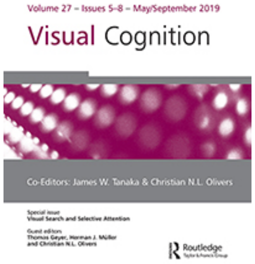

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Desperately seeking friends: How expectation of punishment modulates attention to angry and happy faces

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ABSTRACT
In the literature, a well-known processing advantage for angry schematic faces was largely observed in the "Face in the Crowd" (FIC) visual search task. A debate about automaticity and guidance of these effects by emotional/perceptual features is still raging. In order to modify the emotional context, the present study used a state of expectation of punishment (versus safety state). There was an angry superiority effect in the present study. However, we hypothesized and found that the presentation of a cue signalling an imminent threat (punishment) prior to the FIC task impairs the well-known processing advantage for angry schematic faces. On the reverse, the threat cue also facilitates the detection of happy (smiling) schematic faces. These results suggest that selective attention serves at least two basic affective purposes: (1) To efficiently detect threatening signals and (2) to detect potential coping resources in the environment, depending on motivational context. These findings are further discussed in terms of the threat detection system whose role is to respond to potentially dangerous situations [Öhman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: Toward an evolved module of fear and fear learning. *Psychological Review*, *108*(3), 483–522] and with regards to the counter-regulation principle which suggests that people may be biased towards searching for objects whose valence is opposite to their current affective state [Rothermund, K., Voss, A., & Wentura, D. (2008). Counter-regulation in affective attentional biases: A basic mechanism that warrants flexibility in emotion and motivation. *Emotion*, *8*(1), 34–46].

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Being able to quickly detect threatening stimuli in the environment is one of the most basic survival needs of any autonomous organism. Therefore, successful organisms should be able to process threat-related information on a "high-priority" mode. For now 30 years, cognitive psychology research that tested this hypothesis produced mixed results. For instance, in the "Face in the crowd" (FIC) paradigm, it has been shown that an angry target face is detected inside a matrix of several distractor faces more quickly and more accurately than happy or neutral faces (Hansen & Hansen, 1988). This "anger superiority effect" (ASE) was replicated many times with controlled schematic faces (Juth, Lundqvist, Karlsson, & Ohman, 2005; Öhman, Lundqvist, & Esteves, 2001) and generalized to non-face threatening stimuli (Öhman, Flykt, & Esteves, 2001). A popular explanation of these effects suggests that the bias towards angry faces in the FIC paradigm is driven by an evolved system that can identify threats in a quick and automatic mode in order to produce fast and efficient responses to potentially dangerous situations (Öhman & Mineka, 2001). Conversely, however, other authors have obtained evidence for the opposite effect, namely a happy superiority effect (HSE) (Frischen, Eastwood, & Smilek, 2008; Horstmann & Bauland, 2006; Juth et al., 2005). It is now proposed that HSE is found when using photographic pictures of real faces, while ASE appears for schematic faces or smileys, which suggests that perceptual features rather than emotion drive the search. For instance, the advantage for happy faces (HSE; Juth et al., 2005) was possibly due to perceptual asymmetries in the face materials (Mermillod, Vermeulen, Lundqvist, & Niedenthal, 2009). The later findings showed that happy faces were more easily categorized than angry or neutral faces by an artificial neural network. Therefore, with real faces the HSE effect appears to be driven by simple perceptual

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properties of the stimuli, which might therefore explain the behavioural results without reference to any evolutionary modules (Mermillod et al., 2009). On the reverse, with highly controlled schematic faces, any superiority effect of emotion should be attributed to its emotional constituent rather than to its perceptual properties.

However, the debate about the automaticity and guidance of these effects by emotional/perceptual features has not been settled yet. For instance, some researchers have recently claimed that perceptual and emotional features and processes are not mutually exclusive and one additional study suggests that both emotional and perceptual stimulus properties impact visual search efficiency (Lundqvist, Bruce, & Öhman, 2015). For instance, Lundqvist and colleagues (2015) assessed those perceptual properties of the faces both subjectively and objectively. Subjectively participants had to judge the physical similarities between faces and objectively, they ran a computational perceptual salience analysis in order to obtain an objective measure of the statistical distance between faces. At the emotional level, participants had to assess emotional properties like valence (Positive vs. Negative) and arousal (Active vs. Passive) of the same faces. The results showed that perceptual and emotional properties of the faces equally predicted visual search efficiency of the faces. Importantly, however, only a few studies have examined the role that motivational context may have on the high priority processing of emotional information.

