Received: 25 February 2022 | Revised: 23 May 2022 | Accepted: 6 June 2022

DOI: 10.1002/acp.3975

RESEARCH ARTICLE

WILEY

Molistic processing in facial image comparison

Matthew C. Fysh | Markus Bindemann

School of Psychology, University of Kent, Canterbury, UK

Correspondence
Matthew C. Fysh, School of Psychology, University of Kent, Canterbury, Kent CT2 7NP, UK.
Email: m.c.fysh@kent.ac.uk

Funding information
Economic and Social Research Council, Grant/Award Number: ES/S010181/1

Abstract

When comparing images of faces in criminal investigations, forensic facial examiners report key features such as moles to be particularly diagnostic of identity. However, scientific evidence for the efficacy of moles in facial identification is still limited. The current study systematically examined the effect of moles on facial image comparison by manipulating the presence and location of these small features. We found that observers untrained in facial image comparison spontaneously use moles to support identification decisions (Experiment 1). These effects were amplified when observers were prompted to utilise moles for identification (Experiment 2) and were sensitive to subtle differences in spatial location (Experiment 3). Moreover, identification accuracy was higher when observers were instructed to use moles only and dissociated from facial identification (Experiment 4). These findings demonstrate that observers are sensitive to the presence and location of moles in facial image comparison and shows the power of these small visual features to influence identification decisions.

KEYWORDS
facial image comparison, forensic facial examiners, moles, training, unfamiliar face matching

1 | INTRODUCTION

An extensive body of psychological research demonstrates that comparing an unfamiliar face in one photograph to that in another elicits error rates ranging from 10% to 30% (Burton et al., 2010; Fysh & Bindemann, 2018; White et al., 2021; for reviews see Fysh, 2021; Fysh & Bindemann, 2017). This task, known as *facial image comparison* (Moreton, 2021), is challenging not only for untrained novices such as student participants but for passport officers and police officers too, who perform facial image comparison routinely (White et al., 2014; Wirth & Carbon, 2017). Yet, recent work has found that highly trained professionals, known as forensic facial examiners, are proficient at comparing unfamiliar faces and typically outperform novices and other professional groups in this task (Phillips et al., 2018; Towler et al., 2017; White, Dunn, et al., 2015; White, Phillips, et al., 2015). The higher accuracy rates of facial examiners demonstrate that the applied problem of facial image comparison is solvable, but the precise nature of these individuals' proficiency is unclear.

A potential basis for the advantage of facial examiners relates to their extensive training in morphological feature analysis, which entails a systematic breakdown of each facial region into smaller subcomponents that are then carefully compared and evaluated (see FISWG, 2018; Moreton et al., 2021; Towler, Kemp, & White, 2021). Such training can lead facial examiners to utilise different facial features to novices when comparing face images. In one study, for instance, observers who were untrained in facial comparison reported primary features such as the eyes and nose to be most useful for identification, whereas facial examiners reported greater reliance on smaller details such as skin blemishes (see Towler et al., 2017).

Moles represent a particularly useful subset of skin blemishes for identity comparison, given that these features tend to be low in visual complexity and typically do not share the broad variability that characterise other facial features within individuals. Studies have consistently shown, for example, that the appearance of features such as the eyes, nose, and mouth can vary on a moment-to-moment basis due to superficial changes in facial expression, lighting, and camera-to-subject distance (e.g., Jenkins et al., 2011; Mileva & Burton, 2018; Noyes & Jenkins, 2017), as well as changes in facial adiposity and skin complexion over time (Jenkins et al., 2011).

Because the physical appearance of such features can vary extensively, it can be difficult to establish an objective criterion based on these facial elements for deciding whether face images depict one person or two (see Moreton, 2021). By contrast, moles can be characterised by more definitive parameters, such as presence and location. Importantly, whilst moles typically do not vary within individuals, they vary extensively between individuals, based on factors such as quantity and position. Utilising these characteristics of moles may therefore grant observers a more objective basis for classifying identity. Based on this logic, the presence of a mole on one face and its absence from a comparison face should, for example, imply different identities. And in turn, the concurrent presence and location of moles across face images should imply that the two faces belong to the same person.

This reasoning is based on recent evidence of facial examiners who attribute particular importance to blemishes for facial comparison, and who outperform untrained novices in facial identification by around 10% (Towler et al., 2017). This advantage might arise because such features either are easily missed by untrained observers or because their importance to person identification is overlooked. However, evidence for this possibility is also mixed, as accuracy improves only slightly (e.g., <10%) when observers undergo professional training (Towler et al., 2019) and when they are trained specifically to focus on moles (Carragher et al., 2022; Towler, Keshwa, et al., 2021). For instance, recent work has found only modest improvements in accuracy of around 6% when novices undergo a 6-min professional training procedure (Towler, Keshwa, et al., 2021), and of only around 4% when the lower half of one face within a face pair is masked by a patch of colour (Carragher et al., 2022). These studies reflect that training observers to attend to moles in face matching is insufficient to incur substantial gains in accuracy approaching those exhibited by professional examiners.

At the same time, however, these studies only employed stimuli with naturally occurring moles, instead of manipulating this visual information systematically. A key point here is that only employing face stimuli with naturally occurring moles makes it impossible to dissociate the contribution of moles to person identification from that of other facial information, or indeed from the subjective reports of observers who utilise such features. In addition, only utilising naturally occurring moles also prevents researchers from exploring the converse question of how facial identification is influenced when moles are *incongruent* with the facial identity information. The importance of this question lies in its capacity to establish how heavily observers weigh mole information against the information that is carried by the rest of the face.

The current study aims to clarify the contribution of moles to facial identity comparison by manipulating this information directly and by examining their impact on observers with no a priori training in morphological feature analysis. We examine how facial comparison is impacted by moles that are congruent or incongruent with the identity information in faces, both with and without guidance to utilise moles (Experiments 1 and 2). We then examine how the location of moles contributes to these effects (Experiment 3) and whether mole identification can proceed unbiased by facial context (Experiment 4).

2 | EXPERIMENT 1

This experiment investigates whether observers untrained in facial comparison utilise moles when comparing facial images without prior guidance that moles are useful sources of identity information. To this end, identification accuracy for faces with naturally occurring moles is to be compared against faces to which moles have been artificially added using image manipulation software. If moles are perceived by observers as representing categorical sources of identity information based on their presence and absence, then accuracy should be higher when the added moles provide information that is congruent with the image identities and lowest when moles are incongruent. At the same time, it is also possible that moles do not influence identification decisions, since these features are small and, when these are misaligned with facial identity, will be competing with other facial information.

3 | METHOD

3.1 | Participants

Participants for this experiment comprised 150 people (45 males, 102 females, 3 undisclosed) with a mean age of 26 years ($SD = 8.8$) who were recruited from *Prolific Academic* in exchange for a small fee. These participants were randomly allocated to one of three conditions ($N = 50$ per condition). For all experiments reported in this study, all participants were native English speakers and resided in the United Kingdom at the time of testing. This and all subsequent experiments received full ethical approval by the School of Psychology ethics board at the University of Kent.

