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Smiles in face matching: Idiosyncratic information revealed through a smile improves unfamiliar face matching performance

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Abstract

Unfamiliar face matching is a surprisingly difficult task, yet we often rely on people's matching decisions in applied settings (e.g. border control). Most attempts to improve accuracy (including training and image manipulation) have had very limited success. In a series of studies, we demonstrate that using smiling rather than neutral pairs of images brings about significant improvements in face matching accuracy. This is true for both match and mismatch trials, implying that the information provided through a smile helps us detect images of the same identity as well as distinguishing between images of different identities. Study 1 compares matching performance when images in the face pair display either an open mouth smile or a neutral expression. In Study 2 we add an intermediate level, closed mouth smile, in order to identify the effect of teeth being exposed and Study 3 explores face matching accuracy when only information about the lower part of the face is available. Results demonstrate that an open mouth smile changes the face in an idiosyncratic way which aids face matching decisions. Such findings have practical implications for matching in the applied context where we typically use neutral images to represent ourselves in official documents.

Introduction

The faces we see in our everyday lives allow us to extract information, such as age, gender, mood, and even personality with varying levels of accuracy and agreement (Albright et al., 1997; Bruce & Young, 1986; Rule, Krendl, Ivcevic, & Ambady, 2013; Todorov, Olivola, Dotsch, & Mende-Siedlecki, 2015). Given our expertise with faces, it is surprising that matching two images (i.e., deciding whether they depict the same person or not) is a particularly error-prone task (Bruce et al., 1999; Bruce, Henderson, Newman, & Burton, 2001; Megreya & Burton, 2006; 2008). This is true in even the most favourable circumstances – with images taken on the same day, in good lighting and similar view of the face (Burton, White, & McNeill, 2010).

The frailty of face matching performance, paired with the importance of recognition accuracy in the applied context, has motivated empirical work to establish ways of improving recognition, including training, feedback and exposure to face variability. Unfortunately, despite some improvement, the benefits of such methods are either short-lived or associated with important limitations. Training is the most widely-accepted way of enhancing recognition accuracy in applied settings, however there is little to no evidence for the effectiveness of short-term and intensive training courses (Dolzycka, Herzmann, Sommer, & Wilhelm, 2014; Woodhead, Baddeley, & Simmonds, 1979; although see Towler, White, & Kemp, 2017). This is further highlighted by the lack of association between years of employment as a passport officer and face matching accuracy (White, Burton, Jenkins, & Kemp, 2014a), implying that experience alone cannot produce any significant improvements in face recognition.

Other approaches involve providing participants with performance feedback after every face matching decision or presenting multiple images of the target identity. Feedback is used to alert participants to the unexpected difficulty of the task, whereas showing participants different images of the same person might help them gain important information about the way people vary. While there are studies showing improved face matching performance following these two approaches (White et al., 2014a; White, Kemp, Jenkins, & Burton, 2014b), their benefits are seen in either match or mismatch trials only. Some argue this might be due to a shift in response bias where participants are more likely to classify face pairs as matches rather than mismatches. (Alenezi & Bindemann, 2013). Finally, a simple manipulation that has been shown effective in face matching tasks is aggregating individual responses (White, Burton, Kemp, & Jenkins, 2013) or pairing participants together and asking them to come to a joint decision (Dowsett & Burton, 2015). This, however, might be difficult to implement in an applied context.

Here, we propose an alternative method to face matching improvement that focuses on images rather than perceivers. As we express different emotions our faces reveal information that reflects both anatomical changes in the positioning of bones or muscle contractions as well as idiosyncratic activation patterns related to specific emotions. A smile, in particular, is one of the most common and universally recognised emotional expressions. It generally involves two facial muscles – zygomaticus major whose contraction pulls lip corners up and orbicularis oculi whose contraction leads to changes in the eye region such as wrinkles in the eye corners (crow's feet), narrowing of the eye opening, and bags under the eyes becoming more pronounced (Ekman, 1992). It is, therefore, possible that such changes might reveal

further identity-diagnostic information that can be used to enhance face matching performance. This is particularly relevant in the applied context where a lack of emotional expression is required when using face images in an official capacity (e.g. in passports and national IDs).

Evidence for this suggestion comes from the automatic face recognition literature where different computational algorithms are used to maximise recognition accuracy. Yacoob and Davis (2002), for example, used a PCA-based algorithm to extract the statistical properties of neutral, angry, and happy faces. They then tested how well this model could discriminate between identities and demonstrated that expressive faces had higher discrimination power, meaning that identities were recognised more often when an expressive image was used to represent them in the algorithm. Moreover, neutral images were identified less successfully both when the model was trained on neutral and expressive faces. Emotional faces, on the other hand, had high discrimination power regardless of the image set used to trait the model. Such findings imply that expressive faces provide some extra identity-diagnostic information that can enhance recognition, at least computationally. This is further supported by meta-analytic studies that explore the key factors affecting recognition performance by comparing different face recognition algorithms. A consistent finding is that recognition is significantly impaired when the target and query images express different emotions (Lui et al., 2009), however, when both the target and query images display the same expression all algorithms have higher estimated probability of verification when both faces are smiling (Beveridge, Givens, Phillips, & Draper, 2009).

