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BRIEF REPORTS

Memory for facial expressions: The power of a smile

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Faces with expressions (happy, surprise, anger, fear) were presented at study. Memory for facial expressions was tested by presenting the same faces with neutral expressions and asking participants to determine the expression that had been displayed at study. In three experiments, happy expressions were remembered better than other expressions. The advantage of a happy face was observed even when faces were inverted (upside down) and even when the salient perceptual feature (broad grin) was controlled across conditions. These findings are couched in terms of source monitoring, in which memory for facial expressions reflects encoding of the dispositional context of a prior event.

A smile, a frown, a surprised look—such facial expressions convey powerful socio-emotional dispositions. Indeed, facial expressions often foreshadow, amplify, and even supersede verbal communication (see Ekman, 1993). Both psychological and neurocognitive findings suggest multiple processes involved in the reception, encoding, recognition, and elicitation of facial expressions (for reviews, see Adolphs, 2002; Posamentier & Abdi, 2003). Moreover, ever since Darwin's treatise on emotional expressions (Darwin, 1872), it has been recognized that facial expressions are to a substantial degree universal and common across cultures.

With respect to the encoding of facial expressions, some findings suggest a greater impact of negative expressions (e.g., anger or fear) as opposed to positive ones (e.g., happy or perhaps surprise). For example, the so-called *face-in-the-crowd* effect suggests that angry faces are detected faster than happy faces when they are presented within an array of other faces (Fox et al., 2000; Hansen & Hansen, 1988). Also, negative expressions interfere when performance requires processing of facial characteristics unrelated to the expression (Eastwood, Smilek, & Merikle, 2003). Such interference effects suggest that attentional focus is directed to negative expressions, and as a result, the processing of other stimulus features is compromised.

From a sociobiological perspective, the ability to recognize angry or threatening expressions would be highly advantageous, for survival could depend on an animal's ability to encode and react to such displays. Positive expressions, such as happy or surprise, also convey information important for selection, such as kinship or a willingness to mate. Some studies have suggested a processing advantage for positive expressions over negative ones. Kirita and Endo (1995) showed that reaction time to judge whether a face was happy or sad was faster for happy faces. Such studies have generally used schematic drawings of faces, and the effect is reduced when actual photographs of faces are used (Kirita & Endo, 1995, Experiment 3). Thus, with respect to the relative impact of positive as opposed to negative expressions, some findings suggest an advantage for negative expressions (e.g., the face-in-the-crowd effect), whereas other findings suggest an advantage for positive expressions (e.g., expression identification).

Neurocognitive studies have explored brain regions active during face processing. In neuroimaging studies, the encoding of facial expressions can to some degree be dissociated from the encoding of facial identity. Face recognition, for example, involves temporal-occipital regions, such as the fusiform gyrus (see Posamentier & Abdi, 2003), whereas the encoding of facial expressions appears to recruit other areas, such as the amygdala, cingulate gyrus, insula, and prefrontal regions (Canli, Sivers, Whitfield, Gotlib, & Gabrieli, 2002). With respect to valence, findings suggest that negative emotions are biased toward right-hemisphere activity, whereas positive emotions are biased toward left-hemisphere activity (Canli et al., 2002; Davidson & Irwin, 1999; Dolan et al., 1996).

In the present study, we explored memory for facial expressions. Consider the following scenario: Several days after chatting with a gregarious person at a party, one happens to see that person reading a book in the library. How likely is it that one will remember that person's prior emotional disposition? Would one remember that person's disposition better if it had been angry rather than happy? From this perspective, memory for facial expressions represents the encoding of one aspect of the social context of a prior episode. As such, facial expressions can

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be construed as source information (Johnson, Hashtroudi, & Lindsay, 1993). The source-monitoring framework proposed by Johnson et al. (1993) states that *source* refers to "conditions under which a memory is acquired (e.g., the spatial, temporal, and social context of the event; the media and modalities through which it was perceived)."