3.2 | Stimuli and procedure

The stimuli for this study consisted of 40 face pairs (20 identity matches, 20 mismatches) from the short version of the Kent Face Matching Test (KFMT; Fysh & Bindemann, 2018). Image pairs in this test comprise one high-quality digital photograph, measuring 283×332 pixels with a resolution of 72-ppi, in which subjects adopted a neutral expression whilst facing forwards under even lighting. The second image in each pair was a student ID photograph, which measured 142×192 pixels with a resolution of 72-ppi, and which was relatively unconstrained in terms of expression, pose, and lighting. In addition, each ID image was acquired several months before each person's laboratory photograph was obtained. Full details

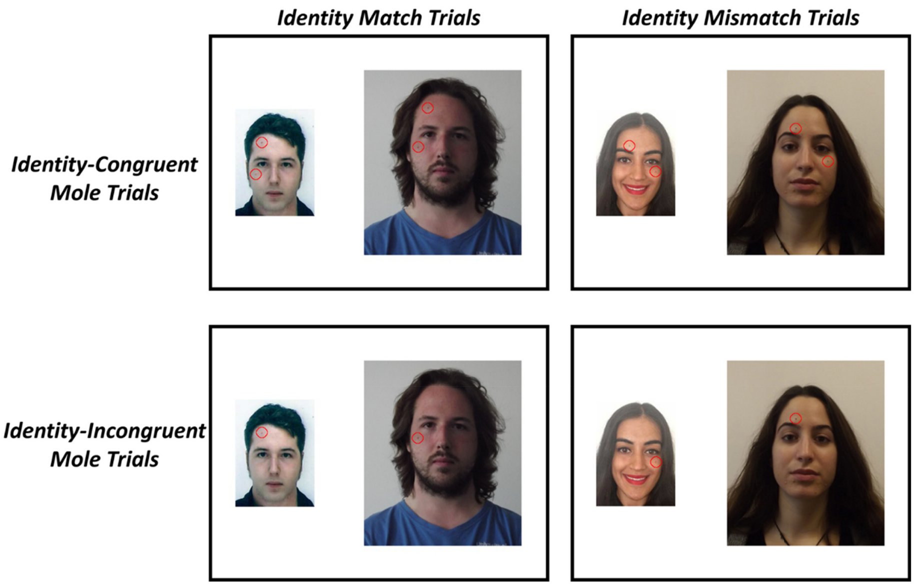

FIGURE 1 Example stimuli from Experiment 1. The top panel depicts match (left) and mismatch trials (right) from the identity-congruent mole condition, and the bottom panel likewise for the identity-incongruent mole condition. For illustrative purposes, manipulated moles in this figure are highlighted with a red circle

of the construction of these stimuli are provided in Fysh and Bindemann (2018).

This experiment consisted of three conditions. The first of these was a control condition that featured the original unedited 40 trials from the short version of the KFMT, in which the only moles that were present were naturally occurring. Typical accuracy in the KFMT is around 66%, and ranges from around 40% to 90% (Fysh & Bindemann, 2018; Fysh, 2018).

The two experimental conditions consisted of stimuli that were manipulated to feature moles. One of these conditions consisted entirely of stimuli featuring moles that were *identity-congruent*, for which graphic editing software (GIMP) was used to superimpose moles onto face trials in such a way as to guide observers to the *correct* decision. To this end, for each identity-congruent match trial two moles per face were added in corresponding facial locations. Conversely, for each identity-congruent mismatch trial, one mole was added to each face per pair, in different locations. Thus, each trial provided two sources of mole information, characterised by either the shared location of two moles on match trials, or the presence of only one mole per face, and their corresponding absences on the other face on mismatch trials. It was therefore possible to achieve 100% in this condition based on counting these moles alone.

The other experimental condition consisted of stimuli that featured *identity-incongruent* moles, whereby moles were placed on match and mismatch trials in such a way as to guide observers towards the *incorrect* decision. To this end, identity match trials in this condition featured one mole per face that differed in location within trials, whereas identity mismatch trials featured two moles per face that converged in their location within trials. In contrast to the identity-congruent condition, it was possible for observers in the identity-incongruent condition to score 0% by basing their answers purely on these moles. Example stimuli from the identity-congruent and identity-incongruent conditions are provided in Figure 1.

This task was distributed to participants using *Qualtrics* survey software. The experimental conditions were administered on a between-subjects basis. Thus, participants were randomly allocated to either the control condition in which they matched the original unedited face pair stimuli from the KFMT, congruent moles condition, or the incongruent moles condition ($N = 50$ each). Trials were presented to participants one at a time in a random order, and the identity of each face pairing was classified as the 'same' or 'different' by clicking on the appropriate response option. Data for this experiment, and all subsequent experiments, can be accessed at https://osf.io/nsjbx/.

4 | ANALYSIS

To analyse the accuracy data for this experiment, a 2 (trial type: match vs. mismatch) $\times$ 3 (mole condition: identity-congruent, control, identity-incongruent) mixed-factor ANOVA was employed, with all subsequent pairwise comparisons adjusted using the Bonferroni correction.

In addition to these frequentist analyses, Bayesian counterparts were also conducted using JASP (JASP Team, 2022), using default parameters. The purpose of this was to establish the extent to which the data favoured the alternative hypothesis over the null model. The size of the Bayes factor (i.e., BF_{10}) ranges from 0 to infinity and indicates the likelihood of the alternative hypothesis over the null hypothesis (Van Doorn et al., 2021), with $BF_{10} = 1$ indicating no evidence for one hypothesis over the other, and BF_{10} values of 1–3, 3–10, and 10–30 indicating anecdotal, substantial, and very strong evidence for the experimental hypothesis, respectively, and $BF_{10} \geq 100$ indicating decisive evidence for the experimental hypothesis over the null. Conversely, Bayes factors below 1 represent evidence in favour of the null hypothesis. When following up main effects and simple main effects, Bayesian posterior odds are reported.