The goal of the present study was to test an integrated framework predicting search performance for negative and positive stimuli in the "Face in the Crowd" paradigm. Several authors have noted that people's sensitivity to positive faces should convey functional advantages. Juth et al. (2005) proposed that positive faces may attract attention because they signal the potential for collaboration and interdependence. Rothermund et al. (2008) proposed a counter-regulation principle according to which people may be biased towards searching for objects whose valence is opposite to their current affective state. This process may contribute to general adaptation and prevent emotional escalation leading to pathology. In support of the latter views, the literature suggests that a "static" form of attentional bias (i.e., exclusive attentional preference for negative information) is actually related to emotional maladjustments. Juth et al. (2005) found that the anger superiority effect was more apparent for highly socially anxious individuals as compared to low socially anxious individuals. Similarly, psychopathological populations such as individuals suffering from anxiety, PTSD or phobia often show a strong attentional bias towards threatening stimuli, which may play an important role in the aetiology and maintenance of anxiety (Beck, Freeman, Shipherd, Hamblen, & Lackner, 2001; Becker, Rinck, Margraf, & Roth, 2001; Mogg & Bradley, 2005).

We suggest that, among well-adjusted individuals, the experience of threat (relative to baseline conditions) should disrupt the detection of negative information but facilitate the detection of positive information. This hypothesis is mainly based on the counter-regulation principle, which suggests that people may be biased towards searching for objects whose valence is opposite to their current affective state (Rothermund et al., 2008). To the best of our knowledge, this moderation effect has never been tested in the past research. Moreover, no prior empirical research has addressed conditions that would prove both detrimental to the detection of angry faces and beneficial to the detection of happy faces. This is unfortunate as our current hypothesis, if supported, would contribute to reconciling apparent divergences between the aforementioned frameworks.

If our hypothesis is correct, an interaction should emerge in this study, such that the presence of the threat cue (relative the presence of a safety cue) should impair the detection of an angry face but facilitate the detection of a happy face.

Method

Design

The experimental design is based upon the Experiment 1 of Öhman, Flykt, et al. (2001). It involved two Expectations (Punishment cue, Safety cue), three crowd expressions (Neutral, Happy, Angry) and three target expressions (Neutral, Happy, Angry) in a full within-subject design. In order to ensure a genuinely varied search task, we used trials where neutral target faces were presented along with happy and angry distractors (Öhman, Flykt, et al., 2001).

Participants

In order to confirm the appropriate sample size for an expected medium effect size .4, we ran, a posteriori, a power analysis using a two-sided significance level test ($\alpha = 0.05$) with 80% power ($\beta = 0.2$), the sample size required to detect such an effect was approximately 52 ($n = 52$). Fifty-five undergraduate students (48 women) of the University of Louvain at Louvain-la-Neuve served as participants in fulfilment of a course requirement. The mean age of the participants was 19.80 years ($SD = 1.67$). The study was introduced as a cognitive psychology research without mention to emotional implications.

Stimuli

Three different triangles were built, one red, one blue, one violet and served as cues. For measuring face in the crowd effects, we designed matrices composed of Neutral, Happy and Angry schematic faces identical to those used by Öhman, Flykt, et al. (2001). They were composed of 9 faces arranged in 3×3 matrices. The matrices were presented in black against a white background. For half of the matrices, all schematic faces displayed the same emotional expression. For the other half, one single face (i.e., the target) displayed an emotional expression different from the other faces of the matrix. All target expressions were combined with all distractor expressions. Moreover, the target expression could occur at any of the possible positions in the matrix. We had 108 matrices divided into 54 different matrices containing a target and 3 distractor matrices (each used 18 times) without targets.

