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Time course of visual attention with emotional faces

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When a briefly presented and then masked visual object is identified, it impairs the identification of the second target for several hundred milliseconds. This phenomenon is known as *attentional blink* or *attentional dwell time*. The present study is an attempt to investigate the role of salient emotional information in shifts of covert visual attention over time. Two experiments were conducted using the dwell time paradigm, in which two successive targets are presented at different locations with a variable stimulus onset asynchrony (SOA). In the first experiment, real emotional faces (happy/sad) were presented as the first target, and letters (L/T) were presented as the second target. The order of stimulus presentation was reversed in the second experiment. In the first experiment, identification of the letters preceded by happy faces showed better performance than did those preceded by sad faces at SOAs less than 200 msec. Similarly, happy faces were identified better than sad faces were at short SOAs in Experiment 2. The results show that the time course of visual attention is dependent on emotional content of the stimuli. The findings indicate that happy faces are associated with distributed attention or broad scope of attention and require fewer attentional resources than do sad faces.

Adaptive behavior requires rapidly switching between potentially relevant stimuli present in the environment. Studies on the time course of visual attention using the attentional dwell time paradigm, in which two successive, masked targets have to be identified, have shown impaired identification of the second target at short SOAs (less than 500 msec) (Duncan, Ward, & Shapiro, 1994; Logan, 2005; Ward, Duncan, & Shapiro, 1996). Similar results have been obtained with rapid serial visual presentation (RSVP) tasks, in which the second target identification is impaired at lag 2, and this effect, called the *attentional blink* (AB), persists to some extent through lag 5 (Raymond, Shapiro, & Arnell, 1995; Shapiro, Raymond, & Arnell, 1994). It has been argued that the reduced performance with the second target is due to one's limited capacity, which results in biased competition of items for eventual identification and influences actions to be performed on objects (Chun & Potter, 1995; Duncan et al., 1994; Ward et al., 1996).

Given their profound social significance, emotional stimuli influence many cognitive processes, including attention and perception. Emotional stimuli—especially negative stimuli—capture attention more readily than neutral stimuli do (Mogg, Bradley, De Bono, & Painter, 1997; Vuilleumier, Armony, Driver, & Dolan, 2001). Positive and negative emotional expressions interact differently with cognitive processes, such as attention and memory (Bradley, Mogg, & Millar, 2000; Eastwood, Smilek, & Merikle, 2001, 2003; Frischen, Eastwood, & Smilek, 2008; Gupta & Srinivasan, 2009; Srinivasan & Gupta, in press; Srinivasan & Hanif, in press; Vuilleumier et al., 2001). For example, in a study by Eastwood et al. (2001), negative faces were detected faster than positive faces were among neutral distractors in a visual search task. Participants required to count features embedded in negative, positive, and neutral schematic faces took longer to do so with negative faces than with positive or neutral faces (Eastwood et al., 2003). Emotional expressions capture attention and interfere with the ongoing task, even when they are not relevant to the current task (Vuilleumier et al., 2001). These findings indicate that faces with negative expressions may capture attention faster and hold attention for a longer duration than positive expressions do.

Results consistent with the attention-capturing ability of negative stimuli have also been reported with AB tasks (Anderson, 2005; Anderson & Phelps, 2001; Arnell, Killman, & Fijavz, 2007; Keil & Ihssen, 2004; Maratos, Mogg, & Bradley, 2008; Mathewson, Arnell, & Mansfield, 2008; Milders, Sahraie, Logan, & Donnellon, 2006; Most, Chun, Widders, & Zald, 2005; Most, Smith, Cooter, Levy, & Zald, 2007; Stein, Zwickel, Ritter, Kitzmantel, & Schneider, 2009). Studies on AB have used emotional stimuli presented as a first target, second target, or distractor in RSVP streams; the majority of the studies used an emotional second target or an emotional distractor. For example, Anderson and Phelps have demonstrated attenuation in AB for arousing negative T2 words in healthy control participants. Other studies have also shown reduced AB for high-arousing negative and positive verbs (Keil & Ihssen, 2004) and sexual/taboo words (Anderson,

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2005). In contrast, less arousing high-valence words that appeared as second targets did not show any reduction in AB. These studies with emotional words mainly as second targets have shown a clear effect for arousal, but not for emotional valence.