Despite the many memory studies on face recognition (for a review, see Posamentier & Abdi, 2003), few studies have focused specifically on memory for facial expressions. That is, most studies of face recognition concern the discrimination of previously presented faces from new faces. Unlike such studies of face discrimination, the present study focuses on facial expression as an aspect of emotional source information. One study has assessed this phenomenon within the context of a standard face recognition test (D'Argembeau, Van der Linden, Comblain, & Etienne, 2003). Black and white photographs of faces with either happy or angry expressions were presented at study. At test, neutral faces were presented, and the participants were given tests of identity recognition (i.e., old/new discrimination). If the subjects judged a face as "old," they were asked to report which expression it displayed at study (i.e., memory for facial expression). Although old/new discrimination was better for happy faces than for angry faces, no difference was observed in (source) memory for the expressions themselves.

To what degree are different facial expressions remembered? We addressed this issue by presenting study faces with various expressions (happy, surprise, anger, fear). At test, participants were shown neutral versions of previously presented faces, and they were asked to determine the expressions displayed at study. We were also interested in the role of facial properties such as configural aspects of faces in determining the degree to which facial expressions are remembered. Previous studies concerning the encoding of facial expressions are equivocal with respect to the relative advantage of positive and negative expressions. Some studies suggest an attentional benefit for angry expressions (Eastwood et al., 2003; Hansen & Hansen, 1988); other studies (Kirita & Endo, 1995) suggest that happy expressions are identified faster. It is uncertain to what degree either attentional demands or ease of encoding determines how well an expression is remembered. Given the sociobiological significance of negative displays of emotion (anger, fear), one might expect these expressions to be remembered best.

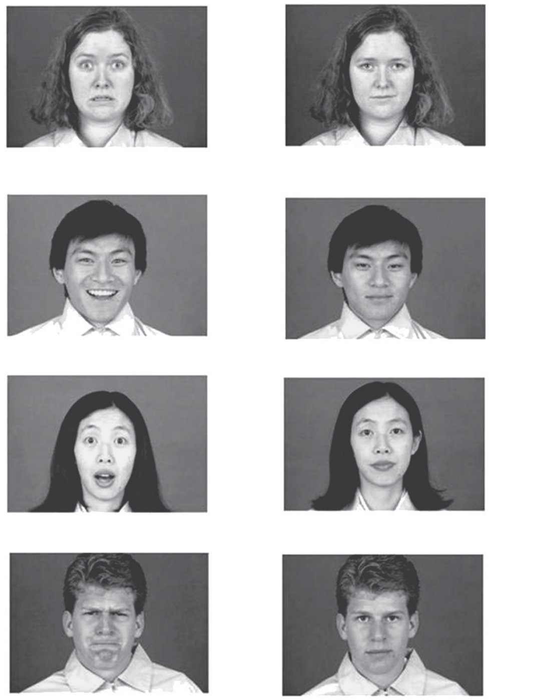

Figure 1. Sample of study and test faces used in Experiment 1 (actual stimuli were in color): Participants were shown faces with expressions during study (including neutral faces). At test, participants were shown neutral versions of study faces as well as new faces and were asked to identify the expression displayed during the study phase or to respond "new" if a face had not been presented at study.

EXPERIMENT 1

Method

Participants. Twenty-eight undergraduate students (7 men and 21 women) from the University of California, Berkeley volunteered for the study and received course credit for their participation. The participants averaged 20.4 years of age and had an average of 15.4 years of education. On the basis of voluntary ethnic identification, 50% were Asian, 35.7% were Caucasian, and 14.3% identified themselves as "Other."

