

Automatic Integration of Emotion From Faces and Hands

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Facial expression and body posture provide rich information about other people's emotional states. Visual information about body posture rapidly and automatically influences perception of facial emotion. Even images of isolated hands carry rich information about emotion, but it is unknown whether this local information is automatically integrated with perception of facial emotion. We created composite stimuli in which facial emotional expressions (anger or fear) were superimposed onto bodies expressing either the same or a different emotion. We manipulated whether the full-body context was shown, or only the hands. Participants judged the emotion of the face, ignoring the bodily context. Consistent with previous findings, whole-body context exerted clear influence on the accuracy and speed judgments of facial emotion judgments. Critically, similar effects were found for faces presented in the context of isolated hands. This demonstrates that emotion from hands is automatically integrated with facial emotion.

Public Significance Statement

We can recognize the emotions of other people using information from both their facial expressions and their body postures. Recent research has shown that cues from the face and the body are automatically integrated, even if people are trying to focus on only one cue. We show that this automatic integration also occurs between faces and isolated hand postures.

Keywords: emotion, body perception, face perception, hands

Recognizing the emotions of other people is a core aspect of social perception. An enormous literature has investigated visual perception of emotion from facial expressions. There is increasing research, however, showing that people are also able to use cues from other perceptual channels, such as the voice (Kuhn et al., 2017; Sauter & Eimer, 2010; Yovel & Belin, 2013) and body posture (de Gelder, 2009; de Gelder et al., 2015; de Gelder & Poyo Solanas, 2021). Although it has long been known that bodily displays of emotion are important in both humans and other animals (Bell, 1847; Darwin, 1872), it is only in recent decades that

researchers have begun to systematically investigate emotion recognition from bodies. This research has found that people are easily able to recognize a range of emotions from still images, movies, and point-light displays of bodies (Atkinson et al., 2004; Coulson, 2004; Dael et al., 2012; de Gelder & Van den Stock, 2011; de Meijer, 1989; Wallbott, 1998). Indeed, in some situations, it is body posture rather than facial expressions that most effectively differentiate intense displays of emotion (Aviezer et al., 2012a).

There is evidence that emotional information from faces, bodies, and voices is automatically and rapidly integrated. For example, when participants are instructed to judge the emotion expressed by a face while ignoring auditory information, judgments are nevertheless biased by simultaneous emotional vocalizations (de Gelder & Vroomen, 2000). Another study by Meeren et al. (2005) showed analogous results for faces and bodies. They created composite stimuli in which the face of one actor modeling an emotional expression (anger or fear) was edited onto the body of a different actor modeling an emotional posture (also anger or fear). This allowed them to manipulate whether the face and the body displayed the same emotion or were incongruent. Although participants were instructed to base their judgments entirely on the emotion displayed by the face, they were unable to ignore the body context, showing slower and less accurate responses on incongruent than on congruent trials. Subsequent studies have replicated this pattern using a variety of different emotions (Aviezer et al., 2008, 2011; Mondloch, 2012; Van den Stock et al., 2007). The integration of information about emotion from bodies and faces is

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Matthew R. Longo served as lead for conceptualization, data curation, formal analysis, methodology, project administration, software, visualization, and writing—original draft. Robert Mackenzie served as lead for investigation and writing—review and editing and served in a supporting role for conceptualization.

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thus automatic and cannot be suppressed even in circumstances where it is counterproductive.

There is also evidence that this integration is extremely rapid. In the study described earlier, [Meeren et al. \(2005\)](#) used electroencephalography to measure the time course of integration between emotional faces and bodies. The amplitude of the P1 component of the visual evoked potential was increased when the body context was incongruent with the emotion expressed by the face. This modulation occurred strikingly early, on average around 115 ms after stimulus presentation. As the earliest face-specific responses in visual cortex occur around 100 ms ([Liu et al., 2002](#)), this modulation of the P1 component is almost certainly too early to reflect feedback from higher level regions of the ventral visual pathway. It is therefore likely to reflect processing from a subcortical pathway involving the amygdala, which is known to have a modulating role on perception of emotional faces ([Morris et al., 1998](#); [Rudrauf et al., 2008](#); [Vuilleumier et al., 2004](#)). Consistent with this interpretation, a functional magnetic resonance imaging (fMRI) study found that a congruent body context produced an increase in the modulatory effect of the amygdala on several cortical regions ([Poyo Solanas et al., 2018](#)).