Similar effects have also been shown in AB tasks with emotional distractors. Emotional stimuli presented as the to-be-ignored stimuli showed involuntary capture of attention, decreasing the accuracy for the subsequent neutral target (Arnell et al., 2007; Mathewson et al., 2008; Most et al., 2005). Arnell et al. presented sad, positive, threatening, taboo/sexual, or emotionally neutral words as to-be-ignored distractors before a single target at different lags in an RSVP stream. They found a larger AB for target identification when it was preceded by the taboo/sexual words than when it was preceded by the sad, positive, threatening, or emotionally neutral words. Further, they found AB to be modulated by emotional words only when they were rated as arousing, but not for valence. Similar effects have also been found with erotic pictures (Most et al., 2007). The findings indicate that arousing words are preferentially attended and encoded at the expense of the second target in an RSVP stream.

Very few studies have manipulated the emotional content of the first target and examined the effect of emotion on the identification of a neutral second target (Mathewson et al., 2008; Milders et al., 2006). Mathewson et al. found larger AB for a neutral second target when it was preceded by highly arousing sexual/taboo words than when it was preceded by other types of emotional or neutral words. The AB studies described thus far have mostly used emotional words or pictures but have not used emotional faces, which are considered an important way of communicating emotional information. In studies with emotional faces, it is important to vary facial expressions in order to understand the effect of emotional information on the time course of attention.

A recent study by Maratos et al. (2008) using schematic neutral faces as the first target have found reduced AB for threatening faces compared with happy and neutral faces at both lags 2 and 3. The happy faces showed better performance than neutral faces only at lag 2. Studies using real faces have shown reduced AB for fearful faces, as compared with AB for happy faces (Fox, Russo, & Georgiou, 2005; Milders et al., 2006). Milders et al. found reduced AB with fearful faces, as compared with that for neutral (Experiment 1) and happy (Experiment 2) faces. In that study, participants were asked to detect a face (as a second target), but not a particular emotional expression depicted by the face, which might affect the way emotional information is processed and might affect shifts of visual attention.

The AB studies so far clearly indicate that the reduced blink effect with emotional stimuli might be due to arousal and not valence (Anderson, 2005; Arnell et al., 2007; Keil & Ihssen, 2004; Most et al., 2007). In addition, most studies have used emotional words, not emotional faces (Anderson, 2005; Arnell et al., 2007; Keil & Ihssen, 2004; Mathewson et al., 2008). Even the small number of studies with emotional faces have used threatening faces and compared them with neutral or happy faces (Fox et al., 2005; Maratos et al., 2008; Milders et al., 2006). A clear effect of valence has been shown only with threatening faces. However, even with the threatening faces, the role of arousal cannot be ruled out, since they could be more arousing than neutral or happy faces.

So far, none of the AB or dwell time studies have used happy or sad faces to explore the shifts in visual attention. More than the fearful face, the sad face is perhaps a better complement for the happy face. It has been shown that sad and happy stimuli interact differently with cognitive processes (Eastwood et al., 2001, 2003; Fenske & Eastwood, 2003; Fredrickson, 2004; Srinivasan & Gupta, in press; Srinivasan & Hanif, in press). Fredrickson has proposed the broaden-and-build theory of positive emotions, arguing that positive emotional stimuli broaden the scope of attention and that negative emotional stimuli may narrow down the scope of attention (Fredrickson & Branigan, 2005; Wadlinger & Issacowitz, 2006). Using a flanker task, Fenske and Eastwood found flanker effect for happy faces, but not for sad faces, indicating that sad faces lead to narrowing of attention and potentially filter out all of the irrelevant information. Srinivasan and Gupta investigated the effect of load on recognition memory for sad and happy distractor faces. They found better recognition memory for the sad faces than for the happy faces, but only when attention was more focused in the high-load condition. Irrespective of load, when attention was distributed, the happy faces were recognized better than the sad faces, indicating that happy faces are associated with distributed attention. These results indicate that sad and happy faces interact differently with attention.

Therefore, two experiments were conducted using real emotional faces to investigate the reciprocal relationship between emotion and temporal dynamics of visual attention. Given previous findings (Fenske & Eastwood, 2003; Frederickson, 2004; Srinivasan & Gupta, in press) linking sad emotion with focused attention (or more resources) and happy emotion with distributed attention (or fewer resources), better performance was expected with the happy faces than with the sad faces, especially at shorter SOAs. Therefore, we hypothesized that a happy face would have less dwell time than a sad face. We also expected that, if emotional faces are presented as the second target, emotion identification would vary depending on the emotional content (happy or sad), with better performance for happy than for sad faces.

EXPERIMENT 1

The present experiment was designed to estimate the duration for which an emotional expression (happy or sad) captures and holds attention, as well as how it affects the identification of the subsequent stimuli—that is, the attentional dwell time across happy and sad emotional faces. Generally, negative emotional expressions are more salient than positive expressions, and, hence, the sad face could capture and hold attention more effectively. In addition, identification of happy expressions might require fewer resources than that of sad expressions. Hence, a happy face was expected to show less disruption to subsequent target identification than a sad face was.