Stimuli and Apparatus. Color photographs of faces with emotional expressions were obtained from the *Japanese and Caucasian Facial Expressions of Emotion* (JACFEE), a set developed by Matsumoto and Ekman (1988). From this collection, we selected 32 faces, each of which displayed one of four expressions—happy, surprise, anger, fear (eight faces per expression). Sample faces are shown in Figure 1. The faces were divided into two sets of 16 faces (half Caucasian, half Asian; half male, half female), with facial expressions distributed evenly across the two sets (4 faces per expression). From the accompanying collection of neutral faces (*Japanese and Caucasian Neutral Faces* [JACNeuF]; Matsumoto & Ekman, 1988), we used as test items photographs of each of the 32 JACFEE faces but with neutral expressions. In addition, we used 18 other neutral faces from the JACNeuF, of which 4 were used as neutral faces at study, 8 were used as new items at test, and 6 were used as buffers during the study phase to reduce primacy and recency effects. The stimuli for both study and test phases were presented using E-Prime software (Psychology Software Tools) on an IBM-compatible computer.

Procedure. In the study phase, participants were shown 20 faces, which included one set of 16 faces with emotional expressions (4 happy, 4 surprise, 4 anger, 4 fear) and 4 faces with neutral expressions. Each face was shown for 3 sec, and participants were instructed to determine the gender of each face by making a keypress response. No mention was given of a subsequent memory test, and thus the learning of facial expressions occurred in an incidental manner. The faces were presented in a random order. To reduce primacy and recency effects, 3 neutral faces were presented at the beginning of the set, and 3 neutral faces were presented at the end of the set. Following the presentation of all faces, the procedure was repeated in the same manner so that participants were given two trials of the gender decision task for each face.

Half the participants were given one set of 16 JACFEE faces for study, and the other half were given a different set of JACFEE faces.

The JACFEE collection has been designed and coded according to a highly reliable and well-studied set of criteria for displays of facial expressions (Biehl et al., 1997). It should be noted, however, that the set includes only one emotional expression for each face, so that one cannot counterbalance specific faces across expressions. In the present study, the use of two different sets of faces served as a replication test to ensure that any observed effects were attributable to facial expressions rather than to extraneous item effects of specific faces.

Immediately following the study phase, participants were shown neutral versions of the 20 study faces intermixed with 8 new neutral faces. A test stimulus consisted of a neutral face with six possible choices (happy, surprise, anger, fear, neutral, new). Participants were asked to make keypress responses to indicate the expression that a face displayed when it was presented during the gender decision task or to indicate "new" if the face had not been presented previously. Participants were instructed to guess if they did not remember the facial expression. The test phase was self-paced.

Results and Discussion

We first analyzed overall *old/new* recognition performance across the five facial expression conditions (happy, surprise, anger, fear, neutral). Since performance was based on a six-alternative, forced-choice test, we defined an *old* response as a study item not identified as "new" (i.e., identifying an item as old, without regard to which facial expression was selected). There was a significant effect of facial expression on *old/new* recognition [$F(4,104) = 5.7$, $MS_e = 0.029$, $p < .001$]. In planned comparisons ($p < .05$), neutral faces (93.8%) were remembered better than happy (77.7%), angry (76.8%), or surprise (75.7%) expressions, whereas fear expressions (86.6%) were intermediate and not significantly different from the other expressions. These findings reflect the general benefit of viewing exactly the same (neutral) face at study and test. There was no difference in performance between the two study sets, which were composed of different faces [$F(1,26) = 0.4$].

We were particularly interested in memory for facial expressions of previously presented faces. We calculated, for each condition, the proportion of correctly identified expressions conditionalized on having identified a face as *old* [e.g., p("Happy"|Old)]. There was a significant effect across conditions [$F(4,104) = 19.3$, $MS_e = 0.076$, $p < .001$]. As is shown in Figure 2, neutral and happy expressions were remembered better than angry, fear, or surprise expressions (ts > 3.4; ps $< .001$). Indeed, memory performance for angry, fearful, and surprised hovered near chance performance. The difference between happy and neutral expressions did not reach significance [$t(27) = 1.81$, $p = .08$].

