

Emotion

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Different Faces in the Crowd: A Happiness Superiority Effect for Schematic Faces in Heterogeneous Backgrounds

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Recently, D.V. Becker, Anderson, Mortensen, Neufeld, and Neel (2011) proposed recommendations to avoid methodological confounds in visual search studies using emotional photographic faces. These confounds were argued to cause the frequently observed Anger Superiority Effect (ASE), the faster detection of angry than happy expressions, and conceal a true Happiness Superiority Effect (HSE). In Experiment 1, we applied these recommendations (for the first time) to visual search among schematic faces that previously had consistently yielded a robust ASE. Contrary to the prevailing literature, but consistent with D.V. Becker et al. (2011), we observed a HSE with schematic faces. The HSE with schematic faces was replicated in Experiments 2 and 3 using a similar method in discrimination tasks rather than fixed target searches. Experiment 4 isolated background heterogeneity as the key determinant leading to the HSE.

Keywords: emotional expressions, visual search, happy superiority effect, anger superiority effect, face-in-the-crowd effect

Emotionally salient stimuli can alter the allocation of attention (Fenske & Raymond, 2006). Hansen and Hansen (1988) provided an early demonstration of this by asking participants to search through arrays of photographic faces to detect emotional targets. Participants were faster to detect angry faces in happy and neutral crowds than happy faces in neutral and angry crowds. Moreover, one experiment demonstrated no significant time increment for detecting angry faces as the number of distractors increased, indicating that angry faces are processed preattentively and ‘pop-out’ of crowds. It was suggested that this Anger Superiority Effect (ASE) was the result of a cognitive mechanism evolved to quickly detect and attend to external sources of threat.

Subsequent research has produced inconsistent results with some studies utilizing photographic faces reporting an ASE (Horstmann & Bauland, 2006; Pinkham, Griffin, Baron, Sasson, & Gur, 2010), some studies finding no difference in detecting happy and angry expressions and others reporting a Happy Superiority Effect (HSE; D.V. Becker, Anderson, Mortensen, Neufeld, & Neel, 2011; Juth, Lundqvist, Karlsson, & Öhman, 2005; Savage, Lipp, Craig, Becker, & Horstmann, 2013). A number of researchers have implicated low-level perceptual features of the emotional

faces as the cause of these inconsistent effects (Horstmann, Lipp, & Becker, 2012; Purcell, Stewart, & Skov, 1996; Savage et al., 2013). To eliminate the confounding influence of emotion irrelevant perceptual features on visual search for photographic emotional faces, some researchers have utilized schematic faces that are simple line drawing emotional face. With few exceptions (e.g., S.I. Becker, Horstmann, & Remington, 2011), the results consistently show faster detection of angry than happy expressions (ASE; for reviews see D.V. Becker et al., 2011; Frischen, Eastwood, & Smilek, 2008; Horstmann, 2009).

In light of the inconsistencies, D.V. Becker and colleagues (2011) reviewed the literature and concluded that methodological problems present in prior studies limit our ability to determine whether angry or happy faces are detected faster in crowds. D.V. Becker and colleagues presented five recommendations for future studies investigating visual search for emotional face. It was argued that implementing these recommendations would “unconfound” the Face-in-the-Crowd Effect. They then demonstrated a HSE when following these recommendations using photographic stimuli. They argued this finding suggests that happy expressions may have evolved to be easily detectable so that affiliative intent expressed by others can be detected quickly and over distance. This finding of a HSE was also consistent with the finding of faster categorization of happy than of neutral or negative expressions (Leppänen & Hietanen, 2003) and provided converging evidence for the prioritization of positive affect in emotional expression processing.

First, D.V. Becker et al. (2011) recommended varying the number of distractors (set size) within participants to detect potential differences in search efficiency. Second, the content of the distractor crowds should be held constant across the conditions of interest. This is to eliminate background properties as the source of any detection time differences. Additionally, fixed-target search designs should be used and low level visual features should be

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controlled for. Finally, heterogeneous backgrounds should be used to prevent participants from searching for emotion unrelated idiosyncratic featural differences between stimuli. Although previous studies utilizing schematic faces have implemented at least some of these recommendations (e.g., Fox et al., 2000; Horstmann, 2007, 2009; Öhman, Lundqvist, & Esteves, 2001), to our knowledge, heterogeneous backgrounds within a trial have never been used in published studies.

The key consequence of using homogenous backgrounds in visual search experiments with schematic faces is that targets can be accurately detected adopting a feature search strategy. Feature search describes a situation where the target is defined by a single feature like a color or shape. In the context of detecting a target emotional expression, participants could find the target by focusing on just one feature such as a particular eye brow line or a mouth curve, depending on the requirements of the task and the stimuli. Under these conditions, the target could be found without processing all the information necessary for identification of the emotion, and hence, search differences may not be driven by the emotional expression displayed, but by some visual feature confounded with it. By using heterogeneous backgrounds we can create a condition where targets can only be accurately detected by adopting a conjunction search strategy. Conjunction search describes a situation where the target is defined by a combination of features (e.g., shape and color; Treisman & Gelade, 1980; Wolfe, 1994). In the context of searching for emotional targets, such a target could only be identified by combining information from both the eye brows and the mouth line. Using heterogeneous backgrounds can thus, unconfound search for happy versus angry targets, because neither of them can be found by attending to a single feature, and hence, differences in search performance cannot be attributed to a feature search strategy.

Current Study

We aimed to determine whether a HSE emerges when adhering to the recommendations proposed by D.V. Becker et al. (2011) in studies of search for emotional schematic faces. This is important as the results of all previous studies investigating visual search for emotional schematic faces could be a result of one or more of the methodological confounds described by D.V. Becker et al. (2011). Determining whether happy or angry faces are detected faster when implementing these recommendations is all the more important as D.V. Becker et al. (2011) predict a HSE rather than an ASE although the majority of prior studies of visual search for emotional schematic faces had yielded an ASE.

To test this, participants completed fixed-target searches for happy and angry expressions among heterogeneous backgrounds that consisted of 1, 2, 4, or 6 search stimuli. Heterogeneous backgrounds were created using random combinations of distractor faces that were neither happy nor angry. These distractor faces were created by combining the eye brow and mouth features of the happy and angry targets. One type of distractor face had happy eyebrows but an angry mouth (sad) and the other had angry eyebrows but a happy mouth (scheming). The stimuli were controlled for on emotion irrelevant differences in low-level perceptual features. Using these faces in heterogeneous backgrounds meant that a target happy or angry face could only be detected by searching for a conjunction of features and not by just searching

for a single feature. Backgrounds were controlled by creating two versions of the task with either happy or angry targets. As we adhered to D.V. Becker et al.'s (2011) recommendations, a HSE was predicted.