Method

Participants. Sixteen student volunteers from the University of Allahabad participated in the experiment. All of them had normal or corrected-to-normal vision and were naive to the purpose of the study.

Apparatus and Stimuli. Two types of stimuli (emotional and neutral) were used in the experiment. Emotional stimuli were happy and sad real faces. The faces were selected from a database of Indian faces that was developed at the Centre of Behavioural and Cognitive Sciences (Gupta & Srinivasan, 2009). The faces were rated for valence on a 7-point Likert scale with the following anchors: 1 (*very sad faces*), 7 (*very happy faces*), and 4 (*neutral faces*). Out of this database, four happy faces (mean rating = 5.85) and four sad faces (mean rating = 2.25) were selected for the study. All faces had the same mean luminance. Neutral stimuli were the letters L and T. Faces subtended a visual angle of 4.53º × 5.87º, and letters subtended a visual angle of 0.51º × 0.84º. The targets were presented 4.76º from the central fixation. The size of the fixation sign was 0.95º × 0.95º. All the stimuli were presented on a black background. The stimuli were presented using DirectRT v2004 (Empirisoft Corp.) on a 19-in. CRT monitor with a resolution of 1,024 × 768 pixels and a refresh rate of 100 Hz. Observers sat 60 cm from the computer monitor.

Procedure. Each trial began with a fixation plus sign (+) at the center of the screen (see Figure 1 for a trial sequence). Participants initiated the trial by pressing the space bar, and the first target was presented after 500 msec. The two targets were always presented in a fixed order with either of the emotional expressions as the first target at one of the two horizontal positions (right or left), followed by either of the letters as a second target at one of the two vertical positions (up or down). The two targets were separated with a variable SOA (0, 100, 200, 400, 600, or 900 msec). Each target was immediately followed by a visual mask made of random lines for 200 msec to limit visual persistence. The task was to identify both of the targets and report at the end of a particular trial. In the case of the first target, participants were instructed to report the emotion of the faces.

After the presentation of both targets, the fixation display appeared on the screen to cue the participants for the response. Participants identified both of the targets and were required to press the left shift key for happy faces, the Z key for sad faces, the "/" key for the letter L, and the right shift key for the letter T. Participants were informed that their responses were not being timed and to be as accurate as possible. Participants responded to the stimuli in the order of presentation: emotion discrimination followed by letter identification. Exposure durations were determined individually for each participant in a practice session that preceded the main experimental session. In the practice session, an informal staircasing procedure was used to find the maximal exposure duration that would limit the participant to 85%–95% accuracy in identifying a particular (first or second) target. Two blocks were used, with participants identifying the first target in one block and the second target in another block. The order of the blocks was counterbalanced across participants. The exposure duration was 30 to 90 msec during the staircase procedure in the practice session. The mean exposure duration used in the experimental session across participants was 60 msec (*SD* = 11.23 msec). The experimental session consisted of a total of 240 trials preceded by a practice session with 140 trials.

Results and Discussion

Identification accuracy for both targets (emotional and neutral) was computed, and analysis was done separately for the two targets (Figure 2). A 2 (emotion) × 6 (SOA)

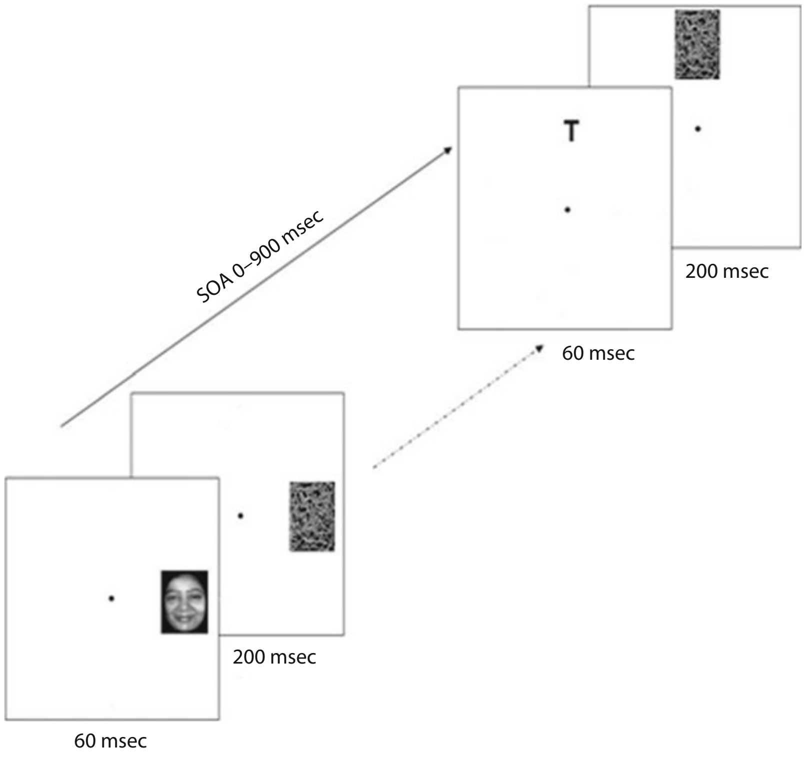

Figure 1. Stimulus sequence in a given trial in Experiment 1.

