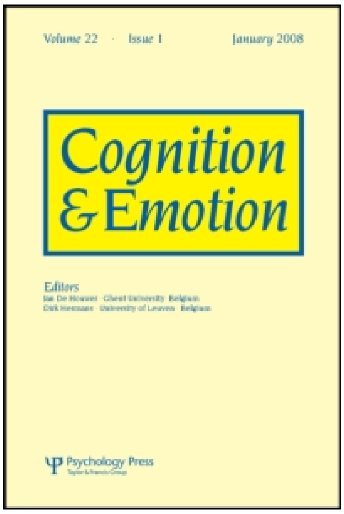

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Emotions help memory for faces: Role of whole and parts

Rashmi Gupta [a]; Narayanan Srinivasan [a]
[a] University of Allahabad, Allahabad, India

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Emotions help memory for faces: Role of whole and parts

Rashmi Gupta and Narayanan Srinivasan
University of Allahabad, Allahabad, India

The role of holistic or parts-based processing in face identification has been explored mostly with neutral faces. In the current study, we investigated the nature of processing (holistic vs. parts) in recognition memory for faces with emotional expressions. There were two phases in this experiment: learning phase and test phase. In the learning phase participants learned face–name associations of happy, neutral, and sad faces. The test phase consisted of a two-choice recognition test (whole face, eyes, or mouth) given either immediately or after a 24-hour delay. Results indicate that emotional faces were remembered better than neutral faces and performance was better with whole faces as compared to isolated parts. The performance in immediate and delayed recognition interacted with emotional information. Sad eyes and happy mouth were remembered better in the delayed recognition condition. These results suggest that in addition to holistic processing, specific parts–emotion combinations play a critical role in delayed recognition memory.

Keywords: Holistic processing; Whole; Parts; Recognition memory; Face identification.

INTRODUCTION

A central theme in face perception research concerns whether face processing is holistic (configurational) or parts (Carey & Diamond, 1994; Farah, Tanaka, & Drain, 1995). Several studies investigating the nature of face representations have suggested the presence of special integrative mechanisms in face processing (Farah, Wilson, Drain, & Tanaka, 1998; Tanaka & Farah, 1993). For example, Tanaka and Farah (1993) showed that participants are better in recognising a feature (e.g., Larry's mouth) within a previously learned face (e.g., Larry's face) than when presented alone (the

Correspondence should be addressed to: Narayanan Srinivasan, Centre of Behavioural and Cognitive Sciences, University of Allahabad, Allahabad 211002, India. E-mail: ammuns@yahoo.com

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whole–part effect). This effect is not observed with scrambled faces or inverted faces suggesting the critical role of holistic or holistic processing.

This issue has been extensively debated in the context of face recognition with faces devoid of emotional expressions. Facial expressions are salient signals for cognition and interact with various cognitive processes such as attention and memory. For example, emotion–attention interaction has been observed in a paradigm like visual search in which angry faces were detected faster than happy faces (Eastwood, Smilek, & Merikle, 2001; Fox et al., 2000). Emotion improves memory performance by facilitating encoding or retrieval of emotional information as compared with non-emotional information (Buchanan & Adolphs, 2003; Christianson, 1992). This emotional memory enhancement effect has been demonstrated in numerous studies using stimuli that have included pictures, words, stories, and narrated slide shows (Buchanan & Adolphs, 2003). However, no studies have examined the effects of emotional content on short- and long-term memory for faces in the context of holistic and parts-based processing.