Procedure

The participants were tested collectively in a computer room. They were seated approximately 70 cm in front of the monitor and they were first asked to read attentively the task description and instruction which informed them that they might hear a white noise between 85 and 100 dB if they were too slow (>800 ms post-stimulus onset) or if their response was incorrect. The levels of auditory stimulation were chosen to be identical to well-known experiments on the startle eyeblink effect (Bradley & Lang, 2000), and to be in agreement with regulations on auditory nuisance. This sound type is known to be highly aversive (Bradley & Lang, 2000). They signed the informed consent (which explains them the task and that they could leave the room without providing any explanation) and were asked to wear headphones. Participants were informed that they would be presented prior to the visual search task with two triangles (a red or a blue one) whether or not they would hear a white noise burst if they failed during the search task. After completing a training session of 54 trials randomly selected from the 216 trials of all experiment, they started the experimental blocks that matter.

As shown in Figure 1, each trial started with a 30 ms presentation of a red or blue triangle (prime) directly postmasked by a 250 ms presentation of a violet triangle mask. Even if 30 ms exposition might appear very short, research has shown that presentation time shorter than 50 ms is sufficient to allow categorization (i.e., Object vs. Animal or Pleasant vs. Unpleasant) of complex images (Lahteenmaki, Hyona, Koivisto, & Nummenmaa, 2015). In their research, Lahteenmaki et al. (2015) showed that for 10 ms exposition, participants performed higher than chance level and for 40 ms presentation, their performance was improved up to 80% accuracy. Decreasing the availability of processing time is a technique often used to prevent the utilization of controlled cognitive processes (Cunningham et al., 2004). One of the two triangles prime was related to a punishment (Punishment cue) and the other one was never related to a punishment (Safety cue). The punishment triangle (PT) was always followed by a short duration (50 ms) white noise (85–100 dB) delivered through headphones when participants answered too slowly (>800 ms.) or erroneously. On the contrary, the Safety triangle (ST) was never followed by a white noise. After the violet mask, a matrix of faces then appeared on the screen for 800 ms. The participants made a "target present" ("S" key) or a "target absent" ("L" key) judgement on an AZERTY keyboard. Participants then received a feedback (i.e., good answer, bad answer or, too slow) and if they answered wrongly or too slowly they received a white noise through the headset if the trial was in a Punishment condition (PT).

The experiment was divided into three blocks of 72 trials each separated by a fixed rest period of 20 s followed by a "get ready period" that the participants could terminate when ready. There were a total of 216 trials which means that each matrix (i.e., each

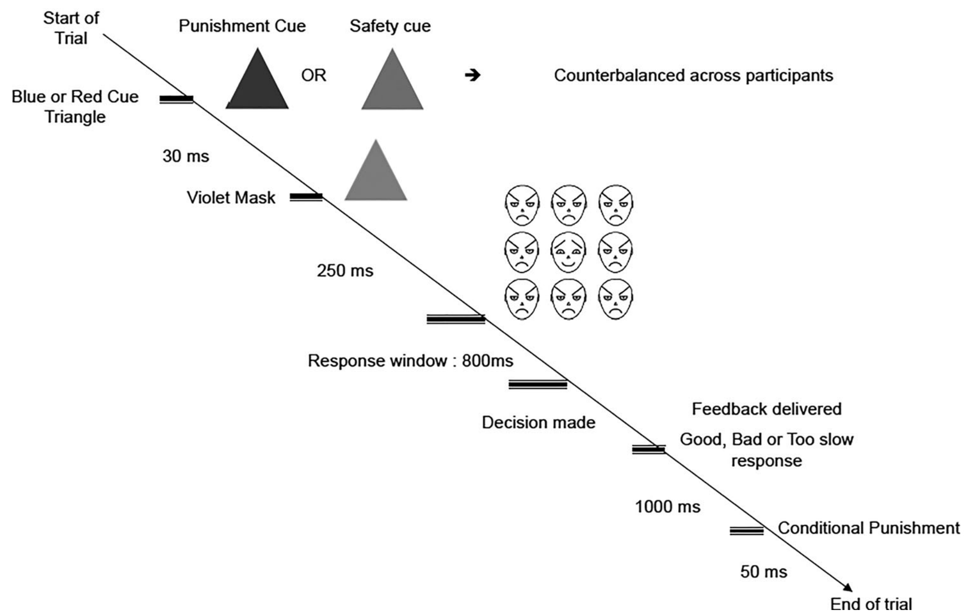

Figure 1. Example of a typical trial sequence used in the present experiment.

target position in the matrix) was presented twice. Then each matrix was associated with either the PT prime for the first appearance and with the ST prime in the second appearance, or vice versa. Within each of the three blocks half of the matrices was paired with a PT prime and the other half was paired with an ST prime. Each block contained each type of associations (Targets, Crowds and Cues). The experiment lasted about 25 min in total.