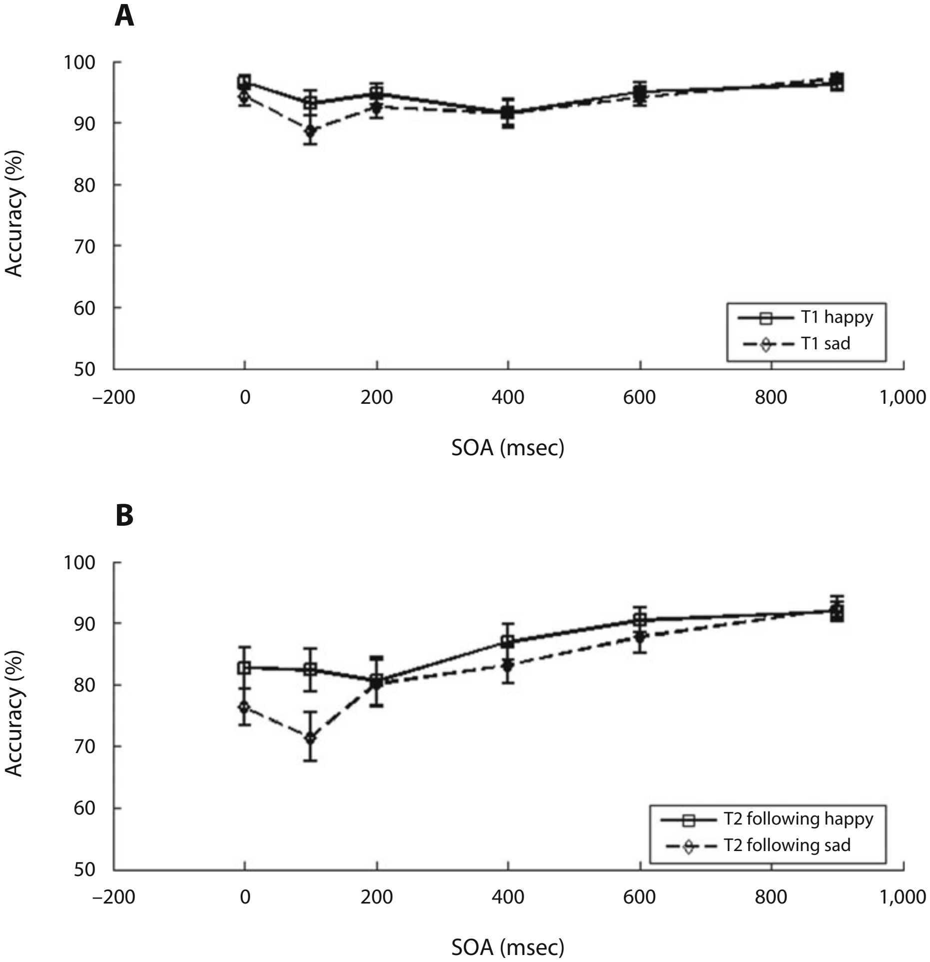

Figure 2. Identification accuracy for (A) the first target (happy and sad faces) and (B) the second target (letters) preceded by a happy or sad face in Experiment 1.

repeated measures ANOVA with accuracy of the first target (happy or sad face) showed a significant main effect of SOA [$F(5,75) = 6.36$, $MS_e = 25.24$, $p < .05$]. Identification accuracy for the first target improved from 95.46% at 0-msec SOA to 96.72% at 900-msec SOA. No significant difference in performance was found between happy and sad faces.

