Emotion-Attention Interactions in Recognition Memory for Distractor Faces

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Abstract

Effective filtering of distractor information has been shown to be dependent on perceptual load. Given the salience of emotional information and the presence of emotion-attention interactions, we wanted to explore the recognition memory for emotional distractors especially as a function of focused attention and distributed attention by manipulating load and the spatial spread of attention. We performed two experiments to study emotion-attention interactions by measuring recognition memory performance for distractor neutral and emotional faces. Participants performed a color discrimination task (low-load) or letter identification task (high-load) with a letter string display in Experiment 1 and a high-load letter identification task with letters presented in a circular array in Experiment 2. The stimuli were presented against a distractor face background. The recognition memory results show that happy faces were recognized better than sad faces under conditions of less focused or distributed attention. When attention is more spatially focused, sad faces were recognized better than happy faces. The study provides evidence for emotion-attention interactions in which specific emotional information like sad or happy is associated with focused or distributed attention respectively. Distractor processing with emotional information also has implications for theories of attention.

Keywords: Emotions; attentional load; recognition memory; distractor faces; focused attention; distributed attention

Introduction

Emotional information direct attention to salient events in the environment that are significant for actions and survival (Oatley & Jenkins, 1996). Emotion-attention interactions have been reported in numerous studies (Dreisbach & Goschke, 2004; Fenske & Eastwood, 2003; Frederickson & Branigan, 2005; Mack & Rock, 1998; Srivastava & Srinivasan, 2008). For example, findings from visual search have shown that negative faces capture attention more efficiently compared to positive faces (Eastwood, Smilek, & Merikle, 2001; Frischen, Eastwood, & Smilek, 2008). Eastwood et al. (2001) observed that the slopes of search functions for locating sad faces embedded in a context of neutral faces were shallower than the slopes of the search functions for locating positive faces embedded in a context of neutral faces.

Using a flanker task, Fenske and Eastwood (2003) found flanker interference with a schematic happy face, but not with a schematic sad face. They suggested that the spatial scope of attention was affected by the emotion conveyed by the face. In another study (Dreisbach & Goschke, 2004), participants were required to detect a target of a certain color, while they had to ignore a distractor presented in what had previously been the target color. Normally this leads to perseveration costs on the first few trials, because the old target color is initially difficult to ignore. However, Dreisbach and Goschke (2004) found that perseveration costs were reduced when the trials were preceded by positively laden pictures relative to neutral and negative pictures. They concluded that positive affect induces cognitive flexibility, biasing attentional orienting towards the new color.

Other studies involving emotion and attention also indicate that sad or happy emotional information interacts differently with visual attention (Mack & Rock, 1998;

Oliver & Nieuwenhuis, 2006; Srivastava & Srinivasan, 2008). Using an inattentional blindness paradigm, Mack and Rock (1998) found that unexpected happy schematic faces were detected better than sad schematic faces. With an attentional dwell time paradigm in which two successive targets need to be identified, Srivastava & Srinivasan (2008) found that neutral targets following happy schematic faces were identified better than those following sad schematic faces. Similarly, happy schematic faces preceded by neutral targets were identified better than sad schematic faces.

Olivers and Nieuwenhuis (2005) observed improved attentional blink performance when participants were asked to concurrently think about their holidays or an imaginary dinner or asked them to concurrently listen and respond to music. They argued that the improved performance could be due to a more positive affective state as evoked by frivolous content of the thoughts or the upbeat nature of the tune. In another study (Olivers & Nieuwenhuis, 2006), they briefly presented positive, negative, or neutral pictures in between rapid serial visual presentation trials and found that the positive pictures improved attentional blink performance. Frederickson and Branigan (2005) found that positive emotions are linked to distributed attention resulting in a global processing bias. In addition, Srinivasan and Hanif (in press) found that global processing benefits identification of a happy expression and local processing might benefit identification of a sad expression. Together, these studies strongly show reciprocal links between distributed attention and positive emotions as well as focused attention and negative emotions.

The "perceptual load" theory (Lavie, 1995, 2000, 2001) accounts for the effects of selective attention based on manipulations load (low or high). An important aspect of load theory is the processing of distractor information under low or high-load conditions. Under conditions of high-load, distractor information is not processed similar to an early selection view of attention proposed by Broadbent (1958). Under conditions of low-load, distractor information is processed resulting in interference in the primary task similar to the late selection view of attention. Excess capacity will be involuntarily allocated to the processing of irrelevant stimuli under low-load conditions. Processing of "task-irrelevant" stimuli may only be prevented if the perceptual load of the task prescribed for the task-relevant stimuli is sufficiently high to exhaust capacity as in the high load conditions. In contrast, the "salience hypothesis" argues that the salience of distractors and not perceptual load per se determines selective attention and distractor processing. Thus, the usual perceptual load effect may occur because the distractor in a high perceptual load display is less likely to capture attention and not because resources are fully utilized (Eltiti, Wallace, & Fox, 2005).

How is load related to focused and distributed attention? Low-load condition is linked to less attentional resources and hence could be linked to distributed attention, which typically involves processing over a large spatial extent. Distributed attention could be linked to differences in the nature of processing even if the spatial extent is held constant (Treisman, 2006; Srinivasan, Srivastava, Lohani, & Baijal, 2009). The high-load condition could be linked to focused attention since focused attention tasks typically involve more attentional resources. This happens with increase in set size in a visual search task and performance that the identification task that requires focused attention shows decrease in performance as a function of set size (Treisman, 2006). However, the spatial extent even in a high-load task might determine whether focused or distributed attention is involved. High-load could be associated with distributed attention when processing is spread over a larger region of space and with focused attention when processing is limited to a small region of space.