Most studies of emotion recognition from body posture have shown the entire body. There is also evidence, however, that even isolated body parts can carry information about emotion ([Blythe et al., 2023, 2026](#); [Grosbras & Paus, 2006](#); [Pollick et al., 2001](#); [Ross & Flack, 2020](#)). For example, in a recent study ([Blythe et al., 2023](#)), we asked participants to classify the emotion from images of full bodies or from the same images when everything was deleted except for individual body parts, such as the head, torso, arms, and hands. Although classification accuracy was highest for full bodies, performance was above chance levels for all body parts. Performance was particularly strong for hands, suggesting that they may be especially effective channels for communication of emotion. Moreover, representational similarity analysis showed that the pattern of confusions between emotions was similar for hands and full bodies. Another study found that socially anxious individuals who tend to avoid looking at other people's faces compensate by looking more at hands ([Kret et al., 2017](#)). Together, these results suggest that the hands have an important role in the interpersonal communication of emotion, consistent with their broader communicative role, for example, in cospeech gestures ([Goldin-Meadow, 2003](#)).

Neuroimaging studies of visual perception of human bodies have shown that different regions of the ventral visual pathway differ in their selectivity for whole bodies versus isolated body parts. [Taylor et al. \(2007\)](#), for example, compared the responsiveness of the extrastriate body area and fusiform body area to body parts and whole bodies. They found that the extrastriate body area showed a progressive increase in responsiveness the more of the body was shown, suggesting that it maintains representation of individual parts, the more of which are shown, the stronger the activation in this region. In contrast, the fusiform body area showed little responsiveness to isolated parts but became active in a step-like way when a large portion of the body was shown, indicating that it maintains representation of the body as a whole.

Other studies have shown that more anterior regions in the temporal lobe show integration of faces and bodies, indicating a more holistic representation of entire people (e.g., [Fisher & Freiwald, 2015](#); [Harry et al., 2016](#); [Kaiser et al., 2014](#)). This integration of

faces and bodies may occur only for whole-body stimuli and not for individual body parts: [Harry et al. \(2016\)](#) found that neural responses to faces in the anterior temporal face patch were correlated at a voxel-by-voxel level with responses to whole bodies, but not with responses to body parts. Thus, although visual representations of whole bodies and body parts appear to coexist in the ventral visual pathway, integration of face and body information may occur only for whole bodies.

Taken together, the results just described suggest that integration of bodies and faces may primarily occur at the level of full bodies. This raises the possibility that the automatic integration of emotion from bodies and faces reported previously ([Meeren et al., 2005](#)) might occur only for full bodies, and not isolated body parts. This, in turn, raises a critical question for models of face-body integration: Does automatic face-body integration depend on holistic representations of whole bodies, or can it arise from local representations of individual body parts? If integration occurs only at the level of whole-body representations, then isolated body parts should not automatically influence facial emotion perception, even if they may carry emotional information (cf. [Blythe et al., 2023](#)). This distinction would align with accounts of processing in the ventral visual pathway that differentiate between representations of whole bodies and body parts, which have been argued to support face-body integration primarily at the level of whole bodies (e.g., [Harry et al., 2016](#)). Alternatively, even isolated body parts such as hands should be sufficient to produce congruency effects, which would demonstrate that automatic integration is not specific to holistic, full-body representations.

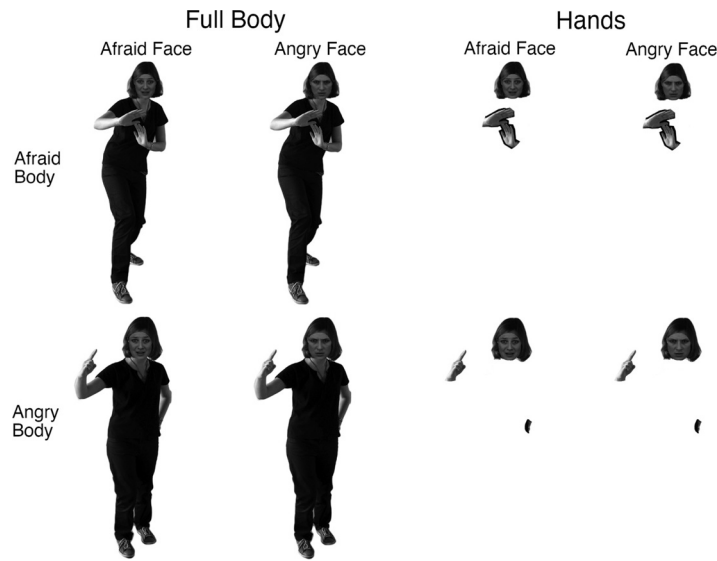
To adjudicate between these interpretations, the present study investigated whether there is automatic integration of information about emotion from faces and hands, comparable with that found in previous research for faces and full bodies. We used the paradigm developed by [Meeren et al. \(2005\)](#), which employs face/body composite stimuli. Faces expressing either anger or fear were edited onto bodies that also expressed either anger or fear. The critical novel manipulation was whether the body context depicted the full body or only the hands, as shown in [Figure 1](#). The participant's task was to judge the emotion (anger/fear) shown in the face, ignoring the body context. We predicted that the automatic integration of emotional information from faces and bodies seen for full bodies in previous research would also occur for faces and hands. This should result in higher accuracy and shorter reaction times (RTs) on congruent trials, in which the emotion in the body matches that in the face, than on incongruent trials, in which the emotion in the body mismatches that in the face. Critically, this prediction directly contrasts with the interpretation that face-body integration depends on holistic, whole-body representations, which would not predict automatic integration between emotional information from faces and isolated body parts like hands.