Identification accuracy for the second target was computed only for trials in which the first target was accurately identified. A 2 (emotion) × 6 (SOA) repeated measures ANOVA with second target accuracy showed a significant main effect of emotion [$F(1,15) = 14.72$, $MS_e = 50.53$, $p < .05$]. Identification accuracy for the second target was significantly better when it was preceded by the happy face (85.78%) than when it was preceded by the sad face (81.84%). The main effect of SOA [$F(5,75) = 11.46$, $MS_e = 98.63$, $p < .05$] was also significant. Overall performance improved, ranging from 79% accuracy at 0-msec SOA to 92% accuracy at 900-msec SOA. The interaction between emotion and SOA [$F(5,75) = 3.84$, $MS_e = 35.58$, $p < .05$] was also significant. Post hoc comparisons with Bonferroni corrections showed significant differences in second-target identification preceded by a happy face, as compared with that preceded by a sad face at SOAs of 0 msec [$t(15) = 4.28$, $p < .01$] and 100 msec [$t(15) = 7.23$, $p < .01$]. At 0 and 100 msec, T2 identification was significantly better when T2 was preceded by a happy face (82.64% and 82.30%, respectively) than when it was preceded by a sad face (76.27% and 71.52%, respectively).

The results are consistent with previous findings and confirm the hypothesis that emotional information does influence the temporal dynamics of visual attention and that attentional dwell time might differ, depending on the emotional content of the stimuli. Better identification accuracy for the neutral second target preceded by the happy face, as compared with that preceded by the sad face, suggests that the happy face might require fewer attentional resources than the sad face (Srinivasan & Gupta, in press). The present finding supports the theory of positive emotions (Fredrickson, 2004), which argues for a broad scope of attention due to positive emotions. A broad scope of attention (or *distributed attention*) associated with happy faces results in a lesser impairment for the second target preceded by happy faces than for that preceded by sad faces.

It is also possible that sad faces have a tendency to hold attention for a longer period of time than happy faces (Eastwood et al., 2003). Previous studies on AB, manipulating task difficulty of the first target, have indicated that AB is linked to the longer processing time than is processing difficulty per se (Visser, 2007; Visser & Ohan, 2007). However, the performance with sad faces is similar to earlier findings in AB studies with neutral stimuli; therefore, the present result with sad faces cannot be explained in terms of a longer dwell time for sad faces. It is to be noted that there was no significant difference in identification accuracy for happy or sad faces as first targets, and the differences in the performance on the neutral second target cannot be attributed to response bias to the happy faces. The present results extend the understanding of the role of emotional information—especially happy and sad—in shifts of visual attention. To further investigate the differences in the interactions between happy and sad faces with the time course of attention, and to examine the effect of available attentional resources on discriminating happy and sad faces, we performed another experiment, in which the happy or sad faces were used as the second target preceded by a neutral first target.

EXPERIMENT 2

The purpose of the second experiment was to investigate the attention-capturing ability of the second target, given that the first target has been identified. Previous studies with emotional stimuli as second targets have explored the blink effect with either emotional faces or words (Anderson, 2005; Keil & Ihssen, 2004; Maratos et al., 2008; Mathewson et al., 2008; Milders et al., 2006). For example, studies with emotional words as stimuli have shown that high-arousal stimuli capture attention more effectively, leading to reduced AB (Anderson, 2005; Keil & Ihssen, 2004). The studies with emotional faces have mostly shown reduced AB for threatening faces, as compared with that for neutral or happy faces, indicating that fearful/threatening faces have a higher priority in the competition for attentional resources (Maratos et al., 2008; Mathewson et al., 2008; Milders et al., 2006). It is possible that threatening/fearful faces are more arousing than happy or sad faces.

If the sad face is expected to capture attention more quickly or better (Eastwood et al., 2001), then one could expect better accuracy with sad faces than with happy faces. From a capacity point of view, identification of the second target depends on available resources. If available resources are used for identification of the neutral first target, then the emotional stimulus that requires fewer resources might be identified better than the emotional stimulus that requires more resources. If happy faces require fewer attentional resources than sad faces do as T1, then we would expect AB to be attenuated for happy faces relative to sad faces, since it may require fewer attentional resources. Hence, we varied the emotional content (happy/sad) of the second target, keeping the first target neutral throughout the experiment.

Method

Participants. Seventeen student volunteers from the University of Allahabad participated in the experiment. All of them had normal or corrected-to-normal vision.

Apparatus and Stimuli. The stimuli and the apparatus were the same as in Experiment 1. The mean exposure duration across the participants was 64 msec ($SD = 13.28$ msec).

Procedure. The order of display was reversed in this experiment, with the letter stimulus (L or T) as the first target and emotional faces (happy or sad) as the second target. Although the order of the presentation was changed, the faces were always presented at either of the horizontal positions, and letters were always presented at either of the vertical positions. The rest of the details were the same as in Experiment 1.

Results and Discussion

Identification accuracy was computed for both targets (emotional faces and the neutral target), and analysis was done separately for each target (Figure 3). A repeated measures ANOVA for first-target (L or T) accuracy showed no significant difference for SOA or emotions. First-target accuracy was approximately the same (96%) and was not affected by the nature of the subsequent emotional face.

