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Time Course of Visual Attention with Emotional Faces

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Abstract

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) 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 compared to those preceded by sad faces at SOAs less than 200 ms. Similarly happy faces were identified better than sad faces 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 less attentional resources than sad faces.

Key words: attention, time course, emotion, distributed attention, focused attention, facial expressions

Time Course of Visual Attention with Emotional Faces

Adaptive behavior requires rapidly switching between potentially relevant stimuli present in the environment. Studies on the time course of visual attention using attentional dwell time paradigm in which two successive, masked targets (both need to be identified) have shown impaired identification of the second target at short SOAs (less than 500 ms) (Duncan, Ward, & Shapiro, 1994; Logan, 2005; Ward, Duncan, & Shapiro, 1996). Similar results have also been obtained with rapid serial visual presentation (RSVP) tasks, in which the second target identification is impaired at lag 2 (attentional blink: AB) and this effect persists to some extent till lag 5 (Raymond, Shapiro, & Arnell, 1992; Shapiro, Raymond, & Arnell, 1994). It has been argued that the reduced performance with the second target is due to the limited capacity resulting in biased competition of items for eventual identification and influencing actions to be performed on objects (Duncan et al., 1994, 1996; Chun & Potter, 1995).

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 (Mogg, Bradley, De Bono, & Painter, 1997; Vuilleumier, Armony, Driver, & Dolan, 2001). Positive and negative emotional expressions interact differently with cognitive processes like attention and memory (Bradley, Mogg, & Miller, 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, negative faces were detected faster than positive faces among neutral distractors in a visual search task (Eastwood et al., 2001). Participants required to count features embedded in negative, positive, and neutral schematic faces took a longer time

with negative faces compared to positive or neutral faces (Eastwood, Smilek, & Merikle, 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 the faces with negative expressions may capture attention faster and holds attention for a longer duration than positive expressions.

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, and Mansfield, 2008; Milders, Saharaie, 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 the first target, the second target, or a distractor in RSVP stream with majority of the studies using an emotional second target or an emotional distractor. For example, Anderson and Phelps (2001) 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, 2005). In contrast, less arousing, high valence words (that appeared as second target) did not show any reduction in AB (Anderson, 2005; Keil & Ihssen, 2004). These studies mainly with emotional words as second targets have shown a clear effect for arousal but not 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; Most et al., 2005; Mathewson et al., 2008). Arnell et al. (2007) presented sad, positive, threatening, taboo/sexual or emotionally

neutral words as to-be-ignored distractors before identification of a single target at different lags in a RSVP stream. They found a larger AB for target identification when it was preceded by the taboo/sexual words compared to the sad/positive/threatening/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 a RSVP stream.

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

A recent study by Maratos, Mogg and Bradley (2008) using schematic neutral faces as the first target have found reduced AB for threatening faces compared to 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 compared to happy faces (Fox, Russo, & Georgiou, 2005; Milders et al., 2006). Milders et al. (2006) found reduced blink with fearful faces compared to neutral (Experiment 1) and happy (Experiment 2) faces. In their study, participants were asked to detect a face (as second target) but not a particular emotional

expression depicted by the face, which might affect the way emotional information is processed and affect shifts of visual attention.

The studies so far with AB 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 but 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; Milders et al., 2006; Maratos et al., 2008). 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 (Fenske & Eastwood, 2003; Eastwood et al., 2001, 2003, Fredrickson, 2004; Srinivasan & Gupta, in press; Srinivasan & Hanif, in press). Fredrickson (2004) has proposed the broaden-and-build theory of positive emotions and has argued that positive emotional stimuli broaden the scope of attention and negative emotional stimuli may narrow down the scope of attention (Fredrickson and Branigan, 2005; Wadlinger & Issacowitz, 2006). Using a flanker task, Fenske & Eastwood (2003) 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 the irrelevant information. Srinivasan and Gupta (in press) investigated the effect of load on the recognition memory for sad and happy distractor faces. They found better recognition memory for the sad

faces compared to the happy faces 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 less resources), better performance was expected with the happy faces compared to the sad faces especially at shorter SOAs. Therefore, we hypothesized that a happy face would have less dwell time than sad face. It was also expected that if emotional faces are presented as the second target, then emotion identification would vary depending on the emotional content (happy and sad) with better performance for happy compared to sad faces.

Experiment 1

The current experiment was designed to estimate the duration for which an emotional expression (happy or sad) captures and holds attention as well as affect the identification of the subsequent stimuli i.e. 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 expression might require fewer resources than sad expression. Hence, a happy face was expected to show less disruption to subsequent target identification compared to a sad face.