Method

Participants

Fifty-six people located in the United Kingdom participated in 2023, five recruited through the experimenter's social network and 51 through the Prolific web service (<https://www.prolific.com/>). Participants ranged from 20 to 75 years of age ($M = 40.9$ years,

Figure 1
Example of One Complete Stimulus Set



Note. Angry and afraid faces from one KDEF model (F1) were edited onto angry and afraid body postures from one BESST model (8). In the full-body condition, the entire body was shown, whereas in the hands condition, only the hands were shown. KDEF = Karolinska Directed Emotional Faces; BESST = Bochum Emotional Stimulus Set. Images used with permission.

$SD = 13.4$). In terms of gender, 32 were female, 22 male, one nonbinary, and one preferred not to say. Forty-eight were right-handed by self-report, six were left-handed, and two were ambidextrous. Participants provided informed consent before participating and procedures were approved by the School of Psychological Sciences Research Ethics Committee at Birkbeck.

In the study of Meeren et al. (2005), the congruence effects showed large effect sizes. Converting the reported F statistics to t statistics gave values of Cohen's d_z of 1.73 for accuracy and 1.53 for RT. A power analysis conducted with G*Power 3.1 (Faul et al., 2007) using the smaller of these two effect sizes showed that eight participants were needed to have a power of 0.95 to detect a comparable effect. We suspected that a potential effect of the hands would be smaller than the effect of full bodies studied by Meeren et al. We therefore aimed to have a power of 0.95 to detect a Cohen's d_z of 0.5, which indicated that 54 participants were required. Our sample size is thus well powered to detect an effect of hands substantially smaller than the effect of full bodies found in previous research.

Stimuli

We combined the image editing procedures used by Meeren et al. (2005) and by Blythe et al. (2023). Like Meeren et al., angry or afraid faces were edited onto bodies, which could express either the same or a different emotion. Like Blythe et al., we edited the emotional bodies to remove everything except the hands.

Face stimuli were taken from the Karolinska Directed Emotional Faces (KDEF; Lundqvist et al., 1998), and body stimuli were taken from the Bochum Emotional Stimulus Set (BESST; Thoma et al., 2013). Nine models (seven women and two men)

from each stimulus set were used (KDEF models: F1, F3, F9, F21, F22, F24, F26, M10, and M11; paired with, respectively, BESST models: 8, 13, 39, 58, 17, 29, 45, 10, and 85). Data from our previous studies (Blythe et al., 2023, 2026) have shown that these body stimuli successfully convey emotion. Six of the nine BESST models were used in Experiment 1 of Blythe et al. (2023), where performance on the six-way classification (i.e., chance is 16.7%) of emotion for these stimuli was 64.5% correct for hands and 74.7% for full bodies. All nine models were used in Blythe et al. (2026), although only hand stimuli were used, with performance for these stimuli of 61.1% correct.

The stimuli were composites in which one KDEF face was superimposed onto a body from the BESST. Thus, for each face/body pair, there were eight stimuli, formed by the factorial combination of the body context (full body, hands), the facial emotion (afraid, angry), and the bodily emotion (afraid, angry). Images were edited using the GNU Image Manipulation Program (Version 2.10.32). An example of one full stimulus set is shown in Figure 1. There were thus 72 stimuli in total.