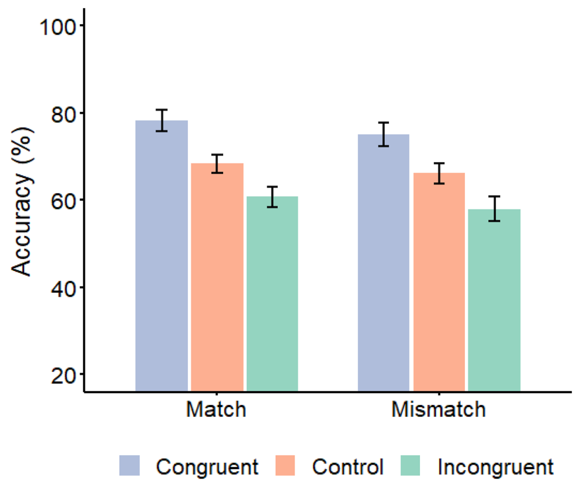

FIGURE 2 Mean percentage accuracy in Experiment 1 across the three conditions, for identity matches and mismatches. Error bars denote standard error of the mean

As an additional step to these analyses, we also converted our data to loglinear signal detection measures of sensitivity (i.e., *d*′) and criterion (see Stanislaw & Todorov, 1999; see also Hautus, 1995). The former of these measures provides an unbiased index of overall performance collapsed across correctly classified match trials (i.e., 'hits') and incorrectly classified mismatch trials (i.e., 'false positives'). A sensitivity rate of zero would indicate chance performance, whereas 3.96 represents a perfect score. Conversely, criterion provides an index of differences in response patterns on match and mismatch trials, to reflect whether observers disproportionately submitted one response over another. A criterion value of zero would correspond to an equal proportion of match and mismatch decisions, whereas values of −1.98 and 1.98 would indicate that an observer had only submitted match or mismatch responses, respectively.

5 | RESULTS

5.1 | Accuracy

Match and mismatch accuracy data for each condition are depicted in Figure 2, which reflects that accuracy was highest in the identity-congruent mole condition, and lowest in the identity-incongruent mole condition. A 2 (trial type) × 3 (mole condition) mixed-factor ANOVA revealed a main effect of moles, $F(2, 147) = 28.76$, $p < .001$, $\eta_p^2 = 0.28$, $BF_{10} = 478 \times 10^4$, due to greater accuracy when moles were identity-congruent compared to when these were identity-incongruent, $p < .001$, posterior odds $= 281 \times 10^5$, and as well as compared to the control condition, $p < .001$, posterior odds $= 120.68$. Accuracy was also lower when moles were identity-incongruent compared to in the control condition, $p = .002$, posterior odds $= 12.35$. There was no effect of trial type, $F(1, 147) = 1.64$, $p = .203$, $\eta_p^2 = .01$, $BF_{10} = 0$, or an interaction, $F(2, 147) = 0.02$, $p = .982$, $\eta_p^2 = .00$, $BF_{10} = 101 \times 10^3$.

5.2 | Sensitivity and criterion

A one-way ANOVA with a Bayesian counterpart revealed a main effect of sensitivity across mole conditions, $F(2, 147) = 31.88$, $p < .001$, $\eta_p^2 = .30$, $BF_{10} = 243 \times 10^7$. Pairwise comparisons revealed that this effect was driven by higher sensitivity in the identity-congruent condition ($M = 1.65$, $SD = 0.96$) compared to the control condition ($M = 0.92$, $SD = 0.42$), $p < .001$, posterior odds $= 2590$, and identity-incongruent conditions ($M = 0.51$, $SD = 0.69$), $p < .001$, posterior odds $= 695 \times 10^4$. Sensitivity was also greater in the control condition relative to the identity-incongruent condition, $p = .014$, posterior odds $= 32.12$.

Conversely, criterion was similar for the identity-congruent ($M = -0.06$, $SD = 0.45$), control ($M = -0.02$, $SD = 0.40$) and identity-incongruent conditions ($M = -0.04$, $SD = 0.37$), $F(2, 147) = 0.12$, $p = .892$, $\eta_p^2 = .00$, $BF_{10} = 0.07$, indicating similar response patterns across these three conditions and limited support for the alternative model over the null. Finally, criterion was confirmed via one-sample *t*-tests to be comparable to zero in all conditions, all $ts \leq 0.98$, all $ps \geq .334$, all $BF_{10} \leq 0.24$, demonstrating that observers' responses were not disproportionately biased towards match or mismatch responses.

6 | DISCUSSION

This experiment shows that viewers spontaneously use moles to support facial comparisons, without instruction or training. When the mole information was congruent with facial identity, an increase in accuracy of 10% occurred, relative to the control condition. And when moles were incongruent with face stimuli, accuracy was reduced by 8%. These findings were corroborated by the analysis of sensitivity, which was highest in the congruent moles condition and lowest in the incongruent condition. Finally, analysis of criterion reflected that the addition of identity-congruent and identity-incongruent moles did not bias observers towards one outcome or another, but instead affected match and mismatch response tendencies similarly. These findings demonstrate the power of these small facial features to turn identification decisions.

7 | EXPERIMENT 2

Experiment 1 demonstrates that viewers use moles spontaneously in facial comparison decisions. We now examine how these effects are enhanced by instruction to utilise moles. There is evidence that training observers to consider such features improves accuracy by up to 6% (Carragher et al., 2022; Towler, Keshwa, et al., 2021). However, these effects were observed with naturally occurring moles, making it difficult to directly interpret the effect of training observers to utilise these features in a counterbalanced design. Thus, we repeated the design of Experiment 1 here, but also prompted observers to incorporate moles into their identification decisions.

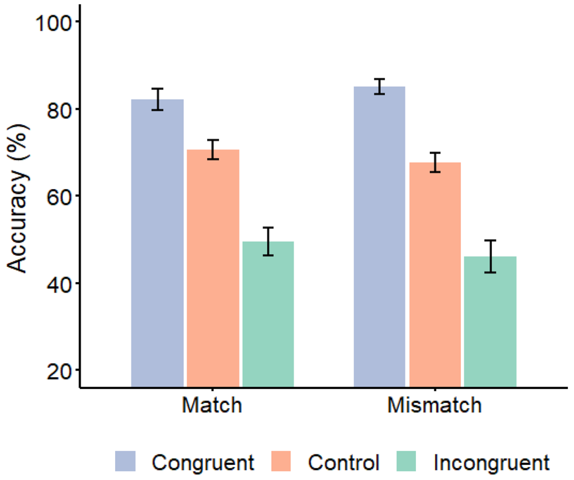

FIGURE 3 Mean percentage accuracy in Experiment 2 across the three mole conditions, for identity matches and mismatches. Error bars denote standard error of the mean

8 | METHOD

8.1 | Participants, stimuli, and procedure

Participants for this study were 150 individuals (86 females, 62 males, 2 undisclosed) with a mean age of 32 years ($SD = 8.1$) recruited from *Prolific Academic* in exchange for a small fee. The stimuli and procedure in this experiment were identical to that of Experiment 1, except that observers were informed that '*Trained facial examiners self-report that blemishes are the facial feature most useful for classifying face pairs*' at the beginning of the task. The content of this prompt was based on the language used by forensic facial examiners in Towler et al. (2017), and we left it deliberately up to observers' interpretation as to whether moles qualified as blemishes, to avoid the task explicitly becoming a mole-matching task, as opposed to a face-matching task. Aside from the addition of this prompt, all other aspects of the procedure remained unchanged.

9 | RESULTS

9.1 | Accuracy

Accuracy data for the three mole conditions are presented in Figure 3 and reflect that match accuracy was highest when moles were congruent with facial identity, followed by the control condition and identity-incongruent condition. Performance on mismatch trials followed a similar pattern, with superior accuracy in the identity-congruent condition compared to the control and identity-incongruent conditions.