Human face recognition studies replicate the detrimental effect of incongruent emotional expressions on recognition accuracy. Bruce (1982), for example, manipulated both view (full

face vs ¾ view) and emotional expression (smile vs neutral) in an old/new recognition paradigm and showed a decrease in hit rates from 90% for congruent emotion pairs to 81% when there was a mismatch in emotional expression (e.g. seeing a neutral image at learning and a smiling image at test). This pattern of results was later reported using a 1 in 10 face matching task (Bruce et al., 1999) implying that emotion incongruence affects both face memory and perception.

Given the findings of automatic recognition systems, it is surprising that no behavioural study has explored the influence of expression on emotionally-congruent face matching performance. The studies below aimed to address this and investigate whether a smile provides any further identity-diagnostic information that can be used to enhance face matching performance. In study 1 we compare face matching accuracy with images in the face pair displaying either a neutral expression or an open-mouth smile. Study 2 replicates Study 1 with an additional closed-mouth smile condition in order to establish the effect of teeth exposed. Finally, Study 3 aims to establish whether information about the shape of mouth and teeth is sufficient to improve matching accuracy. Here, participants perform a face matching task where only the lower part of the face, and the mouth in particular, is visible. Altogether, studies show consistent improvements in face matching accuracy when both images in the face pair display a smile rather than a neutral expression.

Study 1: Neutral vs. Smile

In this study, participants were presented with two images on the screen and asked to decide whether they were of the same person or of two different people. Images in each pair

displayed either a neutral expression or a smile. For consistency, only images with an open mouth smile were included in the set. Based on findings from the automatic face recognition literature (Beveridge et al., 2009; Lui et al., 2009), we expect higher matching accuracy when comparing two smiling rather than neutral images. Results followed the predicted direction and showed an improvement in face matching accuracy for both match and mismatch trials.

Method

Participants

A total of 40 participants (2 male, M = 19.6, age range = 19-24) from the University of X took part in the study. All had normal or corrected-to-normal vision and received payment or course credit for their participation. Sample size was based on previous literature on face matching (e.g. Megreya & Burton, 2006). A post hoc power analysis in GPower (Erdfelder, Faul, & Buchner, 1996) indicated that with the present sample we have achieved more than 95% power with alpha at .05. Informed consent was provided prior to participation and experimental procedures were approved by the ethics committee of the Psychology Department at the University of X.

Materials

A total of 120 face pairs were used as experimental stimuli. These comprised 60 same (match) and 60 different (mismatch) face pairs. In half of those pairs both images displayed a neutral expression and in the other half both images displayed a smile (see Figure 1 for examples). For match pairs both images depicted the same person, whereas mismatch pairs

contained images of two different people – one of the target identity and one of a foil identity matching the verbal description of the target. Images of the same foil identity were used in the neutral and in the smiling condition.

The images used in this experiment were of 60 non-UK professional athletes (30 male, mean age = 31.9, age range = 23-52). They were selected because they are unfamiliar to UK viewers, but multiple photos were available. In addition, the photos were somewhat more naturalistic than media stars typically used in this type of experiment, in that the faces had only minimal make-up and hair styling. All images were downloaded from a Google Image Search by entering the name of the athlete and choosing the first images in full colour, broadly frontal, and with no parts of the face obscured by clothing or glasses. For both target and foil identities we collected as many images as possible, then used a random number generator to determine which photograph to use as a target, match and foil image. Only images with an open-mouth smile were used for this experiment.

FIGURE 1 HERE PLEASE

Design and Procedure

The experiment used a 2 (smile / neutral) x 2 (identity match / mismatch) design. All participants completed 60 trials of a face matching task. For this task, participants were presented with two images on the screen and asked to decide whether these images were of the same person or of two different people by pressing corresponding keys on the keyboard ('a' for same and 'l' for different). The task was not timed, however participants were encouraged to be as quick and accurate as possible. Participants completed an equal number of match and mismatch trials as well as an equal number of smile and neutral trials. They saw

images of each identity twice, however the conditions they saw them in were counterbalanced so that participants never saw the same image twice. In match trials, participants were presented with two different images of the same identity, whereas in mismatch trials they saw images of two different identities (see Figure 1 for examples). On neutral trials, both images in the face pair had a neutral expression, whereas on smiling trials both faces displayed an open mouth smile. Trial order was randomised individually for each participant.

Results and Discussion

Mean matching accuracy across all conditions is presented in Figure 2. A 2 x 2 within subjects ANOVA (expression: neutral vs smile; trial type: match vs mismatch) revealed a significant main effect of expression (F (1, 39) = 25.33, $p < .001$, $\eta_p^2 = .39$) as well as trial type (F (1, 39) = 24.31, $p < .001$, $\eta_p^2 = .38$). There was no significant interaction (F (1, 39) < 1, $p > .05$, $\eta_p^2 = .01$).

FIGURE 2 HERE PLEASE

Results showed that using smiling images in a matching task led to a 9% improvement in accuracy for match trials and a 7% improvement in mismatch trials. This is an important finding as most methods of improving face matching such as facial caricaturing (McIntyre, Hancock, Kittler, & Langton, 2013) or using multiple images per identity (White et al., 2014a) have had limited success. Here, we demonstrate a significant improvement for both match and mismatch trials by just providing further information about the face such as smile

and teeth shape and smile lines around the mouth and eyes. This extends findings from automatic face recognition algorithms (Beveridge et al., 2009; Lui et al., 2009) and shows a comparable effect for emotion-congruent face pairs in human performance. It is therefore possible that smiling provides further idiosyncratic information about people that makes it easier for them to be recognised.

