Interactive processes in matching identity and expressions of unfamiliar faces: Evidence for mutual facilitation effects

Yonata Levy[1, 2] and Shlomo Bentin[1,3]

[1] Department of Psychology, [2] Hadassah-Hebrew University Medical School, [3] Center for Neural Computation

Hebrew University of Jerusalem, Israel

ABSTRACT

This study investigated the interactions between matching identity and expressions of unfamiliar faces. In Experiment 1, participants matched expressions in frontal and in angular views, while we manipulated facial identity. In Experiment 2, participants matched identity in frontal and in angular views, while facial expressions were manipulated. Labeling of expressions was not required. Results showed mutual facilitation between matching facial identity and facial expressions, in accuracy as well as in RT. Thus, matching expressions was better and faster for same-identity images in angular as well as in front views (Experiment 1), and matching identity was better and faster for same-expression images in angular as well as in front views (Experiment 2). The discussion focuses on the implications of these results for the structural encoding of facial identity and facial expressions.

Key words: facial identity, expression recognition, matching

Faces convey a wealth of social cues informing viewers about a person's gender, age, emotional state, speech production and identity. The relationships between these aspects of face processing have been the subject of considerable debate. According to the influential model of Bruce and Young (1986), the perception of both identity and expression are based on a process of structural encoding. The identification of familiar faces and the recognition of variant aspects of faces such as emotional expressions and lip reading, are carried out in parallel to each other. Although high-level information is involved in all these processes they have been thought to operate along separate routes and be functionally independent (Calder, et al. 2000).

Evidence for the putative independence of identity and expression recognition has been obtained in intact as well as in neurologically impaired subjects. For example, Etcoff (1984) reported lack of interference from the irrelevant stimulus dimension when subjects were sorting faces according to identity or to expression. Other studies showed that when smiling faces were used in an expression matching task, no RT advantage was found for familiar vs. unfamiliar faces, although familiarity did speed up identity matching (Bruce, 1986). Similar findings were reported in other studies as well (e.g. Young, McWeeny, Hay & Ellis, 1986; Calder, Burton, Miller, Young & Akamatsu, 2001 and many more).

The most striking evidence in support of the independence of face recognition and perception of facial expressions came from double dissociations reported in neurological patients. Patients with brain lesions who exhibited relatively selective impairments in either face identification or expression recognition have been described, for example, by Tranel, Damasio and Damasio (1988), Humphrey, Donnelly and Riddoch (1993), Keane et al (2002) and Young et al (1993) among others.

Recent neuroimaging research with patients suggested specific brain areas that subserve the recognition of different emotions (Adolphs, 2002). Those brain areas were unique to emotions and were not thought to be involved in identity recognition. Nevertheless, such anatomical facts do not necessarily imply functional independence, since locating brain activities more specifically to particular areas does not preclude interaction among components, which will have behavioral manifestations. Similarly, evidence of involvement of the same brain areas in processing identity and expression does not in itself suffice as an argument against the possible dissociation of these cognitive processes. Behavioral data along with appropriate neural functional modeling are, indeed, crucial in order to clarify the relationships between these systems.

Recent behavioral studies reported mutual effects between identity recognition and recognition of facial expressions. However, the interpretation of these results is not unequivocal. There were studies showing that expressions affected the identification of famous faces, yet not the identification of unfamiliar faces (Endo, Endo, Kirita & Maruyama, 1992; Young, 1986 Sansone & Tiberghien, 1994, reported in Posamentier & Abdi, 2003). Campbell, Brooks, de Haan and Roberts (1996) extended this familiarity effect to personally known faces as well. Their study went beyond happy faces, to test RT in decisions about sad and disgusted faces as well, with similar results across different emotions.

In a study of healthy participants, Schwienberger and Soukup (1998) found that RTs for identity were not influenced by expressions or by facial speech, whereas expression recognition and recognition of facial speech were affected by variation in identity. Consequently, the authors argued that there might be asymmetries between different components of face processing: Whereas identity was independent of other face-variations, expression and facial speech recognition were affected by identity. In a later study, Schweinberger, Burton and Kelly (1999) did not find an effect on identity classification of unfamiliar faces through morphing across emotions. However, much like previous work, expressions clearly influenced the identification of familiar faces (Kaufman & Schweinberger, 2004).

Note that while exposure to famous faces is notoriously biased in favor of particular expressions, extending the familiarity effects to personally known faces (cf. Campbell et al., 1996) still does not rule out the possibility that familiarity with multiple examples of conjunctive identity and expression may account for the observed effects of identity on recognizing expression (cf. Tarr & Bülthoff, 1995). Thus, the crucial test remains with the processing of unfamiliar faces, where there is no previous familiarity with expressive variants of the face and performance depends on decoding the information that is inherent in the stimulus. Studying identity and expression recognition of unfamiliar faces will run against the inherent difficulties of these tasks, as reviewed in Hancock, Bruce and Burton (2000). These authors point out factors such as differences in lighting and viewpoints, as well as configuration and distinctness that affect performance.

To the best of our knowledge, the only apparent evidence of an interaction involving the identity of unfamiliar faces and expressions came from a study by Ganel and Goshen-Gottstein (2004) who found interference effects of expression on identity as well as of identity on expression recognition, not only for familiar faces but for unfamiliar faces as well, albeit the latter effect was only partial and less conspicuous. In a recent fMRI study by the same group, the same sets of stimuli were used, showing active involvement of the fusiform face area (FFA) in processing facial expressions when attention was directed to expression, as well as when expression was the irrelevant variable (Ganel, Valyear, Goshen-Gottstein & Goodale, 2005). These data extend and elaborate previous findings that showed stronger FFA involvement in processing fearful faces compared with neutral faces (e.g. Pessoa, McKenna, Gutierrez & Ungerleider, 2002).

With respect to these data, one wonders to what extent was familiarity indeed controlled for in the above reported studies. For example, in Schweinberger et al., (1999) two unfamiliar faces were given names – Peter and Simon - and were introduced to the subjects during 32 trial presentations (16 with name tags and 16 without name tags). Following these familiarization trials, there were 280 presentations of these two individuals, varying between two expressions. Similarly, in Ganel and Goshen-Gottshtein (2004) there were 16 trial presentations and 84 test presentations, varying between just two individuals with two different expressions. Furthermore, in the latter study unfamiliar faces were shown on the screen alongside with the test stimulus for the entire duration of the test. Considering the multiple exposures that subjects in the above studies had to just two unfamiliar faces, it is questionable as to whether those remained unfamiliar to the participants as the task unfolded. Hence, although suggestive, these data require corroboration. In the current study participants will be exposed to faces of many more individuals in an attempt to better control for familiarity.

Interestingly, similar to the data from healthy individuals, there are recent reports of patients whose deficits do not support dissociation between identity and expression recognition, but rather suggest that there is an interaction between these processes. For example, Young, Hellawell, van de Wal and Johnson (1996) described a woman with a partial bilateral amygdalotomy who experienced difficulties in identity recognition whenever faces were discrepant with their expressions. In a similar vein, Braun, Denault, Cohen and Rouleau (1994) reported a correlation between identity judgments and expression recognition in lobotomized patients. de Gelder, Frissen, Barton and Hadjikhani (2003) report of considerably better identification of expressive faces compared with neutral faces in prosopagnosic patients. The authors considered the data a challenge to face-processing theories that assumed independence between processing facial identity and facial expressions. Data from other pathologies support these contentions (Sansone, Luante, Bidault & Tiberghien, 1998; Salem, Kring & Kerr, 1996; Baudouin, Martin, Tiberghien, Verlut & Franck, 2002).