To analyse these data, a 2 (trial type) × 3 (moles) mixed-factor ANOVA with supplementary Bayes factors revealed a main effect of moles, $F(2, 147) = 88.96$, $p < .001$, $\eta_p^2 = .55$, $BF_{10} = 679 \times 10^{19}$. In line with Figure 3, Bonferroni-adjusted comparisons confirmed that faces with identity-congruent moles were matched more accurately than faces in the control condition, $p < .001$, posterior odds $= 105 \times 10^5$, and faces with identity-incongruent moles, $p < .001$, posterior odds $= 219 \times 10^{21}$. Accuracy was also lower in the identity-incongruent mole condition compared to the control condition, $p < .001$, posterior odds $= 853 \times 10^6$. There was no effect of trial type, $F(1, 147) = 0.26$, $p = .612$, $\eta_p^2 = .00$, $BF_{10} = 0.14$, or a significant interaction, $F(2, 147) = 0.90$, $p = .410$, $\eta_p^2 = .01$, $BF_{10} = 148 \times 10^{18}$.

9.2 | Sensitivity and criterion

Analysis of loglinear sensitivity likewise revealed a main effect of mole condition, $F(2, 147) = 86.96$, $p < .001$, $\eta_p^2 = .54$, with Bonferroni comparisons revealing that this was due to higher sensitivity for faces with identity-congruent moles ($M = 2.14$, $SD = 0.94$) compared to the control condition ($M = 1.06$, $SD = 0.62$), $p < .001$, posterior odds $= 493 \times 10^4$, and faces with identity-incongruent moles ($M = 0.16$, $SD = 1.01$), $p < .001$, posterior odds $= 117 \times 10^{15}$. In addition, sensitivity was also higher in the control compared to the identity-incongruent condition, $p < .001$, posterior odds $= 582 \times 10^5$.

Conversely, there was not a main effect of mole condition on criterion, $F(2, 147) = 0.72$, $p = .490$, $\eta_p^2 = .01$, $BF_{10} = 0.12$, which was comparable across the identity-congruent ($M = 0.03$, $SD = 0.39$), control ($M = -0.05$, $SD = 0.38$), and identity-incongruent conditions ($M = -0.06$, $SD = 0.47$). One-sample t-tests also revealed that criterion was comparable to zero in each condition, all $ts \le 0.92$, all $ps \ge .363$, all $BF_{10} \le 0.23$.

9.3 | Cross-experimental comparison

To examine the effect of instructions on face-matching accuracy in relation to the previous experiment, a 2 (trial type) × 2 (experiment) × 3 (moles) mixed-factor ANOVA with supplementary Bayesian analyses was performed to compare Experiments 1 and 2 (see Figure 4). This revealed an interaction of experiment and moles, $F(2, 294) = 14.54$, $p < .001$, $\eta_p^2 = .09$, $BF_{10} = 275 \times 10^{30}$, due to higher accuracy in the identity-congruent mole condition of Experiment 2 compared to Experiment 1, $F(1, 294) = 7.85$, $p = .005$, $\eta_p^2 = .03$, $BF_{10} = 6.33$, and lower accuracy in the identity-incongruent mole condition of Experiment 2 compared to Experiment 1, $F(1, 294) = 21.00$, $p < .001$, $\eta_p^2 = .07$, $BF_{10} = 82.82$. Accuracy did not differ between the control conditions of Experiments 1 and 2, $F(1, 294) = 0.58$, $p = .448$, $\eta_p^2 = .00$, $BF_{10} = 0.35$. In addition, there was no interaction of experiment and trial type, $F(1, 294) = 0.29$, $p = .592$, $\eta_p^2 = .00$, $BF_{10} = 0.00$, or a three-way interaction, $F(2, 294) = 0.56$, $p = .569$, $\eta_p^2 = .00$, $BF_{10} = 481 \times 10^{26}$.

These findings were also reflected in the analysis of sensitivity, which similarly revealed an interaction of experiment and of moles, $F(2, 294) = 13.77$, $p < .001$, $\eta_p^2 = .09$, $BF_{10} = 174 \times 10^{33}$, due to higher sensitivity in the identity-congruent mole condition in Experiment 2 compared to Experiment 1, $F(1, 294) = 9.28$, $p = .003$,

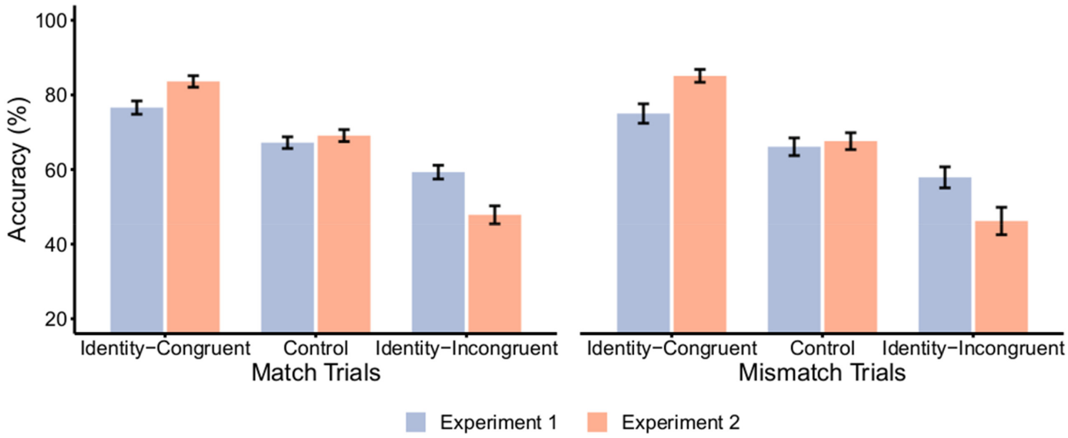

FIGURE 4 Mean percentage accuracies in Experiments 1 and 2 across the three mole conditions, plotted separately for identity matches and mismatches. Error bars denote standard error of the mean

η_p^2 = .03, BF_{10} = 3.81, and lower sensitivity for the identity-incongruent condition in Experiment 2 against Experiment 1, $F(1, 294) = 17.50$, $p < .001$, $\eta_p^2 = .06$, $BF_{10} = 125.65$. Sensitivity was similar between the control conditions, $F(1, 294) = 0.78$, $p = .378$, $\eta_p^2 = .00$, $BF_{10} = 0.46$. Conversely, the analysis of criterion did not reveal a main effect of experiment, $F(1, 294) = 0.09$, $p = .763$, $\eta_p^2 = .00$, $BF_{10} = 0.13$, or an interaction of experiment and mole condition, $F(2, 294) = 0.68$, $p = .509$, $\eta_p^2 = .00$, $BF_{10} = 0.00$.