Manipulating emotional content of the distractor stimuli provides a way to investigate the role of emotions under different conditions of attention or load. Given the link between emotion and attention, studies have investigated emotional processing in the context of load theory. For example, Silvert, et al. (2007) indicated that emotional processing of faces, particularly peripheral faces, was dependent on the available perceptual attentional resources. They found that the recognition accuracy of unattended fearful faces was greater compared to neutral faces in the low load task but not in the high-load task. Lim, Padmala, and Pessoa (2008) investigated the effects of fear conditioning on the visual processing of task-irrelevant faces. They found that responses to old threat faces viewed during the easy letter detection task exhibited faster reaction times compared to the new threat faces or old safe faces indicating that the emotional information in distractors is processed in the low-load condition. In addition, Bishop, Jenkins, and Lawrence (2006) found that performance in the high-load condition interacted with specific emotional states. These studies indicate that emotional information does interact with load.

Given the evidence on emotion-attention/memory interactions and differences in the way attention interacts with happy and sad faces, we decided to investigate the effect of focused or distributed attention on the identification of emotional faces under the low-load and high-load conditions. The current study is based on the paradigm used by Jenkins, Lavie, and Driver (2005), which measured incidental recognition memory for neutral faces previously exposed as task-irrelevant distractors as a function of the attentional load in an unrelated task with superimposed letter strings at exposure. They found better recognition memory for faces in the low-load compared to the high-load condition.

We investigated the effect of different types of attention by manipulating the load of a primary task on recognition memory performance of irrelevant distractor faces with and without emotional expressions. We hypothesized that recognition memory performance will be better for distractor faces with emotional expression as compared to neutral distractor faces. We also hypothesized that memory performance for happy and sad faces will be dependent on the nature of attentional load on primary task. Specifically, in the less focused attention condition sensitivity would be better for happy distractor faces and in the more focused attention condition sensitivity would be better for sad distractor faces.

EXPERIMENT 1

Given that Theeuwes, Kramer, and Belopolsky (2004) have argued that low processing load ensues broadening of the attentional window, types of attention was manipulated using different levels of load imposed by two different tasks used in previous perceptual load studies (Jenkins et al., 2005; Lavie, 2000, 2001). Each display comprised a letter string superimposed on a task-irrelevant unfamiliar emotional and non-emotional face. In the low-load condition, the letter task involved simple color discrimination, typically thought to impose low attentional load. The high-load task required more difficult letter discrimination, which typically resulted in impaired processing of non-face distractors

(Lavie, 2000; 2001). The effect of load in the primary letter task on subsequent explicit recognition of the distractor emotional and neutral faces was assessed in a surprise recognition test at the end of the experiment.

Method

Participants

Nineteen naive volunteers with the mean age of 25.2 years (SD = 2.49 years) from University of Allahabad participated in the experiment. All had normal or corrected-to-normal vision.

Apparatus & Stimuli

To avoid ambiguity in emotional expression, 163 photographs of Indian adults were shown randomly to ten (five males and five females) participants who subsequently did not participate in the experiment. These participants rated the faces 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. One hundred sixty faces were selected for the database based on the ratings and out of those ninety six monochromatic Indian target faces (thirty two happy, sad and neutral faces each) and forty eight foil faces (sixteen happy, sad, and neutral faces each) were randomly selected for the experiment. Overall mean rating for the happy faces, sad faces, and neutral faces was 5.72, 2.34, and 3.76 respectively. Each display comprised a happy, sad, or neutral face roughly with the middle of the nose at fixation and a letter string superimposed across this middle point (see Figure 1). The letter string could be red or blue and comprised of one target letter (X or N) and five non-target letters (H, K, M, W, or Z) arranged in random order (Lavie, 1995). Each letter measured 0.4° × 0.3° visual angle, separated from its neighbors by 0.4°. Faces (5.7° × 6.8°) were grayscale images edited to remove extraneous background. The viewing distance was 120 cm.

Figure 1 about here

Procedure

Each trial began with a central fixation point for 500 ms followed by the stimulus display for 200 ms. Participants made a speeded response, pressing left key for blue- and right key for red-letter strings in the low-load task. Participants pressed the left arrow key for target letter X and right arrow key for target letter N in the high-load task. Feedback was given with a tone for errors or failures to respond within three seconds. Alternating blocks had the high or low-load letter task (starting block was randomly varied). In the high-load condition, string color was constant through a block (red or blue) to minimize any congruency effects from response associations carrying over from the low-load task.

The experiment began with two practice blocks of fifteen trials for each load condition with just the letter strings presented followed by twelve experimental blocks with each consisting of forty eight trials in presented in random order. Thus, each particular face was shown six times in total. The subjects were instructed to focus on the letter strings and perform the identification task as accurately and as quickly as possible. A surprise recognition test was given after all the high and low load blocks had been completed. In the recognition test, participants were presented with a single face in each trial and were asked to indicate whether it had been presented earlier during the letter string part of the experiment.

Results and Discussion

An analysis of variance (ANOVA) with load conditions (low-load vs high-load) and emotions (happy, sad, and neutral) was conducted for the reaction times (RTs) and accuracy. There was a significant main effect for load with RTs from letter string task, $F(1, 18) = 111.03$, $MSE = 47802.2$, $p < .001$, as well as accuracy, $F(1, 18) = 172.7$, $MSE = 59.3$, $p < .001$. Performance (see Figures 2a and 2b) in the letter string task was better in the low-load condition (mean RT = 408.6 ms, 97.80% accuracy) compared to the high-load condition (mean RT = 840.2 ms, 78.9% accuracy) confirming the effect of load in perceptual processing. There was no effect of emotion in RT and accuracy on letter string task.

Figure 2 about here

We calculated the sensitivity (d') and criterion (β) values for the recognition of faces under different load or emotion conditions. Both the d' and β values were subjected to a 2 (load: low-load and high-load) and 3 (emotions: happy, sad, and neutral) repeated measures ANOVA. The analysis with the d' values showed a significant main effect for load, $F(1, 18) = 33.8$, $MSE = 0.132$, $p < .001$, with larger d' value in the low-load (0.72) compared to the high-load (0.33) condition. In accordance with the load hypothesis, overall performance was significantly better for faces exposed as irrelevant distractors under low-load conditions in the letter string task than for faces exposed under high-load. More importantly, load significantly interacted with emotion, $F(2, 36) = 5.06$, $MSE = 0.088$, $p < .01$, indicating that sensitivity for the faces on low-load and high-load was dependent on the type of emotion (see Figure 3). We performed all the post-hoc analyses with the Bonferroni correction.