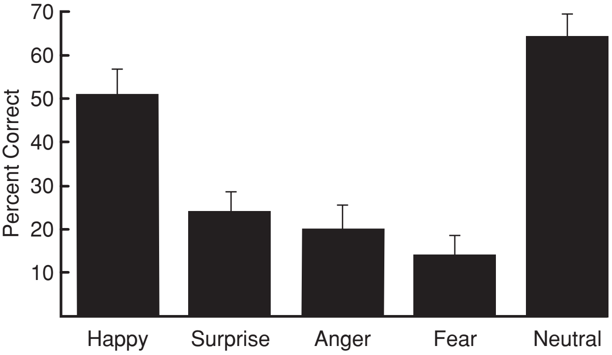

Figure 2. Memory for facial expressions: Shown are correct scores conditionalized on making an "old" judgment in Experiment 1. Across the different emotional expressions (happy, anger, fear, surprise), happy expressions were recognized better than others. Neutral expressions were remembered well, although only these were remembered equally well at study and at test.

The findings could not be attributed to response biases, because false alarm (FA) error rates across facial expressions were comparable, except for a slight bias toward identifying new items as "neutral" ("happy" FA = 6%, "anger" FA = 6%, "fear" FA = 5%, "surprise" FA = 9%, and "neutral" FA = 12%). Moreover, we performed a d' analysis to compare an individual's hit rate for each facial expression [e.g., p("Happy"|Old)] with the corresponding false alarm rate [e.g., p("Happy"|New)] and found the same pattern of results (to prevent out of range values in the d' calculations, scores of 1.0 were assigned .99 and scores of 0 were assigned .01). Specifically, there was an overall difference in d' measures across the five facial expressions [$F(4,108) = 13.2$, $MS_e = 1.33$, $p < .001$], with happy faces remembered better than all others except for neutral (d' scores, averaged across participants: happy = 1.39, anger = 0.40, fear = 0.34, surprise = 0.36, neutral = 2.10). Finally, the findings could not be attributed to the specific faces used, for there was no difference between the two face sets [$F(1,26) = .10$].

EXPERIMENT 2

Rather surprisingly, participants remembered a happy expression of a previously presented face better than an angry, surprised, or fearful expression. These findings appear contrary to those of studies in which angry or sad faces have been detected more readily and thus have attracted greater attention than happy faces have (Eastwood et al., 2003; Fox et al., 2000). However, the findings are consistent with those of studies in which happy faces have been identified or recognized faster than angry/sad faces (D'Argembeau et al., 2003; Kirita & Endo, 1995).

A well-studied aspect of faces is that they have both configural components (e.g., head shape, spatial relation of parts) and featural components (eyes, nose, mouth). One way to assess the role of configural and featural components is to use inverted (i.e., upside-down) faces, which tend to diminish configural properties (Prkachin, 2003; Valentine, 1988). Face inversion has been studied with respect to facial expressions (Prkachin, 2003; White, 2000). Interpretation of these inversion effects is mixed with respect to the degree to which expressions are based on holistic, configural properties as opposed to more discrete featural properties. If the memory advantage for happy faces is attributed to configural properties, the effect should disappear when inverted faces are used. In Experiment 2, we used the same paradigm as in Experiment 1, but the faces at both study and test were inverted.

Method

Participants. Twenty-eight college undergraduates (9 men and 19 women) were tested in this study and were given course credit for their participation. The participants averaged 19.3 years of age and 14.9 years of education. Their ethnic identification was 39.2% Asian, 46.4% Caucasian, and 14.2% "Other."

Procedure. The design and procedure were identical to those of Experiment 1, except for two changes. In the present experiment, all faces were rotated 180º (i.e., upside down) at both study and test. Also, during the study phase, each face was presented for 4 sec instead of 3 sec (as in Experiment 1). In summary, 20 inverted faces (4 happy, 4 surprise, 4 angry, 4 sad, 4 neutral) were presented at study in an incidental manner using a gender judgment task. At test, neutral versions of these faces were intermixed with 8 new neutral ones, and participants determined whether a test face had previously displayed a happy, surprise, angry, sad, or neutral expression during the gender decision task or whether a test face was new.