Experiment 1

Method

Participants. Participants were 38 undergraduate students (27 females, $M = 19.04$, $SD = 2.61$) who received course credit. Data from an additional three participants who only completed one of the two tasks were excluded from analysis.

Apparatus and materials. The experimental task was displayed on 17" monitors with a refresh rate of 85 Hz and a screen resolution of $1,024 \times 768$ pixels in a laboratory seating up to six participants and executed in DMDX (Forster & Forster, 2003). Responses were made with the left and right shift keys on a standard keyboard with response mapping counterbalanced across participants.

The stimuli (see Figure 1, upper row) were four emotional schematic faces adapted from Lipp, Price, and Tellegen (2009). All faces shared the common features of two gray circles representing eyes, a triangle representing the nose, a curved line representing the mouth and two lines above the eyes representing eye brows. Four different emotional expressions (happy, angry, sad, and scheming) were created by swapping the eye brown lines and inverting the curve of the mouth. The face circumferences present in the Lipp et al. (2009) faces were removed. This was to eliminate the possibility that differences in detection time reflect the interaction between angry and happy features with the face circumference (Horstmann, Becker, Bergmann, & Burghaus, 2010; S.I. Becker, Horstmann & Remington, 2011; Purcell & Stewart, 2010). Each image was 85×115 pixels in size. The stimuli were matched in brightness and contrast.

Procedure. Participants were seated ~50 cm away from the monitor. They were instructed that they would complete two tasks. In each task, they indicated whether a target face was present on the display or not by pressing the right or left shift key. In one task, the target they searched for was always a happy face and in the other the target was always an angry face. The order of the happy and angry tasks was counterbalanced. They were informed that distracting nontarget faces may be present and were provided examples of all stimuli before commencing the tasks. Participants

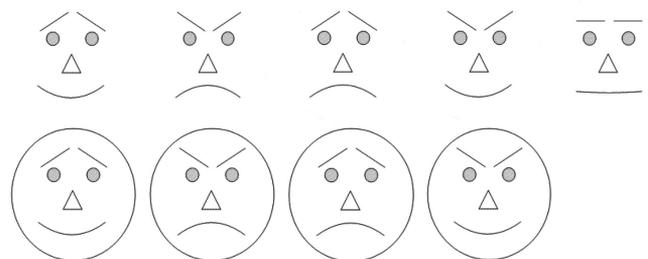


Figure 1. Schematic stimuli used in Experiments 1, 2, and 4 (upper row) and Experiment 3 (lower row). Emotions depicted from left to right are happy, angry, sad, scheming, and neutral.

completed 12 practice trials before each main task with task order counterbalanced.

On each trial a centered black fixation cross was presented on a white background for 500 ms followed by the search array that was displayed until the participant made a response or for 5,000 ms. The search array was circular around fixation and consisted of six potential stimulus locations. Stimuli were presented at set sizes of 1, 2, 4, or 6. At set size two, stimuli always occupied opposing locations so stimuli could appear at positions 1 and 4, 2 and 5, or 3 and 6. At set size four stimuli appear at positions 1, 2, 4 and 5, 2, 3, 5, and 6, or 3, 4, 6, and 1. At set size six all positions were occupied. Backgrounds consisted of random combinations of sad and scheming faces. These faces differed from the target faces in either the mouth or eyebrows. Across both tasks, the background configurations were held constant and only the expression of the target face was altered. This was done so that potential differences in detection time between happy and angry targets could not be attributed to the backgrounds alone.

Participants received feedback of an incorrect response with the word "WRONG" presented at the bottom of the screen for 500 ms. Half of the trials were target trials and half were nontarget trials showing random combinations of sad and scheming faces. For each task, the target appeared in each target location at each set size three times resulting in 72 target trials and 72 nontarget trials matched in set size, totaling 144 trials for each task.

Data preparation and analysis. Incorrect responses were coded as missing and responses faster than 100 ms and those more than 3 SDs from a participant's mean were classified as within subject outliers and removed. This constituted 7% of responses. Response time and error rate data were analyzed with separate 2 (Trial type: target, nontarget) \times 2 (Target emotion: happy, angry) \times 4 (Set size: 1, 2, 4, 6) repeated measures ANOVAs.¹

Results

Response times. Consistent with the key prediction of a HSE when the recommendations of D.V. Becker et al. (2011) were followed, participants were faster to indicate the presence and absence of happy faces than angry faces at each set size (see Figure 2). This was confirmed by a significant main effect of emotion, $F(1, 37) = 22.14, p < .001, \eta_p^2 = .37$. Participants were also significantly slower to respond as the number of distractors increased, $F(3, 111) = 800.20, p < .001, \eta_p^2 = .96$. Participants were slower to respond at each increase in set size, all $t_s > 7.13, p_s < .001$. They were also slower to respond on nontarget than on target trials, $F(1, 37) = 389.76, p < .001, \eta_p^2 = .91$. A trial type \times set size interaction emerged, $F(3, 111) = 186.61, p < .001, \eta_p^2 = .84$. Although participants were faster to respond on target than nontarget trials at all set sizes $t_s(111) > 5.35, p < .001$, the magnitude of this difference did not increase from set sizes 1 to 2, $t(111) = .02, p = .984$, but did increase from set sizes 2 to 4 and 4 to 6 $t_s > 13.65, p_s < .001$. No other effects were significant $F_s < 1.70, p_s > .189$.