10 | DISCUSSION

These results demonstrate that prompting observers to utilise moles substantially enhances the influence of these features on facial identity comparisons. In Experiment 1, the difference in accuracy between identity-congruent and identity-incongruent mole conditions when collapsed across match and mismatch trials was 18%, and in Experiment 2 this increased to 36%. A marked effect on performance sensitivity was also observed across the mole conditions, without a corresponding shift in response criterion. This suggests that observers were utilising the moles effectively, and that these small features provided an objective criterion for judging facial identity. Together, these experiments demonstrate that even observers who are not forensically trained will spontaneously use moles for identification decisions, and that these effects are amplified with simple instructions.

11 | EXPERIMENT 3

Experiments 1 and 2 demonstrate that observers consider the presence and absence of moles when comparing one face image to another. We now examine whether observers are similarly sensitive to the *location* of moles. Such sensitivity has been demonstrated to vertical and horizontal changes in the location of facial features such as the eyes, nose, and mouth (e.g., McIntyre et al., 2013; Ramon, 2015; Ramon & Rossion, 2010). Here we examine whether observers are also sensitive to the location of moles during facial comparison, across three conditions in which moles were located in (i) the *same* location on both faces within a pair, (ii) a *similar* location on both faces, and (iii) *different* locations.

These variations in mole locations generate three predictions. When moles are in the same location, accuracy should be high on match trials, and low on mismatch trials, given that the unanimous placement of moles will be signalling that two face images are of the same person. The opposite pattern should emerge when moles are placed in different locations, with high mismatch accuracy and low match accuracy. Accuracy on trials in which mole locations are similar but not the same, will reveal the extent to which observers are sensitive to subtle changes in the identity information provided by moles.

12 | METHOD

12.1 | Participants, stimuli, and procedure

One hundred and fifty participants (112 females, 34 males, 4 undisclosed) with a mean age of 28 years (SD = 8.9) were recruited for this experiment from *Prolific Academic* in exchange for a small fee.

For this experiment, three new conditions were created. The first condition combined the congruent match stimuli with the incongruent mismatch stimuli from Experiments 1 and 2, to create a condition in which all pairs of faces featured moles that were in the *same* location. For the second condition, the position of the moles was manipulated by displacing the position of the moles by 10 pixels along the vertical or horizontal plane, to create a condition in which the location of moles was *similar* across all face pair stimuli. For the final condition, these moles were displaced by a further 10 pixels, to create a condition in which the placement of moles was *different* across all stimuli. Example stimuli of these conditions are provided in Figure 5. The procedure for this experiment was otherwise identical to that of Experiment 2.

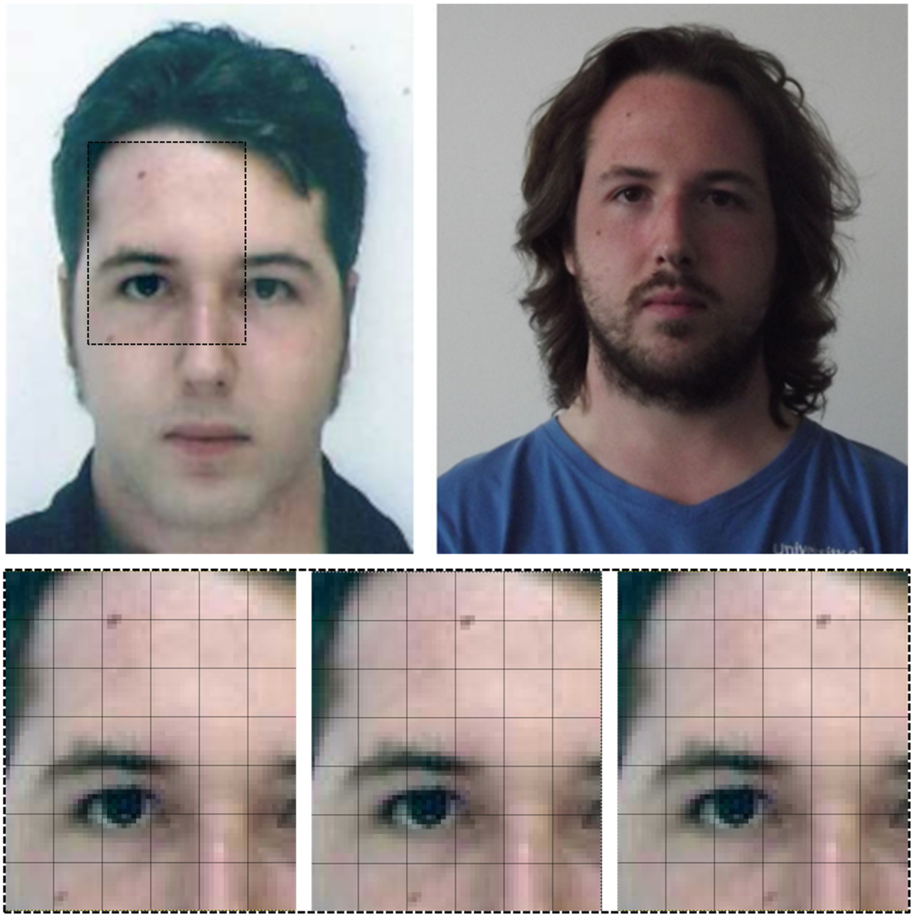

FIGURE 5 Illustration of the mole displacement locations in Experiment 3. The two upper images depict an identity match trial in the same-location condition, and for illustrative purposes, both face images are presented at the same size here. The bottom row provides an enlarged example of the highlighted facial section of the ID photograph, to illustrate the displacement of the moles across the same (left), similar (middle), and different (right) location conditions. For reference, each grid quadrant represents 10 × 10 pixels

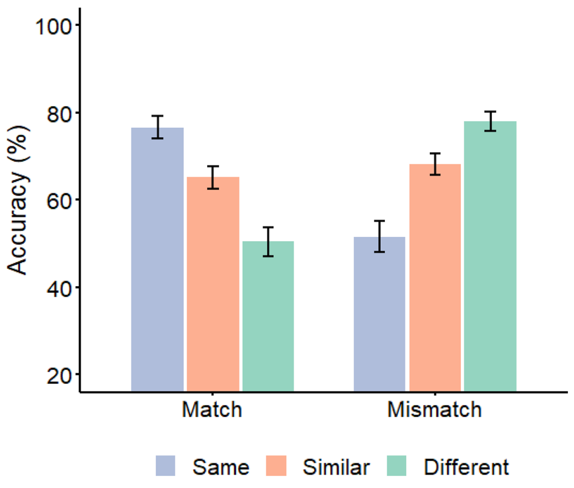

FIGURE 6 Mean percentage accuracy in Experiment 3 across the three mole location conditions, for matches and mismatches. Error bars denote standard error of the mean

13 | RESULTS

13.1 | Accuracy

The cross-subject mean accuracy rates depicted in Figure 6 reflect that match accuracy was highest in the same-location condition and lowest in the different-location condition. Conversely, accuracy on mismatch trials showed the opposite pattern, with higher accuracy in the different location condition and lowest accuracy in the same location condition.