A 2 (emotion) $\times$ 6 (SOA) repeated measures ANOVA with identification accuracy for the second target (happy or sad face) showed a significant main effect of SOA [$F(5,80) = 8.475$, $MS_e = 100.07$, $p < .05$]. Overall performance improved with SOA (81.30% at 0 msec to 91.47% at 900 msec). The main effect of emotion discrimination was not significant. The interaction between SOA and emotion discrimination was significant [$F(5,80) = 2.51$, $MS_e = 70.95$, $p < .05$]. Post hoc comparisons with Bonferroni corrections showed significant differences in emotion identification for happy faces as compared with that for sad faces at SOAs of 0 msec [$t(16) = 3.65$, $p < .05$] and 100 msec [$t(16) = 5.64$, $p < .01$]. Happy faces were identified significantly better (85.02% and 84.01%) at 0 and 100 msec, respectively, than sad faces were (77.57% and 72.49%).

The results are consistent with our findings from Experiment 1. Happy faces were identified better than sad faces were at short SOAs. The results indicate the critical role of attentional resources in the processing of specific emotional information. Arnell et al. (2007) did not find any difference between positive and sad words, but the present study clearly shows a difference between happy and sad faces. Better performance with happy faces suggests that they require fewer attentional resources than sad faces do (Srinivasan & Gupta, in press). Awh et al. (2004) did not find AB with a face identification task and have argued for a multiple-resources view of attention. Unlike their results, our results showed AB for emotion identification—especially sad faces—indicating that emotion recognition is susceptible to the lack of resources due to first-target identification. Our results also indicate that sad faces do not necessarily capture attention better than happy faces, given the lack of effect of second-target emotion on the identification of the neutral first target.

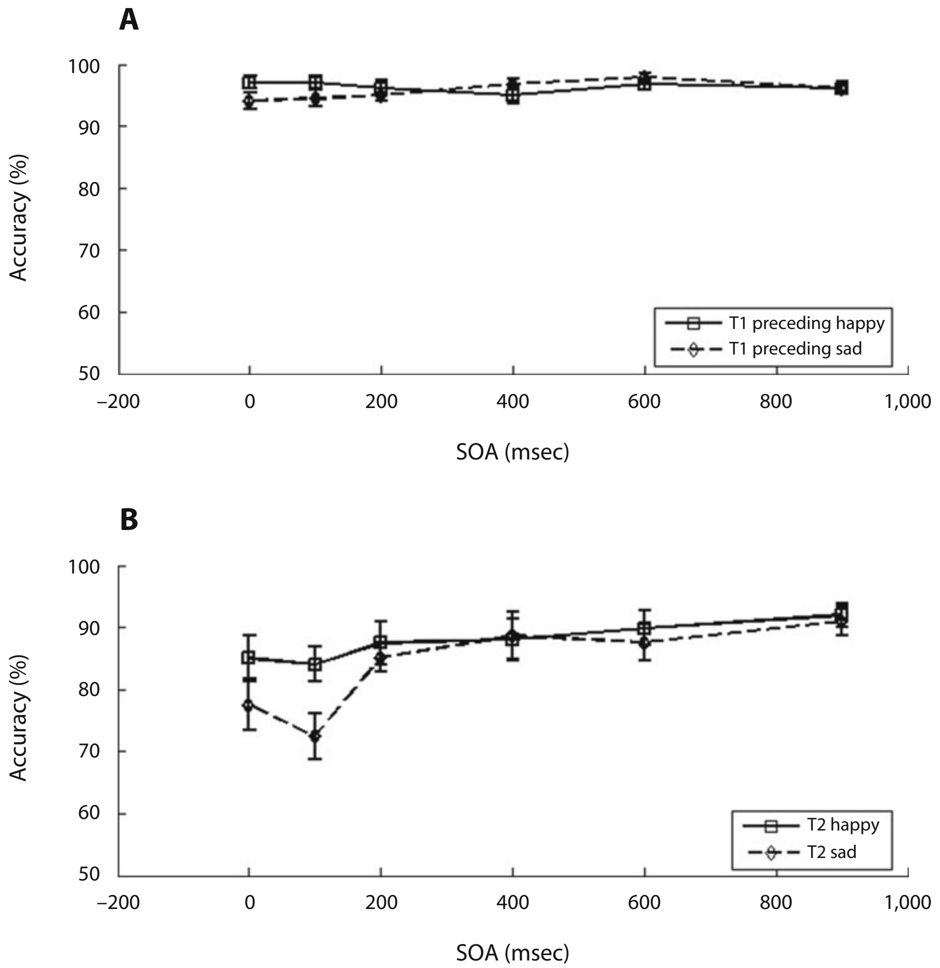

Figure 3. Identification accuracy for (A) the first target (letters) followed by happy or sad faces and (B) the second target (happy and sad faces) in Experiment 2.