In sum, recent research questions the independence of processing facial identity and facial expressions. Evidence is not fully convincing, however, with respect to unfamiliar faces. Whereas there are studies demonstrating the influence of identity on recognition of expressions, the inverse effect was predominantly found for familiar faces.

The present study set out to further investigate the interactive nature of identity and expression recognition of unfamiliar faces. Using a version of the Garner (1976) paradigm, we tested the implicit influence of the irrelevant dimension – identity or expression – on tasks that required identity matching of expressive unfamiliar faces, or expression matching on same or different identity faces. The original Garner (1976) paradigm, in which two stimuli are presented and the task is a forced-choice one, has been previously used to study the relationship between different aspects of face processing (identity and gender, Ganel & Goshen-Gottstein, 2002; expression and lip reading, Schweinberger & Soukup, 1998; identity and emotion, Schweinberger et al., 1999; gender and expression, le Gal & Bruce, 2002; gaze direction and expression, Ganel, Goshen-Gottstein, & Goodale, 2005). In the current study Garner's paradigm was modified in the following way. Stimuli sets were modeled on the Benton Facial Recognition Test (BFRT; Benton et al., 1994). The BFRT is a test that minimizes memory load and is commonly used for research as well as for clinical purposes. In the BFRT, participants are presented with a target face above six test faces with neutral expressions and are asked to indicate which of the images matches the target. While the target face is always in front view the test faces are presented in different angular views or with varying degrees of shading, to control for direct pictorial matching. Unlike the BFRT, in the current experiments targets and test stimuli varied not only along the dimension of identity but along the dimension of expression as well, thus testing for subjects' selective attention – Garner effect - for these two dimensions. Participants were required to make a speeded choice between stimuli and their performance was used to measure whether dimensions were separable, i.e. processed independently, or integral, i.e. each affecting the processing of the other. If processing of facial identity and facial expression are independent processes, the irrelevant dimension - identity in Experiment 1 and expression in Experiment 2 - should not affect performance. However, if the processing of facial identity and facial expression interact, accuracy should be higher and RTs should be faster when targets and their matched test faces shared both dimensions.

Finally, in most previous work on expression recognition the task required matching verbal labels to facial stimuli. Thus, performance in these studies involved overt semantic attribution. Such language dependency is not trivial given that expression terms are not simply descriptive but are rather categorical and judgmental. Expression terms serve to label what Izard (1994) referred to as *the expression-feeling* *link*, which she defined as the popular belief in an association between a specific emotion expression and a specific corresponding conscious experience (emotion feeling, felt action tendency or motivational state).[1] Clearly, if the research question concerns the perceptual processes involved in identity recognition or in recognition of facial expressions, both of which presumed to be innate (Izard, 1994), easy (Ekman, 1975) and categorical (Calder et al. 1996), research procedures that will minimize the role of semantic attribution are called for. In the light of the above, participants in the current experiments were not told that the stimuli varied with respect to the irrelevant dimension (expressions or identity), nor were they required to label the expressions that they matched. Although there is no way to prevent perceivers from tacitly labeling the expressions, we made an effort to minimize this possibility, rendering expression matching analogical to identity matching in that overt labeling did not figure in either task.

Stimulus selection

Seventy Hebrew University students were photographed bearing five different expressions: neutral, happiness, disgust, surprise and anger. Subjects were asked to model the required expression twice, in two different ways. Colored portraits were taken from five different angles by a professional photographer. All had a uniform, blue background. None of the students wore glasses while being photographed and none had facial hair. Using Photoshop, all portraits were edited to remove earrings or other facial accessories as well as distinctive scars and bruises, and to equate size and luminosity.

[1] There are on going debates concerning the characterization of facial expressions in relations to internal emotional states. The questions concern the claims that there exists a universal mapping of facial expressions to emotions (ex. Russell, 1994; Fridlund, 1994).

The typicality of the posed expressions has been initially determined by asking a group of 40 Hebrew University students (24 males; 16 females; age 21;6-25; M=24.0) to label the expression on each face. Portraits of 44 individuals were selected (17 males and 27 females) for whom all five expressions were correctly identified by at least 34 out of the 40 judges (85%). Indeed, happiness and surprise were correctly identified by all participants, whereas anger and disgust were identified less accurately, yet never below the 85% accuracy. In order to control for pictorial similarity, stimuli were rated by a different group of 24 undergraduates, 12 males; 12 females; age 21-26; M= 24.2) in the following way. Each photographed person contributed six different images: Two images expressed happiness, two expressed disgust and two were neutral.. Two same-gender portraits were presented in each trial in one of four conditions: In the SPSE condition the two portraits were of the Same Person mimicking the Same Expression twice, in what the photographed person believed to be a different manner. In the SPDE the two portraits were of the Same Person mimicking Different Expressions. In the DPSE the two portraits were of Different Persons, both mimicking the Same Expression. In the DPDE the two portraits were of Different Persons each mimicking a Different Expression. Each photographed model was presented once in each condition yielding 88 trials (22 per condition), presented in random order. Participants were instructed to rate the pictorial similarity of the portraits within each pair.

Out of the 44 models, we selected 15 for whom, for both the same and different person comparisons, paired t-tests showed no significant differences between same and different expression conditions, for either similarity ratings or RT (i.e., SPSE ≈ SDDF and DFSE ≈ DFDE). The stimuli used in the following experiments were portraits of these 15 models. Note that the ratings guided our selection of *individuals* whose portraits served as stimuli. Thus, images of angry and surprised faces used in experiment 1 were of the same individuals whose happy and disgusted faced were rated in the pilot study and no significant differences were found between them.

Experiment 1

Experiment 1 investigated the influence of facial identity on matching expressions. Importantly, participants had to match expressions but did not have to label them, reducing the potential impact of overt semantic attribution. If the processing of expression-relevant information interacts with the processing of face identity, matching expressions should be better when the target and its expression-matched face are of the same person than when they are of different people, bearing the same expression.

Participants were requested to match the expressions of a target face to one of four test faces presented in either front or angular views. Jointly with the procedure of stimuli selection described above, the presentation of stimuli in different views minimized the possibility of matching images on the basis of pictorial similarity. In the Same Person condition (SP) the identity of the target face was the same as that of the four test faces, and in the Different Person condition (DP) the identity of the target face was different from the identity of the four test faces (of the same individual, see Figure 1).

Assuming interactive processes, we predicted that for all expressions, accuracy will be greater and reaction times will be faster when target and matched stimulus share the same identity (SP), than when target and matched stimulus have different identities (DP). We further predicted that although matching may be faster and more accurate for front views than for angular tilted faces the advantage of the SP condition will be seen for all views presented.

Methods

Participants Twenty four Hebrew University undergraduate students (8 males and 16 females) participated in this experiment for course credit or for payment. None of the participants in the present experiment took part in the procedure for stimulus selection.

Materials and Design: Images of 12 out of the 15 individuals (9 females; 8 males) selected on the basis of the procedure described above were used in the experimental trials, while images of the remaining individuals were used in the practice trials.

Displays consisted of a front expressive face as target, and four test faces placed underneath. Test faces were either front, or 45^0R i.e. face tilted 45^0 to the left such that participants saw the right side of the face, or 45^0L i.e. faces tilted 45^0 to the right such that participants saw the left side of the face. Test stimuli were either the same or different identity than the target face. To reiterate, all four test faces in a display shared the same identity, which could be either the same identity (SP) or different (DP) than the target face.