A 2 (trial type: match, mismatch) × 3 (mole location: same, similar, different) mixed-factor ANOVA with supplementary Bayes factors revealed an interaction, $F(2, 147) = 27.36$, $p < .001$, $\eta_p^2 = .27$, $BF_{10} = 605 \times 10^{10}$. Analysis of simple main effects with Bayesian paired-samples *t*-tests showed that this reflected greater match than mismatch accuracy in the same location condition, $F(1, 147) = 24.78$, $p < .001$, $\eta_p^2 = .14$, $BF_{10} = 628.41$, and the reverse pattern in the different location condition, $F(1, 147) = 29.98$, $p < .001$, $\eta_p^2 = .17$, $BF_{10} = 9633.24$. Accuracy was comparable between match and mismatch trials in the similar location condition, $F(1, 147) = 0.38$, $p = .538$, $\eta_p^2 = .00$, $BF_{10} = 0.19$.

Match accuracy also varied across the three location conditions, $F(2, 147) = 21.22$, $p < .001$, $\eta_p^2 = .22$, $BF_{10} = 146 \times 10^3$. Bonferroni-adjusted comparisons showed that accuracy was higher in the samelocation compared to the different location condition, $p < .001$, posterior odds $= 899 \times 10^3$, and higher in the similar location condition than the different location condition, $p = .004$, posterior odds $= 38.07$. The match accuracy advantage in the same location condition over the similar location did not reach significance, $p = .065$, posterior odds $= 15.30$. Mismatch accuracy also varied across conditions, $F(2, 147) = 22.76$, $p < .001$, $\eta_p^2 = .24$, $BF_{10} = 450 \times 10^4$, but showed the reverse pattern. Accuracy was higher in the different location condition compared to the same location condition, $p < .001$, posterior odds $= 131 \times 10^4$, and the similar location condition compared to the same location conditions, $p < .001$, posterior odds $= 8.85$, but was comparable between the similar and different location conditions, $p = .237$, posterior odds $= 119.56$.

13.2 | Sensitivity and criterion

Analysis of sensitivity did not find a main effect of mole location, $F(2, 147) = 0.58$, $p = .562$, $\eta_p^2 = .01$, $BF_{10} = 0.11$, due to similar sensitivity rates in the same location ($M = 0.85$, $SD = 0.54$), similar location ($M = 0.95$, $SD = 0.55$), and different location conditions ($M = 0.85$, $SD = .54$). However, analysis of criterion revealed an effect of location, $F(2, 147) = 24.48$, $p < .001$, $\eta_p^2 = .25$, $BF_{10} = 154 \times 10^5$, due to a greater tendency to classify faces as identity matches in the same location condition ($M = -0.39$, $SD = 0.61$) compared to the similar location condition ($M = 0.05$, $SD = 0.50$), $p < .001$, posterior odds $= 142.74$, and the different location condition ($M = 0.42$, $SD = 0.61$), $p < .001$, posterior odds $= 410 \times 10^4$. In addition, this match bias was also found in the similar location condition compared to the different location condition, $p = .005$, posterior odds $= 22.39$. In line with these results, criterion was also significantly below zero in the same location condition, $t(49) = 4.46$, $p < .001$, $BF_{10} = 444.49$, significantly above zero in the different location condition, $t(49) = 4.87$, $p < .001$, $BF_{10} = 1613.12$, and was comparable to zero in the similar location condition, $t(49) = 0.74$, $p = .463$, $BF_{10} = 0.20$.

14 | DISCUSSION

Experiments 1 and 2 reflected that observers are sensitive to the presence and absence of moles when comparing images of unfamiliar faces. The results of the current experiment build upon these findings by demonstrating that observers are also sensitive to the *location* of moles in faces. This location effect was such that small spatial displacement of the moles was sufficient to alter identity judgements and this effect was exaggerated as this displacement increased. Unlike in Experiments 1 and 2, however, here this effect was characterised by a shift in percentage accuracy from match trials to mismatch trials as mole locations became increasingly different. This was reflected in response criterion, due to observers being more likely to classify faces as mismatching when these presented with moles that were in different locations, but was not reflected in sensitivity, due to the proportionate shift in match and mismatch accuracy within and between these conditions. Considered together, the experiments presented so far demonstrate that observers are sensitive to the presence, absence, and location of moles, and that these features alter how observers proceed with facial image comparison. It remains unclear from these experiments, however, as to whether observers were primarily judging the similarity of the moles and using the face as confirmatory evidence, or vice versa. We explore this question in Experiment 4.

15 | EXPERIMENT 4

The previous experiments consistently demonstrate that moles influence facial comparison decisions. These effects occur spontaneously, are amplified by instruction, and are sensitive to subtle changes in the location of moles. We now examine the converse question of whether participants can compare moles without being influenced by the facial context against which they are presented. The importance of this question is driven by the perceived diagnosticity of moles by forensic facial examiners (Towler et al., 2017). If this information is attributed a privileged status in facial comparison because it is of a less ambiguous nature than other feature judgements (Moreton, 2021), then it is important to establish that moles can be reliably matched, and that the classification of moles can proceed independently from other facial information. To explore this, the current experiment examined observers' ability to compare moles whilst they were instructed to ignore the facial context. This provides a measure of whether mole identification can proceed unbiased.

16 | METHOD

16.1 | Participants, stimuli, and procedure

Fifty participants (37 females, 13 males) with a mean age of 30 years ($SD = 9.96$) were recruited via *Prolific Academic* in exchange for a small fee. This study was run online via *Qualtrics* and consisted of two tasks. The first task measured face identification in the original (i.e., with no added moles) short version of the KFMT to provide a baseline measure of face identification accuracy for these stimuli. Conversely, the second task sought to establish whether observers' ability to compare moles across faces is influenced by whether the facial identity context is congruent or incongruent with the mole information. Therefore, this task presented observers with 20 mole match trials (10 identity-congruent, 10 identity-incongruent), and 20 mole mismatch trials (10 identity-congruent, 10 identity-incongruent). In other words, half of the mole match trials consisted of *facial* matches, and the other half were *facial* mismatches, and likewise for the mole mismatch trials. Example mole match and mole mismatch trials are provided in Figure 7.

Prior to beginning this second task, observers were instructed to decide whether each pair of onscreen faces shared the same moles or whether these differed between faces, and were asked to ignore the facial context. In addition, mole match and mismatch trials were counterbalanced across participants between two versions of the task and were equated in terms of difficulty.[1] Trials in both blocks were presented one at a time, in a random order.