Procedure

The experiment was conducted online using the Gorilla platform (Anwyl-Irvine et al., 2020). Participants completed the study using their own device (computers and tablets were allowed, but not mobile phones). The exact viewing distance and size of stimuli thus varied according to each participant's screen size. The participant was instructed that their task was to judge the emotion being expressed by the face and that they should base their judgment only on the face and not on any other body parts that might be present.

Each trial started with a fixation cross that lasted for 200 ms, following by the face/body stimulus, which lasted for 300 ms. After the stimulus disappeared, the participant responded by clicking one of two buttons at the bottom of the screen labeled “Angry” and “Afraid.” There were 72 trials, one for each stimulus, which were presented in random order. Trials in which RT exceeded 4 s were excluded from analyses (2.8% of trials).

The main analyses were rerun, including only the 51 participants recruited from Prolific. As there were no substantive differences to the overall analysis, only the latter is reported.

Transparency and Openness

Stimuli and raw data are available on the Open Science Framework (<https://osf.io/rjnvz/>). The study was not preregistered. Data were analyzed using Microsoft Excel and JASP 0.18.1 (<https://jasp-stats.org/>). We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study.

Results

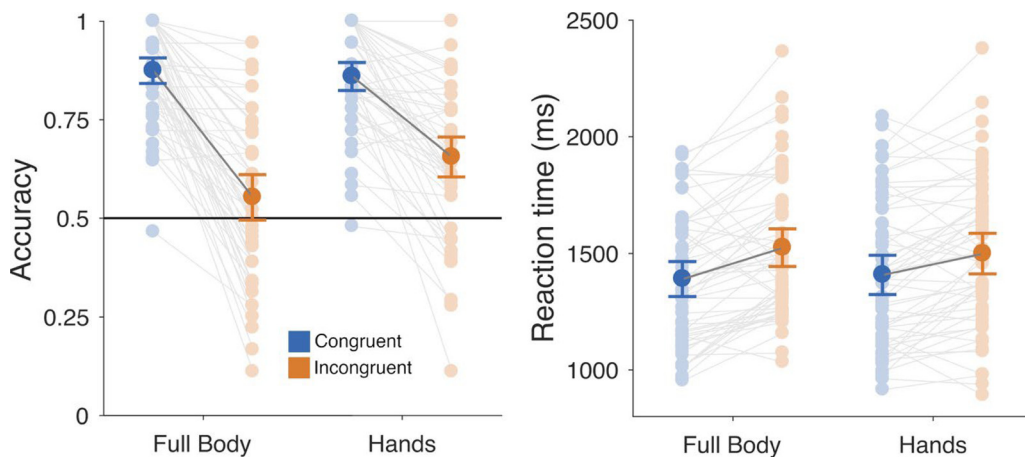
The results are shown in Figure 2. An analysis of variance (ANOVA) on accuracy revealed significant main effects of body context, $F(1, 55) = 15.71, p < .001, \eta_p^2 = .222$, and congruence, $F(1, 55) = 121.74, p < .0001, \eta_p^2 = .689$. The effect of congruence shows that performance was more accurate when the body context was congruent with the facial emotion than when it was incongruent, consistent with previous results (Meeren et al., 2005; Van den Stock et al., 2007). These main effects were modulated by a significant interaction between body context and congruence, $F(1, 55) = 27.20, p < .0001, \eta_p^2 = .331$. This interaction shows that the magnitude of the congruence effect differences depending on whether the full body is shown or only the hands. Paired t tests showed clear congruence effects when the full body was shown (87.4 vs. 55.3%

correct), $t(55) = 11.13, p < .0001, d_z = 1.487$, replicating previous results (Meeren et al., 2005; Van den Stock et al., 2007). Critically, however, there was also a significant congruence effect when only hands were shown (86.0 vs. 65.5% correct), $t(55) = 8.69, p < .0001, d_z = 1.161$. The magnitude of the congruence effect for hands was significantly smaller than that for full bodies (20.4 vs. 32.2%), $t(55) = 5.22, p < .0001, d_z = 0.697$.

An ANOVA on RT data showed a similar main effect of congruence, $F(1, 55) = 33.30, p < .0001, \eta_p^2 = .377$. Unlike accuracy, there was no main effect of body context, $F(1, 55) = 0.05, p = .822, \eta_p^2 = .00$, nor an interaction, $F(1, 55) = 1.82, p = .183, \eta_p^2 = .032$. Responses on congruent trials were significantly faster than on incongruent trials both when the full body was shown (1,390 vs. 1,524 ms), $t(55) = 4.89, p < .0001, d_z = 0.679$, and when only hands were shown (1,408 vs. 1,499 ms), $t(55) = 3.66, p < .001, d_z = 0.508$. Consistent with the lack of an interaction in the ANOVA, there was no significant difference between the two body contexts in the magnitude of the congruence effect, $t(55) = 1.30, p = .200, d_z = 0.180$. The clear congruence effects in RT show that the effects of accuracy reported previously cannot be interpreted in terms of a speed–accuracy trade-off.