Study 2: Neutral vs. Closed Smile vs. Open Smile

Study 1 showed clear improvements in face matching accuracy when comparing two smiling rather than neutral images. Study 2 aimed to follow up on these findings by exploring the effect of smiling across different intensities. Here, we used the same neutral and smiling images from Study 1 but we also added an intermediate condition with images of the same identities displaying a closed mouth smile. This way we will be able to detect whether the improvement can be achieved by any smile or relies on information in the open-mouthed smiles tested in Study 1.

Method

Participants

A total of 60 participants (7 male, $M = 20.6$, age range = 19-27) from the University of X took part in the study. All had normal or corrected-to-normal vision and received payment or course credit for their participation. Sample size was based on Study 1. As we are adding a new level of the expression variable, it was necessary to recruit a larger sample size in order to maintain the same level of power. A post hoc power analysis in GPower (Erdfelder, Faul, & Buchner, 1996) indicated that with the present sample we have achieved more than 95% power with alpha at .05. Informed consent was provided prior to participation and experimental procedures were approved by the ethics committee of the Psychology Department at the University of X. Only participants who had not taken part in Study 1 were recruited for the present experiment.

Materials

The same 120 face pairs as in Study 1 were used for the present experiment. We collected 60 additional pairs of images depicting the same target and foil identities with both images in the pair displaying a closed mouth smile (see Figure 3 for examples).

In order to ensure that the stimuli captured the desired intensity of emotion, all images were rated by a separate sample of 54 participants. Participants were presented with all 270 images individually and asked to rate how happy the person in each image was on a scale from 1 (not at all) to 9 (extremely). Analysis was run by item rather than by participant. A one-way repeated measures ANOVA showed a significant main effect of expression ($F_{(2, 106)} =$ 781.62, $p < .001$, $\eta_p^2 = .94$). Follow-up Tukey HSD tests showed significant differences between all levels of the expression factor with open smiles ($M = 6.97$, $SD = .48$, 95% CI [6.85, 7.10]) rated as the happiest, followed by closed-mouth smiles ($M = 5.45$, $SD = .69$, 95% CI [5.27, 5.62]) and finally the neutral expression ($M = 3.10$, $SD = .84$, 95% CI [2.86,

3.34]). This validates the stimuli sample and shows clear differences in the intensity of emotional expressions across the three conditions.

FIGURE 3 HERE PLEASE

Design and Procedure

The experiment used a 3 (neutral / closed smile / open smile) x 2 (identity match / mismatch) design. Other than the extra level of the expression factor, the experiment used the same design and procedure as Study 1. Participants completed 60 trials of the face matching task with an equal number of match and mismatch trials as well as an equal number of neutral, closed and open smile trials. Again, they saw images of each identity twice but images were counterbalanced so that they never saw the same image twice. Examples of match and mismatch trials across all emotional expressions can be seen in Figure 3.

Results and Discussion

Figure 4 shows the mean matching accuracy across all conditions. A 3 x 2 within subjects ANOVA (expression: neutral vs closed smile vs open smile; trial type: match vs mismatch) revealed a significant main effect of expression (F (2, 118) = 20.87, $p < .001$, $\eta_p^2 = .26$). There was no significant main effect of trial type (F (1, 59) < 1, $p > .05$, $\eta_p^2 < .01$) nor a significant interaction between expression and trial type (F (2,118) = 2.80, $p > .05$, $\eta_p^2 = .05$). Follow-up Tukey HSD tests showed that face matching accuracy with open smile images ($M = 0.86$, $SD = 0.15$, 95% CI [0.83, 0.89]) was significantly higher than matching images with a neutral expression ($M = 0.76$, $SD = 0.17$, 95% CI [0.73, 0.79]) and a closed-mouth smile ($M = 0.79$, $SD = 0.16$, 95% CI [0.76, 0.81]) and that was true for both match and mismatch trials

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(p < .001). No difference in matching accuracy was found for images with a neutral expression and images with a closed-mouth smile.

FIGURE 4 HERE PLEASE

Such results replicate the findings reported in Study 1 that presenting participants with two smiling images improves their face matching accuracy for both match and mismatch trials. This further supports the idea that a smile might provide some additional information that is diagnostic of identity. No improvement was seen in the closed-mouth smile condition compared to the neutral condition and there were very clear differences in the intensity ratings of these two types of images. It seems that the perceptual information provided by the shape and size of the teeth as well as the distortion in the face produced by an open-mouth smile are more likely to drive the increase in accuracy for smiling images by providing further opportunity for the face to reveal more of its idiosyncratic features.

Study 3: Lower Face Matching

Overview

Study 2 showed that an open mouth smile is critical to the face matching improvement reported in the first two studies. Here, we aim to explore whether this effect is mostly due to the extra information about the shape and/or size of the mouth and teeth or there is something in the way a smile transforms the whole face that makes smiling images easier to match. Participants performed the same task as in Study 1, however, all images were cropped so that only information about the lower part of the face was available to them.

Method

Participants

A total of 34 participants (3 male, M = 21.2, age range = 19-29) took part in the study. Sample size was based on Study 1 and a post hoc power analysis in GPower (Erdfelder, Faul, & Buchner, 1996) indicated that we have achieved more than 95% power with alpha at .05. All had normal or corrected-to-normal vision and received payment or course credits for their participation. Informed consent was provided prior to participation and only participants who had not participated in the previous studies were recruited.