Methodology

Participants

Sixteen student volunteers from 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 has been 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 one corresponding to very sad faces, seven corresponding to very happy faces, and four corresponding to neutral faces. Out of this database, four happy (mean rating = 5.85) and four sad faces (mean rating = 2.25) were selected for the study. All the faces had the same mean luminance. Neutral stimuli were letters (L and T). Faces subtended a visual angle of $4.53^\circ \times 5.87^\circ$ and letters subtended a visual angle of $0.51^\circ \times 0.84^\circ$. The targets were presented 4.76° from the central fixation. The size of the fixation sign was $0.95^\circ \times 0.95^\circ$. All the stimuli were presented on a black background. The stimuli were presented using DirectRT- 4 (Empirisoft Corp, USA) on 19'' CRT monitor with resolution of 1024x768 and refresh rate of 100 Hz. Observers sat a distance of 60 cm from the computer monitor.

Procedure

Each trial began with a fixation plus sign at the centre of the screen (see Figure 1 for a trial sequence). Participants initiated the trial by pressing the space bar key and the first target was

presented after 500ms. 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 and 900 ms). Each target was immediately followed by a visual mask (made of random lines) for 200 ms to limit visual persistence. The task was to identify both the targets and report at the end of a particular trial. The participants were instructed to report the emotion of the faces in case of the first target.

After the presentation of both the targets, the fixation display appeared on the screen to cue the participants for the response. Participants identified both the targets and were required to press “*left shift key*” for happy face, “*Z key*” for sad face and “*/*” for number L and “*right shift key*” for number T. Participants were informed that their responses were not being timed and to be as accurate as possible. Participants responded the stimuli in the order of presentation; emotion discrimination followed by letter identification. Exposure durations were determined individually for each subject 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 limiting 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 varied between 30-90 ms during the staircase procedure in the practice session. The mean exposure duration used in the experimental session across participants was 60 ms (SD = 11.23 ms). The experimental session consisted of a total of 240 trials preceded by a practice session with 140 trials.

Insert Figure 1 here

Results and Discussion

Identification accuracy of both the targets (emotional stimuli and neutral stimuli) was computed and analysis was done separately for the two targets. A 2 (emotion) x 6 (SOA) repeated measures ANOVA with accuracy of the first target (happy or sad face) showed a significant main effect for SOA, $F(5, 75) = 6.36$, $MSE = 25.24$, $p < .05$. The identification of the first target improved from 95.46% at 0 ms to 96.72 % at 900 ms. No significant difference in performance was found between happy and sad faces.

Insert Figure 2 here

Identification accuracy of the second target was computed only for trials in which the first target was accurately identified. A 2 (emotion) x 6 (SOA) repeated measures analysis of variance with second target accuracy showed a significant main effect of emotion, $F(1,15) = 14.72$, $MSE = 50.53$, $p < .05$. Identification of the second target was significantly better when it was preceded by the happy face (85.78 %) compared to the sad face (81.84 %). The main effect for SOA, $F(5, 75) = 11.46$, $MSE = 98.63$, $p < .05$ was also significant. Overall performance improved with SOA ranging from 79% accuracy at 0 ms to 92% accuracy at 900 ms SOA. The interaction between emotion and SOA, $F(5, 75) = 3.84$, $MSE = 35.58$, $p < .05$ was also

significant. Post-hoc comparisons (with Bonferroni corrections) showed significant differences in second target identification preceded by happy face compared to sad face at SOAs of 0 ms, $t(15) = 4.28, p < .01$ and 100 ms, $t(15) = 7.23, p < .01$. At 0 and 100 ms, T2 identification was significantly better when it was preceded by happy faces (82.64 % and 82.30 %) than sad faces (76.27% and 71.52%).

The results are consistent with previous findings and confirm the hypothesis that emotional information does influence the temporal dynamics of visual attention and attentional dwell time might differ depending on the emotional content of the stimuli. Better identification of the neutral second target preceded by the happy face compared to the sad face suggest that the happy face might require less attentional resources than sad face (Srinivasan & Gupta, in press). The current finding supports the theory of positive emotions (Frederickson, 1998) that 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 compared to sad faces.