Results and Discussion

Analyses of recognition performance for inverted faces revealed a significant effect across the five facial expression conditions [$F(4,104) = 3.55$, $MS_e = 0.037$, $p < .01$]. In planned comparisons ($p < .05$), happy (81.2%), angry (79.5%), fear (76.8%) and neutral (79.5%) faces were all better remembered than surprise faces (64.2%). No other comparisons reached significance. There was no difference in performance between the two study sets [$F(1,26) = 0.58$].

As is shown in Figure 3, memory for facial expressions of inverted faces revealed the same pattern of results that was found in Experiment 1. There was a significant effect of face expression memory across conditions [$F(4,104) = 13.8$, $MS_e = 0.069$, $p < .001$], with neutral and happy expressions remembered better than angry, fear, or surprise expressions (ts > 3.2; ps $< .01$). The difference between happy and neutral expressions was not significant [$t(27) = 0.87$, $p = .39$].

False alarm rates across the facial expressions were comparable, except for a guessing bias to report new items as "neutral" ("happy" FA = 13%, "anger" FA = 6%, "fear" FA = 9%, "surprise" FA = 14%, and "neutral" FA = 20%). In a d' analysis, we found the same pattern of results as that obtained for hit rates [$F(4,108) = 7.05$, $MS_e = 1.31$, $p < .001$] (d' scores, averaged across participants: happy = 1.10, anger = 0.23, fear = 0.02, surprise = 0.10, and neutral = 0.64). Thus, differences in memory for facial expressions could not be attributed to differences in FA biases. There was no difference between the two sets of faces [$F(1,27) = 0.28$].

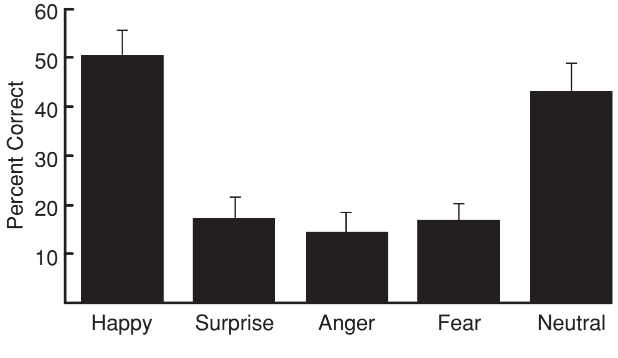

Figure 3. Memory for facial expressions: Shown are correct scores conditionalized on making an "old" judgment for inverted faces in Experiment 2. Happy and neutral faces were remembered better than angry, fear, or surprise expressions.

EXPERIMENT 3

The benefit of a happy face persisted even when configural properties of faces were disrupted by presenting upside-down faces. When compared with other facial expressions, a happy smile appears to be recognized easily, even for such inverted faces (view Figure 1 upside down). In particular, the display of a broad grin with exposed teeth is quite distinctive, both in terms of perceptual and social qualities. In Experiment 3, we attempted to disentangle the perceptual qualities of a broad grin from its social implications. Neutral faces were digitally altered by inserting a broad grin from another face onto the otherwise neutral expression. The grin was inserted in its correct orientation, suggesting a happy face, or the grin was inverted, so that it was upside down with respect to the orientation of the rest of the face. As shown in Figure 4, inverted grins have the appearance of grimaces (see also Yin, 1969). These grimace faces are rather distinctive, perhaps even more distinctive than a truly smiling face. Importantly, both "happy" and "grimace" faces included the same broad grin, yet only one suggests a happy disposition. In the present experiment, memory was assessed for the expression of grimace and happy faces when the faces were presented upside down. In this way, we could determine whether the benefit of a happy face persists even when the perceptual features are equated across conditions.

Method

Participants. Thirty-two college undergraduates (14 men and 18 women) were tested in this experiment and were given course credit for their participation (average age = 19.0 years; average years of education = 14.3). Ethnic identification was 40.6% Asian, 37.5% Caucasian, and 22% "Other."