The experiment contained 288 sets representing the cross of congruence (2) X views (3) X expressions (4), for 12 photographed individuals. Two different versions of the experiment were created, each with 144 sets equally distributed between SP and DP conditions, with every individual appearing in two out of the four expressions in each version. Across the 72 trials in each condition, the position of the face that matched the target expression varied equally among all four corners. Subjects saw one version containing 144 displays. Figure 1 is an example of a display set. Additional eight displays used for training were prepared with images of individuals who did not appear in the experimental trials.

Insert Figure 1 about here

Procedure: Participants were requested to press the button as soon as they found 'The photograph that has the same expression as the image above'. Speed and accuracy of the response were equally emphasized. The buttons used to collect the responses were 7, 9, 1 and 3 on the keypad, corresponding to the four corners on the display where the faces appeared. No reference was made to the fact that faces varied in their identities. Displays were removed from the screen as soon as a response was recorded.

The stimuli were presented on a 17" EIZO computer monitor with a resolution of 1280 X1024 pixels and a refresh rate of 100 Hz. Seen from a distance of 70 cm, each face occupied 4.1º x 4.9º of the visual field. An ITI of 1 sec followed the response, during which the screen was blank. RTs were recorded from the trial onset with a 1000 Hz resolution.

Subjects were tested individually in a quiet room. The experiment started with eight training trials after which the 144 experimental trials were presented in a random order, with a short interval after the first 72 sets.

Results

As shown in Figure 2, matching was faster and more accurate when target and test faces shared the same identity (SP) than when the identity of the test stimuli was different than that of the target (DP). Importantly, the effect of identity congruence was observed in all viewing orientations and expression types. The statistical reliability of these effects was assessed by Congruence (SP, DP) X View (front, 45ºL, 45ºR) X Target expression (anger, disgust, happiness, surprise). The dependent variables were RT and accuracy.

Figure 2 about here

Reaction Times: Table 1 presents mean RT for the different experimental conditions. ANOVA of the RTs showed that matching face expressions across different individuals (DP) was significantly delayed relative to matching expressions of the same person (SP) [$F(1,23) = 43.9$, $MSe = 3780738$, $p < .001$]. There was a main effect of Expression $(3,69) = 23.8$, $MSe = 3722507$, $p < .001$] but no main effect for orientation [$F(2,46)=1.8$, $MSe = 2743523$, $p = .178$]. Post hoc univariate analysis of the effect of Expression showed that RTs to happy expressions (3793 ms) were faster than to the other expressions [5589 ms, 5081 ms, 5208 ms, for anger, disgust, and surprised, respectively; $F(1,23) = 50.2$, $p < .001$], and slower for anger than for both disgust [$F(1,23) = 4.8$, $p < .05$] and surprise [$F(1,23) = 4.4$, $p < .05$].

Although the congruence effect was qualified by a significant interaction with the expression on the target [$F(3,69) = 6.6$, $MSe = 1426425$, $p < .005$], additional Congruence X Orientation ANOVA, run separately for each Expression, showed that congruence speeded up responses for all expressions [$F(1,23) = 35.9$, $p < .001$, $F(1,23) = 27.2$, $P < .001$, $P(1,23) = 13.6$ $p < .005$, and $F(1,23) = 11.9$, $p < .005$, for anger, disgust, happiness and surprise, respectively). One way ANOVA of the congruency effects across expression types (that is, of the difference between the RT to the SP and to DP conditions), followed by univariate contrasts showed that the effect of SP was smaller for happy faces than for angry faces [$F(1,23) = 12.2$, $p < .005$], and for disgusted faces [$F(1,23) = 16.7$, $p < .005$], but no smaller than the effect for surprised faces [$F(1,23) = 2.6$, $p > .12$].

The effect of stimuli orientation differed across target expressions [F(6,138) = 2.7, p < .05]. Post hoc exploration of this interaction by ANOVA showed that the orientation effect was significant for disgust [F(2,46) = 6.5, p < .05], closed to significant for anger [F(2,46) = 3.2, p < .06], but was not significant for either happiness or surprise [for both expressions F(2,46) < 1.00]. The three-way interaction between Congruence, Orientation and Expression was not significant [F(3,128 = 1.2].

[Tables 1 and 2 about here]

Accuracy: As can be gleaned from Table 2, the pattern of results with respect to matching accuracy was very similar to the RT results, and those were analyzed with the same ANOVA design. Accuracy was significantly higher in the SP condition than in the DP condition [F(1,23) = 96.9; MSe = 1.0, p = 0.001], and there was neither a significant main effect of orientation [F(2,46) = 1.7, MSe = 1.6, p = 0.19], nor an interaction between orientation and congruence [F(2,46) = 2.9, MSe = 1.1, p = 0.068]. The main effect of expression type was significant [F(3,69) = 23.1 MSe = 6.6, p < .001], and significantly modulated the congruency effect [F(3,59) = 12.2, MSe = 1.6, p < .001]. Post hoc univariate analysis of expression type revealed that matching accuracy for happy targets (96.4%) was significantly higher than for all other expressions [82.4%, 73.0% and 76.7% for anger, disgust and surprise, respectively; F(1,23) = 151.3, p < .001]. In addition, accuracy for anger was higher than both disgust [F(1,23) = 4.6, p < .05] and surprise [F(1,23) = 6.2, p < .025]. No other interactions were significant.

Like for RTs, the Congruence X Expression interaction was explored by separate ANOVAs for each expression type. SP was significant for anger [F(1,23) = 15.8, MSe = 2.8, p < .005], for disgust [F(1,23) = 49.6, MSe = 2.2, p < .001], and for surprise [F(1,23) = 44.0, MSe = 1.1, p < .001], but not for happiness [F(1,23) < 1.0].

One-way ANOVA of the SP effect across target expressions showed that, indeed, the SP for happy faces (-0.2%) was significantly smaller than for all other effects [11.1%, 17.4% and 11.8% for anger, disgust, and surprise, respectively; $F(1,23) = 72.6$, $p < .001$].

Discussion

In experiment 1, participants were asked to match the identity of expressive images of 12 unfamiliar persons, presented in front as well as angular views. Labeling expressions was not required. The results suggest facilitation of expression matching when there was person identity, suggesting an interaction between matching identity and expressions on unfamiliar faces.

Accuracy results confirmed previous reports concerning the ease with which happiness can be identified relative to other expressions (Elfenbein & Ambady, 2002; Izard, 1994). This was reinforced by the absence of an accuracy effect of the SP condition on matching happy faces. Interestingly, in the DP condition, happy faces were more accurately matched compared to other expressions. Significant advantages in RT for happy faces were seen, however, in both SP and DP. Thus, given that accuracy reached ceiling for matching happy faces, the advantage of SP can be seen only in the speeded decisions.

Despite the fact that the images used in experiment 1 have been almost unanimously judged as conveying the expressions tested, participants were less accurate in matching expressions in all but happy faces. We suggest that the differences in performance between rating and matching expressions were due to the nature and conditions of the tasks. In the course of stimuli selection, participants were shown a single image and had to select a label from those provided by the experimenter. Participants were encouraged to take their time and be confident of their choices. Here, on the other hand, participants had to do a speeded matching to target, of one out of four expressive faces. Labels were not provided nor were they required. Apparently, the matching task induced errors of performance which the categorization task did not.