It is also possible that sad faces have a tendency to hold attention for a longer period of time than a happy face (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 processing difficulty per se (Visser, 2007; Visser & Ohan, 2007). However, the performance with the sad faces is similar to earlier findings in AB studies with neutral stimuli and hence the current result with sad faces cannot be explained in terms of longer dwell time for sad faces. It is to be noted that there was no significant difference in identification of happy or sad faces as first target and the differences in the performance of the neutral second target cannot be attributed to response bias to the happy faces. The current results extend the understanding of the role of

emotional information especially happy and sad in shifts of visual attention. To investigate further the differences in the interaction 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 is being identified. Previous studies with emotional stimuli as second target have explored the blink effect with either emotional faces or words (Milders et al., 2006; Maratos et al., 2008; Mathewson et al., 2008; Anderson, 2005; Keil & Issen, 2004). For example, the studies with emotional words as stimuli have shown that high arousal stimuli do capture attention more effectively leading to reduced attentional blink (Anderson, 2005; Keil & Issen, 2004). The studies with emotional faces have mostly shown reduced AB for threatening faces compared to neutral or happy faces indicating that fearful/threatening faces have a higher priority during the competition for attentional resources (Milders et al., 2006; Maratos et al., 2008; Mathewson et al., 2008). 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 compared to 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 less attentional resource than sad faces as T1, then we would expect AB to be attenuated for happy faces compared to sad faces since it may require less attentional resources. Hence, we varied the emotional content (happy/ sad) of second target keeping the first target neutral throughout the experiment.

Method

Participants

Seventeen student volunteers from 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 ms (SD = 13.28 ms).

Procedure

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

Results and Discussion

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

Insert Figure 3 here

A 2 (emotion) x 6 (SOA) repeated measures ANOVA with identification accuracy of the second target (happy and sad face) showed a significant main effect of SOA $F(5, 80) = 8.475$, $MSE = 100.07$, $p < .05$. Overall performance improved with SOA (81.30 % at 0 ms to 91.47 % at 900 ms). The main effect of emotion discrimination was not significant. The interaction between SOA and emotion discrimination was significant $F(5, 80) = 2.51$, $MSE = 70.95$, $p < .05$. Post-hoc comparisons (with Bonferroni corrections) showed significant differences in emotion identification for happy face compared to sad face at SOAs of 0 ms, $t(16) = 3.65$, $p < 0.05$ and 100 ms, $t(16) = 5.64$, $p < 0.01$. Happy faces were identified significantly better (85.02 % and 84.01%) at 0 and 100 ms than sad faces (77.57% and 72.49%).

The results are consistent with findings from Experiment 1. Happy faces were identified better than sad faces (at short SOAs). The results indicate the critical role of attentional resources in processing of specific emotional information. While Arnell et al. (2007) did not find any difference between positive and sad words, the current study clearly shows a difference between happy and sad faces. Better performance with happy face suggests that it requires less attentional

resources than sad face (Srinivasan & Gupta, submitted). 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, we found AB for emotion identification, especially sad faces indicating that emotion recognition is susceptible to the lack of resources due to first target identification. The results also indicate that sad faces do not necessarily capture attention better than happy face given the lack of effect of second target emotion on the identification of the neutral first target.

General Discussion

The current study examined the role of happy and sad emotional information in shifts of visual attention. The study focused on two main issues: (a) the dependence of dwell time on the emotional content of attended stimuli and (b) the role of attentional resources in switching from one object to another especially an emotional object. Results from the first experiment showing better second target performance with neutral targets following happy faces at short SOAs indicate that dwell time is 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 indicate that happy faces require less attentional resource compared to sad faces. A similar result has been found in the second experiment that showed reduced attentional blink for happy faces compared to sad faces. The results from both the experiments are consistent with happy face requiring fewer resources. Happy faces were identified better than sad faces under conditions of less attention. The results are not fully consistent with views that suggest sad faces attract attention better than happy faces (Eastwood, Smilek, & Merikle, 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, Arnell, and

Mansfield (2008) presented taboo, sad, threatening, positive, emotional neutral words and found larger attentional blink for taboo words compared to sad/happy/threatening/emotionally neutral words. Our results with emotional faces do indicate that valence has an effect on the time course of attention independent of arousal. This is also consistent with other studies with faces that have shown reduced blink for happy, threatening, or fearful faces indicating that emotional information does modulate the magnitude of attentional blink (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, Russo, & Georgiou, 2005; Maratos, Mogg, & Bradley, 2008; Milders et al., 2006; Stein et al., 2009). We have 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 involves spatial shifts of attention. Many of the AB studies with faces have used scrambled faces as distractors and have used neutral face as the other target in addition to the emotional stimuli. For example, Milders et al. (2006) used neutral faces as first target and fearful or happy faces as second target. More importantly, the tasks involved detection of a face and the effect of the emotion (valence) was incidental. An exception is Maratos et al. (2008) in neutral/threatening/happy schematic faces were as second target and observers had to identify the emotional content of the second face. Interestingly, they found less AB for happy faces compared to neutral face. Given that the second target task consisted of three possibilities, it is not clear what kind 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. (2009) found a blink effect with fearful faces but did not compare the fearful face with other types of emotional faces. Fearful or threatening faces have been compared to happy faces and reduced blink 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 blink with happy faces compared to neutral faces (Milders et al., 2006).