Results

We conducted the statistical analyses on response accuracy (CRs) and on response times (RTs). The statistical design was a $2 \times 2 \times 2$ with Punishment level of the prime triangle (Punishment "PT", Safety "ST") × Target (Angry vs. Happy) × Distractor (Neutral crowd vs. Emotional crowd) repeated measures ANOVA. Only response times (RTs) on target trials for which participants responded accurately were retained for analysis. RTs were also cleaned for outliers following a two standard deviations cutoff (Ratcliff, 1993). Data from neutral trials were not included in the analysis to prevent potential spurious effects caused by the idiosyncratic feature of a horizontal line in schematic neutral faces (see Öhman, Flykt, et al., 2001, p. 383), and also because detection performances for non-emotional faces were irrelevant to our hypothesis.

Results showed that the participants were overall more accurate, F (1, 54) = 25.02, $p < .001$, $\eta p^2 = .32$ but not faster, F (1, 53) < 1, n.s., to detect a threatening face (RTs, $M = 591$ ms, $SE = 6$; CRs, $M = .68$, $SE = .02$) than a happy one (RTs, $M = 592$ ms, $SE = 7$; CRs, $M = .60$, $SE = .02$). The search time was longer, F (1, 53) = 39.30, $p < .001$, $\eta p^2 = 43$ and less accurate, F (1, 54) = 177.36, $p < .001$, $\eta p^2 = .77$ among emotional distractors (RTs, $M = 608$ ms, $SE = 7$; CRs, $M = .51$, $SE = .02$) than among neutral ones (RTs, $M = 576$ ms, $SE = 6$; CRs, $M = .77$, $SD = .02$). An interaction between target and distractor, F (1, 54) = 9.78, $p = .003$, $\eta p^2 = .15$ was found in accuracy: the advantage of angry targets was particularly marked amongst emotional distractors (Angry $M = .57$, $SE = .02$; Happy $M = .45$, $SE = .02$) compared to neutral distractors (Angry $M = .79$, $SE = .02$; Happy $M = .76$, $SE = .02$). The interaction between target and distractor did not reach significance in response time F (1, 53) = 3.37, $p = .07$, $\eta p^2 = .06$.

Turning to the role of punishment, importantly, the main effect of punishment was not significant, neither in accuracy F (1, 54) < 1, n.s., nor in response times F (1, 53) < 1, n.s. However, critical to the present research endeavour, accuracy analysis showed that target interacted significantly with punishment, F (1, 54) = 10.95, $p = .002$, $\eta p^2 = .17$. Participants were less accurate at detecting Angry targets when preceded by PT ($M = .66$; $SE = .02$) than when preceded by ST ($M = .69$;

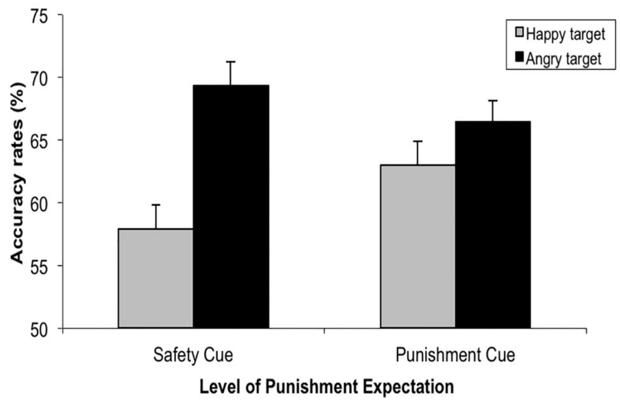

Figure 2. Mean accuracy rates (SE) of angry and happy targets detection as a function of the level of punishment expectation.