Materials

The images used for this study were exactly the same as in Study 1, however participants were presented with the lower part of each face only. Images were cropped in Adobe Photoshop so that only information from the mouth below was available to participants. See Figure 5 for examples.

FIGURE 5 HERE PLEASE

Design and Procedure

Study 3 had the same design and procedure as Study 1. It used a 2 (smile / neutral) x 2 (identity match / mismatch) design. Each participant completed 60 trials, with an equal number of match / mismatch and smile / neutral trials. Participants were presented with two

images on the screen and asked to decide whether they depicted the same person or not.

Figure 5 shows examples of match and mismatch trials across the two emotion conditions.

Results and Discussion

Mean matching accuracy across all conditions is presented in Figure 6. A 2 x 2 within subjects ANOVA (expression: neutral vs smile; trial type: match vs mismatch) revealed a significant main effect of expression (F (1, 33) = 41.73, p < .001, η_p^2 = .56). There was no significant main effect of trial type (F (1, 33) < 1, p > .05, η_p^2 < .01), however there was a significant interaction between expression and trial type (F (1, 33) = 26.49, p < .001, η_p^2 = .45). Simple main effects showed a significant improvement in face matching accuracy when both images had a smiling expression on match (F (1, 66) = 67.90, p < .001, η_p^2 = .51) but not on mismatch trials (F (1, 66) = 1.68, p > .05, η_p^2 = .02). Such results imply that a smile provides enough idiosyncratic information for us to tell different images of the same person together but not to tell images of different people apart. It is therefore possible that the way a smile changes the whole face (i.e. smiles lines around the mouth and eyes, exaggerating of bags under eyes) also contributes to the improvement in face matching accuracy seen when both images in the face pair have a smiling rather than a neutral expression.

FIGURE 6 HERE PLEASE

General Discussion

The present series of studies focused on the influence of emotional expressions and smiling, in particular, on face matching performance. This was motivated by the possibility that smiling faces might present participants with some extra identity-diagnostic information from

the shape of the smile and teeth as well as wrinkles around the mouth and eyes. Results provided support for this suggestion, showing higher matching accuracy when both images in the face pair had a smiling rather than a neutral expression. Such findings are consistent with automatic face recognition studies which show that smiling images are much better recognised than neutral images (Beveridge et al., 2009; Yacoob & Davis, 2002). While face recognition algorithms might not necessarily simulate the processes of human face recognition, our results demonstrate that people are actually able to extract the information provided through a smile and use it in a constructive way to improve recognition rates. It should be noted that findings from these experiments are not in contrast to human recognition studies demonstrating a significant decrease in performance with the introduction of expression incongruence (Bruce, 1982; Bruce et al., 1999). These studies explore a different key comparison – while they compare trials where one image has a neutral expression and the other a smiling expression, the present studies investigated congruent pairs only (i.e. both images in the face pair have either a smiling or a neutral expression).

What is probably most impressive about the improvement in matching performance brought about by a smile is that this advantage was seen in both match and mismatch trials. This implies that smiling can overcome differences in match and mismatch mechanisms and provide identity-diagnostic information that is relevant both in situations where we need to compare images of the same person and images of different people. This is in contrast to most methods of improving matching performance established so far, such as feedback which has been shown to improve performance on mismatch trials only or within-person variability that improves performance on match trials only (Alenezi & Bindemann, 2013; White et al., 2014a).

Results from Study 2 demonstrate that this effect cannot be achieved with any smile but with an open mouth smile specifically. This implies that changes in the face due to the high intensity of emotional expression as well as the presence of more features for comparison (i.e. shape and size of smile and teeth) are essential to the reported improvement in face matching accuracy. It is interesting to consider that this same distortion of facial features following an emotional expression has been used to justify using neutral images when it comes to official identification documents (e.g. passports or identity cards, see Identity & Passport Service, 2005). Nevertheless, here we show that a smile in particular changes the face in an idiosyncratic way that leads to an improvement rather than a detriment in human face matching performance. In fact, our findings fit well with Jenkins et al. (2011) who asked participants to rate different images of the same familiar celebrities for likeness (i.e., how well each image resembled that identity). They reported significantly higher likeness ratings attributed to images with an open mouth smile compared to neutral images. This implies that a smile might make people look more like themselves, thus supporting its idiosyncratic quality. Nevertheless, we should also acknowledge the potential for other facial movements and expressions to provide more idiosyncratic information than neutral faces. It is, of course, possible that the performance boost we report here is not exclusive to an open mouth smile.

Furthermore, findings from Study 3 show that information about the smile and teeth is sufficient to produce the reported increase in accuracy when comparing different images of the same person. The effect was absent in mismatch trials, implying that we need access to all the changes in the face triggered by a smile in order to discriminate between identities accurately. This is further highlighted by the presence of a performance boost when matching

whole faces (as in Study 1) compared to their lower part only (as in Study 3). We confirmed this by carrying out a between-experiment analysis. A 2x2x2 mixed factorial ANOVA (between experiment/subjects factor: whole/lower face stimuli; within-subjects factors: smile/neutral and match/mismatch trials) revealed a main effect across experiments (F (1, 66) = 13.85, $p < .001$, $\eta_p^2 = .17$), with higher overall accuracy for whole faces (whole: $M = 0.79$, $SD = 0.18$, 95% CI [0.76, 0.82]; lower : $M = 0.72$, $SD = 0.15$, 95% CI [0.69, 0.74]). However, a significant three-way interaction (F (1, 66) = 8.89, $p = .004$, $\eta_p^2 = .12$) was driven by the fact that this performance boost occurred only for match, and not mismatch trials (compare figures 2 and 6). This is interesting because it suggests that viewers can make accurate mismatch judgements on the basis of the lower face half alone – perhaps because any observed difference is enough to trigger a mismatch response. However, to make the decision that two faces are the same person requires viewers to take into account evidence across the whole face.