Could the facilitation observed be a reflection of judgments of pictorial similarity among conceptually neutral sets of facial features, without recourse to the notion of identity? Whereas this could be a valid criticism, recall that the impact of pictorial similarity has been reduced in the present study through the procedure for the selection of stimuli in which the images were rated for pictorial similarity between same and different expressions, and same and different individuals. It was further controlled in the design of the experiment through the requirement to match angular views to front targets. Importantly, there was no main effect of view, suggesting that angular views did not inhibit matching. Therefore, we suggest that matching was not a mere reflection of pictorial similarity.

The results of this experiment suggest the following: if faces have their own blue-prints for expressions such that, if one sees a face, it will facilitate the recognition of expressions on this face, then that which facilitates such matching does not differ from any other constituent property that determines the uniqueness of that specific face, i.e. its identity. We return to this point in the General Discussion.

Is there a parallel, facilitatory effect of same expression on identity matching? Recall that previous work demonstrated the effect of identity on expression recognition but was not clear on the effect of expressions on identity recognition (Schwienberger & Soukup, 1998; Schweinberger et al, 1999). Mutual interaction has therefore not been shown convincingly for unfamiliar faces. The next experiment is designed to investigate the effect of expression on identity matching of unfamiliar faces.

Experiment 2

In the present experiment participants were requested to match the identity of a target face to one of four test faces presented in either front or angular views. In the Same Expression condition (SE) the expression on the target face was the same as the expression on all four test faces, and in the Different Expression condition (DE) the expression on the target face was different from the expression shared by all four test faces.

Similar to Experiment 1, angular views were introduced along side with front views in order to minimize the possibility of matching images on the basis of pictorial similarity. Recall that the process of stimuli selection, described above, was likewise designed to control for this potential confound.

Assuming an interaction between processing face identity and expression, we predicted that accuracy will be greater and reaction times will be faster when target and matching stimulus will have the same expression (SE), than when target and matching stimulus will have different expressions (DE). We further predicted that although matching may be faster and more accurate for front views than for tilted faces the advantage of the SE condition will be seen in all three views presented.

Methods

Participants Twenty four Hebrew University undergraduate students (seven males and 17 females) participated in this experiment for course credit or for payment. None of the participants in the present experiment took part in either the procedure for stimulus selection or in Experiment 1.

Materials and Design: Images of 12 out of the 15 individuals (seven females; five males) selected on the basis of the procedure described above, were used in the experimental trials, while images of the remaining three individuals were used in the practice trials.

Displays consisted of a front-view target with a happy or a disgusted expression, and four test faces placed underneath. Test faces were either front, or 45^0R i.e. face tilted 45^0 to the left such that participants saw the right side of the face, or 45^0L i.e. faces tilted 45^0 to the right such that participants saw the left side of the face. Test stimuli were bearing either the same or a different expression than the target face. To reiterate, all four test faces in a display shared the same expression- happy or disgusted - which could be either the expression of the target face (same expression -SE) or an alternative expression (different expression -DE).

Altogether 144 trials were presented to the participants in the experimental phase, equally distributed between SE and DE conditions. Each individual appeared in 12 trials, six times in each condition. Among the six repeated presentations, three were of a disgusted face and three of a happy face, with matching test faces randomly placed in one of the four corners of the display. Across the 72 trials in each condition, the position of the face that matched the target identity varied equally among all four corners. Figure 3 is an example of a display set. Additional eight displays used for training were prepared with images of individuals who did not appear in the experimental trials.

Insert Figure 3 about here

Procedure: Participants were requested to press the button as soon as they found 'The photograph that has the same person as the image above'. The buttons used to collect the responses were 7, 9, 1 and 3 on the keypad, corresponding to the four corners on the display where the faces appeared. No reference was made to the fact that faces varied in their expressions. Speed and accuracy were equally emphasized. Displays were removed from the screen as soon as a response was recorded.

The stimuli were presented on a 17" EIZO computer monitor with a resolution of 1280 x 1024 pixels and a refresh rate of 100 Hz. Seen from a distance of 70 cm, each face occupied 4.1º x 4.9º of the visual field. An ITI of 500 ms followed the response, during which the screen was blank. RTs were recorded from the trial onset with a 1000 Hz resolution. Subjects were tested individually in a quiet room. The experiment started with eight training trials after which the 144 experimental trials were presented in a random order, with a short interval after the first 72 sets.

Results

As shown in Figure 4, matching was faster and more accurate in the SE condition than in the DE condition. Importantly, whereas there were noticeable differences among views and expressions, the effect of expression congruence was observed across all views and expression types. The statistical reliability of these effects was assessed by Congruency (SE, DE) X View (front, 45ºL, 45ºR) X Target expression (happiness, disgust). The dependent variables were RT and accuracy.

Figure 4 about here

Reaction Times: Table 3 presents mean RT for the different experimental conditions. ANOVA of the RTs showed that identifying faces in the DE condition took significantly longer than identifying faces in the SE condition [$F(1,23) = 28.5$, $MSe = 124035$, $p < .001$]. There was a main effect of View [$F(2,46)=25.8$, $MSe = 117670$, $p < .001$], but no effect of Expression type [$F(1,23) < 1.0$]. Post hoc contrasts showed that RTs differed according to Views. RT was faster for front-view stimuli (2216 ms) than for 45ºR view (2415 ms) [$F(1,23) = 20.3$, $MSe = 746739$, $p < .001$] and slowest for 45ºL view (2571 ms) [$F(1,23) = 41.2$, $MSe = 1173364$, $p < 001$]. The difference between the two tilted views was also significant [$F(1,23) = 10.3$ $MSe = 903988$, $p < .005$].

The only significant interaction was between View and Congruence [F(2,46)=3.6, MSe = 81701, p<0.05]. One-way ANOVAs for each view showed that Congruence was, in fact, significant at all views [F(1,23) = 39.6 MSe = 73647, p < 0.001, F(1,23) = 5.2 MSe = 90640 p < 0.05, and F(1,23) = 6.0 MSe = 123149, p < 0.025, for the front-view, 45ºR-view and 45ºL-view, respectively.

Tables 3 and 4 about here

Accuracy: Table 4 presents mean accuracy for the different experimental conditions. The main effect of Congruence approached significance [F(1,23) = 3.1; MSe = 0.4, p = 0.09], the main effect of View was significant [F(2,46) = 9.4, MSe = 0.4, p < 0.001] and there was no main effect of Expression type [F(1,23) < 1.0]. The effect of Congruence, however, was qualified by an interaction with Expression type [F(1,23) = 10.5, MSe = 0.7, p < .01], a trend of interaction with View [F(2,46) = 3.1, MSe = 0.4, p = .07], and by a second order interaction between the three factors [F(2,46) = 4.8, MSe = 0.3, p < .025]

Addressing first the significant effect of view, post hoc contrasts showed that accuracy was significantly higher for front-view stimuli (96.4%) than for either 45ºL (92.5%) or 45ºR (93.6%) views [F(1,23) = 13.7, MSe = 2.2, p < .01 and F(1,23) = 12.4, MSe = 4.5, p < .01, respectively], and there were no differences between right and left angular views [F(1,23) = 1.5, MSe = 2.8, NS].

The sources of the interactions were assessed using separate one-way ANOVA for each visual angle, followed by planned t-tests. These analyses showed no significant main effects when faces were seen in front view [F(1,23) < 1.0 and F(1,23) = 2.1 MSe = 0.1, p = 0.16 for condition and expression , respectively]. Similarly, there were no main effects for the 45ºR view [F(1,23) < 1.0, for both congruency and expression]. In contrast, for the 45ºL view, accuracy was significantly higher in the SE (94.9%) than in the DE (90.6%) condition [$F(1,23) = 4.7$, $MSe = 0.7$, $p < .05$]. However, a significant Congruence X Expression interaction [$F(1,23) = 14.3$, $MSe = 0.5$, $p < 0.01$], followed by planned t-tests revealed that the significant Congruence effect held only for matching happy-happy and happy-disgusted faces [$t(23) = 3.469$, $p < .01$]. When the target face was disgusted the difference between SE and DE was not significant [$t(23) = 1.273$, $p = .22$].