Pair-wise comparisons indicated that in the low-load condition, the d' value was significantly greater for the happy faces compared to the sad faces, $t(18) = 7.25$, $p < .001$, and neutral faces compared to the sad faces, $t(18) = 5.14$, $p < .01$. There was no difference in d' value between happy and neutral faces, $t(18) = 2.11$, $p = 0.14$. In the high-load condition, there was no significant difference in the d' value among all the three types of faces. Sensitivity was significantly higher for distractor happy faces presented during the low-load task compared to the high-load task, $t(18) = 8.24$, $p < .001$. However, no significant difference was observed in the d' value for faces with sad expression in both the load conditions. It should be noted that the performance was poor for sad faces under both the load conditions. Significant reduction in the d' value from low-load to high-load was found with neutral faces, $t(18) = 6.99$, $p < .001$, consistent with previous findings (Jenkins et al., 2005).

Figure 3 about here

The analysis with the criterion (β) values showed a significant main effect of load, $F(1, 18) = 33.8$, $MSE = 0.033$, $p < .001$, and emotion, $F(2, 36) = 9.42$, $MSE = 0.198$, $p < .001$. Criterion value was higher for the high-load compared to the low-load condition. Criterion value was also higher for the neutral distractor faces compared to faces with happy, $t(18) = 5.29$, $p < .001$, and sad expression, $t(18) = 5.34$, $p < .001$. There was no difference in β between faces with happy and sad expressions. In addition, load significantly interacted with emotion, $F(2, 36) = 5.06$, $MSE = 0.022$, $p < .01$. In the low-load condition, β value was significantly higher for neutral faces compared to faces with happy, $t(18) = 11.8$. $p < .001$, and sad expressions, $t(18) = 8.93$, $p < .001$. There was no significant difference in the β value for faces with happy and sad expression. In the high-load condition, the β value was once again significantly higher for faces with neutral expression compared to faces with happy, $t(18) = 10.6$, $p < .001$, and sad expression, $t(18) = 13.7$, $p < .001$. There was no significant difference in the β values between the faces with happy and sad expression. These results indicate that strict criteria were used when decisions had to be made under the high-load condition as well as for faces with neutral expression. Participants were less ready to indicate that the presented faces were seen earlier in the high-load condition. A similar effect was found for neutral faces compared to the emotional faces.

Figure 4 about here

The results with the neutral faces were similar to those obtained in Jenkins et al. (2005). Recognition accuracy for sad faces was not altered by attentional load whereas the recognition accuracy for happy faces was altered by attentional load such that high-load results in a reduced accuracy for the happy faces. Incidental memory of irrelevant distractor faces was dependent on both load and emotional information. For a given attentional load, processing of distractor information depends on the amount or nature of attentional processing. In the low-load condition, happy faces were remembered better than sad faces. However, there was no difference in performance between happy and sad faces in the high-load condition. There was also no difference in recognition memory for sad faces across load conditions. Not only did the sad expression did not interact with load but the recognition memory for sad faces were poor indicating that the sad expression did not facilitate the identification of distractor faces.

The low-load condition is associated with less-focused attention or put another way, attention is more distributed and involves a larger spatial spread (Theeuwes, ramer, & Belopolsky, 2004). Whether the high-load condition is associated with more focused or distributed attention might depend on the manipulation of the spatial spread of condition. High-load could be associated with distributed attention when processing is spread over a larger region of space and with focused attention when processing is limited to a small region of space. In the current study, the low-load task could be performed by processing color information from a larger spatial area (employing distributed attention) compared to the high-load letter identification task that involves more focused attention.

Other studies have shown that manipulating the way attention is focused or distributed leads to differences in emotional information processing (Srinivasan & Hanif, in press; Srivastava & Srinivasan, 2008). Essentially focused attention is associated with sad faces and distributed attention is associated with happy faces. These results are consistent with other results exploring emotion-attention interactions (Fenske & Eastwood, 2003; Frederickson & Branigan, 2001). While there was a difference between sad and happy face recognition memory performance in the low-load task, there was no difference in the high-load task.

Given the happy-sad differences in the low-load task, we wondered whether the absence of an effect for emotions in the high-load task might be due to differences in the way attention might be deployed within the high-load task. A possible factor that might play such a role is the position of the target letter to be identified in the letter string display. The occurrence of target in the central or peripheral locations might lead to differences in the way attentional resources are allocated with peripheral target presentation leading to distributed attention and central target presentation leading to focused attention. Given this, we analyzed the recognition accuracy for the faces as a function of location of the target letters presented centrally (middle two locations) and peripherally (two locations at the end on either side) in the high-load condition.

A repeated measure ANOVA with location (central and periphery) and emotion (happy, sad, and neutral) was performed with the d' as well as the β values for the faces presented in the high-load condition. The effect of location was significant, $F(1, 18) = 7.24$, $MSE = 0.414$, $p < .01$, with larger d' value for the distractor faces with letters presented at the centre (0.537) compared to letters presented in the periphery (0.213). Sensitivity was greater for the distractor faces that were associated with target letters presented at the centre. The two-way interaction between location and emotion was also significant, $F(2, 36) = 3.53$, $MSE = 0.598$, $p < .05$. With the central location, d' value was significantly greater for the sad faces compared to happy faces, $t(18) = 3.85$, $p < .01$ (see Figure 5a). With the periphery, there was a trend with the sensitivity (0.417) for the happy faces better than sad faces (0.156), but, the difference was not significant, $t(18) = 1.38$, $p = 0.30$ (see Figure 5b).