Evidence for holistic factors has come from multiple studies involving perception, attention, and memory (Calder, Young, Keane, & Dean, 2000; Tanaka & Farah, 1993; White, 2000). Inverting the face makes it harder to recognise the expression (de Gelder, Teunisse, & Benson, 1997). In addition, an advantage for detecting angry faces in visual search was not obtained when stimuli were inverted or when only some features were presented in isolation suggesting that the effect is due to holistic processing of the whole face configuration (Eastwood et al., 2001; Fox et al., 2000). However, there are some indications that parts also play an important role in emotion recognition (de Gelder, Vroomen, & Bertelson, 1998; McKelvie, 1995; White, 2000). For example, McKelvie (1995) found that face inversion did not hinder identification of a smiling expression but reduced identification accuracy for fearful, sad, and angry expressions. On the other hand, identification of emotions was easier when only the upper part of the face carried the affective messages and the lower part was neutral than when the full face was shown. This effect was obtained only for angry, fearful and sad faces but not with happy faces (de Gelder et al., 1998). These results suggest that some parts are relatively more important than others for emotion identification. White (2000) has proposed that both parts and configurational information play a role in emotion identification. Given the evidence for both whole and parts in emotion identification, we wanted to explore their role in memory for faces that contained emotional information. The part–whole paradigm (Tanaka & Farah, 1993) has already been used to investigate the role of whole versus parts in face identity and it provides a suitable method to investigate the putative role of whole and parts in obtaining emotional information that may affect memory for faces. In this paradigm, participants were required to learn face–name association followed by a two-choice recognition test. In the whole-face trial condition, participants were presented with two faces, the target and foil. The target and the foil faces were not different with respect to emotional expressions. In the isolated-part condition, participants were presented with one feature from the target face and foil feature displaying the same emotion. Participants were instructed to find the target face (whole-face condition) or the target feature (isolated-part condition).

Since previous studies have shown a long-term enhancement effect for emotional information, we expected that recognition memory would be better for emotional faces compared to neutral faces. We also expected that performance would be better with whole faces compared to parts indicating the importance of holistic factors. We also hypothesised that long-term memory, but not immediate memory, performance with emotional expressions may be dependent on a specific part (mouth for happy expressions and eyes for sad expressions).

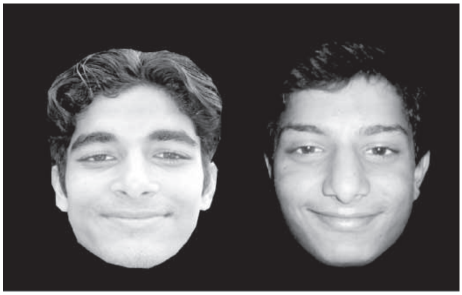
METHOD

Participants

Thirty (14 male and 16 female) volunteers (fifteen each in immediate recognition and delayed recognition conditions) with a mean age of 21.4 years ($SD = 2.3$ years) from Allahabad University participated in the experiment. All participants had normal or corrected-to-normal visual acuity.

Stimuli and apparatus

To avoid the ambiguity in emotional expression, 100 photographs of Indian adults were shown randomly to ten (5 male and 5 female) participants who subsequently did not participate in the experiment. These participants rated the faces on a 7-point Likert scale with 1 corresponding to sad faces, 7 corresponding to happy faces, and 4 corresponding to neutral faces. Ninety faces were selected for the database based on the ratings and out of those images thirty monochromatic Indian target faces (10 happy, 10 sad, and 10 neutral faces) and fifteen foil faces (5 happy, 5 sad, 5 neutral faces) were randomly selected for the experiment. Mean rating for the target happy faces was 6.01, for the sad faces 2.02, and for neutral faces 3.84. We ensured that the stimulus set did not include the same person with different expressions. The whole face subtended a visual angle of $6.84° \times 5.7°$. Part stimuli for target and foil faces contained just one feature (eyes or mouth) obtained by eliminating the remainder of the face (see Figure 1).



Which is Ramesh?

Which is Ramesh's mouth?

Which is Ramesh's eyes?

Figure 1. Example of whole face, mouth, and eyes stimuli used in the study.

Procedure

Participants viewed the stimuli from a distance of 100 cm. The commercially available research software (DirectRT, Empirisoft Corporation, New York) was used for stimulus presentation and data collection.

Learning phase. In each learning trial, the face stimulus (happy, sad, or neutral) was randomly presented with its name underneath it (for five seconds). The participants were asked to learn these face–name associations. The interval between successive face presentations was 3 seconds.