The advantage for matching smiling faces reported in the present series of studies fits well with existing literature on emotion and face recognition. There is evidence for the superiority of emotional faces in face recognition where seeing faces with a happy rather than a neutral expression during learning brings about significant improvements at later recognition (Kottoor, 1989). A similar effect has been reported for familiar faces with studies showing faster response times both when asked to identify faces as familiar or unfamiliar and when naming famous faces with a smiling rather than a neutral expression (Endo, Endo, Kirita, & Maruyama, 1992; Gallegos & Tranel, 2005). Here, we extend these findings and show that a smiling expression enhances not only face memory and recognition, but also purely perceptual tasks such as face matching.

Overall, these studies describe a way of improving face matching accuracy which, unlike other methods, makes it easier for perceivers both to tell people together and apart. Our results demonstrate that comparing two smiling rather than neutral images in a matching task increases accuracy, possibly due to the additional idiosyncratic information provided by an open mouth smile (i.e. shape of smile and teeth, smile lines around the mouth and eyes). This is particularly relevant in applied settings such as passport control. While we are required to use neutral images only in all identification documents, the present findings indicate that a smiling rather than a neutral image might be a better representation of our likeness.

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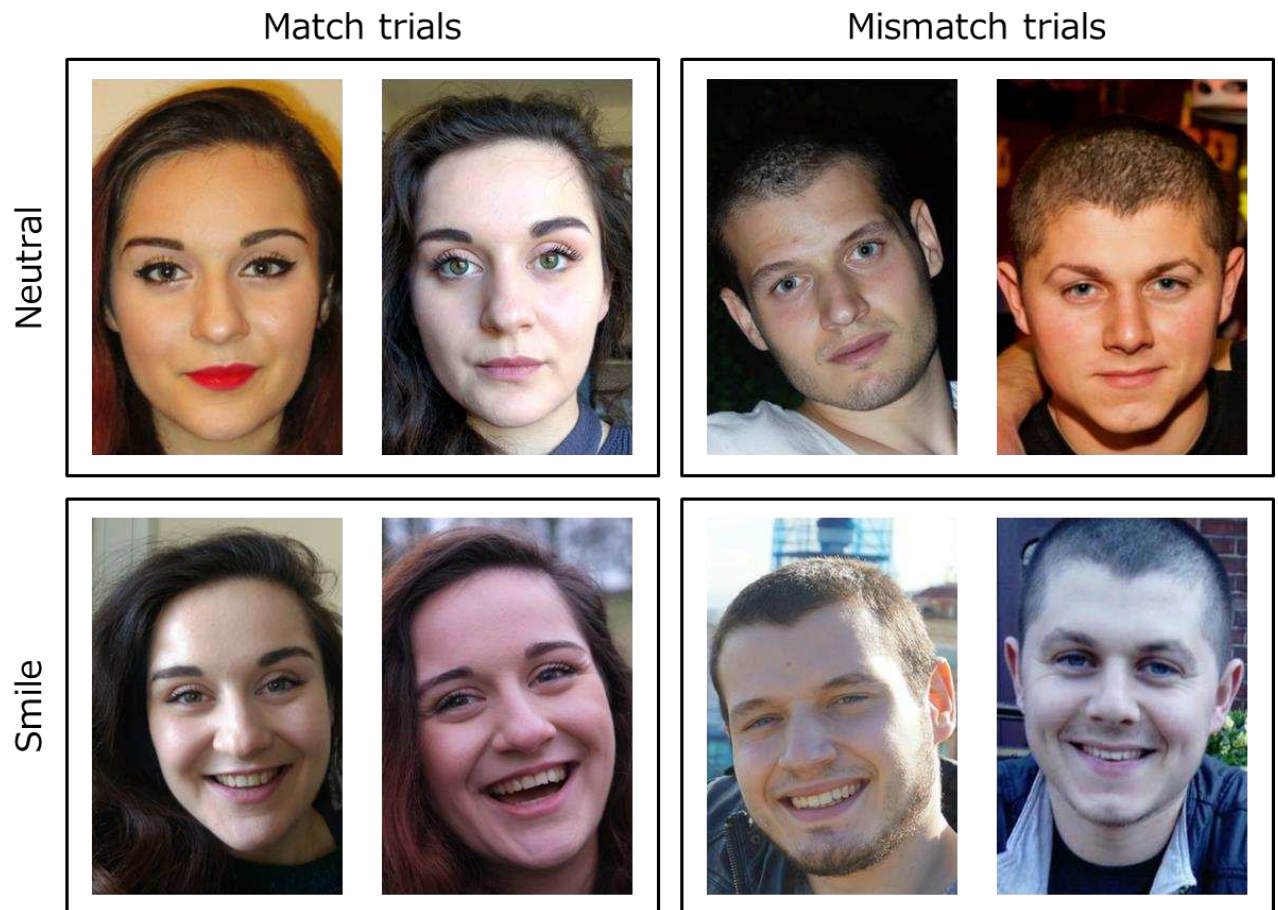
Figure 1. Trial type examples. Match trials used images of the same identity and mismatch trials used images of two different identities. For mismatch trials, each column contains images of the same identity (Copyright restrictions prevent publication of the original images used in the experiment. Images included in the figure feature people who did not appear in the experiment, but who have given their permission for the images to be reproduced here.)
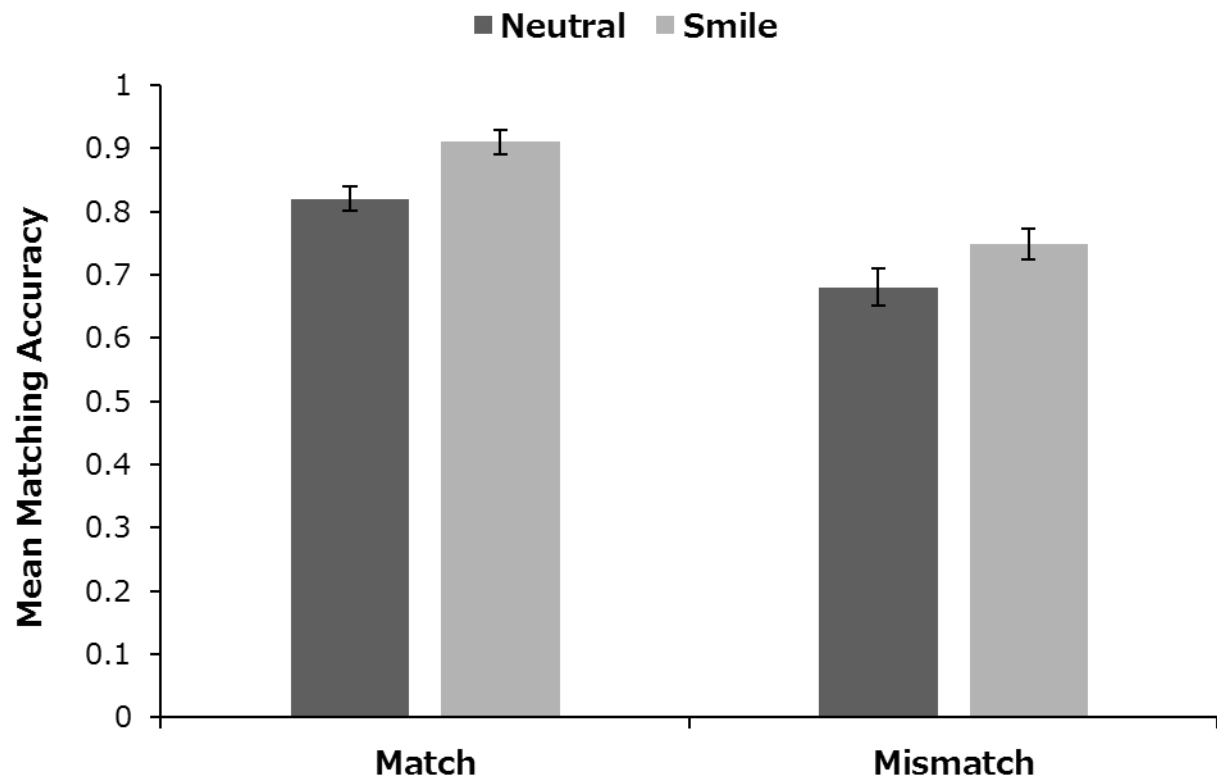
Figure 2. Mean matching accuracy across expression and trial type in Study 1. Error bars

