 4.15, p < .001$]. This was further confirmed by significantly more accuracy in the invalid disgusted condition than in the invalid fearful condition, $t(19) = 2.07, p < .05$. No other significant effects or interactions were found, all $Fs < 1.00$.

Saccadic reaction times (SRTs)

Trials with SRTs faster than 80 ms or slower than 3 standard deviations from the individual mean correct SRTs (cf. Bannerman et al., 2010) were discarded (3.0%).

SRTs after fearful face cues

A repeated-measures ANOVA of the fearful face cue condition, with the within-participant variables face orientation (upright vs. inverted), face emotion (neutral vs. fearful), and validity (valid vs. invalid) led to the following results. The main effect of validity was again significant, $F(1, 19) = 50.75, p < .001$, partial $\eta^2 = 0.73$. Participants made faster saccades in the valid condition ($M = 153$ ms) than in the invalid condition ($M = 181$ ms). Also, the main effect of orientation was significant, $F(1, 19) = 4.22, p < .05$, partial $\eta^2 = 0.18$. Performance was faster in the inverted face condition ($M = 164$ ms) than in the upright face condition ($M = 170$ ms). Furthermore, the two-way interaction of face orientation and validity tended towards significance, $F(1, 19) = 3.93, p < .06$, partial $\eta^2 = 0.17$. However, mean validity effects in the upright face condition [valid: $M = 155$ ms vs. invalid: $M = 185$ ms, $t(19) = 7.45, p < .001$] were almost the same as in the inverted face condition (valid: $M = 150$ ms vs. invalid: $M = 177$ ms, $t(19) = 6.32, p < .001$). No other significant main effect or interaction was found, all $Fs < 1.00$.

Discussion

Again, we found an inversion-sensitive fear advantage: more rapid capture by irrelevant fearful face cues than by neutral face cues, only if the face cues were presented upright but not if they were shown upside-down. In contrast to Experiment 1, the fear advantage was found even though the cues were entirely task-irrelevant. Replicating our Experiment 1, but deviating from Bannerman et al. (2010), the stimulus-driven fear advantage was present in the SERs but not in the SRTs. Again, participants probably used a more liberal response criterion in our experiment, so that an effect of the faces on the direction of the saccades (rather than on the speed of a target-directed saccade as in Bannerman et al., 2010) was observed in our experiment. As in Experiment 1, for a number of possible reasons ranging from floor effects in the valid condition to better emotion recognition in the invalid condition, the fear
advantage was present in invalid but not in valid conditions. Also, again, the error rates were on average higher with inverted faces, supporting the conclusion that ambiguity might be responsible for erroneous saccades to invalid upright fearful faces (cf. Whalen, 1998) and both types of invalid inverted faces (see current Experiment 1).

Most interestingly, when we looked at disgusted face cues as an alternative type of threatening cue, we found validity effects that did not differ as much from that of the neutral faces. In addition, with the disgusted faces as cues, we also failed to find clear evidence for an influence of face inversion on the cueing effects. Admittedly, the differences between the cueing effects of disgusted and fearful faces were not strong enough to yield a significant three-way interaction between cue validity, negative emotion (of the face cue), and cue type. When we compared the performance in the blocks with the fearful faces cues with that in blocks with disgusted face cues by one joint ANOVA, we only found less errors when disgusted faces were used than when fearful faces were used as cues,—a difference that was selectively due to the invalid conditions. In summary, however, the full pattern of results that we and Bannerman et al. (2010) found in the conditions with fearful faces as cues could not be replicated with the disgusted faces as cues. Jointly, these results suggest that the capture by fearful faces could indeed at least partly reflect an emotion-specific attentional effect.

This leads us to the question of what might have prevented an equal threat advantage with the disgusting stimuli as with the fearful faces, especially because past studies have sometimes found a threat advantage with disgust-related stimuli (e.g., Carretié et al., 2011; van Hooff et al., 2013). One straightforward answer is that we used disgusted faces as cues, whereas some prior studies used disgusting pictures as distractors or cues. Of course, the facial expression of disgust is not disgusting itself. The aversive reactions that are found in response to the disgusting images in the studies of Carretié et al., Cisler and Olatunji (2010), and van Hooff et al. were, therefore, probably eliciting completely different emotions (e.g., felt disgust) and behavior (e.g., aversion) as compared to the face cues of the present study: in contrast to a disgusting image, a disgusted face probably elicits completely different emotions (e.g., curiosity) and behavior (e.g., the scrutinizing of the emotional expression). Another possible answer why the capture effects with disgust-related cues could not be found in the present study could be based on the visual characteristics of the stimuli. It is possible that huge differences in terms of visual strength existed between different emotion stimuli of past studies (Horstmann, 2009). In contrast, in the present study, different emotional face cues were carefully equated at least for their luminance/contrast and spectral power. It might therefore be that part of what appeared to be disgust-related effects in past studies instead reflected visual characteristics.