Test phase. A two-choice recognition test was administered either immediately after the learning phase (immediate recognition condition) or 24 hours later (delayed recognition condition). In the whole-face trial condition, participants were presented with two faces, the target and foil. The target and the foil faces did not differ with respect to emotional expressions. In the isolated-part condition, participants were presented with one feature from the target face and foil feature displaying the same emotion. Participants were instructed to find the target face (whole-face condition) or the target feature (isolated-part condition). In half of the trials the (full-face or features) foil was from the previously learned set and in other half they were not from the previously learned set. There were a total of 90 test trials presented randomly in which 30 were whole-face trials and 60 (30 eyes and 30 mouth trials) were part-based trials.

RESULTS

We computed the recognition accuracy for faces and features for all the conditions (see Figure 2). A $2 \times [3 \times 3]$ mixed analysis of variance (ANOVA) with Memory Condition (immediate recognition vs. delayed recognition) as a between factor, Test Type (eyes, mouth, or whole face), and Emotional Expression (happy, sad, or neutral) as within factors was performed on the percentage of correct responses. The main effect for Emotional Expression, $F(2, 56) = 19.19$, $MSE = 183.8$, $p < .001$, was significant. We performed Tukey's HSD for post hoc comparisons for the significant main effect and two-way interactions. Performance with sad, $F(1, 56) = 7.34$, $p < .001$, and happy faces, $F(1, 56) = 7.76$, $p < .001$, was significantly better compared to neutral faces. Happy (63%) and sad (63%) faces were remembered better compared to non-emotional faces (52%). No significant difference in performance was found between happy and sad faces. There was no significant difference in overall accuracy between the immediate and delayed recognition conditions.

Two-way interaction between Memory Condition and Emotional Expression, $F(2, 56) = 5.575$, $MSE = 183.8$, $p < .01$, was significant. Post hoc analysis showed that there was a significant decrease in recognition accuracy for neutral stimuli in the delayed recognition condition (48%) compared to the immediate recognition condition (56%), $F(1, 56) = 3.95$, $p < .01$. Performance with sad stimuli (64%) was significantly better compared to neutral stimuli, $F(1, 56) = 7.125$, $p < .01$, and similarly performance with happy stimuli (65.3%) was significantly better compared to neutral stimuli, $F(1, 56) = 8.51$, $p < .001$, only in the delayed recognition condition. These results confirm our hypothesis on the facilitatory role of emotions in recognition memory for faces.