In addition, none of the studies have compared happy with sad faces, which are complementary to each other. The current study has examined the effects of emotions (valence) by directly comparing sad and happy faces and found that the specific emotional information (happy or sad) interacts with attention in attentional dwell time tasks. Moreover, the current findings indicate that happy faces require less attentional resources compared to sad faces. The results are in line with the previous findings (Eastwood et al., 2003) from visual search in which negative faces were found to be more effective in holding attention compared to positive faces (Eastwood et al., 2003). Participants counting a feature embedded in schematic faces with positive, negative and neutral emotional expressions found that feature counting took longer time when it was embedded in negative as opposed to 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 with the performance with happy and sad faces along with letter identification with 0 ms SOA. At 0 ms SOA, both the letter stimuli and emotional faces are presented simultaneously with the only difference being the task instructions

of 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 sad faces in both the 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 compared to 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 sad faces. Given that humans are very good in 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, in press; Srinivasan & Hanif, in press). Srinivasan and Hanif (in press) 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 better identified than a sad schematic face. These experiments do employ other paradigms and may involve other processes that do not interact with familiarity. Mack and Rock (1998) using (low and high frequency) words as stimuli found that there was no significant effect for familiarity but in general, the performance for familiar words was better than that of unfamiliar words. Jackson and Raymond (2006) found that familiar faces showed lesser AB than unfamiliar faces indicating that familiarity plays a role in AB. It is to be noted that these studies have employed different stimuli and task compared to our study. In summation, the current

experiments cannot rule out that familiarity does not play any role in the results obtained the current study. 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 lack of AB for happy faces. However, the magnitude of the blink effect obtained with the sad faces is similar to those obtained with non-emotional stimuli in AB studies (Duncan et al., 1994; Raymond et al., 1992; 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 compared to 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 compared to 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 from the current study are consistent with other studies indicating differences in emotion-attention interactions 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 (in press) investigated the effect of recognition memory performance of emotional distractor information when subjects performed a primary task under different attentional load (less focused vs. more focused) conditions. Performance was better for happy faces in the less focused or distributed attention conditions and

sad faces in the more focused attention conditions. Fredrickson's (2004) broaden and build theory of positive emotions state that positive emotions broaden the scope of attention and widening 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 indicative broad scope of attention. Srinivasan & Hanif (in press) have shown that global processing facilitates identification of happy faces and 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 smaller flanker compatibility effect for negative target face compared with positive target faces. These findings suggest that negative expression constrict the focus of visual attention more effectively compared to positive expression. In addition, it can be argued, since negative emotion requires focused attention, sufficient attentional resources are required for identification. Therefore, less impairment is found for subsequent happy faces than sad faces at short SOAs when there are not enough resources. The results from the current study are consistent with findings based on the broaden-and-build theory. These results strongly link sad faces with focused attention and local processing as well as happy faces with distributed attention and global processing.

The current study has 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 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 based on emotions with distributed attention linked to happy emotion and focused attention linked to sad emotion.

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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.

Figure3: 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.