$SE = .02$), t (54) = −2.02, $p = .048$. Conversely, participants were more accurate at detecting Happy targets when preceded by PT ($M = .63$; $SE = .02$) than when preceded by ST ($M = .58$; $SE = .02$), t (54) = 2.45, $p = .02$ (Figure 2). Interestingly, complementary analyses also revealed that when preceded by ST prime, angry targets were better detected than happy targets, t (54) = 6.40, $p < .001$ However, when preceded by PT prime angry targets were no longer better detected than happy targets, t (54) = 1.78, $p = .08$. So the well-known advantage for angry schematic faces over happy schematic faces disappeared in a motivational threathening context. Importantly, as expected, none of the other interactions involving punishment were significant. Analysis showed that crowd neither interacted significantly with punishment, in accuracy F (1, 54) = 1.24, $p = .27$, $\eta p^2 = .02$, nor in response time F (1, 53) = 1.01, $p = .32$, $\eta p^2 = .02$. The three-way interaction involving target, crowd and punishment was far from significance both in accuracy, F (1, 54) < 1, n.s. and response time, F (1, 53) < 1, n.s. This absence of significance in the three-way interaction means that the interaction between punishment and target was not affected by crowd type.

Discussion

In full support to our interaction predictions, we found that the presentation of a cue signalling an imminent threat prior to the FIC task impairs the detection of an angry face, whereas it facilitates the detection of a happy face. The presentation of a concurrent threat also disrupted the anger superiority effect, which was successfully replicated on trials that were preceded by a neutral cue.

The finding that a threat signal interferes with the processing of angry faces confirms previous findings that selective attention of negative information is impaired in the presence of a concurrent threat of a higher magnitude or relevance (Amir et al., 1996; Constans, McCloskey, Vasterling, Brailey, & Mathews, 2004; Mathews & Sebastian, 1993) and extends this effect to the domain of face processing. It has to be noted that this specific result can be explained both by a fear-module theory such as the one proposed by Öhman and colleagues (Öhman & Mineka, 2001) and by a counter-regulation model (Rothermund et al., 2008) but for different reasons. If the processing advantage for angry faces (ASE) relies on the availability of a fear system, then this advantage should be disrupted when the fear system is concurrently used to process another threatening stimulus of higher intensity. In other words, the ASE would be disrupted when the fear system is "kept busy" by a higher priority threat. The counter-regulation principle actually predicts the same behavioural outcome, but for a different reason: if the organism is in a negative (threatened) affective/motivational state, then it will allocate attention to stimuli of an opposite valence (i.e., positive faces) in order to facilitate regulation of the current state and perseverance of goal pursuit. Therefore, attention focus would be diverted from angry faces leading to a disruption of the ASE.

However, we also found that participants were more accurate at detecting happy targets when preceded by a threat cue. This result is consistent with the notion that a negative emotional state might tune the organism towards a search for potential coping resources (e.g., sources of protection and cooperation). This is in line with functionalist views of negative emotion as a state aimed at maximizing the chances of success of an organism facing a challenging situation (Arnold, 1960). This result is not naturally accounted for by theories based on an attentional system specialized in threat-relevant information, which are generally agnostic to how positive information is processed. However, this effect is consistent with the attentional counter-regulation principle (Rothermund et al., 2008), which posits that attention is allocated to information that is opposite in valence to people's current affective-motivational state. This principle may ensure behavioural flexibility in situations where the organism is involved in (high salience) success- or failure-related outcomes.

These results suggest that selective attention in the FIC task may be ruled by at least 2 categories of goals. First, it is ruled by the necessity to quickly detect threatening information. Second, it may also be governed by the need to detect coping resources in the environment. In order to achieve both of these goals, it might be possible that a fear system such as the one proposed by Öhman and colleagues (e.g., Öhman & Mineka, 2001) co-exists with attentional systems guided by coping-related goals. The combined action of these two hypothetical systems should provide a decisive adaptive advantage in challenging situations. However, while the expectation of threat weakened the processing of angry faces (and facilitated the processing of happy faces), the processing of angry schematic faces was nevertheless overall (across punishment and safe cues/ trials) improved for angry relative to happy faces. Therefore, although one possible explanation lies in physical characterisics of the faces, it might also be suggested that the "fear-detection" system outperforms the "coping-resources-detection" system in attention guidance in visual search tasks. Future research will be needed to test whether such systems are functionally and neurophysiologically distinct and whether one actually outperforms the other. Further research will also be needed to investigate individual differences in coping-oriented attention. For instance, it might be possible that certain mood disorders are characterized by impairment in the capacity to efficiently detect coping resources in the environment.