Error rates. As shown in Table 1, consistent with response time data, participants made fewer errors searching for happy expressions than angry expressions, as indicated by a significant main effect of emotion $F(1, 37) = 8.54, p = .006, \eta_p^2 = .19$. Participants also made more errors on target trials than on nontarget trials, $F(1, 37) = 27.54, p < .001, \eta_p^2 = .43$, and with

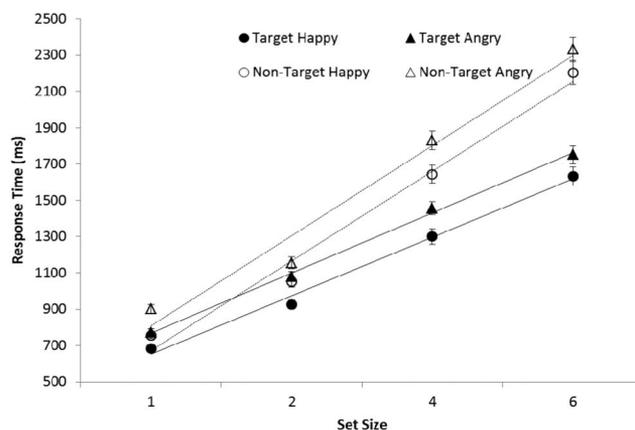


Figure 2. Response times for indicating the presence or absence of happy and angry targets among heterogeneous backgrounds as a function of set size in Experiment 1. Error bars depict SEM.

increasing set size, $F(3, 111) = 37.12, p < .001, \eta_p^2 = .50$. These factors interacted as indicated by a significant trial type \times set size interaction, $F(3, 111) = 17.18, p < .001, \eta_p^2 = .32$. Error rates did not differ significantly between target and nontarget trials at set size 1, $t(111) = 1.29, p = .199$, but more errors were made on target than nontarget trials at set sizes 2, 4, and 6, $t_s(111) > 2.65, p_s < .009$. There was also a marginally significant emotion \times set size interaction, $F(3, 111) = 2.31, p = .088, \eta_p^2 = .06$. Although simple effects must be interpreted with caution, fewer errors were made in the happy than the angry task at set sizes 1 and 6 $t_s(111) > 2.05, p_s < .043$, but not at set sizes 2 and 4, $t_s(111) < 1.27, p > .207$. All other interactive effects did not reach the threshold of significance, $F_s < 0.55, p > .630$.

Discussion

The aim of Experiment 1 was to determine the direction of the search advantage with schematic emotional faces when adhering to D.V. Becker et al.'s (2011) methodological recommendations. Consistent with the prediction that a HSE would emerge, participants were faster and more accurate in indicating the presence and absence of happy than of angry faces. To our knowledge, this is the first report of a HSE with schematic emotional faces without altering the face circumferences. The extant literature exclusively presents evidence for an ASE or no difference between search times for happy and angry expressions (D.V. Becker et al., 2011; Frisken et al., 2008).

The key difference between the current and previous studies is the use of heterogeneous backgrounds and, therefore, a task that required the processing of conjunctions of emotion relevant features rather than just one feature. It may be the case that participants complete the task searching for this feature when homogeneous backgrounds are used and a single feature differentiates the

¹ For each experiment, data were also analyzed excluding any participant who had error rates approaching chance overall or in any one condition ($>30\%$). This did not alter any of the conclusions presented in analysis of either response times or error rates. As such, we report result including all participants who provided a complete dataset.

Table 1
Error Data for Experiments 1–4 as a Function of Target Emotion, Set Size, and Trial Type

	Target trials				Nontarget trials			
	1	2	4	6	1	2	4	6
Experiment 1								
Happy	2.34 (4.49)	6.29 (6.08)	9.50 (8.56)	12.87 (9.23)	2.92 (4.43)	3.07 (4.22)	4.39 (5.19)	4.68 (6.65)
Angry	3.36 (4.39)	6.29 (6.73)	10.23 (9.54)	16.96 (9.83)	5.70 (6.77)	3.51 (7.01)	5.12 (10.84)	7.02 (8.14)
Experiment 2								
Happy	1.74 (4.34)	5.03 (6.21)	11.63 (8.85)	17.36 (11.70)				
Angry	1.56 (2.90)	6.77 (6.87)	7.47 (8.54)	10.59 (11.05)				
Experiment 3								
Happy	4.07 (5.25)	11.67 (10.35)	20.93 (12.78)	27.04 (13.59)				
Angry	2.59 (4.06)	8.70 (8.47)	13.15 (8.93)	19.07 (9.97)				
Experiment 4a								
Happy	5.25 (6.08)	3.40 (5.83)	2.01 (3.55)	1.70 (2.92)	6.17 (7.83)	2.78 (4.50)	1.54 (2.85)	2.01 (4.02)
Angry	5.40 (6.83)	4.94 (5.28)	3.86 (4.16)	2.31 (3.61)	4.94 (5.28)	2.93 (5.05)	2.47 (4.87)	0.77 (1.95)
Experiment 4b								
Happy	5.71 (6.83)	8.18 (7.91)	6.33 (6.92)	5.86 (6.63)	6.17 (8.48)	3.70 (4.97)	2.93 (4.50)	3.24 (4.67)
Angry	7.71 (8.11)	5.40 (7.33)	6.33 (6.79)	8.33 (9.89)	7.87 (6.42)	4.94 (8.05)	3.70 (7.63)	3.24 (7.20)
Experiment 4c								
Happy	7.94 (7.77)	4.29 (5.40)	8.25 (7.55)	15.56 (11.34)	8.10 (7.54)	5.56 (8.31)	3.81 (5.68)	3.33 (4.90)
Angry	8.25 (10.38)	4.92 (6.71)	4.29 (8.21)	8.10 (9.46)	8.10 (9.37)	4.76 (10.01)	5.40 (8.14)	3.33 (8.86)

target from the background faces. Using this search strategy does not necessitate processing of all the information that would allow for the emotion to be identified. This means that differences in the speed of detecting happy and angry expressions may not reflect processes related to the emotional expression represented. In the current study, participants must search for a conjunction of features. All of the features that allow for recognition of the represented emotion must be processed. This means that any difference in detection time for happy and angry faces may be a result of the emotional expressions represented by the stimuli. Given this is the first report of a HSE with schematic faces not because of altering the stimuli themselves, Experiments 2 and 3 were conducted to establish the robustness and reliability of this HSE in heterogeneous backgrounds.

Experiment 2

To determine whether the HSE in heterogeneous backgrounds observed in Experiment 1 is reliable, we seek to replicate this finding using similar methods in a discrimination search task. In these tasks, participants must still search to detect a target, but must then identify the nature of a target that is presented on every trial. This removes the need for nontarget trials that provide no information about target detection and reduces the number of trials a participant must complete. Although using discrimination search tasks is not in line with the D.V. Becker et al. (2011) recommendation of using fixed target searches, previous research from our lab suggests that this methodological factor does not alter the outcome of results when using photographic faces (Savage et al., 2013). If the HSE observed in Experiment 1 was because of the use of heterogeneous backgrounds, a HSE should also be observed in Experiment 2.