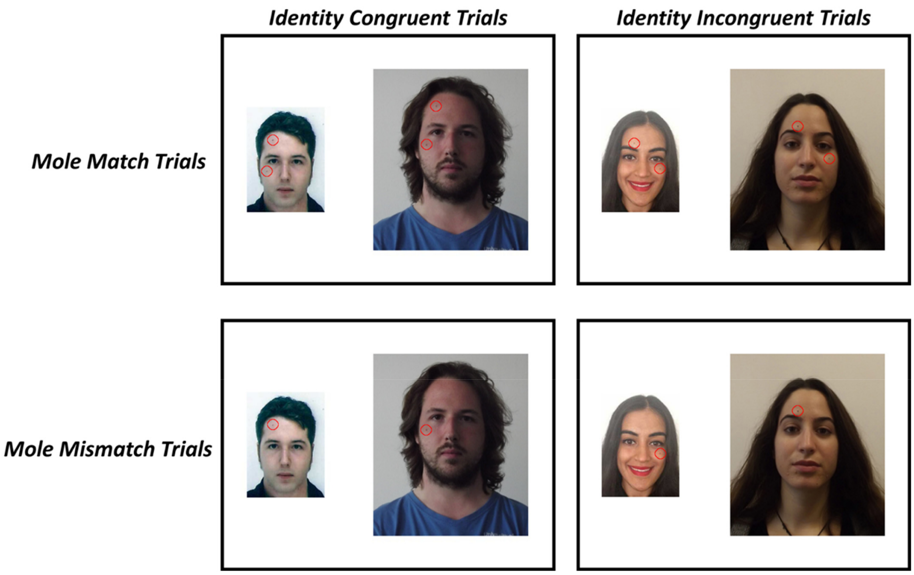

FIGURE 7 Example stimuli from Experiment 4. The top panel depicts identity-congruent (left) and identity-incongruent face pairings (right) from the mole-match trials, and the bottom panel likewise for the mole mismatch mole trials. For illustrative purposes, manipulated moles in this figure are highlighted with a red circle

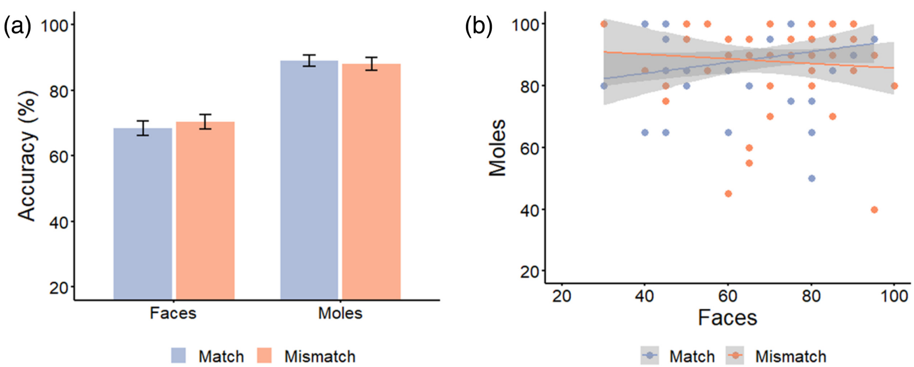

FIGURE 8 (a) Mean percentage accuracy in Experiment 4 for mole and face identification, and (b) the correlation of both tasks

17 | RESULTS

17.1 | Moles versus faces

First, the match and mismatch accuracy data were compared for mole and face identifications (see Figure 8). For this analysis, the accuracy of face identity classifications was compared against the accuracy of mole classifications. In terms of percentage accuracy, performance on mole matches (M = 89%, SD = 11.74) and mole mismatches (M = 88%, SD = 13.89) was higher than for face matches (M = 68%, SD = 16.14) and face mismatches (M = 70%, SD = 15.86). This pattern was corroborated via a 2 (task: mole identification vs. face identification) × 2 (trial type: match vs. mismatch) within-subjects ANOVA which revealed a main effect of task due to higher accuracy for mole than face identification, $F(1, 49) = 96.79$, $p < .001$, $\eta_p^2 = .66$, $BF_{10} = 152 \times 10^{13}$. There was no effect of trial type, $F(1, 49) = 0.03$, $p = .867$, $\eta_p^2 = .00$, $BF_{10} = 0.16$, and no interaction, $F(1, 49) = 0.55$, $p = .463$, $\eta_p^2 = .01$, $BF_{10} = 622 \times 10^{11}$.

Sensitivity was also higher for the identification of moles (M = 2.55, SD = 0.88) than faces (M = 1.06, SD = 0.48), $t(49) = 10.36$, $p < .001$, $d = 1.47$, $BF_{10} = 129 \times 10^{9}$. By contrast, criterion was similar for facial identification (M = 0.03, SD = 0.40) and mole identification (M = −0.02, SD = 0.35), $t(49) = 0.81$, $p = .420$, $d = .11$, $BF_{10} = 0.21$. Criterion was also comparable to zero for facial identification, $t(49) = 0.61$, $p = .536$, $BF_{10} = 0.19$, and for mole identification, $t(49) = 0.46$, $p = .648$, $BF_{10} = 0.17$, reflecting the absence of a response bias in both conditions.

In addition, we investigated whether mole and face comparison are associated processes, by correlating accuracy for these tasks (see Figure 8). Pearson's correlation analyses revealed that mole identification dissociated from face identification on match trials, $r(48) = .24$, $p = .091$, $BF_{10} = 0.71$, and mismatch trials, $r(48) = -.09$, $p = .557$, $BF_{10} = 0.21$.

17.2 | Congruency effects

Next, we examined whether mole matching was influenced by the facial context within which these were presented (i.e., identity congruency). These data are depicted in Figure 9, and were analysed via a 2 (trial type: mole match vs. mole mismatch) × 2 (congruency: identity-congruent vs. identity-incongruent) within-subjects ANOVA with supplementary Bayesian analyses, which revealed an interaction between factors, $F(1, 49) = 6.22$, $p = .016$, $\eta_p^2 = .11$, $BF_{10} = 1197.53$. Analysis of simple main effects with paired-sample Bayesian t-tests showed that accuracy was higher when the facial context was congruent with the

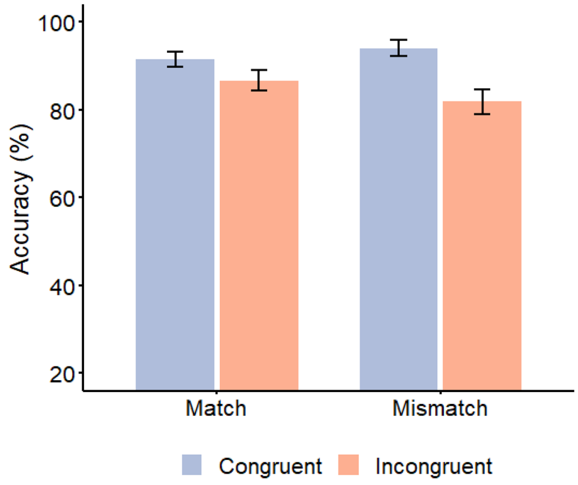

FIGURE 9 Mean accuracy in Experiment 4 for mole matches and mismatches with a congruent or incongruent facial context. Error bars denote standard error of the mean

mole information compared to when it was incongruent, both on mole-match trials, $F(1, 49) = 4.39$, $p = .041$, $\eta_p^2 = .08$, $BF_{10} = 1.14$, and mismatch trials, $F(1, 49) = 19.76$, $p < .001$, $\eta_p^2 = .20$, $BF_{10} = 430.32$. Accuracy did not differ between identity-congruent mole match and mole mismatch trials, $F(1, 49) = 1.41$, $p = .241$, $\eta_p^2 = .03$, $BF_{10} = 0.29$, or between identity-incongruent mole match and mole mismatch trials, $F(1, 49) = 2.76$, $p = .103$, $\eta_p^2 = .05$, $BF_{10} = 0.55$.