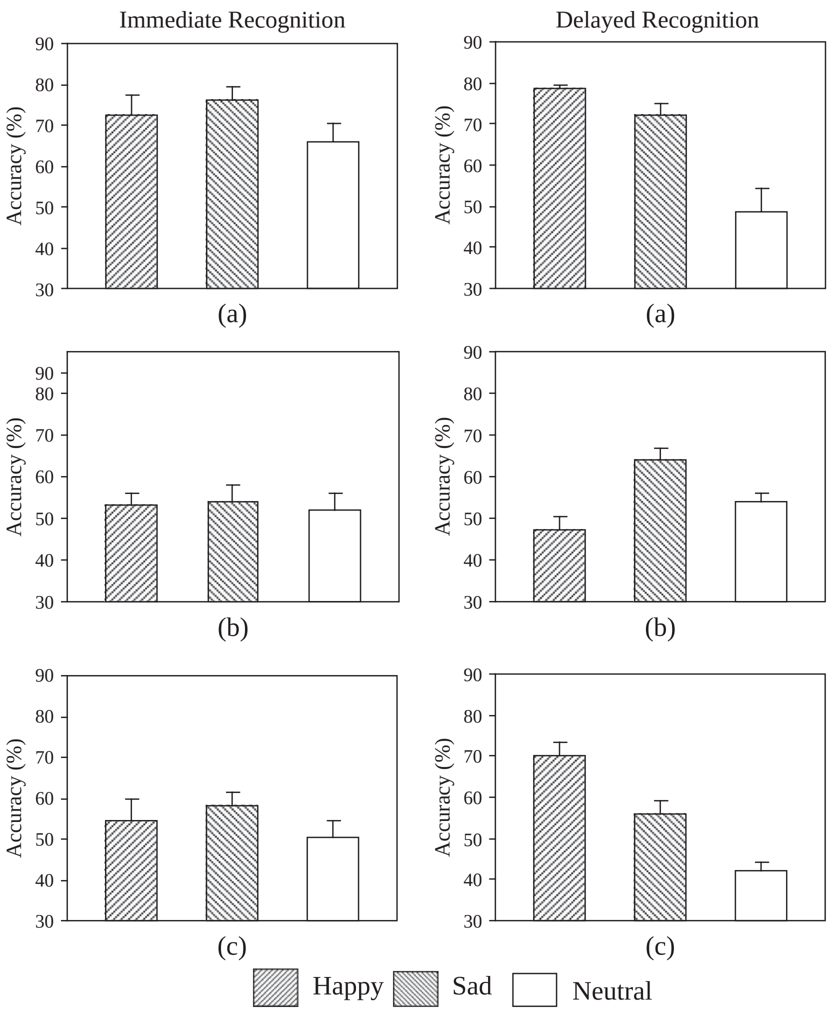


Figure 2. Recognition accuracy in the immediate and delayed recognition conditions for (a) whole face, (b) eyes, and (c) mouth for happy, sad, and neutral faces.

The main effect for Test Type, $F(2, 56) = 30.49$, $MSE = 203.0$, $p < .001$, was also significant. Post hoc analysis showed that performance with whole face was significantly better as compared to eyes, $F(1, 56) = 9.92$, $p < .001$, and mouth, $F(1, 56) = 9.18$, $p < .001$. Recognition memory was better with whole faces (69%) as compared to mouth (54%) or eyes (55%). No significant difference in performance was found between eyes and mouth. The interaction between Test Type and Emotional Expression,

$F(4, 112) = 4.908$, $MSE = 217.8$, $p < .01$, was also found to be significant. The better performance with emotions was dependent on the nature of the stimulus (whole face, mouth or eyes). Post hoc analysis showed significant performance difference between whole face (75.6%) and mouth (62.3%), $F(1, 112) = 4.937$, $p < .005$, as well as between mouth (62.3%) and eyes (50.3%), $F(1, 112) = 4.455$, $p < .005$, with happy expression. For a sad expression, significant difference was found only between whole face (74%) and eyes (59%), $F(1, 112) = 5.568$, $p < .001$. In addition, there was a significant drop in accuracy for neutral whole (57.3%) faces compared to sad (74%), $F(1, 112) = 6.199$, $p < .001$, or happy faces (75.6%), $F(1, 112) = 6.311$, $p < .001$. These results confirm our prediction that performance would be better with whole faces compared to parts, indicating the importance of holistic factors.

A significant three-way interaction between all three factors, Memory Condition, Test Type, and Emotional Expression, $F(4, 112) = 3.75$, $MSE = 217.7$, $p < .01$, indicated that the performance in immediate and delayed recognition conditions was dependent on emotional information as well as the whole–part nature of the faces. We used Bonferroni correction for post hoc comparison of the three-way interaction. Post hoc analysis showed that performance with neutral whole faces (48.6%) was worse than performance with sad (72%), $F(1, 112) = 6.142$, $p < .001$, and happy whole faces (78%), $F(1, 112) = 7.71$, $p < .001$, in the delayed recognition condition. Memory performance goes down significantly for non-emotional faces indicating long-term recognition memory is better for faces with emotional expression as compared to non-emotional faces.

However, there were differences in performance for specific emotion–parts combinations between the immediate and delayed recognition conditions. Performance with happy mouth (70%) was better than sad mouth (56%) in the delayed recognition condition, $F(1, 112) = 3.67$, $p = .01$. Correspondingly performance with sad eyes (64%) was better than happy eyes (47.3%) in the delayed recognition condition, $F(1, 112) = 4.41$, $p < .01$. However, there was no such difference present in the immediate memory condition. Performance was also found to be significantly different between immediate and delayed recognition condition for happy mouth, $F(1, 112) = 4.04$, $p < .01$. The difference between immediate and delayed recognition for sad eyes was not significant but close to significance, $F(1, 112) = 2.62$, $p = .06$. In addition, performance with whole emotional faces was better compared to emotional parts for both sad and happy expressions in immediate recognition. Performance with sad whole face was better than sad eyes, $F(1, 112) = 5.77$, $p < .001$, as well as sad mouth, $F(1, 112) = 4.72$, $p < .01$. Similarly, performance with happy whole face was better than happy eyes, $F(1, 112) = 5.06$, $p < .001$, as well as happy mouth, $F(1, 112) = 4.72$, $p < .01$, in the immediate recognition condition. However, this whole advantage over both the parts with emotional faces in the immediate recognition condition did not carry over to the delayed recognition condition due to better performances in the happy-mouth and sad-eyes conditions.