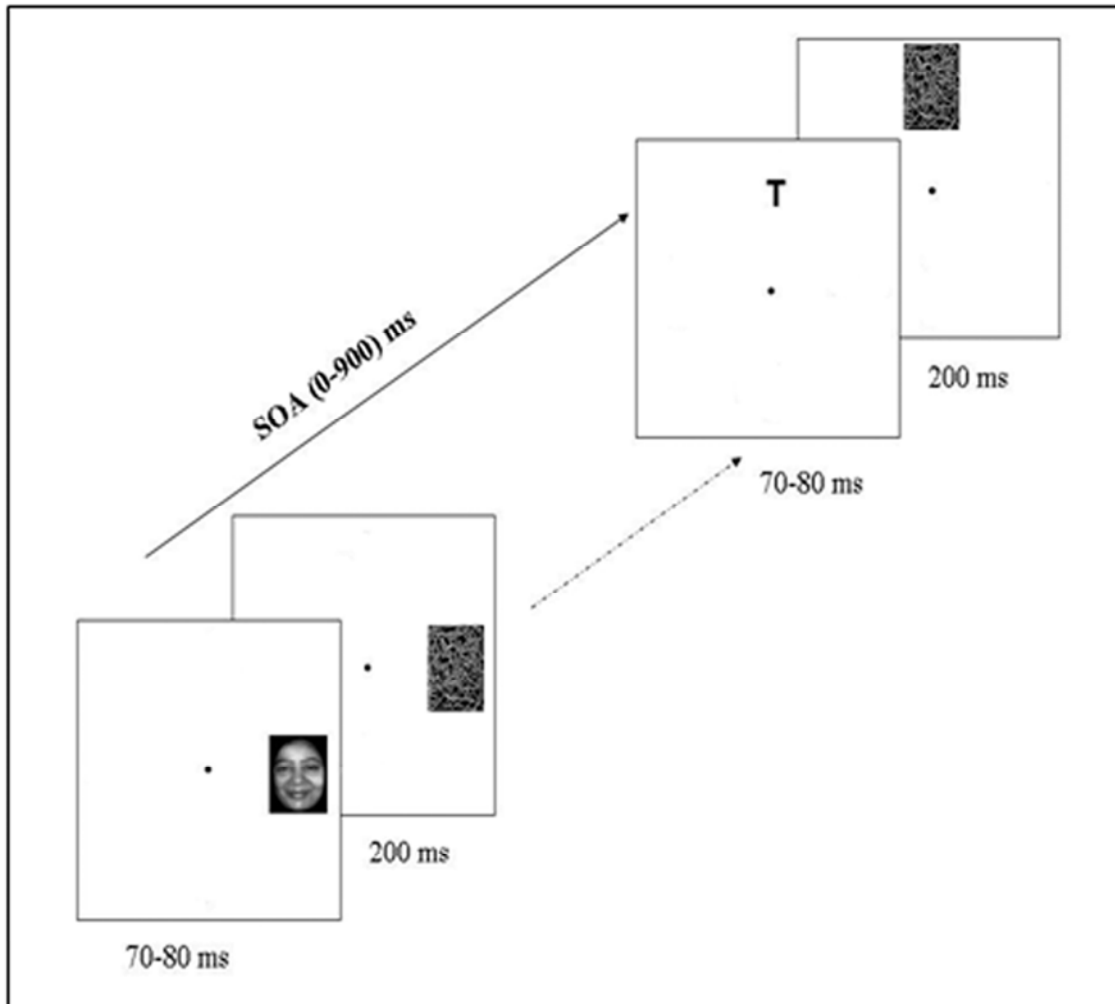


Figure 1

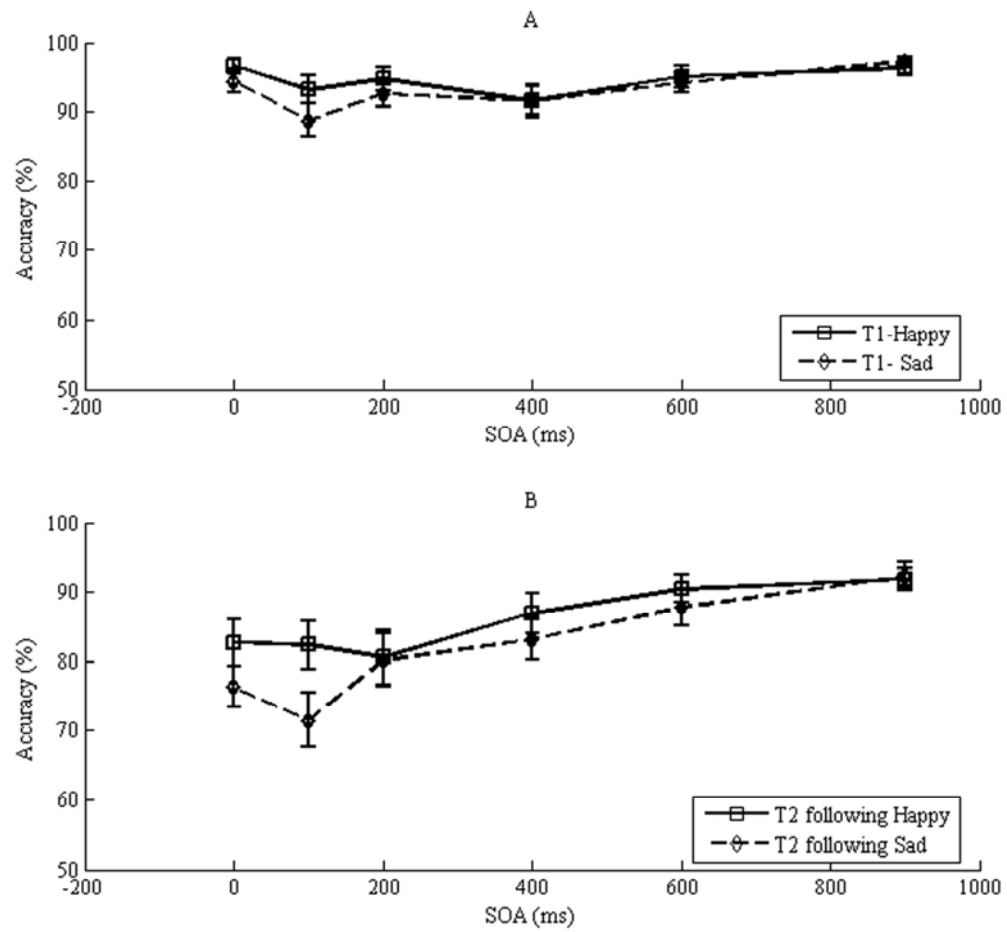