Figure 5 about here

The analysis with β values showed a significant effect of location, $F(1, 18) = 7.24$, $MSE = 0.104$, $p < .01$, and emotion, $F(2, 36) = 16.6$, $MSE = 0.233$, $p < .001$. Criterion value was higher for the central locations compared to the peripheral locations. Criterion value was also high for the neutral faces compared to the faces with happy, $t(18) = 4.86$, $p < .01$, and sad expressions, $t(18) = 8.10$, $p < .001$. There was no difference in criterion for the faces with happy and sad expression. Location significantly interacted with emotion, $F(2, 36) = 3.53$, $MSE = 0.150$, $p < .05$. In the central location, the β value for sad faces was significantly lower compared to happy faces, $t(18) = 5.50$, $p < .001$. There was no difference in β value for the happy and neutral faces. In the peripheral location, there was no difference in β value for the faces with happy and sad expressions. These results indicated that lenient criteria were used for distractor faces especially sad faces presented along with target letters that appeared at the central location. Participants were more ready to indicate that the sad faces were seen earlier in the experiment compared to the happy and neutral face under the more focused attention condition.

Figure 6 about here

The results are consistent with our hypothesis that in the low-load (distributed attention) condition, sensitivity was greater for happy faces than sad faces. In the high focused attention condition (when the target letter was presented in the centre position), sensitivity was greater for sad faces compared to happy faces. In the low focused attention condition (when target was presented at the periphery), there was an indication that sensitivity for faces with happy expression was better compared to faces with sad expression. The second experiment sought to replicate the results with respect to the way sad or happy emotions interacted with distributed attention by presenting target letters at the periphery.

EXPERIMENT 2

Experiment 1 strongly indicated a link between sad expression and more focused attention as well as happy expression and less focused attention. To examine directly the interaction between happy faces and distributed attention under high-load conditions, we further increased the spatial scope of attention by presenting the circular array of letters around the edge of distractor faces (See Figure 7). We hypothesized that similar to the peripheral target presentation in Experiment 1, spatial attention would be more distributed given the presentation of targets in a circular array, which would result in better sensitivity for happy faces compared to sad and neutral faces.

Method

Participants

Seventeen naive undergraduate volunteers with the mean age of 24.6 years (SD = 2.44 years) from University of Allahabad participated in the experiment. All had normal or corrected-to-normal vision.

Stimuli

Unlike Experiment 1, the letter strings were presented in a circular array of radius 2.38° always superimposed over a face (see Figure 7). The viewing distance was 120 cm. One hundred forty four faces used in Experiment 1 were again used with seventy two faces presented during the letter identification phase and seventy two new faces (foils) in the subsequent recognition test. The number of happy, sad, and neutral faces was kept equal.

Figure 7 about here

Procedure

The experiment began with a practice block of twenty trials with only circular array of letter display presented, followed by six experimental blocks, each consisting of seventy two trials in random order. Thus, each particular face was shown six times in total. The subjects were requested to focus on the circular letter display and ignore the irrelevant faces. A surprise recognition test was given similar to Experiment 1.

Results and Discussion

A repeated measure ANOVA with emotion (happy, sad, and neutral) was performed separately for RTs and accuracy on the letter identification task. There was a significant main effect only for accuracy, $F(2, 32) = 3.20$. $MSE = 11.1$, $p < .05$. Post-hoc comparisons showed that letter identification accuracy was significantly lower when the sad faces were distractor (69.2%) compared to happy faces (72.1%), $t(16) = 3.57$, $p < .05$.

Figure 8 about here

A repeated measure ANOVA with emotion (happy, sad, and neutral) was performed separately for d' and β values. For the d' measure, the effect of emotion was significant, $F(2, 32) = 4.82$, $MSE = 0.256$, $p < .01$. Sensitivity was significantly better for the faces with happy expression compared to sad, $t(16) = 3.77$, $p < .05$ and neutral, $t(16) = 3.65$, $p < .05$. There was no difference in the d' values between faces with sad and neutral expression (see Figure 9).

Figure 9 about here

For the criterion (β) value, the effect of emotion was significant, $F(2, 32) = 5.92$, $MSE = 0.333$, $p < .01$. Criterion value was significantly lower for the faces with happy expression compared to sad, $t(16) = 3.83$, $p < .05$, and neutral expression, $t(16) = 4.50$, $p < .01$. There was no difference in the β value for the faces with sad and neutral expression. These results indicated that in the case of distributed attention, a lenient criterion was used to make the decision in recognizing the distractor faces with happy expression. Participants were more ready to indicate that a happy face was seen earlier compared to a sad or neutral face under distributed attention condition.

Figure 10 about here

Similar to Experiment 1 there was no difference in RTs in the letter string task as a function of emotion of the faces. However, unlike Experiment 1, there was an effect of emotion in the letter string task. Sad faces affected letter identification greater than happy faces indicating distractor information can affect processing even in a high-load task. This is consistent with results indicating that negative faces tend to draw attention towards them resulting in larger interference similar to those seen in flanker tasks (Eastwood et al., 2003). As expected, emotional faces were remembered better than neutral faces. The sensitivity results of Experiment 2 strengthen the findings of the Experiment 1 i.e., happy faces are preferentially linked with less focused, distributed attention while sad faces are linked to more focused attention.

General Discussion

The present study examined the role of emotion in recognition memory for distractors especially as a function of focused attention and distributed attention by manipulating load and the spatial spread of attention. The results clearly suggest that emotional information affect memory for faces that are in agreement with the recent studies indicating a role of emotions in memory encoding and recall (Gupta & Srinivasan, 2009). Emotional information did not always benefit recognition memory performance and the performance was dependent on specific emotional expressions. Recognition of happy and sad faces was dependent on the spatial distribution of attention. Recognition was better for happy faces compared to sad faces under low-load condition in which attention is more distributed. In Experiment 1 with peripheral letter targets in which attention is more distributed, there was a trend indicating that happy faces are recognized better than sad faces in the high-load condition. However, this effect was clearly shown in Experiment 2 in which attention had to be distributed over a large spatial region compared to Experiment 1. With centrally presented letter targets associated with more spatially focused attention, sad faces were recognized more than happy faces. These results clearly indicate that emotions do interact with attention and this interaction is dependent on the type of emotional expression.