Discussion

While trends were in the predicted direction the accuracy of identity matching was facilitated by the similarity of expression between target and test faces only for happiness, and only when the test faces were tilted to the right, that is, the subject saw the left side of the faces. It is possible that the absence of a stronger effect of expression congruence on accuracy reflects a ceiling effect. Since there was no time limitation and performance was mostly above 95% correct, this might have obscures subtle differences between SE and DE conditions for accuracy, although this leaves open the question as to why this effect was significant for happy faces.

On the other hand, the RT results clearly showed that matching the identity of two unfamiliar faces was considerably faster in the SE than in the DE condition. While faster performance was seen in front views, the advantage of matching faces that shared expressions was evident across the different angles as well. We suggest that although facilitation effects varied according to the details of the task, involving all the manipulated variables, the overall pattern suggests a genuine interaction between processing expression and processing identity.

Finally, the current findings do not converge on previous reports in which it was shown that the left side of the face is more easily identified than the right side of the face (Sieroff, 2001; Kowatari et al. 2004 and many others). While accuracy was similar for the two views of titled faces, RTs were significantly faster for faces in which the right side of the face was exposed to the viewer than when the viewer saw the left side of the face. We do not have an explanation for this finding, yet we would like to stress the fact that the angular views nevertheless, served their intended purpose which was to minimize the effects of pictorial matching.

General Discussion

The current study set out to investigate the mutual interactive effects between face identification and recognition of facial expressions. The selection of stimuli and the mode of presentation minimized potential effects of pictorial similarity and the task did not require overt semantic attribution. Moreover, participants had a single exposure to the unfamiliar faces in the course of the task, thus matching could not rely on memory and had to be performed on the basis of an on-the-spot structural encoding. Such measures, we rationalized, would afford a more direct test of the interactive effects between identity and expression matching.

Our results were consistent in showing mutual facilitation effects between identity and expression matching of unfamiliar faces. Matching expressions of unfamiliar faces was faster and more accurate for front as well as angular views of faces portraying the same person, than for faces portraying different people (experiment 1); matching identity of unfamiliar faces presented in frontal as well as in angular views was faster and more accurate for faces bearing the same expression than for faces bearing different expressions (experiment 2).

Similar to previous work (e.g. Schwienberger and colleagues, 1998; 2000), results shown in Tables 1-4 suggest a considerably stronger effect of identity over expression matching than of expression over identity matching.[2] This result is not surprising given that expressions are generalized categories whereas identities are idiosyncratic. It is therefore likely that face-specific properties are more central to identity, and there are limited structural aspects of expression that can benefit identity recognition. As for the effects of identity on expression recognition, it must be the case that the physiognomy of the face delineates the range of potential facial movements and hence, the variations available to the face when conveying expressions. The facial musculature moves within its unique coordinates regulating the molding of the face to form culturally-acceptable variants for a given expression. Identity recognition therefore entails recognition of the ways in which the face can move and become expressive. As specified by Bruce & Young (1986), these features are probably extracted during the structural encoding stage, which is the common basis for recognizing expression as well as identity. Our present data shows that this interaction has measurable consequences.

The results of the current experiments showed that behavior differs for the different expressions, with happy being the easiest and the fastest. This is in line with previous work in which expressions of happy faces were more easily recognizable. Earlier work showed happy to be universal, whereas other expressions were more culture specific (Elfenbein & Ambady, 2002; Izard, 1994). Results likewise show that front views allowed for more accurate as well as faster matching. Yet, while views and expression types affected performance, congruency between the target and the irrelevant dimension was a major facilitating factor at all times.

In conclusion, our results are in line with recent studies that argue for an interactive, processing approach to structural encoding of facial information that

[2] While experiment 1 had four expressions, experiment 2 had only two. Consequently, we preferred not to compare them statistically.

allows for cross-talk between higher and lower levels of analyses from early on. A recently proposed model by Haxby et al. (2000; 2002) is an example of a theoretical framework within which one can conceptualize such interactive processes. Haxby et al (2000) were concerned primarily with the neural bases for face perception. While still within the separation framework, Haxby et al suggest a procedure for face processing with a core system that comprises three regions of occipitotemporal visual extrastriate cortex, and an extended neural system involved in interpretative aspects of faces. They propose two separate procedures, with different anatomical foci that are within this core system. One sub-procedure is engaged in the analysis of the invariant features of faces, and those relate to identity, whereas the other processes variant features, which are the features most relevant to expressions, eye gaze direction and speech related movements, i.e. information that is most relevant to social interaction. Interestingly, although Haxby et al. (2000; 2002) state that core components that process identity and expression at the perceptual level are separate, in a diagram representing this model there is a bi-directional arrow connecting these systems. Our results suggest that this bi-directional arrow correctly represents the interaction that exists between the core components. Furthermore, the fact that the irrelevant dimension facilitated decision about the relevant dimension in our experiments suggests that there is no clear-cut separation between what Haxby et al labeled core systems that are perceptual in nature, and the extended neural systems that are engaged in assigning meaning to the perceived stimuli. Attribution, although not necessarily overt, seems to be taking place within core systems as well. Recent imaging data, suggesting the involvement of the FFA in processing expressions (Ganel et al., 2005; Pessoa et al. 2002) lend further support to this contention.

Authors note

This study has been supported by Milton and Silvia Bard Fund as well as by NIMH grant R01 MH 64458 to SB. We would like to thank Nofit Zecharia and Efrat Oust for running the experiment and participating in the analyses of the data. Tal Golan provided efficient research assistance.

References

Adolphs, R. (2002) Neural systems for recognizing emotions. *Current Opinion in Neurobiology, 12,* 169-177.

Baudouin, J. Y., Martin, F., Tiberghien, G., Verlut, I., & Franck, N. (2002). Selective attention to facial identity and emotion in schizophrenia. *Neuropsychologia, 40,* 503-511 (1996).

Benton, A.L., Sivan, A. B., Hamsher, K. Varney, N. R. & Spreen, O. (1994) *Contributions to neuropsychological assessment*. New York: Oxford University Press.

Braun, C. M., Denault, C, Cohen, H, Rouleau, I. (1994) Discrimination of facial identity and facial affect by temporal and frontal lobectomy patients. *Brain and Cognition, 24(2),* 198-212

Bruce, V. (1986) Influences of familiarity on the processing of faces. *Perception, 3,* 105-135.

Bruce, V. & Young, A. (1986) Understanding face recognition. *British Journal of Psychology, 47A,* 5-28

Calder, A. J., Burton, A. M., Miller, P., Young, A. W., & Akamatsu, S. (2001). A principal component analysis of facial expressions. *Vision Research, 41,* 1179-1208.

Calder, A. J., Young, A. W., Kean, J., & Dean, M. (2000) Configural information in facial expression perception. *Journal of Experimental Psychology: Human Perception and Performance, 26(2),* 527-551.

Calder, A. J., Young, A. W., Rowland, D., Perrett, D. I., Hodges, J. R. & Etcoff, N. (1996). Facial emotion recognition after bilateral amygdala damage differentially severe impairment of fear. *Cognitive Neuropsychology, 13,* 699–745.