Method

Participants were 32 undergraduate volunteers (8 males, $M = 20.19$, $SD = 5.40$) who completed a discrimination task. Rather

than indicating the presence or absence of a target, a happy or angry target was present on each trial and participants were required to detect and then categorize this target. As such only target trials were included and these happy and angry target trials appeared mixed rather than blocked within each task. Trials were created as described in Experiment 1 resulting in 144 trials in total (72 happy and 72 angry target trials). Participants were familiarized with the target and background stimuli before commencing the task and were instructed to categorize the target (happy or angry) by pressing the right and left shift keys, with response mapping counterbalanced across participants. Data were processed in the same manner as in Experiment 1. Fewer than 9% of responses were excluded because of incorrect responses or outlying response times. Response time and error rate data were submitted to separate 2 (Target emotion: happy, angry) \times 4 (Set size: 1, 2, 4, 6) repeated measures ANOVAs.

Results

Response times. As predicted, results displayed in Figure 3 indicate that participants were faster to discriminate happy than angry faces. This was supported by a significant main effect of target emotion, $F(1, 31) = 18.22$, $p < .001$, $\eta_p^2 = .37$. This HSE was moderated by set size, $F(3, 93) = 4.32$, $p < .021$, $\eta_p^2 = .122$. There was no significant difference between discriminating happy and angry expressions at set size 1, $t(93) = 0.44$, $p = .66$, but faster discrimination of happy targets emerged at set sizes 2, 4, and 6, $ts(93) > 4.01$, $ps < .001$. Consistent with previous research, a main effect of set size was also observed, $F(3, 93) = 211.89$, $p < .001$, $\eta_p^2 = .870$. Each increase in set size resulted in significantly slower response times, $ts(93) > 4.47$ all $ps < .001$.

Error rates. Table 1 indicates that there was no significant difference in errors made on happy and angry trials overall, $F(1, 31) = 3.23$, $p = .082$, $\eta_p^2 = .09$, but overall error rates tended to increase as set size increased, $F(3, 93) = 39.21$, $p < .001$, $\eta_p^2 = .56$. This effect was moderated by the nature of the target, $F(3, 93) = 5.50$, $p = .004$, $\eta_p^2 = .15$. Follow up comparisons indicated

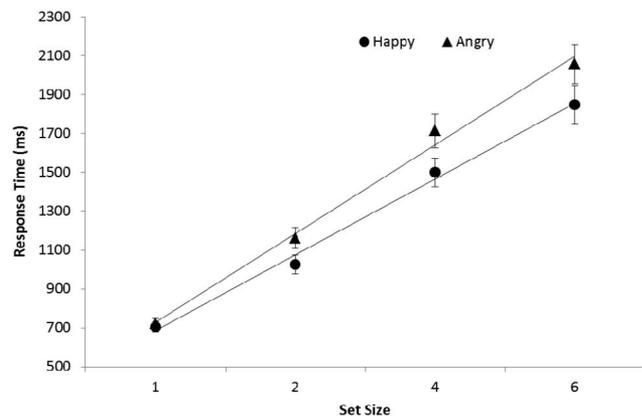


Figure 3. Response times for discriminating happy or angry targets without circumference among heterogeneous backgrounds as a function of set size in Experiment 2. Error bars depict SEM.

that there was no difference in errors made on happy and angry trials at set sizes 1 and 2, $t_s(93) < 0.93$, $ps > .356$, but more errors were committed on happy than angry trials at set sizes 4 and 6, $t_s(93) > 2.23$, $ps < .028$.

Discussion

Experiment 2 replicated the finding of a HSE in heterogeneous backgrounds with schematic faces observed in Experiment 1. This finding demonstrates that the HSE is also observed in heterogeneous backgrounds in discrimination search tasks where there is a happy or an angry target present on each trial and the nature of the target must be identified. It also demonstrates that fixed target search is not critical for the HSE to emerge. It seems likely that the HSE observed with schematic faces seems to be because of background heterogeneity; however, there were some slight differences between the results of Experiment 1 and Experiment 2 that need consideration.

First, in Experiment 1 there was no indication of an emotion by set size interaction, but in Experiment 2 a significant emotion \times set size interaction emerged. At set size 1, the difference in discriminating happy and angry targets was not significant in Experiment 2, but at larger set sizes it was. Considering the key methodological difference between Experiments 1 and 2 provides a potential explanation for this. In Experiment 1 at set size 1, participants indicated the presence or the absence of a happy or angry target and in doing so had to process the configuration of eye brow and mouth features to make a correct response. Thus, processing of all of the information necessary to identify the emotion was necessary to make a correct response. In Experiment 2, the target was always present and participants only had to indicate which target, happy or angry, was present on each trial. At set size 1, this discrimination could be solved featurally, that is, by only looking at the mouth or only looking at the eye brows. Such a feature based solution was not available for accurate responding at larger set sizes. In Experiments 1 and 2, a HSE is observed when the conjunction of the eye brow and mouth features must be processed to respond correctly.

Second, error rates in Experiment 1 were consistent with response times. Fewer errors were made in the happy task where

response time was fastest. In Experiment 2, happy faces were also generally discriminated faster, but where differences in error rates were observed there were more errors made on happy trials. There are a couple of potential explanations for this pattern of results.

First, this difference could be because of the change in methodology and may speak to differences in the ease of discriminating happy and angry targets from background faces. In Experiment 1, if a participant had difficulty discriminating angry from scheming or sad faces and mistook a scheming or sad face for an angry face, this would be recorded as an error as they would indicate that an angry target was present when it was not. In Experiment 2, mistaking a scheming face for an angry face has different consequences. If this mistake was made on an angry target trial this would be recorded as a correct response, but if it was made on a happy target trial, it would be recorded as an error. Given that scheming and sad faces appeared equally on happy and angry target trials, mistaking a scheming or sad face for an angry face would have increased incorrect responding on happy target trials in Experiment 2 (whereas it would have increased incorrect responding in the angry task in Experiment 1).

A second potential explanation is that participants were trading off accuracy for speed on happy trials in Experiment 2. If this were the case we may find that faster response times are associated with more errors. Analysis of the data indicated no significant relationship between mean response times and error rates in any condition. Additionally, trading off accuracy for speed should manifest in faster response times on incorrect trials. Mean response times did not differ between correct and incorrect trials at any set size, $t_s < 1.35$, $ps > .187$. Looking at happy and angry trials separately, there was no difference between response times for correct and incorrect responses on angry trials, $t(29) = 1.18$, $p = .247$, but participants were significantly slower on incorrect happy trials than on correct happy trials, $t(30) = 5.92$, $p < .001$. This analysis suggests that participants were not sacrificing accuracy for speed on happy trials. Considering the results from Experiments 1 and 2 together along with these additional analyses suggests that the HSE observed in heterogeneous backgrounds is unlikely to be because of a speed-accuracy trade-off, that is, participants prioritizing speed over accuracy selectively in happy trials, but rather to differences in the ease of identifying the happy and the angry faces among the sad or scheming backgrounds.