Stimuli. Other than the stimuli used in this experiment, the design was nearly identical to that of Experiment 2. In the present experiment, grins from the JACFEE set of happy faces were digitally superimposed onto 12 different neutral faces using Photoshop (Adobe Systems). For one set, the grins had the same orientation as the face. For another set with the same faces, the grins were inverted (i.e., rotated 180º) with respect to the face. These inverted grins had the appearance of a grimace (see Figure 4). At study, 6 of these faces were presented as happy faces and the other 6 were presented as grimace faces. The faces in the happy and grimace conditions were counterbalanced across participants.

At study, 24 inverted faces (6 happy, 6 grimace, 6 fear, and 6 neutral) were presented in the gender judgment task (4-sec exposure). Three additional neutral faces were presented at the beginning of the list, and 3 were presented at the end, to reduce primacy and recency effects, respectively. Following presentation of the faces, the set was presented again for a second exposure. At test, neutral versions of these inverted faces were intermixed with 8 new neutral faces, and participants determined whether a test face had been displayed previously with a happy, grimace, fear, or neutral expression during the gender decision task or whether a test face was new (chance = 20%).

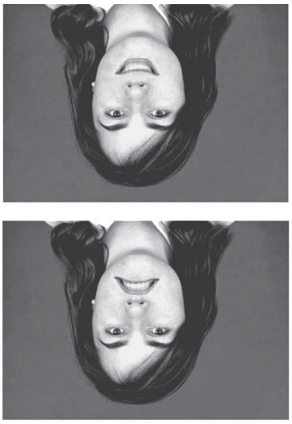

Figure 4. Sample of study faces used to control for perceptual distinctiveness of a broad grin (Experiment 3; actual stimuli were in color): Inverted faces were presented with a digitally inserted grin in the same orientation as that of the face (upper face) or rotated 180º from the orientation of the face (lower face). Thus, both faces display broad grins, but the upper face displays a "happy" expression, whereas the lower faces displays a "grimace" expression.

Results and Discussion

Analyses revealed a significant effect across the four facial expression conditions [$F(3,93) = 4.77$, $MS_e = 0.027$, $p < .01$]. In planned comparisons ($p < .05$), neutral expressions (84.9%) were remembered better than happy (74.0%), grimace (72.9%), and fear (70.8%) expressions. No other comparisons reached significance.

As is shown in Figure 5, memory for facial expressions differed across conditions [$F(3,93) = 5.01$, $MS_e = 0.069$, $p < .01$]. Neutral expressions were remembered better than grimace or fear expressions (ts > 2.4, ps $< .05$) but were not significantly different from happy expressions ($t = 1.5$, $p = .15$). Importantly, happy expressions were remembered better than grimace expressions ($t = 2.1$, $p < .05$), despite the fact that the only difference between these two conditions was the orientation of the smile with respect to the face. The difference between happy and fear expressions was not significant ($t = 1.0$, $p = .33$).

False alarm rates across the facial responses were comparable across expressions, though somewhat biased toward "neutral" responses ("happy" FA = 8%, "grimace" FA = 12%, "fear" FA = 8%, and "neutral" FA = 19%). In a d' analysis, we found a similar pattern of results [$F(3,93) = 4.09$, $MS_e = 0.751$, $p < .01$] (d' scores, averaged across participants: happy = 1.07, grimace = 0.35, fear = 0.76, and neutral = 0.87).

GENERAL DISCUSSION

In three experiments, memory for facial expression was assessed by presenting neutral faces and asking subjects to identify facial expressions displayed during the study phase. In this manner, we were interested in memory for an aspect of the socio-emotional context of a prior episode. Among the facial expressions tested—surprise, happy, fear, and anger—happy expressions were remembered best. The benefit of a smile occurred even when configural properties were disrupted (upside-down faces, Experiment 2) and even when faces were equated for the perceptual salience of a broad grin (happy vs. grimace faces, Experiment 3).