Figure 2

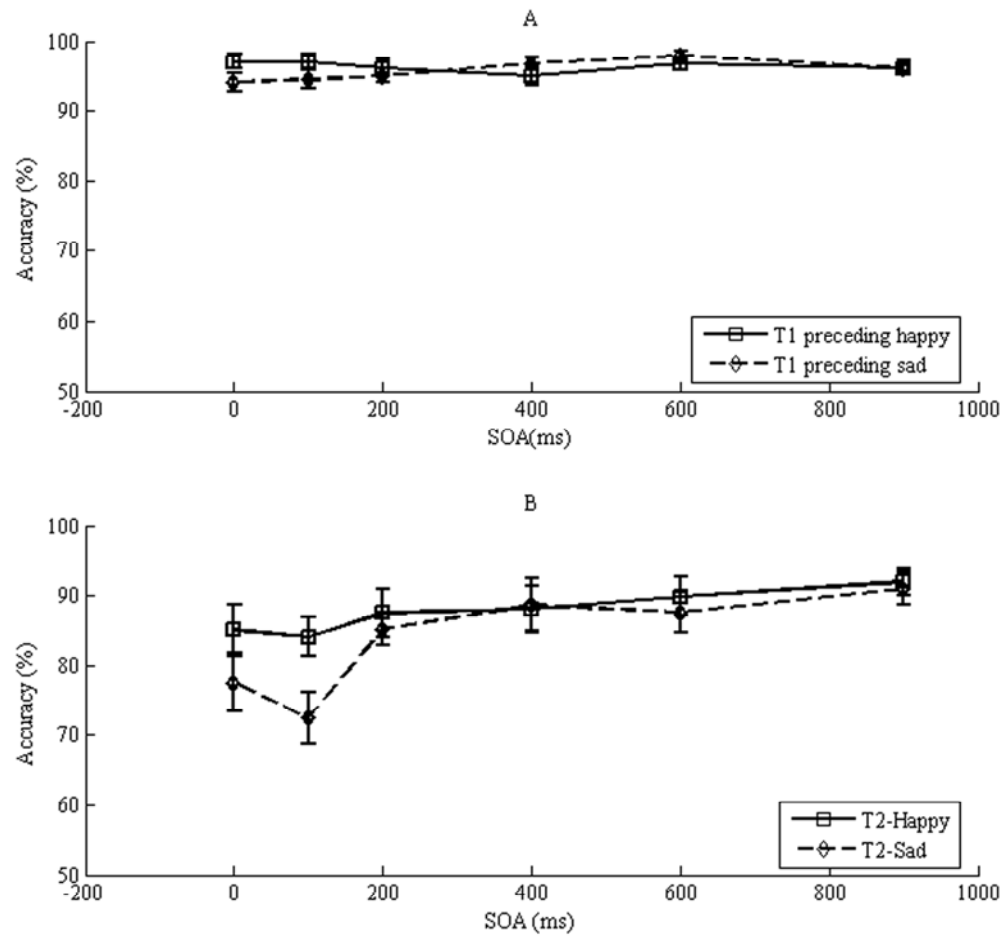


Figure 3