GENERAL DISCUSSION

The present study examined the role of happy and sad emotional information in shifts of visual attention. The study focused on two main issues: (1) the dependence of dwell time on the emotional content of attended stimuli and (2) the role of attentional resources in switching from one object to another—especially an emotional object. Results from the first experiment, which showed better second-target performance with neutral targets following happy faces at short SOAs, indicated that dwell time was dependent on the nature of the stimuli (i.e., the emotional information present in the stimulus). Very little AB was obtained with the happy face, and the findings showed that happy faces required fewer attentional resources than the sad faces did. A similar result has been found in the second experiment, which showed reduced AB for happy faces, as compared with that for sad faces. The results from both of the experiments are consistent with the happy faces' requiring fewer resources. Happy faces were identified better than sad faces were under conditions of less attention. These results are not fully consistent with views that suggest sad faces attract attention better than happy faces do (Eastwood et al., 2001).

A number of AB studies have used emotional words as stimuli and have argued that arousal, rather than valence, produces reduced AB. For example, Mathewson et al. (2008) presented taboo, sad, threatening, positive, and emotionally neutral words and found larger AB for taboo words than for sad, happy, threatening, or emotionally neutral words. Our results with emotional faces indicate that valence has an effect on the time course of attention, independent of arousal. This is consistent with other studies with faces that have shown reduced blink for happy, threatening, or fearful faces, indicating that emotional information modulates the magnitude of AB (Maratos et al., 2008; Milders et al., 2006; Srivastava & Srinivasan, 2008; Stein et al., 2009).

There are many methodological differences between our study and prior studies with emotional faces (Fox et al., 2005; Maratos et al., 2008; Milders et al., 2006; Stein et al., 2009). We used an emotion-discrimination task, and our neutral stimuli were letters. In addition, the dwell-time paradigm does not have any distractor stimuli like the AB paradigm, and it involves spatial shifts of attention. Many of the AB studies with faces have used scrambled faces as distractors and have used neutral faces as the other target, in addition to the emotional stimuli. For example, Milders et al. used neutral faces as a first target and fearful or happy faces as a second target. More important, the tasks involved the detection of a face, and the effect of the emotion (valence) was incidental. An exception is Maratos et al.'s study in which neutral, threatening, or happy schematic faces were used as second targets, and observers had to identify the emotional content of the second face. Interestingly, they found less AB for happy faces than for neutral faces. Given that the second-target task consisted of three possibilities, it is not clear what kinds of errors participants made with the second target. The use of emotion discrimination in our study ensured that emotional information (sad or happy) was processed, resulting in better performance with the happy face.

Most of the AB studies using emotional faces have used threatening or fearful faces and have compared them with neutral or happy faces (Maratos et al., 2008; Milders et al., 2006; Srivastava & Srinivasan, 2008; Stein et al., 2009). Stein et al. found a blink effect with fearful faces, but they did not compare the fearful face with other types of emotional faces. Fearful or threatening faces have been compared with happy faces, and reduced AB has been obtained with fearful or threatening faces (Maratos et al., 2008; Milders et al., 2006). It should be noted that some studies have found a smaller AB with happy faces than with neutral faces (Milders et al., 2006).

In addition, none of the studies has compared happy with sad faces, which are complementary to each other. The present study examined the effects of emotions (valence) by directly comparing sad and happy faces and found that the specific emotional information (happy or sad) interacted with attention in attentional dwell-time tasks. Moreover, the present findings indicate that happy faces require fewer attentional resources than sad faces do. The results are in line with previous findings (Eastwood et al., 2003) from visual search, in which negative faces were found to be more effective in holding attention than positive faces were. Participants counting features embedded in schematic faces with positive, negative, and neutral emotional expressions found that feature counting took longer when the features were embedded in negative than in positive faces, indicating the effectiveness of negative schematic faces in holding attention (Eastwood et al., 2003).

The results show that performance with happy faces is better when there is a competition for attentional resources. This can be clearly seen in the performance with happy and sad faces, along with letter identification, with 0 msec SOA. At 0 msec SOA, both the letter stimuli and the emotional faces were presented simultaneously, with the only difference being the task instructions regarding what should be identified first (emotion in Experiment 1 and letters in Experiment 2). The joint performance of emotion and letter identification was better with happy faces than with sad faces in both experiments, indicating that the presence of the happy face (associated with distributed attention) facilitated efficient allocation of attention across the two stimuli.