DISCUSSION

The present study examined the role of emotion in face recognition as a function of holistic or parts information immediately and following a 24-hour delay. As we expected, recognition memory was found to be better for emotional faces compared to neutral faces. Whole faces were remembered more compared to parts, indicating the importance of holistic factors in recognition memory. However, information from specific parts helped memory in the long-delay condition, indicating the importance of featural information in delayed recognition memory.

The results clearly suggest that emotional information does facilitate memory for faces. The enhancement of face identification performance in the context of emotional expressions argues for interaction between the face identification and facial expression identification systems. This is in agreement with recent studies showing partial overlap for facial identity and facial expression identification (Posamentier & Abdi, 2003). The facilitatory role of emotions fits with connections between emotional areas and processing/memory areas. For example, there are back projections from amygdala and orbitofrontal cortex to parts of the cortex that are crucial for object representations.

We found that performance was better for whole faces indicating the critical role of holistic processing in face identification. The advantage for whole faces over parts in the immediate recognition memory condition is in complete agreement with the findings from Tanaka and Farah (1993) and this advantage is present even for faces/parts with emotional expressions in the immediate memory condition. Holistic information also played a role with whole emotional faces in the delayed recognition condition indicating better long-term memory for whole faces that contain emotional information. However, our results extend the findings of Tanaka and Farah (1993) showing that specific parts can play a significant role in long-term memory especially when they contain pertinent emotional information.

It is to be noted that performance improved after the longer delay period only for specific feature–emotional expression combinations (happy mouth and sad eyes). This indicates that the time course of consolidation of emotional information based on holistic factors and features might be different. In other words, emotional information from whole faces might be consolidated faster than emotional information from features. It has been shown that consolidation processes take around 30 minutes to a few hours (McGaugh, 2000) for storing information in long-term memory. The time course of neural changes in the basolateral amygdala (McGaugh, 2000; Pelletier, Likhtik, Filali, & Pare, 2005), which typically peaked after 30 minutes and lasted for as much as 2 hours, may provide a neural substrate for consolidation of memories with emotional content and especially feature information specific to particular emotions (eyes for sad faces and mouths for happy faces). The fact that sad eyes and happy mouths are recognised better could mean that these are the most salient features in each of those emotional expressions, especially after long delays. This is consistent with studies suggesting that the upper face plays an important role in the recognition of sad expressions (de Gelder et al., 1998).

The results indicate that while holistic factors helped in short-delay as well as long-delay conditions, parts information helped only in the long-delay conditions. This has several implications for studies looking at the whole versus parts issue in face identification. While feature information is extracted from the face, it does not play a critical role in short-term face-recognition memory. Configurational factors play a larger role in short-term but features play a larger role in long-term memory. The results predict that the advantage for wholes will be reduced or eliminated if long-term memory is utilised for face identification.

Finally, present research has implications for psychiatry and forensics. There is evidence that children with autism show impairment in face recognition (Klin et al., 1999; Korkman, Kirk, & Kemp, 1998). Therefore, it is important to examine the nature of holistic and feature-based processing with emotional expressions in a memory task, especially with sad eyes and happy mouth. The crucial role played by emotional expressions in long-term memory for faces and features also has implications for identification of suspects by witnesses or in eye witness testimony.

In summary, the results of the current study indicate the critical role played by emotions in both short-term and long-term memory of faces. Processes involved in face-recognition memory are influenced by salient emotional information. The results also suggest that holistic processing plays a significant role in recognition memory but long-term recognition is also dependent on the emotional information available through emotion-specific parts. Further studies are needed to explore the role of holistic and feature-based processing in memory for faces with other emotional expressions.

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