General discussion

In the current study, we set out to test the emotion-specificity of a stronger attraction of attention to fear-related than to neutral face cues. This was tested by means of saccades toward a target in a variant of the gap paradigm (cf. Saslow, 1967). Saccades were chosen because of their swiftness and their strong coupling to attention (Deubel & Schneider, 1996; Kowler et al., 1995), and because prior work has demonstrated a fear advantage under these conditions (Bannerman et al., 2010). The impact of the cues on saccades was tested with a gap between face cue and target, because under these conditions, saccades towards the targets can be initiated especially fast. This was done to test for rapid attentional effects. In two experiments, we found a fear advantage, with stronger attraction of attention to fearful face cues than to neutral face cues. The results of Bannerman et al. were, thus, conceptually replicated in the present experiments. When we used 20-ms faces as cues, we found a stronger cueing or validity effect—that is a larger difference between valid and invalid conditions—, with fearful faces as cues than with neutral faces as cues. At variance with the results of Bannerman et al. (2010), however, this effect was found in the SERs and not in the SRTs. This difference, however, is not considered as theoretically significant as it can be explained by the participants’ trading off accuracy for speed, depending on their choice of a response criterion. Thus, the difference most likely reflected a more liberal response criterion of the participants in the current study than in the study of Bannerman et al. To decrease their SRTs, participants in the current study probably admitted more errors, and, as a consequence, the difference between the validity effects was reflected in an increased SER for upright fearful faces as compared to upright neutral faces. As in the study of Bannerman et al., this capture effect difference between the fearful and the neutral faces was present in the invalid but not in the valid conditions. It is difficult to name one particular reason for why the cueing effect difference was present in the invalid conditions only. Possibly this was not only due to longer attentional dwell times on the fearful faces, as suggested by Bannerman et al. There, the authors argued in favor of delayed disengagement from the fearful face cues that might have been selectively at work in invalid but not in valid conditions and, thus, may have inflated the attentional effect of fearful faces only under invalid conditions. It is equally possible though, that in valid conditions a floor effect of almost optimal performance prevented the fear advantage. This might have been...
difficult to see in the SRT effects of Bannerman et al. because it is not known how quickly optimal saccades towards the targets can be initiated. However, in the present study floor effects were likely to operate since SER effects revealed that participants virtually conducted no erroneous saccades in the valid conditions whatsoever. Another possibility is that the fear advantage depended on the recognition of the faces’ emotions. If fear recognition was crucial, this could also explain why the fear advantage was stronger in invalid than valid conditions: When we tested our participants’ ability to categorize the emotions of the facial cues, we found that their performance was much better in invalid than valid conditions. The reason for this is that in the valid conditions, the target crosses had probably backward-masked the cues at the same positions, so that is was not as easy to see the emotional expression of the face cues in the valid as in the invalid conditions. Such recognition would have also fostered a cueing-effect difference that depends on emotions in invalid conditions.

In addition to these conceptual replications of past studies, in Experiment 1 we also observed that the fear advantage was absent with inverted faces. This was also in line with the observations of Bannerman et al. (2010). In addition, we also found (1) that the categorization of the emotional expressions of the cues was lower under inverted than under upright conditions and (2) that in Experiments 1 and 2 the cueing effects under invalid inverted conditions tended to be higher than for valid neutral face cues. The first of these findings shows that the manipulation of the faces’ orientations had indeed the predicted effect on emotion recognition, so that it appears safer to attribute the influence of inversion to emotion recognition rather than to face recognition. In fact, we think that it is remarkable that our participants were able to discriminate (at least upright) facial emotions of only 20-ms-duration faces which were presented more than 9° in the periphery: This finding also backs up the assumption of a very high sensitivity of the human visual system for different emotional face expressions (here: of fearful vs. neutral expressions). To note, since luminance/contrast and spectral power had been equated across different emotional expressions, it is unlikely that one of these visual characteristics was responsible for this ability. The second of these findings—increased rates of erroneous saccades to the invalid upright fearful face cues and to almost all inverted face cues—shows that the common denominator of all attention effects in the present study could be their ambiguity-elicited interestingness. Among the upright face cues, ambiguity of the fearful face cues was higher than that of the neutral face cues because only the fearful faces would have been indicative of a threat elsewhere in the environment (Boll et al., 2011; Whalen, 1998). For the inverted faces, the higher ambiguity would have been a consequence of the lower familiarity of these faces. The only exception from this rule would have been the invalid inverted fearful face cues in Experiment 1 that were easier to ignore than the invalid inverted neutral face cues, but this could have been due to the particular requirement of judging the faces’ emotional expressions. This judgment might have been a little easier for the inverted fearful than for the inverted neutral faces, with the consequence of lesser numbers of erroneous saccades in the invalid condition.