In addition to recognition performance (measured by d'), emotion-attention interaction was also observed in decision-related processes (measured by β). For example, criterion results showed that in the case of more focused attention condition (central position) a lenient criterion was used in making decisions regarding the identification of sad distractor faces (Experiment 1), while in the case of less focused attention conditions, a lenient criterion was used in making decisions regarding the identification of happy distractor faces (Experiment 2).

The results are consistent with other studies indicating interactions between emotion and attention as a function of sad or happy emotions or emotional faces

(Derryberry & Tucker, 1994; Fenske & Eastwood, 2003; Frederickson & Branigan, 2001; Frederickson & Branigan, 2005; Frederickson & Levenson, 1998; Mack & Rock, 1998; Srinivasan & Hanif, in press; Srivastava & Srinivasan, 2008). Srivastava and Srinivasan (2008) examined the influence of emotional stimuli on temporal dynamics of visual attention using an attentional dwell time paradigm. They found that identification of neutral stimuli preceded by happy faces was better than those preceded by sad faces. Similarly, identification of happy faces was better compared to sad faces when it was preceded by neutral stimuli. These results clearly suggest that happy faces are associated with distributed attention or less attentional resources compared to sad faces. Fenske and Eastwood (2003) found a similar effect suggesting that facial affect modulates the focused attention and faces expressing negative emotion constrict attention to themselves more effectively than faces expressing positive emotion.

Fredrickson's (2004) broaden-and-build theory of positive emotions states that positive emotions broaden the scope of attention and widening the arrays of percepts, thoughts, and actions. A corollary hypothesis states that negative emotions shrink the scope of attention leading more focused attention (Frederickson, 2004; Frederickson & Branigan, 2005; Frederickson & Levenson, 1998, Heather & Issacowitz, 2006). Frederickson & Branigan (2005) found that individuals in a positive emotional state showed a tendency to choose the global arrangement over the local arrangement with hierarchical stimuli. They interpreted the global bias as indicative broad scope of attention. Srinivasan and Hanif (in press) showed that emotion identification was linked to the scope of attention using hierarchical stimuli. Happy emotion was identified better if it was preceded by global processing compared to local processing. Global processing facilitated identification of happy and local processing facilitated identification of sad emotion. These results could also be linked to approach and avoidance behavior interactions with the scope of attention (Förster Friedman, Özelsel, & Denzler, 2006) with approach behavior linked to global processing and avoidance behavior linked to local processing.

Together, these results strongly link sad faces with focused attention and local processing as well as happy faces with distributed attention and global processing. These results are consistent with findings based on the broaden-and-build theory. Our results extend the findings of broaden-and-build theory showing that positive content of the stimuli can also play a significant role in broadening the attention, even if the observer do not experience a positive emotional state. It is to be noted that Frederickson and Branigan (2005) did not find any local bias under focused attention conditions whereas the current study found sad faces are remembered better in the more focused central target presentation in the high-load condition.

Mack and Rock (1998) found that an unexpected happy schematic face was detected more often than a sad schematic face. They suggested that the better performance with happy faces might be due to familiarity with happy faces being more familiar or due to the aversive nature of sad faces leading to repulsion of attention. The results from the current study and related studies provide a more parsimonious explanation for the results of Mack and Rock (1998) based on differences in the interaction of attention with happy and sad faces. Happy faces are associated with less focused attention and hence are detected better compared to sad faces which are associated with more focused attention.

What are the implications of the current results for perceptual load theory? According to load theory, distractor interference will be present, in general, for low-load but not high-load conditions. However, we do find that emotional distractors, more specifically the sad faces, affect the primary letter identification task under high-load condition. Consideration of the special significance of emotional faces in guiding social and motivational activities suggests why this might be the case. It may be adaptive not to ignore emotional faces especially negative faces, which are vital cues and provide powerful signals for rapid nonverbal communication, even when they are irrelevant and one is performing a demanding task.

The present finding is to some extent consistent with the salience hypothesis (Eltiti et al., 2005), which claims that distractor salience and not perceptual load per se, is the most important factor in determining distractor processing. They showed in their experiments that interference was eliminated in the low-load condition when the distractors appeared as offset and only the target appeared as onset. Onset of the distractor served as the salient event compared to the offset of the distractor. Interference was also observed in the high-load condition where both the target and distarctors appeared as onsets. These results were explained by the salience hypothesis which suggested that that interference occurs in the high-load condition since both the target and the distractors are salient items, thus leading to the capture of attention by both simultaneously and resulting in the interference of target processing by the distractors since attention is devoted to both. Our results suggest that emotional information present in distractors was processed and may lead to interference even in the high-load condition, if attention is distributed over larger spatial regions.

With a visual search task, Theeuwes et al. (2004) found that attentional set plays a critical role in distractor processing. They argued that a broad attentional window required in a low-load trial broadens the scope of attention in the subsequent high-load trial leading to distractor interference even in high-load condition. Given the role of scope of attention in distractor processing, the results from the current study link scope of attention to processing of emotional information. Both stimulus content (emotional information) and the nature of scope of attention (focused vs distributed) needs to be taken into account by theories of selective attention.

To summarize, the results strongly show distractor information does affect processing in the high-load condition indicating that salient distractor stimuli are processed even under high-load conditions. The evidence indicates that emotion and attention interact, with sad faces being associated with focused attention and happy faces with distributed attention (Fenske & Eastwood, 2003; Frederickson & Branigan, 2001; Srinivasan & Hanif, in press; Srivastava & Srinivasan, 2008). Further studies can explore emotion-attention interactions in the context of other types of emotional stimuli as well as attentional manipulations other than load.