It is also important to note that the stimuli used in Experiments 1 and 2 have not previously been used in published research. The faces appeared without circumferences to eliminate the possibility that differences in detection time were driven by an interaction of facial features and the circumference of the face (S.I. Becker et al., 2011; Horstmann et al., 2010). It may be the case that this particular set of stimuli elicits a HSE when presented without circumferences regardless of the background. Experiment 3 was designed to test this alternative hypothesis.

Experiment 3

In Experiment 3 we seek to determine whether the HSE in heterogeneous backgrounds observed in Experiments 1 and 2 is because of the absence of facial circumferences. To do this, we replicate Experiment 2 with the original Lipp et al. (2009) stimuli that include facial circumferences. Given that heterogeneous backgrounds are used, we predict that a HSE will be observed.

Method

Participants were 30 (7 males, $M = 18.57$, $SD = 1.52$) undergraduate student volunteers. The apparatus, materials, and procedure were identical to those described in Experiment 2, except the unaltered stimuli from Lipp et al. (2009) including circumferences were utilized (see Figure 1, lower row). Thirteen percent of responses were excluded from analysis because of incorrect responses or outlying response times. Response times and error rates were analyzed using separate 2 (Target emotion: happy, angry) \times 4 (Set size: 1, 2, 4, 6) repeated measures ANOVAs.

Results

Response times. Results displayed in Figure 4 indicate that participants were faster to discriminate happy than angry faces. This was supported by a significant main effect of target emotion, $F(1, 29) = 6.91$, $p = .014$, $\eta_p^2 = .192$. A main effect of set size was also observed, $F(3, 87) = 264.61$, $p < .001$, $\eta_p^2 = .901$. Each increase in set size resulted in significantly longer response times, $ts > 4.17$ all $ps < .001$. The emotion \times set size interaction was not significant, $F(3, 87) = 1.89$, $p = .150$, $\eta_p^2 = .061$; however, inspection of response times suggests a trend consistent with Experiment 2 where discrimination times for happy and angry targets do not differ at set size 1, but appear to emerge at larger set sizes. Although simple effects must be interpreted with extreme caution given the lack of a significant interaction, there is some evidence to support this. Although there was no significant difference between discrimination times at set size 1 and 2, $ts(87) < 1.34$, $ps > .184$, happy faces were detected faster at set sizes 4 and 6, $ts(87) > 2.45$, $ps < .016$.

Error rates. Again the error rates displayed in Table 1 suggest an increase as set size increased, $F(3, 87) = 65.91$, $p < .001$, $\eta_p^2 = .69$, and in this experiment significantly more errors were made on happy than on angry trials, $F(1, 29) = 16.43$, $p < .001$, $\eta_p^2 = .36$. The factors of set size and emotion interacted significantly, $F(3, 87) = 3.46$, $p = .024$, $\eta_p^2 = .11$, such that errors made on happy and angry trials did not differ significantly at set sizes 1 and 2, $ts(87) < 1.58$, $ps > .117$, but more errors were made on

happy than angry trials at set sizes 4 and 6, $ts(87) > 4.16$, $p < .001$.²

Discussion

The aim of Experiment 3 was to determine whether the HSE with schematic faces in heterogeneous backgrounds observed in Experiments 1 and 2 could be replicated using the original Lipp et al. (2009) stimuli that included facial circumferences. Although these exact same stimuli elicited an ASE when presented among homogeneous neutral backgrounds in the original Lipp et al. (2009) study, in the current study, among heterogeneous backgrounds, the predicted HSE was observed. Together, Experiments 1–3 suggest that happy schematic faces are detected more quickly in heterogeneous backgrounds when processing of a conjunction of eye brow and mouth features is necessary. These results are in line with the hypothesis of D.V. Becker et al., that happy faces are processed more quickly and easily than angry expressions, and that the ASE reported in previous literature was because of the fact that low level visual confounds drove the search asymmetry in favor of angry faces. Aside from background heterogeneity, there are a number of potential alternative explanations that need to be considered.

First, the current results may be because of the use of emotional rather than neutral backgrounds. Previous experiments that have held backgrounds constant across emotion conditions have only used homogeneous backgrounds and have not investigated whether happy or angry faces are detected faster among other types of emotional backgrounds. It may be the case that the use of emotional (sad or scheming) faces as backgrounds in Experiments 1–3 leads to a HSE even in homogeneous backgrounds. Additionally, the stimuli used in Experiments 1 and 2 without circumferences have not previously been used in the literature. Although an ASE was reported by Lipp et al. (2009) using similar stimuli, it may be the case that when circumferences are removed, search for happy faces is also facilitated. Experiment 3 confirmed that including the facial circumference did not lead to an ASE in heterogeneous backgrounds, however, it is unclear whether the stimuli without circumferences will always elicit a HSE even when presented among homogeneous backgrounds.

Experiment 4 aimed to test these alternative explanations. Participants completed six blocks of fixed-target searches for happy and angry faces in homogeneous neutral, sad, or scheming backgrounds. In doing so, all of the recommendations of D.V. Becker et al. (2011) were followed except the recommendation to use of heterogeneous backgrounds. As the methods and stimuli utilized were similar to prior studies (e.g., Dickins & Lipp, 2014; Lipp et al., 2009), an ASE was predicted in homogenous backgrounds.

² As in Experiment 2, we conducted additional analyses to determine whether a speed–accuracy trade-off was likely to affect the observed results. Analysis revealed no relationship between mean response times and error rates in any condition. There was also no difference in response times on correct and incorrect trials at any set size $ts < 1$, $ps > .333$. Looking at each emotion condition separately, participants were faster to respond on correct than incorrect happy and angry trials, $ts > 2.07$, $ps < .047$. Given these results, a speed–accuracy trade-off explanation for the current results seems unlikely.

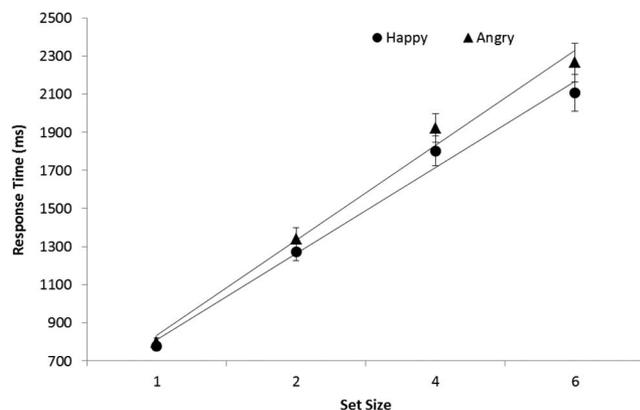


Figure 4. Response times for discriminating happy or angry targets with face circumferences among heterogeneous backgrounds as a function of set size in Experiment 3. Error bars depict SEM.