Campbel, R., Brooks, B., de Haan E. & Roberts, T. (1996) Dissociating face processing skills: Decisions about lip read speech, expression and identity. *The Quarterly Journal of Experimental Psychology, 49A,* 2, 295-314

de Gelder B, Frissen I, Barton J, Hadjikhani N (2003) A modulatory role for facial expressions in prosopagnosia. *Proceedings of the National Academy of Sciences* (pp.13105-13110, *100(22).*

Ekman, P. (1975). Face muscles talk every language. *Psychology Today, 9* (4)

Ekman P. & Friesen, W. V. (1971) Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology, 17,* 124-129.

Elfenbein, H. A. & Ambady, N. (2002) On the universality and cultural specificity of emotion recognition: a meta-analysis. *Psychological Bulletin, 128(2),* 203-235.

Endo, N., Endo, M., Kirita, T., and Maruyama, K. (1992). The effects of expression on face recognition. *Tohoku Psychological Folia* **52:** 37–44.

Fridlund, A. J. (1994). *Human facial expression.* San Diego, CA: Academic Press

Ganel, T & Goshen-Gottstein, Y. (2004) Effects of Familiarity on the Perceptual Integrality of the Identity and Expression of Faces: The Parallel-Route Hypothesis Revisited. *Journal of Experimental Psychology: Human Perception & Performance. 30(3),* 583-597

Ganel, T, Goshen-Gottstein, Y. & Goodale, M. A. (2005). Interactions between the processing of gaze direction and facial expression. *Vision Research, 45,* 1191-1200.

Ganel, T, Valyear, K. F. Goshen-Gottstein, Y. & Goodale, M. A. (2005) The involvement of the "fusiform face area" in processing facial expression *Neuropsychologia 43, 1645–1654*

Garner, W. R. (1976). Interaction of stimulus dimensions in concept and choice processes. *Cognitive Psychology, 8,* 89-123

Hancock, P. J. B., Bruce, V., & Burton, A. M. (2000) Recognition of unfamiliar faces. *Trends in the Cognitive Sciences, 4(9),* 330-337.

Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2000). The distributed human neural system for face perception. *Trends in Cognitive Science, 4,* 223–233.

Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2002).Human neural systems for face recognition and social communication. *Biological Psychiatry, 51*, 59–67.

Humphreys, G. W., Donnelly, N. & Riddoch, M. J. (1993). Expression is computed separately from facial identity, and it is computed separately for moving and static faces: Neuropsychological evidence. *Neuropsychologia, 31*, 173-181.

Izard, C. E. (1994). Innate and universal facial expressions: Evidence from developmental and cross-cultural research. *Psychological Bulletin, 115*, 288-299

Kaufman, J. M. & Schweinberger, S. R. (2004) Expression influences the recognition of familiar faces. *Perception, 33*, 399-408.

Keane J, Calder, A. J., Hodges, J.R., Young, A.W. (2002) Face and emotion processing in frontal variant frontotemporal dementia. *Neuropsychologia. 40(6)*, 655-65

Kowatari Y, Yamamoto M, Takahashi T, Kansaku K, Kitazawa S, Ueno S, Yamane S (2004) Dominance of the left oblique view in activating the cortical network for face recognition. *Neuroscience Research, 50 (4),* 475-480.

le Gal, P., & Bruce, V. (2002). Evaluating the independence of sex and expression in judgments of faces. *Perception & Psychophysics, 64,* 230-243

Pessoa, L., McKenna, M., Gutierrez, E., & Ungerleider, L. G. (2002) Neural processing of emotional faces requires attention. In: *Proceedings of the National Academy of Sciences (*pp.11458–11463*), 99.*

Posamentier, M. T.,& Abdi, H. (2003). Processing faces and facial expressions. *Neuropsychology Review, 13,* 113-143.

Russell, J. A. (1994). Is there universal recognition of emotion from facial expression? A review of the cross-cultural studies. *Psychological Bulletin, 115,* 102-141

Salem, J. E., Kring, A. M. & Kerr, S. L. (1993) More evidence for generalized poor performance iin facial emotion perception in schizophrenia. *Journal of abnormal Psychology, 102(2),* 312-318.

Sansone, S., Luaute, J. P., Bidault, E. & Tiberghien, G (1998) Une conception neuropsychologique unitaire du syndrome de Capgras. *Annales-Medico-Psychologiques. 156 (7),* 433-444

Sansone, S., & Tiberghien, G. (1994). Traitement de l'expression faciale et reconnaissance des visages: Independence ou interaction? *Psychologie Francaise, 39*(4), 327–344.

Schweinberger, S. R., Burton, A. M., & Kelly, S. W. (1999). Asymmetric dependencies in perceiving identity and emotion: Experiments with morphed faces. *Perception & Psychophysics, 61,* 1102-1115

Schweinberger, S. R & Soukup, G. R. (1998) Asymmetric relationship among perceptions of facial identity. *Journal of Experimental Psychology: Human Perception and Performance, 24(6),* 1748-1765.

Sieroff, E. (2001) Feature processing and superiority of three-quarter views in face recognition. *Brain and Cognition, 46*, 272–276.

Tarr, M.J. & Bülthoff, H.H. (1995). Is human object recognition better described by geon-structural-descriptions or by multiple-views? Journal of Experimental Psychology: *Human Perception and Performance, 21*, 1494-1505.

Tranel, D., Damasio, A. R., & Damasio, H. (1988). Intact recognition of facial expression, sex, and age in patients with impaired recognition of face identity. *Neurology, 28*, 690-696.

Young, A. W., McWeeny, K. H., Hay, D. C., and Ellis, A. W. (1986). Matching familiar and unfamiliar faces on identity and expression. *Psychological Research, 48*, 63–68.

Young, A. W., Newcombe, F., de Haan, E. H. F., Small, M. & Hay, D. C. (1993). Face perception after brain injury. *Brain, 116*, 941-959

Young, A. W., Hellawell, D. J., van de Wal, C., & Johnson, M. (1996). Facial expression processing after amygdalotomy. *Neuropsychologia, 34*, 31-39

Table 1. RTs in milliseconds (SEm) in the SP and DP conditions in Experiment 1-Expression Matching task

	SP			DP		
Expression	Front	45ºL	45ºR	Front	45ºL	45ºR
Anger	4354 (378)	5007 (260)	5459 (494)	6298 (561)	5765 (425)	6654 (645)
Disgust	4335 (313)	3959 (304)	4446 (304)	6616 (639)	5332 (479)	5798 (481)
Happiness	3541 (237)	3539 (245)	3523 (232)	4121 (328)	4149 (262)	3892 (269)
Surprise	4961 (415)	4898 (366)	4647 (451)	5807 (531)	5286 (444)	5835 (553)

Table 2. Percent correct matching of expressions (SEm) in the SP and DP conditions in Experiment 1 - Expression Matching task

	SP			DP		
Expression	Front	45ºL	45ºR	Front	45ºL	45ºR
Anger	91.7% (2.0%)	85.4% (2.9%)	86.8% (2.2%)	78.5% (3.1%)	77.1% (3.6%)	75.0% (4.5%)
Disgust	81.9% (4.2%)	80.6% (3.8%)	82.6% (3.7%)	61.1% (5.9%)	67.4% (5.7%)	64.6% (4.6%)
Happiness	98.6% (1.0%)	95.8% (3.1%)	94.4% (2.2%)	98.6% (1.0%)	95.1% (2.1%)	95.8% (1.8%)
Surprise	86.8% (2.7%)	84.0% 2.3%)	77.1% (4.1%)	70.8% (3.1%)	65.3% (3.6%)	76.4% (3.2%)