When converted to sensitivity, paired frequentist and Bayesian *t*-tests did not reveal a difference between mole match ($M = 2.69$, $SD = 1.09$) and mole mismatch trials ($M = 2.69$, $SD = 1.16$), $t(49) = 0.04$, $p = .97$, $d = .01$, $BF_{10} = 0.15$. Conversely, criterion was higher in the mole match condition ($M = -0.12$, $SD = 0.33$) than the mole mismatch condition ($M = -0.31$, $SD = 0.33$), $t(49) = 2.99$, $p < .01$, $d = .42$, $BF_{10} = 7.75$, reflecting a higher tendency in this condition to classify moles as matching. This response bias was also detected in both the mole match and mole mismatch conditions via one-sample *t*-tests, $t(49) = 2.60$, $p = .012$, $BF_{10} = 3.19$ and $t(49) = 5.77$, $p < .001$, $BF_{10} = 301 \times 10^2$, respectively.

18 | DISCUSSION

The results of this experiment show that mole identification is influenced to a small extent by information from the face context. However, mole identification is substantially more accurate than face identification, and accuracy for these tasks does not correlate. This indicates that mole matching and face matching are dissociable tasks.

19 | GENERAL DISCUSSION

Moles are considered to be highly diagnostic of facial identity by forensic facial examiners who compare and identify unfamiliar faces in criminal investigations (Moreton, 2021; Towler et al., 2017). However, scientific evidence demonstrating the benefits of moles for facial image comparison is limited. The current study investigated this by systematically manipulating the presence of moles in faces to understand how these features impact identification whilst all other facial information remained constant.

We found that participants who are completely untrained in facial comparison spontaneously utilised moles to make identification decisions (Experiment 1). These effects, which were expressed via accuracy and sensitivity, became enhanced further with the simple instruction that professionals find these features useful for identification (Experiment 2), and were observed for identity match and mismatch trials, demonstrating that both the presence and absence of moles was used to inform identification decisions. In addition, response accuracy and criterion were influenced by small spatial displacements of moles, indicating that the use of these features was also characterised by precise coding of their location (Experiment 3). These location effects demonstrate further that the facial context against which moles are presented is important for informing identification decisions. This was also evident when observers were asked to classify moles directly, where the congruency of the facial context continued to influence mole identification to some extent (Experiment 4). This makes good sense considering that the face provides the visual context against which the precise spatial location of moles must be coded. However, mole identification was markedly more accurate than facial image comparison under these circumstances, and mole and face identification did not correlate, indicating that both tasks are driven by dissociable processes.

These findings expand on previous studies that have provided mixed evidence for the beneficial effects of moles on facial image comparison. Whilst facial examiners consistently outperform novices (Phillips et al., 2018; Robertson et al., 2016; Towler, Keshwa, et al., 2021; White, Dunn, et al., 2015), and report that moles are highly diagnostic of identity (Towler et al., 2017), attempts to enhance facial image comparison in novices by training these observers to utilise moles have been met with limited success (Carragher et al., 2022; Towler et al., 2019; Towler, Kemp, & White, 2021, see Towler, Kemp, & White, 2021 for a review). At the same time, these studies employed stimuli in which moles occurred naturally, thus making it difficult to delineate the contribution of moles to identification accuracy relative to the information provided by the rest of the face. Our experiments expand understanding by systematically demonstrating the power of moles to influence facial image comparison decisions. We show that observers can make use of the presence, absence, and location of moles to boost facial comparison decisions beyond accuracy levels that are typically observed in face matching (e.g., Burton et al., 2010; Fysh & Bindemann, 2018).

It is particularly interesting that moles influenced accuracy when these were incongruent with the identity information of the face pairings. The consistency of this finding across experiments demonstrates the power of these small features to turn facial comparison decisions, even when other visual evidence from the face context indicates the contrary. Currently, it is unclear as to why this might be. However, one possible explanation is that the probability of two faces sharing a mole in the same location and yet *not* being the same person is implicitly understood by observers to be low, thus leading this feature to outweigh other facial information. Such reasoning is applied by facial examiners, fingerprint examiners, and document examiners when performing their respective tasks (e.g., Growns & Martire, 2020a; Martire et al., 2018; for a review see Growns & Martire, 2020b). Given that a definitive criterion for evaluating the similarity of two people is typically difficult to establish in facial comparison because of idiosyncratic variability in facial identity information (Bindemann & Sandford, 2011; Jenkins et al., 2011; Mileva et al., 2020, see also, Bindemann & Burton, 2021), it is possible that moles provide observers with a more grounded criterion for identity classification.

Finally, while the current experiments demonstrate the power of moles for informing—and overturning—facial comparison decisions, performance was similar in the control conditions of Experiments 1 and 2. This indicates that the unmanipulated face set for these experiments contained insufficient mole information to boost facial comparison, at least when observers were prompted to use this information in Experiment 2 relative to its spontaneous use in Experiment 1. This face set was based on photographs of real faces (see Fysh & Bindemann, 2018), so these findings should generalise to similar natural face presentations. This indicates that the utility of moles for supporting facial comparison may be curtailed by the frequency with which such facial features occur in the general population. Databases that speak to the prominence of such features, and therefore allow for a quantitative evaluation of facial comparison evidence, are key to establishing the importance of moles beyond our experimental demonstration (see Moreton, 2021).

ACKNOWLEDGMENTS

This work was funded by a research grant from the Economic and Social Research Council (ESRC Grant no. ES/S010181/1) to Markus Bindemann, A. Mike Burton, and Cade McCall.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The datasets generated during and/or analysed during the current study are available in the OSF repository https://osf.io/nsjbx/.

ORCID

Matthew C. Fysh https://orcid.org/0000-0002-3812-3749

Markus Bindemann https://orcid.org/0000-0002-9608-4186

ENDNOTE

[1] Accuracy was comparable for the two sets of match trials ($M = 70\%$, $SD = 21$ vs. $M = 71\%$, $SD = 20$), $t(18) = 0.13$, $p = .90$, and the two sets of mismatch trials ($M = 71\%$, $SD = 20$ vs. $M = 68\%$, $SD = 20$), $t(18) = 0.34$, $p = .74$.

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How to cite this article: Fysh, M. C., & Bindemann, M. (2022). Molistic processing in facial image comparison. *Applied Cognitive Psychology*, *36*(4), 830–841. https://doi.org/10.1002/acp.3975