The fear advantage for the upright faces poses another important question: how does this fear advantage come about? All our evidence suggests remarkably quick human discrimination abilities for emotional expressions. We think that emotional expressions of great potential informational utility, such as fearful facial expressions, could have developed so as to exploit already existing visual abilities (Horstmann & Ansorge, 2009). This means that the facial expressions of the highest adaptive value (e.g., fearful expressions) were most likely to increase inclusive fitness of the human species if a safe communication of these expressions to conspecifics was ensured by the selection of an easily recognizable facial display. For two reasons, this scenario of facial expressions adapting to the visual system is more likely than the alternative scenario according to which the visual system adapted to the facial expressions. First, the possibility of a selection of emotional expressions taking advantage of existing visual discrimination abilities would be in line with the fact that many visual capabilities of primates were passed down from different mammal species without the same facial displays as primates. Therefore, many primate visual capabilities predated the particular facial displays of these species. Second, as emotional facial expressions are at least partly under top-down motor control up until today and because the more basic visual discrimination capabilities would not be under top-down control to a similar degree, it also would have been easier to adapt the flexible facial expressions to the more rigid visual capabilities rather than to adapt the more rigid visual capabilities to the more flexible facial displays.

Also, two lines of evidence in the present study suggested that the fear advantage was emotion specific. In the first experiment we were able to show that the participants were indeed able to categorize the facial emotional expressions with above chance accuracy and that this ability decreased when the faces were inverted. This shows that it is not just the face recognition that suffered from face inversion. Rather, in line with the hypothesis, emotion recognition suffered from inversion. In the second experiment we used blocks with disgusted faces to test whether the fear advantage would generalize to a different threat-related stimulus, namely disgusted faces (and in fact would therefore be a threat advantage rather than a fear...
advantage). This was not found. Although there was a tendency for disgusted faces to also attract more attention than neutral faces, this tendency was less affected by face inversion. This points to a potential origin of the numerical cueing effect differences between disgusted and neutral faces in terms of a low-level visual characteristic because the inversion manipulation would have affected face-specific or emotion-specific effects but would have left other low-level visual effects unaltered.

This is not to say that disgust-related stimuli could not also lead to different attentional responses than neutral stimuli. First of all, a disgusted face elicits a very different emotional response than a disgusting stimulus: The negative emotion of disgust would only be reliably evoked by disgusting stimuli but not by disgusted faces. Disgusted faces could even elicit positive emotions, such as curiosity. Secondly, in the current study, we investigated only rapidly emerging attention differences. In contrast, in past studies later occurring attention-related processes, such as an even longer dwelling of attention following early inspections, could have contributed more to the performance with disgust-related stimuli. It might be that the latter processes are more sensitive to disgust than the rapid attentional effects.

Before concluding, we want to add a cautionary remark. Oftentimes, arguments in favor of an evolutionary origin of attentional dispositions in humans are based on criteria of modular processing that we also investigated and confirmed in our present study, such as the speed, the stimulus-driven nature, and the input-dependence of a processing capability in question (Frischen, Eastwood, & Smilek, 2008; Öhman, 1993; Öhman et al., 2001). However, we are aware of the fact that modular processing could have causes besides an evolutionary origin, such as experiences gained during ontogenetic development, and that an evolutionary origin ultimately requires demonstrating a genetic cause of a psychological disposition. Although much of the present article was written in the spirit of an evolutionary perspective on the attentional fear advantage, we therefore acknowledge that alternative explanations for this disposition are conceivable.

Finally, so far we have portrayed the cueing effect of the present study as a perfectly stimulus-driven effect. However, the general cueing effect of all face cues could have likewise been due to a form of top-down contingent capture, either because participants top-down searched for target onsets (cf. Folk, Remington, & Johnston, 1992)—a feature which was shared by all face cues—or because participants top-down searched for target singletons (Bacon & Egeth, 1994)—again, a characteristic that was common to all face cues, too. In other words, it is not certain whether the portion of the cueing effect that was shared by all face cues was of a stimulus-driven type. This was only certain for the stronger cueing effect of the upright fearful face cues as compared to the upright neutral face cues because fearful and neutral facial expressions were equally distinct from the searched-for target crosses.

Conclusion

In the current study, we confirmed a fear advantage: the emotion-specificity of rapid stimulus-driven attraction of attention to fearful faces. Our observation supports a high sensitivity of the human visual system to the features contained within socially relevant facial displays of high importance, and, thus, of high adaptive value.

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References