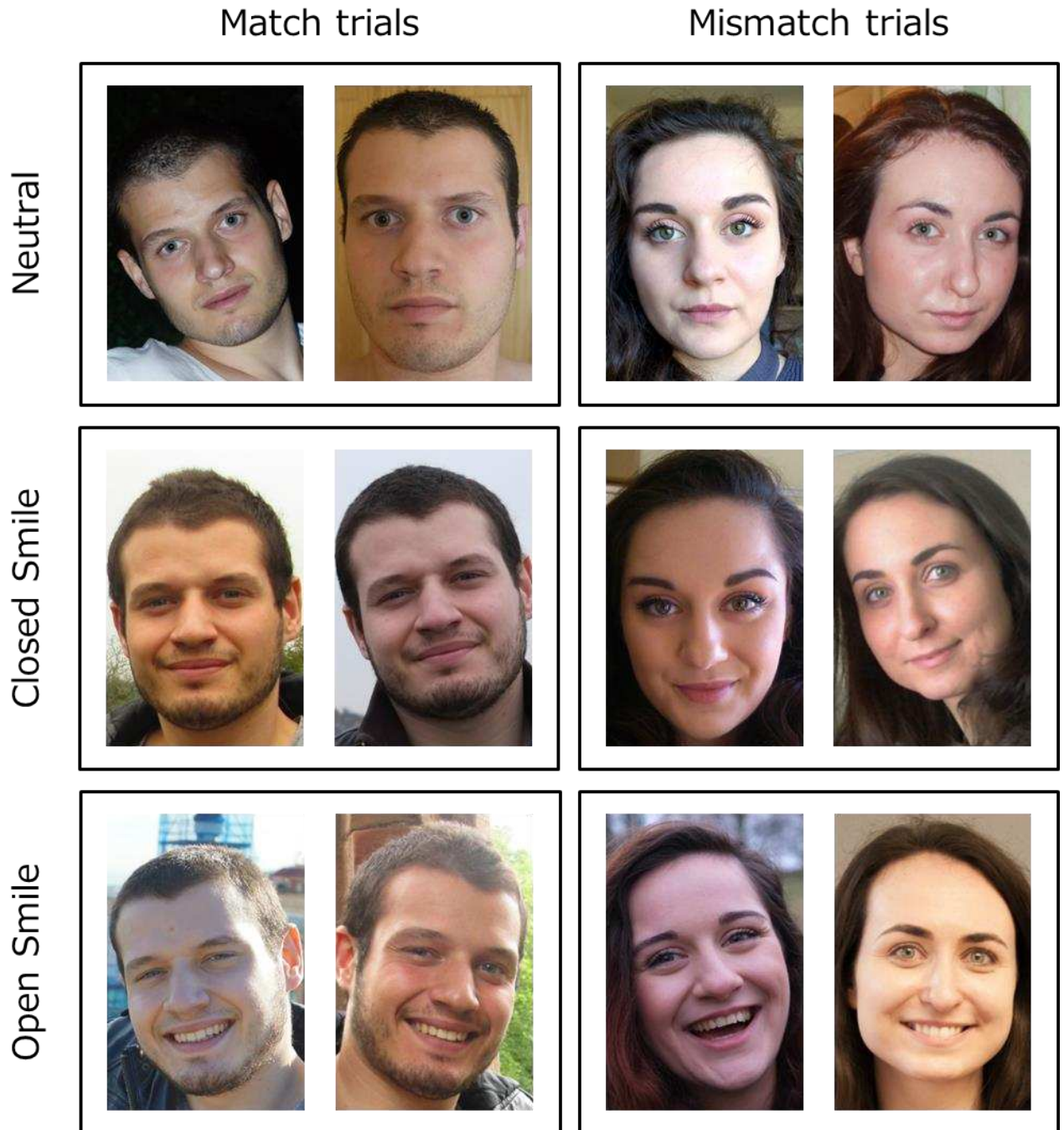represent within-subjects standard error (Cousineau, 2005).