Table 3. RTs in milliseconds (SEm) in the SE and DE conditions in Experiment 2 - Identity Matching task

	Same Expression		Different Expression	
	Target-Test	Target-Test	Target-Test	Target-Test
	H-H	D-D	H-D	D-H
Front	2041 ms (118)	2043 ms (101)	2435 ms (143)	2346 ms (126)
45ºL	2534 ms (174)	2468 ms (152)	2669 ms (181)	2613 ms (164)
45ºR	2344 ms (130)	2276 ms (141)	2440 ms (175)	2566 ms (155)

Table 4. Percentage of correct matching of expressions (SEm) in the SE and DE conditions in Experiment 2 - Expression Matching task

	SE		DE	
	Target-Test	Target-Test	Target-Test	Target-Test
	Happy-Happy	Disgust-Disgust	Happy-Disgust	Disgust-Happy
Front	97.2 (1.1)	95.5 (1.5)	96.5 (1.0)	96.2 (1.0)
45ºL	96.5 (1.1)	92.4 (1.7)	87.5 (2.5)	93.7 (1.9)
45ºR	95.5 (1.3)	91.7 (1.7)	92.0 (2.1)	95.1 (1.1)

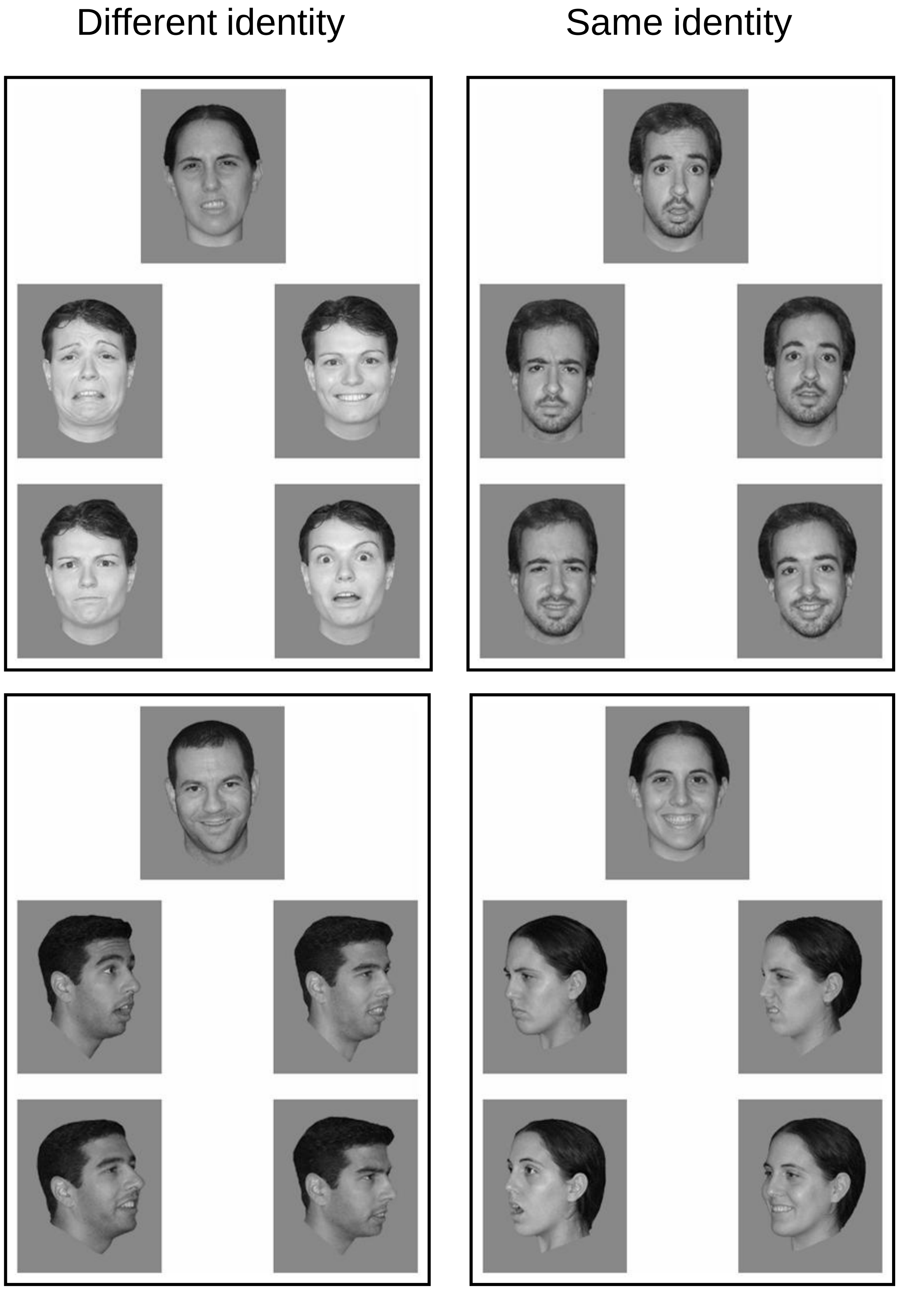
Figure captions:

Figure 1: A display set for Experiment 1 – Expression matching task

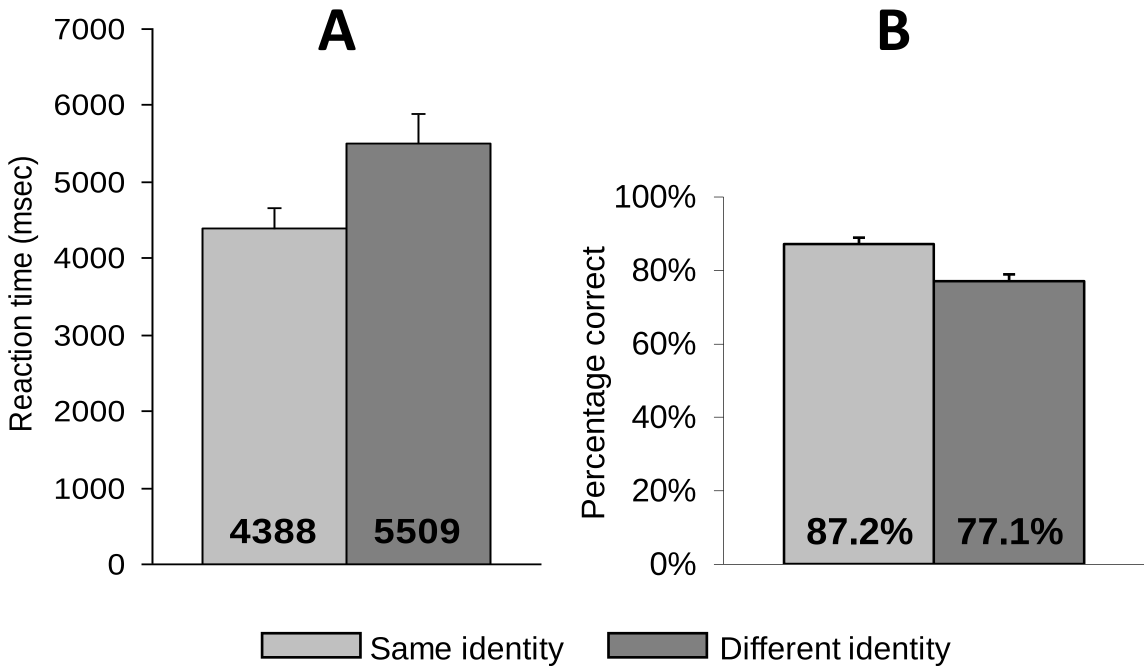
Figure 2: (A) Reaction times (in milliseconds) and (B) Accuracy (percentage of correct responses) in matching facial expressions between faces of same and different identity. The error bars are standard errors of the mean.