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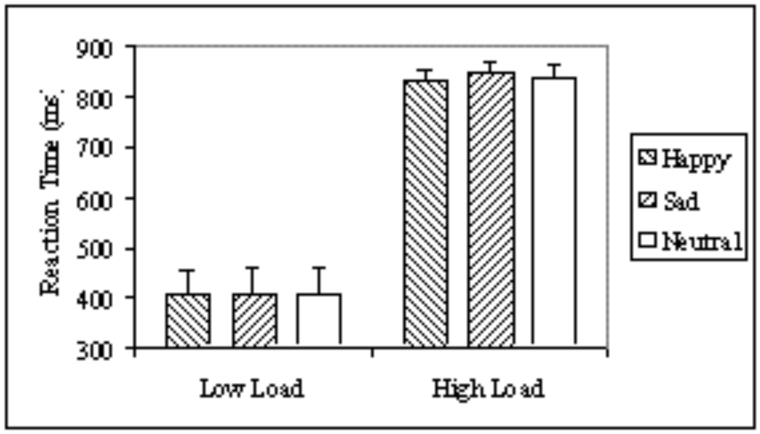
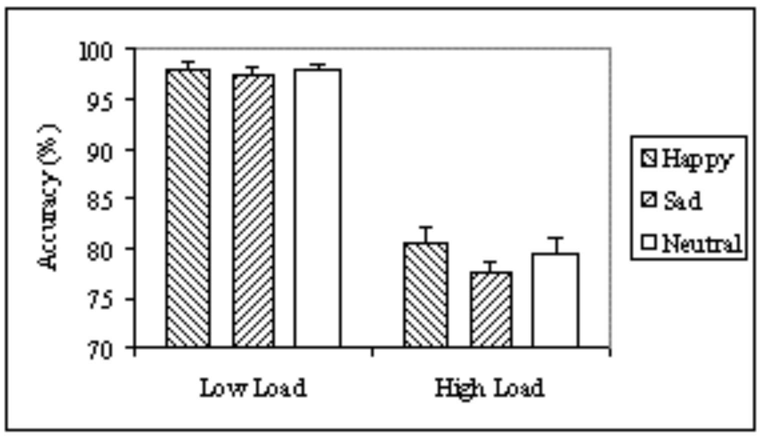
List of Figures

Figure 1

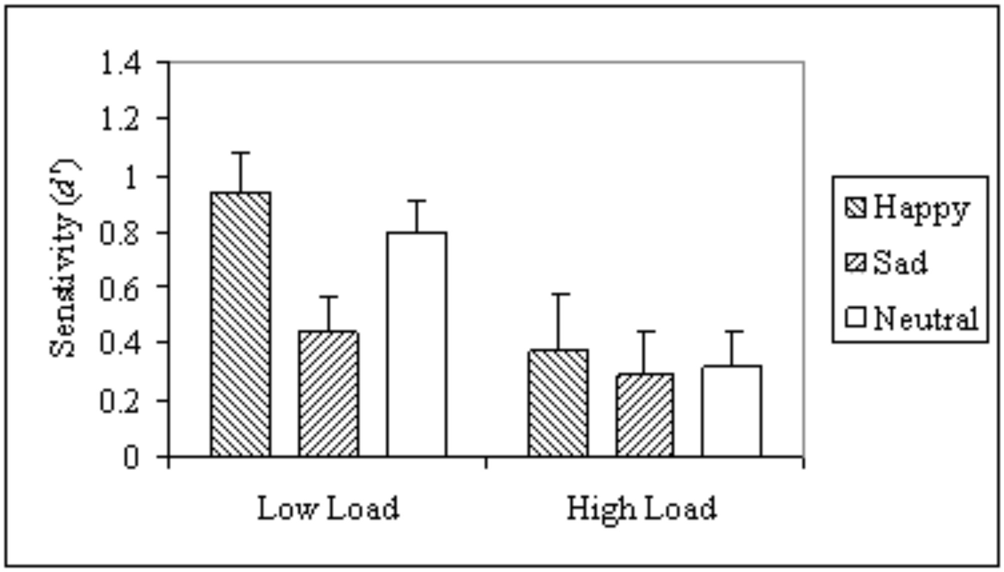

900
800
700
600
500
400
300
Reaction Time (ms)
Low Load
High Load
Happy
Sad
Neutral

(a)


100
95
90
85
80
75
70
Accuracy (%)
Low Load
High Load
Happy
Sad
Neutral

(b)

Figure 2


1.4
1.2
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0.8
0.6
0.4
0.2
0
Senstivity (d')
Low Load
High Load
Happy
Sad
Neutral