It can be argued that better performance with happy faces might be due to the familiarity of happy faces, as compared with that of sad faces. The results are consistent with arguments based on familiarity, assuming that people have more prior experience with happy faces in photographs (due to a potentially larger prevalence of happy faces in pictures) than with sad faces. Given that humans are very good at identifying emotions in faces, we are not sure that there is a tendency to identify the happy expression better than the sad expression in faces. Hence, we feel that familiarity per se might not be responsible for the differences in the time course of attention with happy and sad faces.

A number of studies have shown that performance is better with sad or happy faces, depending on the task conditions (Gupta & Srinivasan, 2009; Srinivasan & Hanif, in press). Srinivasan and Hanif found no overall difference in identification for happy and sad emotional expressions in faces. Mack and Rock (1998) found that a happy schematic face was identified better than a sad schematic face was. These experiments employed other paradigms and may have involved other processes that would not interact with familiarity. Mack and Rock (1998), using low- and high-frequency words as stimuli, found that there was no significant effect of familiarity, but, in general, the performance for familiar words was better than that for unfamiliar words. Jackson and Raymond (2006) found that familiar faces showed a smaller AB than unfamiliar faces did, indicating that familiarity plays a role in AB. It is to be noted that these studies employed stimuli and tasks that differ from those used in our study. In summation, the present experiments cannot rule out the possibility that familiarity does not play any role in our results. Further studies would be needed to explore the role of familiarity in the context of different emotions in AB and dwell-time studies.

Other factors that might have played a role in the results are response bias and longer dwell time with sad stimuli. It is possible to interpret the results of Experiment 1 in terms of longer dwell time with sad faces, rather than as a lack of AB for happy faces. However, the magnitude of the blink effect obtained with the sad faces is similar to those obtained with nonemotional stimuli in AB studies (Duncan et al., 1994; Raymond et al., 1995; Shapiro et al., 1994). The potentially longer dwell time with sad faces alone cannot explain the results from Experiment 2. It is also possible that the better identification of happy than of sad emotion is due to response bias (i.e., there could be a tendency to respond in favor of happy rather than sad, especially in demanding conditions seen with the second-target identification in Experiment 2 at short SOAs). However, response bias cannot explain the results of better identification of letters following happy faces than of those following sad faces. The results of Experiment 1 argue against explanations based on response bias, and the results of both experiments can be explained using the notion of the broad scope of attention associated with happy faces.

The results of the present study are consistent with those of other studies indicating differences in emotion–

attention interactions that are based on the nature of the emotion or emotional information present in the stimuli (Fenske & Eastwood, 2003; Fredrickson, 2004; Fredrickson & Branigan, 2005; Srinivasan & Gupta, in press). Srinivasan and Gupta investigated the effect of emotional distractor information on recognition memory performance when participants performed a primary task under different attentional load conditions (less focused vs. more focused). Performance was better for happy faces in the less focused or distributed-attention conditions and was better for sad faces in the more focused attention conditions. Fredrickson's *broaden-and-build theory* of positive emotions states that positive emotions broaden the scope of attention and widen the array of percepts, thoughts, and actions. A corollary *narrow hypothesis* states that negative emotions shrink these same arrays (Fredrickson, 2004; Fredrickson & Branigan, 2005; Wadlinger & Issacowitz, 2006).

Fredrickson and Branigan (2005) found that an individual in a positive emotional state, as measured by self-reports and electromyography facial signals, showed a tendency to choose the global configuration over the local configuration. They interpreted the global bias as being indicative of a broad scope of attention. Srinivasan and Hanif (in press) have shown that global processing facilitates identification of happy faces and that local processing facilitates identification of sad faces. Fenske and Eastwood (2003) found similar effects using a flanker task, indicating that sad or happy faces are associated with different scopes of attention. They used a flanker paradigm and showed a smaller flanker-compatibility effect for negative target faces than for positive target faces. These findings suggest that negative expressions constrict the focus of visual attention more effectively than positive expressions do. In addition, it can be argued that since negative emotions require more focused attention, more attentional resources are required for identification. Therefore, less impairment is found for subsequent happy faces than for subsequent sad faces at short SOAs when there are not enough resources. The results from the present study are consistent with findings that are based on the broaden-and-build theory. These results strongly link sad faces with focused attention and local processing while linking happy faces with distributed attention and global processing.

The present study investigated the time course of visual attention with real emotional faces. To conclude, the results indicate that time course of visual attention is dependent on the nature of the stimuli and is influenced by the emotional content of the stimulus. Emotions influence the temporal dynamics of visual attention, but the available attentional resources also influence emotional processing. Attentional processes might be deployed differently, on the basis of emotions, with distributed attention linked to happy emotion and focused attention linked to sad emotion.

AUTHOR NOTE

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