One previous study has assessed memory for facial expression (D'Argembeau et al., 2003). Following presentation of angry and happy faces, participants viewed neutral faces at test and made *old*/*new* recognition judgments. If a face was judged as old, they were asked to report whether the face had been presented as angry or happy. The authors found a benefit for happy faces on *old*/*new* judgments but not on angry/happy (i.e., source) judgments. In the present study, we did not observe a reliable benefit for happy faces on derived measures of *old*/*new* recognition. It should be noted, however, that hit rates were calculated from the source recognition scores, so that "old" responses were based on the number of study items not given a response of "new." In a recent analysis, recognition judgments were assessed in a paradigm similar to that used in the present study, but traditional *old*/*new* recognition judgments were requested (Marian & Shimamura, 2004). Just as D'Argembeau et al., we found a reliable benefit for happy expressions on *old*/*new* judgments.

Unlike D'Argembeau et al. (2003), we observed better "source" memory for happy expressions than for other emotional expressions. We used incidental learning instructions, whereas D'Argembeau et al. used intentional learning instructions. Moreover, we compared happy expressions with several other expressions—surprise, fear, and anger. Finally, D'Argembeau et al. used two successive recognition responses to obtain measures of identity memory and memory for expressions. In the present study, we used one forced-choice response, which is similar to the procedure in source memory tests (Dodson & Shimamura, 2000). It may be that methodological differences between D'Argembeau et al.'s study and ours determine the boundary conditions of this effect (e.g., the particular set of expressions used or the method of testing).

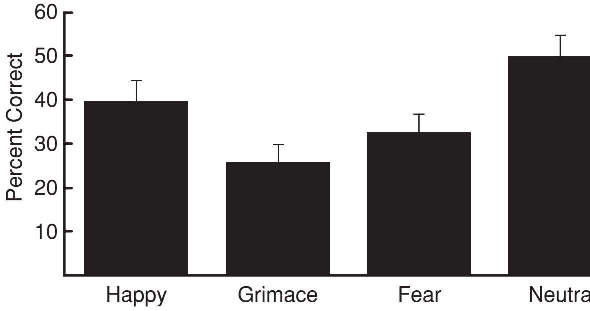

Figure 5. Memory for facial expression in Experiment 3: Note that "happy" expressions were recognized better than "grimace" expressions, despite the fact that the only difference between conditions was the orientation of the mouth with respect to the face.

Our findings fit well with a source-monitoring framework (Johnson et al., 1993) in which an episode comprises many different components, including perceptual, conceptual, and dispositional features. Memory for a past episode (i.e., source memory) depends on the degree to which these components are processed during encoding. In the present study, facial expression was viewed as part of the dispositional or emotional context of a prior experience. Our findings suggest that happy faces are processed more strongly than other emotionally laden expressions, such as anger, fear, or surprise.

Given previous findings suggesting that angry faces draw attentional resources more than happy faces do (Eastwood et al., 2003; Hansen & Hansen, 1988), it was somewhat surprising that happy expressions were remembered better than other expressions. One possibility is that angry faces draw attention to whatever has motivated the negative emotion rather than to the particular person who elicited the emotion. In other words, angry faces direct attention to the context or event that elicits anger (Why is the person angry at me?), whereas a smile directs attention to the particular person (i.e., source) who elicits the smile (Who is the person smiling at me?). To the extent that a smiling face communicates a social bond (familiarity, attractiveness, kinship), attention may be directed to the particular face eliciting the happy expression. These factors could determine the manner in which attention and memory are influenced by facial expressions. In any event, the present methods and findings offer a new direction in the analysis of facial expressions. Viewed from a source-monitoring perspective, facial expressions are an aspect of the dispositional context within which an event is experienced. Issues of attentional focus and socio-emotional interpretations of expressions may determine the degree to which the affective quality of an event is remembered.

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