Figure 3

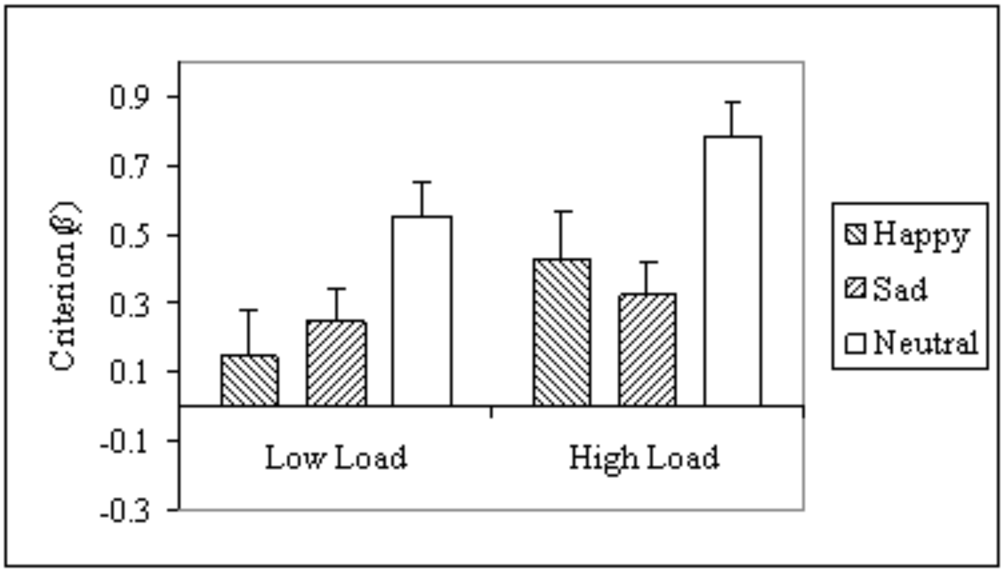
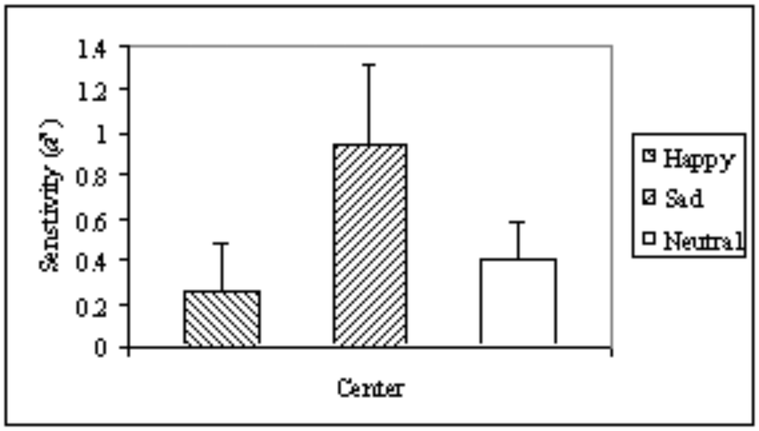
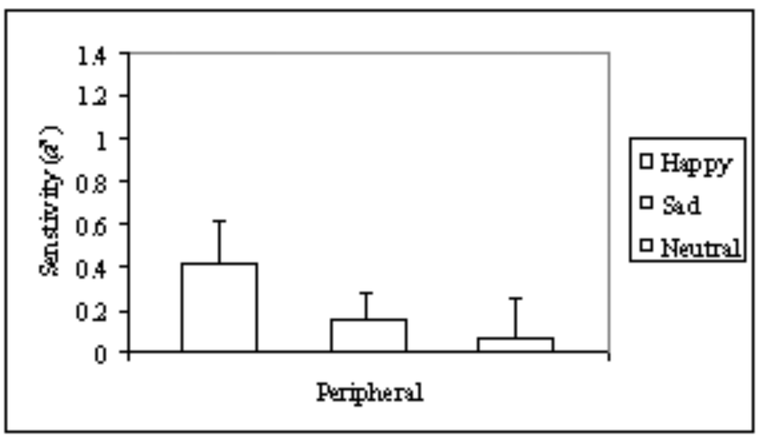

0.9
0.7
0.5
0.3
0.1
-0.1
-0.3
Criterion (β)
Low Load
High Load
Happy
Sad
Neutral

Figure 4

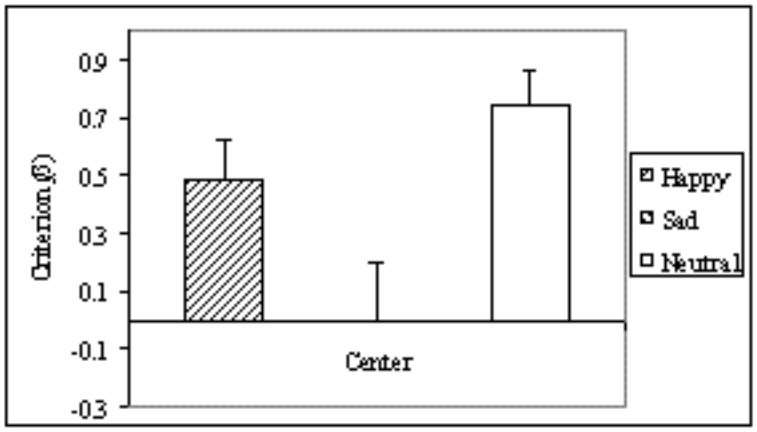

1.4
1.2
1
0.8
0.6
0.4
0.2
0
Senstivity (d')
Center
Happy
Sad
Neutral

(a)

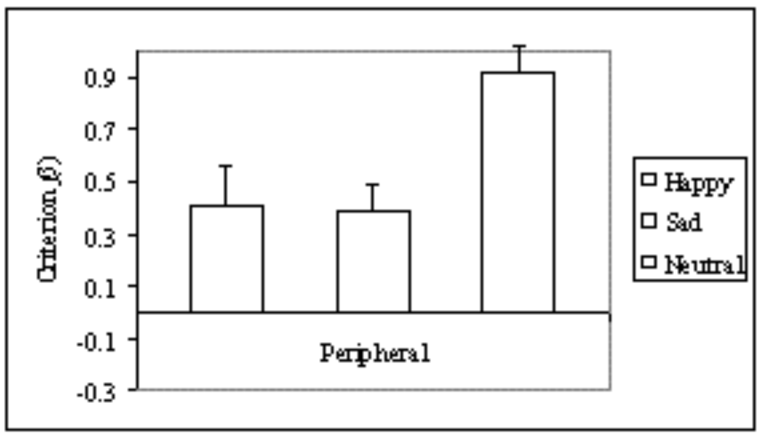

1.4
1.2
1
0.8
0.6
0.4
0.2
0
Senstivity (d')
Peripheral
Happy
Sad
Neutral

(b)

Figure 5


0.9
0.7
0.5
0.3
0.1
-0.1
-0.3
Criterion (β)
Center
Happy
Sad
Neutral

(a)


0.9
0.7
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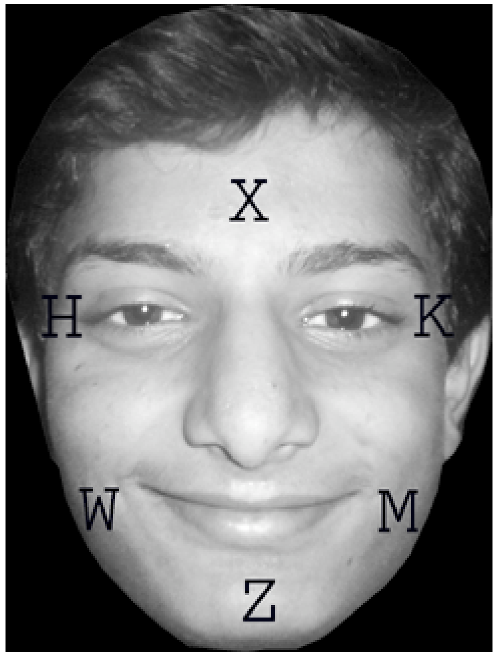
0.1
-0.1
-0.3
Criterion (β)
Peripheral
Happy
Sad
Neutral