Figure 3. Trial type and stimuli examples for Study 2. Match trials used images of the same identity and mismatch trials used images of two different identities. For mismatch trials, each column contains images of the same identity. (Copyright restrictions prevent publication of the original images used in the experiment. Images included in the figure feature people who did not appear in the experiment, but who have given their permission for the images to be reproduced here.)
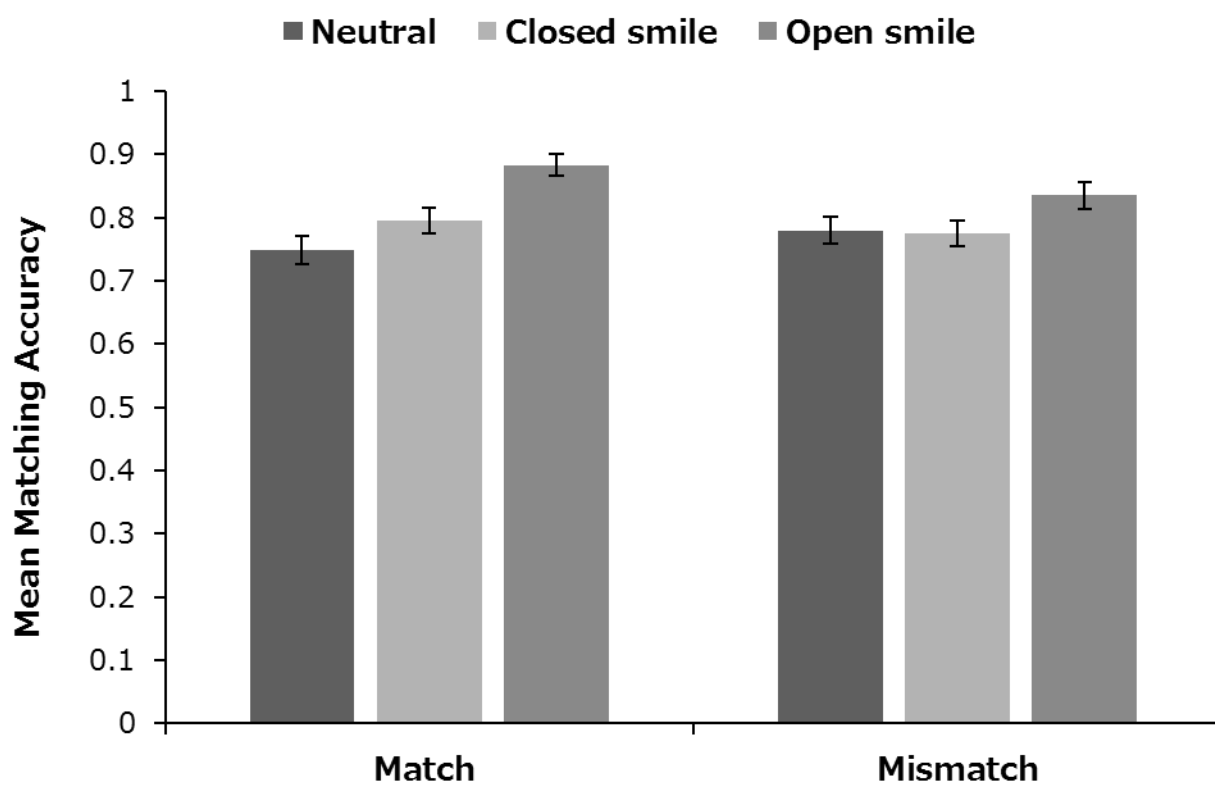
Figure 4. Mean matching accuracy across expression and trial type conditions in Study 2.