Experiment 4

Method

Participants. Participants were 36 undergraduate volunteers (27 females, $M = 19.20$, $SD = 2.49$), who received course credit.

Apparatus and materials. The apparatus and materials were the same as in Experiment 1 with the addition of a neutral schematic face (see Figure 1). This face was composed of the same eyes and nose as the emotional faces; however, the eyebrow and mouth were horizontal lines.

Procedure. Participants searched for happy or angry targets among homogenous neutral, sad, or scheming backgrounds, yielding six tasks. The background faces were always constant within each task and all consisted of the same emotional face. The order of the tasks was counterbalanced across participants. Participants completed six blocks of 144 trials, one block for each target type within each background. Data were preprocessed as in Experiment 1. Results for each background were analyzed separately. Missing responses constituted 5% (Neutral backgrounds), 7% (Sad backgrounds), and 10% (Scheming backgrounds) of trials with no evidence for a speed-accuracy trade-off. Data from one participant were not available in the scheming background task as he or she did not complete this task.

Results

Neutral backgrounds.

Response times. Contrary to predictions (Figure 5a), there was no time difference in indicating the presence or absence of happy and angry expressions among neutral faces, $F(1, 35) = 8.89$, $p = .355$, $\eta_p^2 = .02$. However, participants were overall faster to respond on target than nontarget trials, $F(1, 35) = 12.88$, $p = .001$, $\eta_p^2 = .27$, and faster to respond at smaller than larger set sizes, $F(3, 105) = 16.47$, $p < .001$, $\eta_p^2 = .32$. Participants were faster to respond at set size 1 than at set sizes 2, 4 and 6, $t_s(105) = 2.70$, $p = .008$, but no difference in response times was observed at set sizes 2, 4, or 6, $t_s(105) < 1.26$, $p = .211$.

Error rates. As in the response time data, there was no significant difference in error rates between angry and happy tasks, $F(1, 35) = 0.89$, $p = .351$, $\eta_p^2 = .03$, (see Table 1). There was, however, a significant main effect of trial type, $F(1, 35) = 4.89$, $p = .03$, $\eta_p^2 = .12$, indicating that fewer errors were made on nontarget trials than on target trials. In this task, more errors were also committed at smaller than at larger set sizes, $F(3, 105) = 18.16$, $p < .001$, $\eta_p^2 = .34$. More errors were made at set size 1 than at set sizes 2, 4, and 6, $t_s(105) > 3.00$, $ps < .003$. No other effects were significant $F_s < 2.64$, $ps > .113$.

Sad backgrounds.

Response times. As can be seen in Figure 5b, overall response times did not differ as a function of target emotion, $F(1, 35) = 1.42$, $p = .242$, $\eta_p^2 = .04$. However, there were significant interactions of trial type and emotion, $F(1, 35) = 16.75$, $p < .001$, $\eta_p^2 = .33$, and set size $F(3, 105) = 8.47$, $p < .001$, $\eta_p^2 = .20$ as well as a significant three way emotion by trial type by set size interaction, $F(3, 105) = 3.87$, $p = .013$, $\eta_p^2 = .10$. Analyzing target and nontarget trials separately to follow this significant three way interaction, revealed the predicted ASE, $t_s(105) > 2.92$, $ps < .004$, in target trials at all set sizes except size 1, $t(105) = .48$, $p = .632$

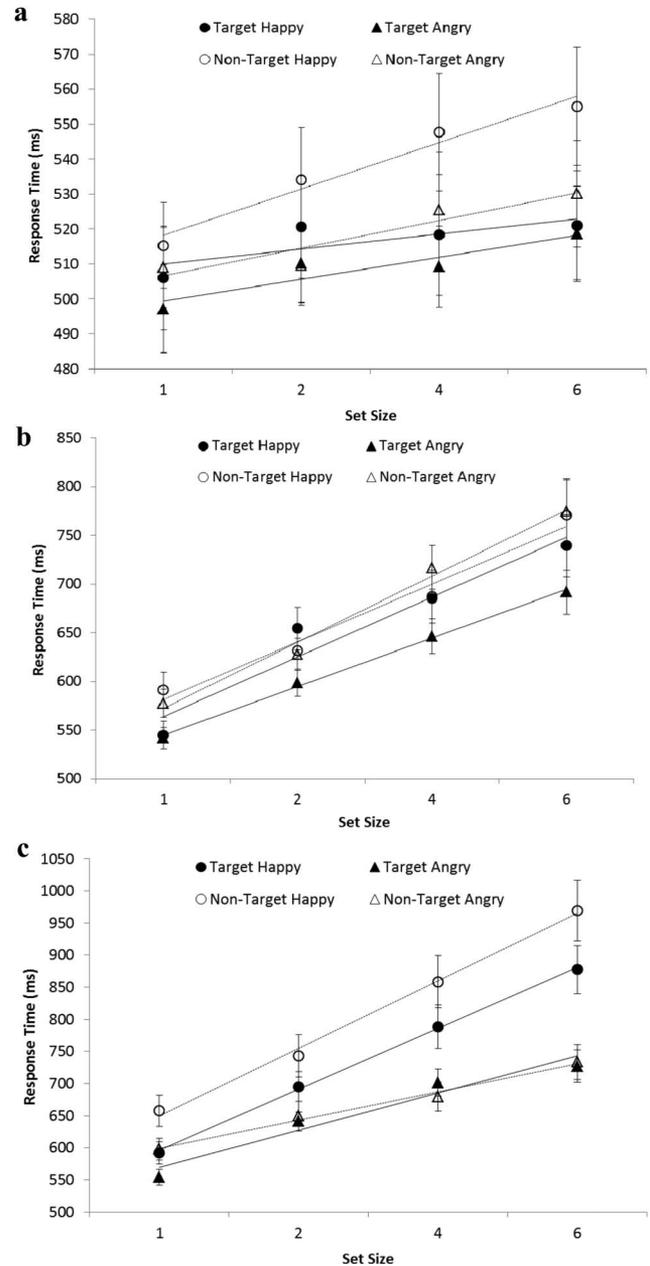


Figure 5. Response times for indicating the presence or absence of happy and angry targets among homogeneous (a) neutral, (b) sad, and (c) scheming backgrounds as a function of set size in Experiment 4. Error bars depict SEM.