(b)

Figure 6



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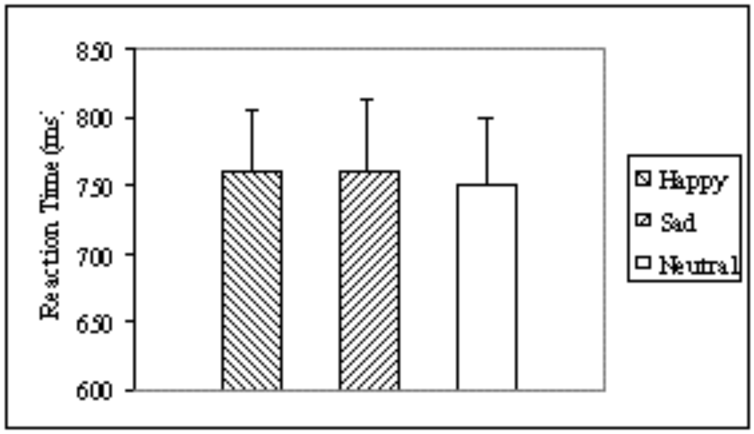
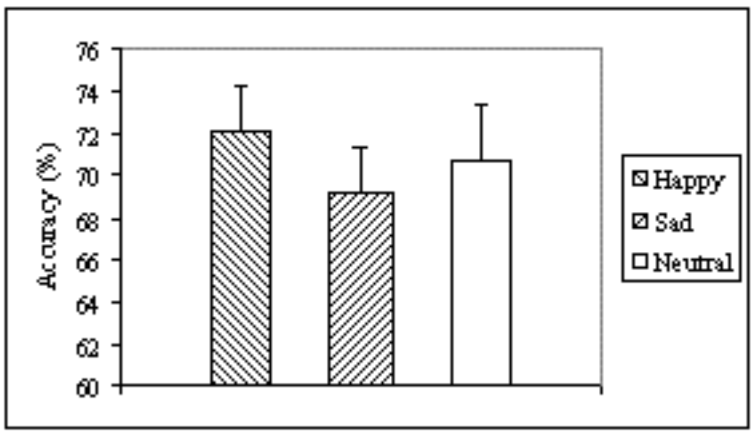


850
800
750
700
650
600
Reaction Time (ms)
Happy
Sad
Neutral

(a)



76
74
72
70
68
66
64
62
60
Accuracy (%)
Happy
Sad
Neutral

(b)

Figure 8

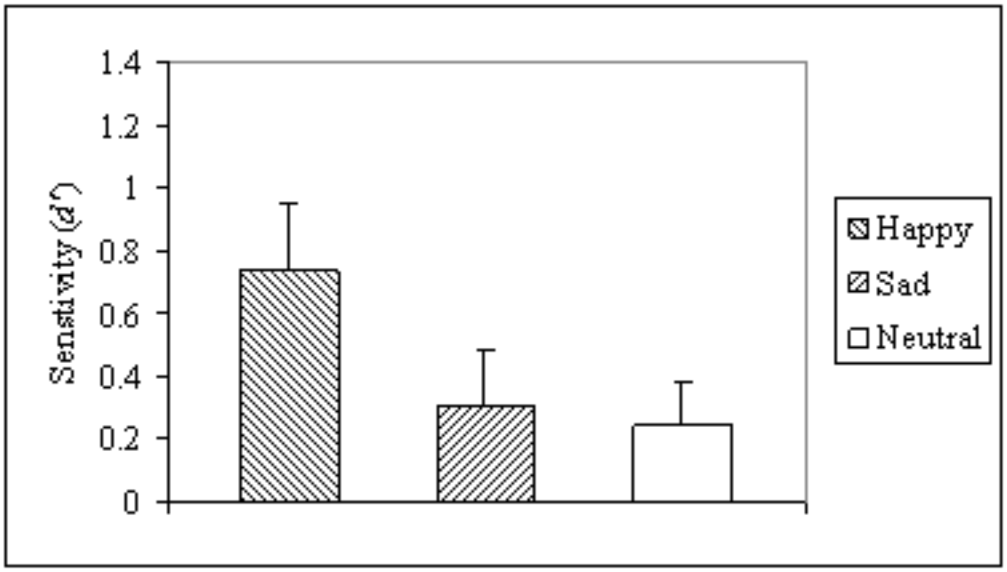


Figure 9

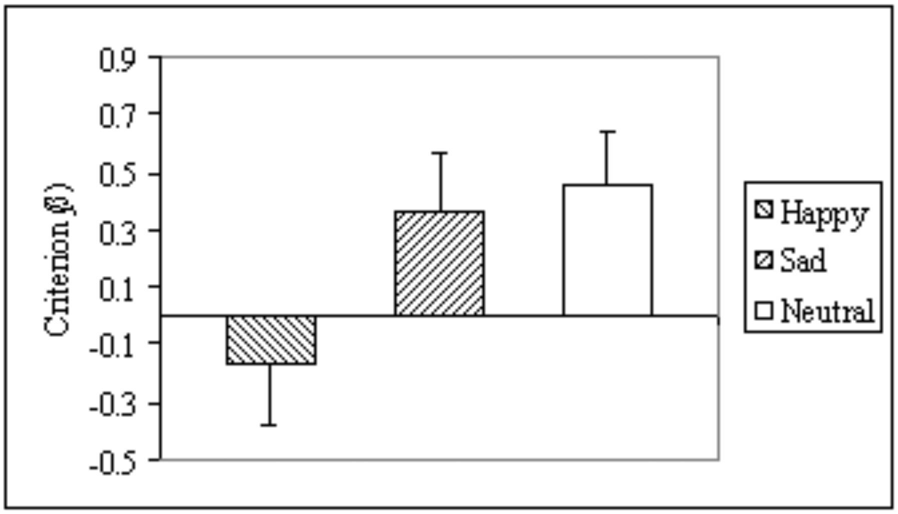


Figure 10