Importantly, our findings are in line with the literature on the factors that guide attention in visual search tasks (for a recent review see Wolfe & Horowitz, 2017). For instance, while some attributes like colour are clearly known as attention guiding properties creating pop out effects, emotion, particularly from faces, seems rather to be a modulating or a prioritizing factor. For instance, a research found in an emotion search task that increasing the number of distracting items increased search time of more than 60 ms per added item, which largely suggests serial processing of emotional faces (Gerritsen, Frischen, Blake, Smilek, & Eastwood, 2008). However, the search time was shorter for threat items (62 ms per added distractor) than for positive items (82 ms), which suggests a modulation by emotional content. In line with these later results and with the current findings, Notebaert and colleagues (2011, Experiment 2) created threat items by coupling simple visual items (i.e., one colour, CS+) to a painful, aversive electrocutaneous stimulus (Unconditioned stimulus). They found by using this simple aversive conditioning procedure that the CS+ stimuli did not pop out from the search array but that they took however less time to be detected than neutral (non-conditioned) stimuli. This means that threat stimuli did not capture attention as simple attributes would but prioritize attention in a rather serial way. This is coherent with our data and with other research showing that value of the stimulation may favour the guidance of attention (Wolfe & Horowitz, 2017). Interestingly, this value might be either intrinsic as emotional value of a face or of a contextual cue or extrinsic as acquired value subsequent to an aversive conditioning. Following this view, our effects might be driven by prior knowledge about the meaning of stimulation rather than by feature properties of the stimuli.

Some limitations and possible alternative accounts for the findings have to be considered. First, one may wonder why no effect was obtained on response times. However, we could speculate that this result reflects our methodological choice to use a response window procedure rather than an absence of true behavioural changes (which were present in the accuracy data). In line with previous research (Draine & Greenwald, 1998), our procedure aimed at controlling response latencies by constraining participants to respond within a specified interval of time in order to optimize the measurement of detection accuracy. Since we used latencies parameters that decreased accuracy rates but maintained constant response times, it becomes obvious that the effects could only emerge in accuracy data.

Second, it could be argued that the ASE vanished in the PT condition because the threat cue captured *generic* attentional resources that were no longer available to process the face stimuli. Although this explanation opens interesting possibilities, if it were true, then the processing for both negative and positive faces should have been impaired, not only for negative ones. In addition, whereas the detection of angry faces was impaired by the threat cue, the detection of happy face detection was *facilitated* by this cue, which further unwarrants the explanation of a generic attentional depletion caused by the threat cue. This specific pattern of findings obtained for happy and angry faces also allows ruling out explanations based on learning-related changes in performance (i.e., participants would perform better after learning that errors lead to a punishment). If this were the case, then the threat cue should have facilitated performances for the detection of both happy and angry faces.

Finally, methodological concerns may be raised regarding the application of the Öhman, Flykt, et al. (2001) design. Specifically, we used a design in which targets and crowds were mixed. However, the happy target improvement and the angry target deterioration in the punishment condition were present both against neutral and emotional crowds, which rules out an account of our findings in terms of crowd-valence effects. Indeed, if there were crowd-valence effects our results should be influenced by the type of distractors people have to process in the present visual search task.

Conclusion

We showed that the expectation of an aversive stimulation modulated attentional search in the "Face in the Crowd" paradigm. Specifically, the presence of a signal predicting subsequent punishment impaired the detection of angry faces and facilitated the detection of happy faces. This is consistent with the notion that attention is guided not only by the need to quickly detect threatening stimuli in normal conditions but also by the need to seek for coping resources in the environment when experiencing imminent threat.

Disclosure statement

No potential conflict of interest was reported by the authors.

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