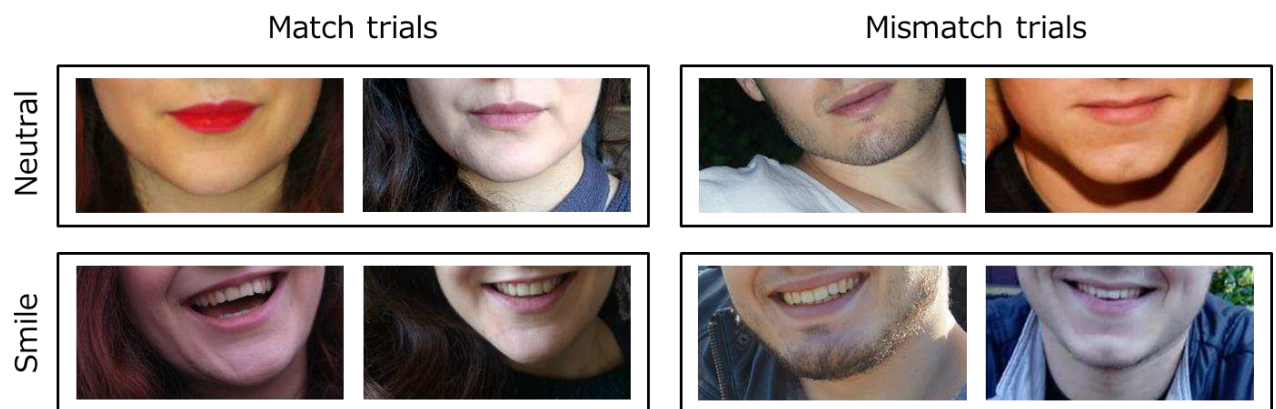Error bars represent within-subjects standard error (Cousineau, 2005).

Figure 5. Trial type and stimuli examples for Study 3. Match trials used images of the same identity and mismatch trials used images of two different identities. (Copyright restrictions prevent publication of the original images used in the experiment. Images included in the figure feature people who did not appear in the experiment, but who have given their permission for the images to be reproduced here.)
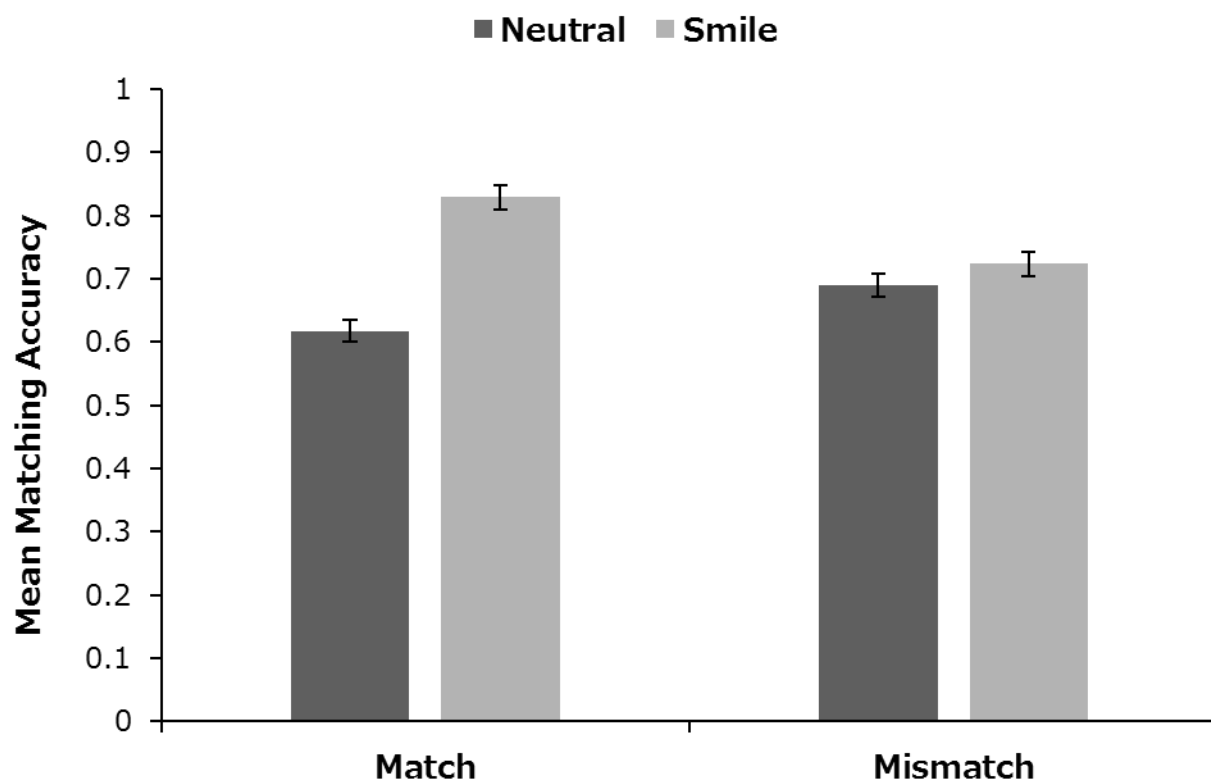
Figure 6. Mean matching accuracy across expression and trial type conditions in Study 3.

Error bars represent within-subjects standard error (Cousineau, 2005).