(significant emotion by set size interaction, $F(3, 105) = 3.21$, $p = .039$, $\eta_p^2 = .08$). There was no significant ASE on nontarget trials at any set size, $F(3, 105) = 0.87$, $p = .436$, $\eta_p^2 = .03$. Additionally, there were omnibus main effects of trial type, $F(1, 35) = 21.10$, $p < .001$, $\eta_p^2 = .38$, and set size, $F(3, 105) = 104.04$, $p < .001$, $\eta_p^2 = .75$. Participants were slower to respond on nontarget than target trials and slower to respond at each increase in set size $t_s(105) > 3.44$, $ps < .001$. The emotion \times set size interaction was not significant, $F(3, 105) = 0.98$, $p = .372$, $\eta_p^2 = .03$.

Error rates. As can be seen in Table 1, analysis of error rates revealed no significant effect of emotion or any interaction with the factor of emotion and trial type or set size $F_s > 2.10$, $ps > .113$. There was, however, a significant main effect of trial type, $F(1, 35) = 22.76$, $p < .001$, $\eta_p^2 = .39$, with more errors committed on target than on nontarget trials. There was also a significant main effect of set size, $F(3, 105) = 4.02$, $p = .008$, $\eta_p^2 = .11$, with more errors committed at set size 1 than at set sizes 2, 4, and 6, $ts(105) = 2.04$, $p < .044$. This effect was moderated by trial type, $F(3, 105) = 3.87$, $p = .015$, $\eta_p^2 = .10$. Follow up comparisons indicated no significant difference in error rates for target and nontarget trials at set size 1, $t(105) = 0.32$, $p = .747$, but more errors were committed in target than nontarget trials at set sizes 2, 4, and 6 $ts(105) > 2.53$, $ps < .013$.

Scheming backgrounds.

Response times. As predicted, an ASE emerged (Figure 5c) in search among scheming faces. Participants were faster to indicate the presence and absence of angry than happy faces, as indicated by a main effect of emotion, $F(1, 34) = 26.64$, $p < .001$, $\eta_p^2 = .44$. This main effect of emotion was moderated by set size, $F(3, 102) = 41.26$, $p < .001$, $\eta_p^2 = .55$, and trial type, $F(3, 102) = 12.34$, $p = .001$, $\eta_p^2 = .27$. The ASE was significant in target and nontarget trials, $ts(102) > 9.84$, $ps < .001$, and at all set sizes, $ts(102) > 3.44$, $ps < .001$, but was significantly larger in nontarget trials, $t(102) = 4.97$, $p < .001$, and significantly larger with each increase in set size, $ts(102) > 2.29$, $ps < .024$. Overall, participants were faster to respond on target than nontarget trials, $F(1, 34) = 19.365$, $p < .001$, $\eta_p^2 = .36$, and slower to respond with each increase in set size, $F(3, 102) = 112.16$, $p < .001$, $\eta_p^2 = .77$, $ts(102) > 3.72$, $ps < .001$. All other effects were not significant, $F_s < 2.07$, $p > .115$.

Error rates. There was no overall difference in errors made in the happy and angry tasks, $F(1, 34) = 1.92$, $p = .175$, $\eta_p^2 = .05$ (see Table 1). However, there were significant main effects of set size, $F(3, 102) = 12.26$, $p < .001$, $\eta_p^2 = .27$, and trial type, $F(1, 34) = 22.99$, $p < .001$, $\eta_p^2 = .40$, with significantly more errors committed at set size 1 than at set size 2 and 4, $ts(102) = 3.95$, $p < .001$, but not at set size 6, $ts(102) < 0.77$, $p > .443$, and on target than nontarget trials. There were also significant two way interactions of emotion and set size, $F(3, 102) = 4.16$, $p = .010$, $\eta_p^2 = .11$, emotion and trial type, $F(1, 34) = 11.97$, $p = .001$, $\eta_p^2 = .26$, and set size and emotion, $F(3, 102) = 15.92$, $p < .001$, $\eta_p^2 = .32$. Finally, there was a significant three way interaction of emotion, trial type and set size, $F(3, 102) = 6.20$, $p = .001$, $\eta_p^2 = .15$. Following up this interaction by analyzing target and nontarget trials separately revealed that on target trials, there was no difference in errors committed on happy and angry target trials at set sizes 1 and 2, $ts(102) < 0.41$, $ps > .683$, but fewer errors were made on angry than happy target trials at set sizes 4 and 6, $ts(102) > 2.53$, $ps < .013$. On nontarget trials there were no significant effects or interactions of emotion, $F_s < .99$, $ps > .398$. Error rates only varied significantly as a function of set size, $F(3, 102) = 12.45$, $p < .001$. More errors were committed at set size 1 than at set sizes 2, 4, and 6, $ts(102) > 3.52$, $ps < .001$, on nontarget trials.

Discussion

The aim of Experiment 4 was to isolate background heterogeneity as the methodological factor leading to the HSE observed in Experiment 1. The results confirm that the HSE observed in Experiment 1 was not because of the stimuli or the use of emotional stimuli as backgrounds, as here we find an ASE with the same stimuli in homogeneous emotional backgrounds. Where significant emotion effects were observed in error rates they also provided evidence for an ASE in homogeneous backgrounds. This implicates background heterogeneity as the key determinant of the HSE observed in Experiments 1–3.

General Discussion

The current study confirmed that applying the D.V. Becker et al. (2011) guidelines to “unconfound” the face-in-the-crowd effect for photographic faces also results in a HSE in search for schematic faces. Experiments 2 and 3 showed that the finding of a HSE in heterogeneous backgrounds was replicable and was not because of the absence of the facial circumference. Experiment 4 isolated background heterogeneity as the key determinant of this effect. These findings are important as the results from all previous studies investigating visual search for emotional schematic faces may have been because of methodological confounds identified by D.V. Becker et al. (2011). This is the first study in this domain to avoid all of these potential confounds and we find support for a HSE as predicted by D.V. Becker et al. (2011), which contradicts the majority of previous studies (e.g., Frischen et al., 2008; Horstmann, 2007, 2009). Given these novel findings it is important to consider the mechanism that may underlie this effect.