Figure 3: A display set for Experiment 2 – Identity matching task

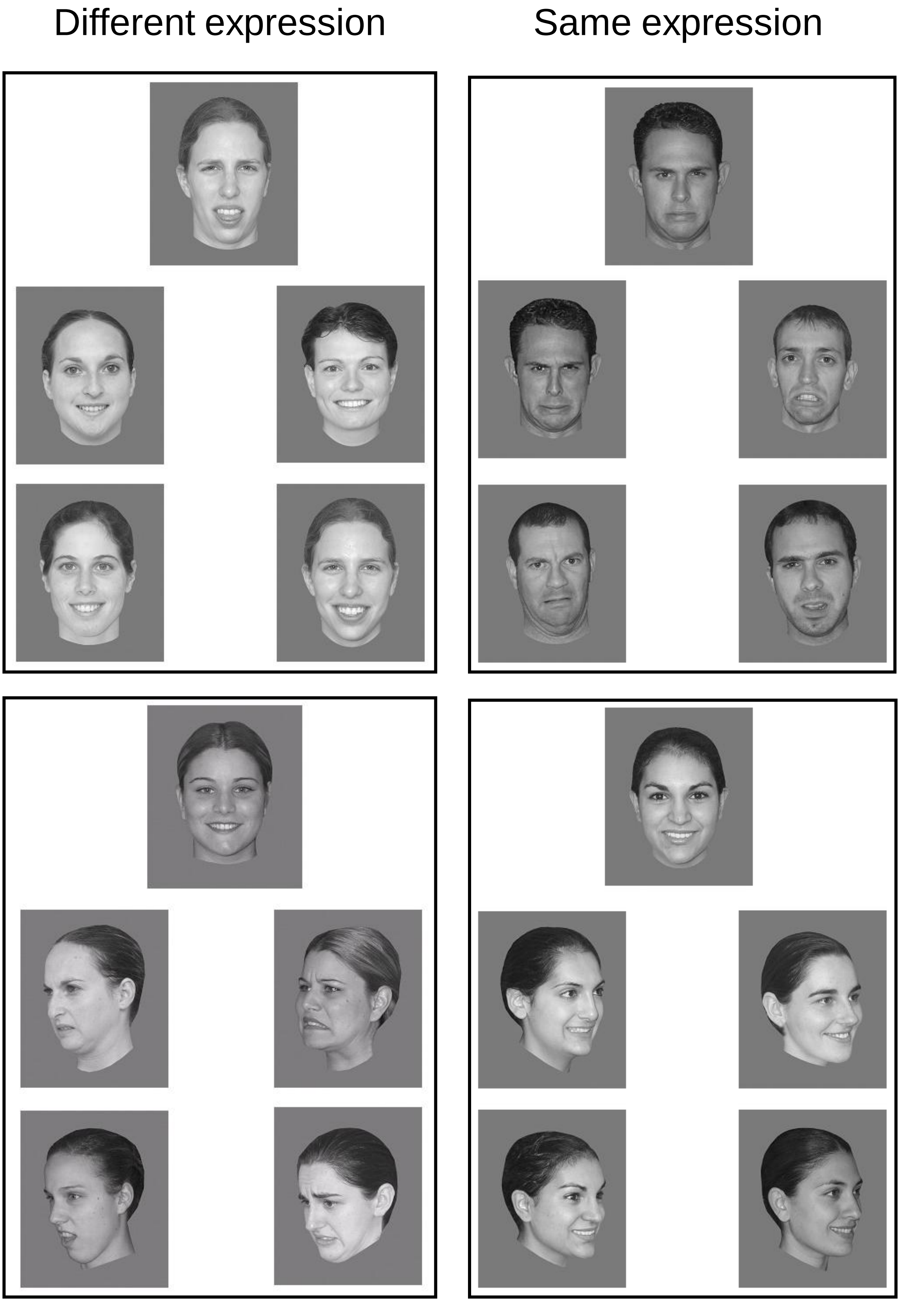
Figure 4: (A) Reaction times (in milliseconds) and (B) Accuracy (percentage of correct responses) in identity matching between faces with same or different expressions. The error bars are standard errors of the mean.



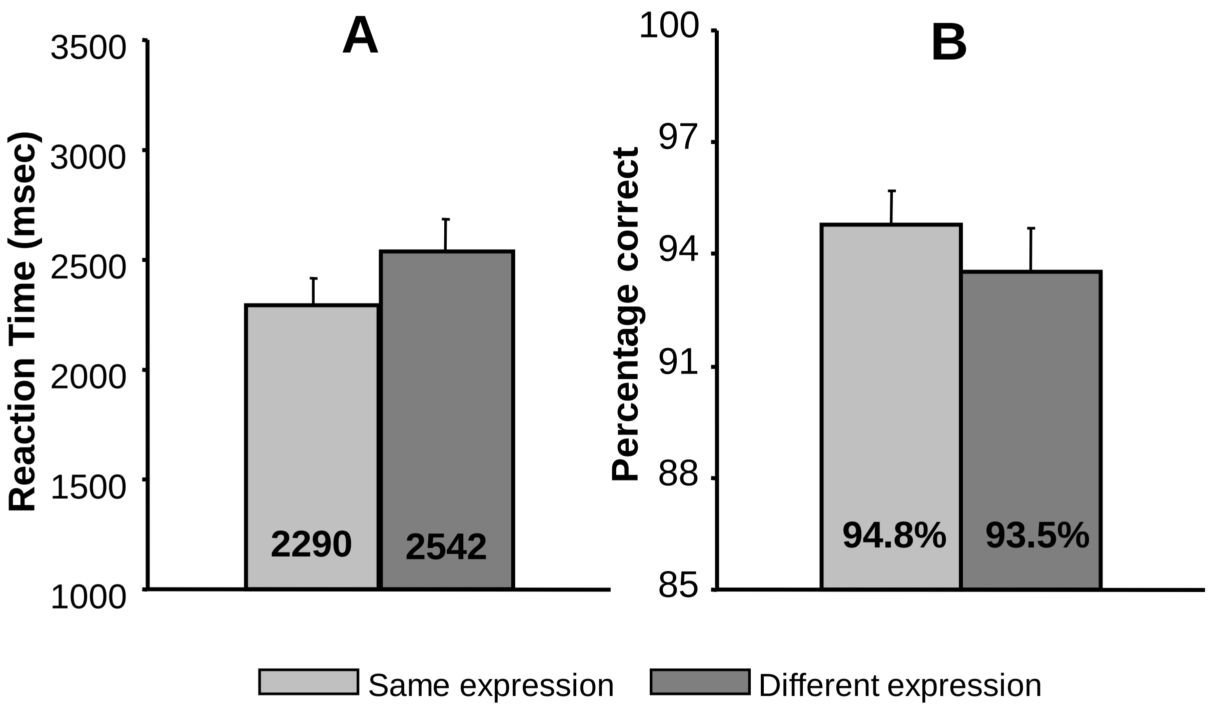
Levy & Bentin Figure 1



Levy et al., Figure 2



Levy & Bentin Figure 3



Levy & Bentin., Figure 4