The main consequence of manipulating background heterogeneity was that Experiments 1–3 required a conjunction search, whereas the tasks in Experiment 4 could be completed accurately using a feature based search strategy. Feature search describes a situation where the target is defined by a single feature like a color or shape. Conjunction search describes a situation where the target is defined by a combination of features for example, shape and color. In conjunction search, the background items share one of the target features, thus preventing the target from being found by attending to a single perceptual feature. Thus, accurate performance in Experiment 1–3 (except at set size 1 in Experiments 2 and 3) required combining information from more than one feature (i.e., both mouth and eye brows) to identify the target because the sad and scheming background faces shared a feature with each of the targets. To perform the task accurately, participants had to attend to all of the emotion defining features of the target and a HSE was observed. In Experiment 4 (and at set size 1 in Experiments 2 and 3), participants could focus on a particular feature that would always signal the target within a given block of trials (either mouth or eye brows). Under these conditions, accurate responding did not require processing of all of the features that would allow the emotion to be recognized, and a HSE was not observed.

The current results do not implicate a particular feature (either eye brow or mouth) as “the feature” that drives the ASE observed in Experiment 4 as the current study was not designed for this purpose and results demonstrate that neither the angry eye brows alone or the angry mouth alone can explain the faster detection of angry expressions. The results suggest that differences in the search strategy required for accurate task performance and that the

use of these different strategies may influence the degree to which emotions are interpreted (D.V. Becker et al., 2011).

It is interesting that the HSE observed in Experiment 1 under the recommendations of D.V. Becker et al. (2011), was not evident as a difference in search efficiency, as would be indicated by a significant emotion \times set size interaction, but as an overall difference in detection time that was also observed in nontarget trials. Although there was a significant interaction in Experiment 2, and a similar nonsignificant trend in Experiment 3, this interaction was mainly driven by the absence of a difference in response times to happy and angry targets at set size 1. As discussed earlier, at this set size, Experiments 2 and 3 are not comparable with Experiment 1, as processing of the conjunction of emotion relevant features was not required to discriminate happy and angry targets.

In the previous literature, differences in search efficiency have commonly been equated with differences in the set size effect, or the “slope” of the reaction time (RT) \times set size function (e.g., Treisman & Sato, 1990; Wolfe, 1994). Hence, the failure to observe a difference in search efficiency in the present study suggests that the HSE observed in heterogeneous backgrounds does not reflect differences in search efficiency, but on processes that occur either before the trial commences or after the target has been fixated on. Possible candidate processes include less hesitation in beginning scanning, a lower threshold for deciding that no target is present or faster response selection for one target (Horstmann, 2007). Below we present two potential explanations for the observed results.

Emotion Account

The HSE observed here may reflect a positivity bias. We tend to expect positive over negative expressions and experiences and the congruence between our expectations and an affectively positive stimulus such as a happy face can facilitate identification of that stimulus (Leppänen & Hietanen, 2003). It is clear that, at least under some circumstances, the ASE observed with schematic face stimuli is driven by emotion unrelated perceptual differences between the happy and angry faces (S.I. Becker et al., 2011; Coelho, Cloete, & Wallis, 2010; Horstmann et al., 2010). Because Experiments 1–3 (except at set size 1 in Experiments 2 and 3) required a conjunction rather than a feature search, perceptual differences no longer facilitated the detection of angry features and the conjunction of features necessary for recognizing the emotional expression represented was processed. This may have allowed the positivity bias to be observed in the form of a HSE.

If this mechanism explains the HSE it could contribute to a broader understanding of emotion processing. Currently, results demonstrating a happy categorization advantage provide evidence for a system that expects positive expressions and experiences and therefore processes them with priority. At the same time, results demonstrating an ASE in visual search are argued to reflect a system that is biased toward detecting and processing threat cues. Given that the system underlying these effects is the same integrating these opposing conclusions is difficult. The HSE observed in our research as well as in the literature (e.g., D.V. Becker et al., 2011) along with the happy categorization advantage observed in the categorization literature provides converging evidence for a system that prioritizes the processing of positive expressions when

all the information necessary to recognize the represented emotion must be processed within the task.

Visual Perception Account

An alternative explanation implicates the unavoidable emotion related perceptual differences between happy and angry targets. It is possible that the gestalt of the happy face was more easily discriminable from heterogeneous sad and scheming backgrounds than the angry gestalt. This could be because of the convergence of happy eye-brow and mouth lines being easier to identify than the divergent lines of an angry face (cf. S.I. Becker et al., 2011; Horstmann, Scharlau, & Ansorge, 2006). Participants may have fixated on the angry target just as quickly as the happy target, but failed to identify it as a target as the gestalt was harder to discriminate among sad or scheming distractors that also feature divergent lines. Accuracy data from Experiments 1–3 support the idea that angry faces were more difficult to discriminate from the background faces. Failure to identify the target quickly would necessitate time consuming refixation on the target or prolong decision times, explaining the observed HSE in the intercept. Future research using eye tracking technology may allow us to determine the point at which the time increment for detecting angry faces in heterogeneous backgrounds arises.

If it is the case that search differences are sensitive to methodological changes and can be attributed to unavoidable emotion related visual confounds, it seems like these problems could be avoided and more ecological validity gained by using photographs of real faces. Unfortunately, recent research using photographic emotional faces demonstrates that these studies are also susceptible to the influence of unavoidable emotion related visual confounds. A recent study by Savage et al. (2013) demonstrated that the choice of face database can lead to either a HSE or an ASE. Even within the same database, the choice of stimuli matters. Angry faces were found faster than happy faces, but faces labeled exuberantly happy in the same database were detected faster still. These differences could not be explained by independent ratings of valence, arousal or expressive intensity. Furthermore, recently collected data from our lab suggests that the difference between two studies that yielded an ASE or a HSE using similar methods and faces from the same database could be explained by the inclusion of just three different expressive models even though a further five expressive models were identical across the two experiments. Given the fact that emotional faces must be visually nonidentical to represent different emotions, the problem of emotion related confounds is unavoidable and problematic in the visual search paradigm. This highlights the importance of using convergent evidence across different stimuli and methods when drawing conclusions about the nature of emotion processing.

Conclusion

It is possible that detection times in visual search for emotional faces may be influenced by both perceptual and emotional processes depending on task demands. If a task can be completed most efficiently by utilizing low level perceptual features then detection times primarily will reflect the influence of perception. When the efficiency of a more basic system is diminished by changing task demands, such as by introducing heterogeneous backgrounds and

requiring the processing of a conjunction of features rather than the detection of one feature, the influence of emotion on detection times may be observed with a consequent reversal of the pattern of results—HSE versus ASE. These results highlight the importance of apparently innocuous methodological choices for experimental designs in the study of emotion as well as the importance of using convergent evidence across different stimulus sets and methods when drawing conclusions about emotional expression processing.

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