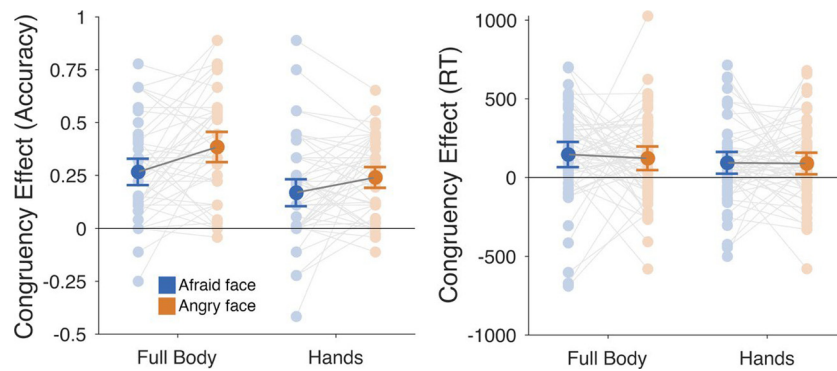
We next conducted analyses on the congruency effects (i.e., congruent – incongruent) for both accuracy and RT, including the emotion of the face stimulus as a factor, as shown in Figure 3. For accuracy, there was a significant main effect of body part, $F(1, 55) = 28.50, p < .0001, \eta_p^2 = .341$, with larger congruency effects for full bodies than for hands, consistent with the previous analyses. There was also a significant main effect of emotion, $F(1, 55) = 16.61, p < .0001, \eta_p^2 = .232$. Congruency effects were larger for judgments of angry than of fearful faces, suggesting a larger influence of fearful than of angry body postures. There was no significant interaction of body part and facial emotion, $F(1, 55) = 1.08, p = .303, \eta_p^2 = .019$. Congruency effects were significantly larger for angry than for fearful facial expressions both when full bodies were shown,

Figure 2
Accuracy and Reaction Time Data for Full-Body and Hands Contexts



Note. Left panel: Accuracy data. Clear congruency effects were apparent when faces were accompanied by a full-body emotional expression or only by hands. Right panel: Reaction time data. Again, clear congruency effects were found for both full-body and hands contexts. Light-colored points are individual participant data, whereas dark-colored points are grand means. Error bars show 95% confidence intervals. See the online article for the color version of this figure.

Figure 3
Congruency Effects for Accuracy and RT for Afraid and Angry Faces



Note. Congruency effects (i.e., congruent – incongruent) for accuracy (left panel) and RT (right panel) are plotted separately for afraid and angry faces. For accuracy, congruency effects were found in all cases, but were larger for full body than for hands and larger for angry faces than for afraid faces. For RT, congruency effects were again found in all cases but did not differ in magnitude across conditions. Light-colored points are individual participant data, whereas dark-colored points are grand means. Error bars show 95% confidence intervals. RT = reaction time. See the online article for the color version of this figure.

$t(55) = 3.53, p < .001, d_z = 0.472$, and when only hands were shown, $t(55) = 2.31, p < .05, d_z = 0.309$.

For RT, an ANOVA found no main effects of body part, $F(1, 55) = 1.82, p = .183, \eta_p^2 = .032$, or facial emotion, $F(1, 55) = 0.16, p = .692, \eta_p^2 = .003$, nor an interaction, $F(1, 55) = 0.06, p = .805, \eta_p^2 = .001$. Thus, although there were significant congruency effects in all cases, these did not differ in magnitude across conditions.

Finally, there was a large age range of participants in this study. Previous research has found that older adults show reduced ability to recognize emotions from faces, voices, and bodies (Ruffman et al., 2008, 2009). At the same time, other evidence using face-body composites suggests that older adults are most strongly influenced by bodily context (Foul et al., 2018). This combination of relatively poor facial emotion recognition and heightened sensitivity to body context suggests that older adults might be especially susceptible to the present manipulation. Although this study was not designed to look at effects of aging, we reran the ANOVAs on accuracy and RT, including only the subset of 31 participants who were aged 40 and under to ensure that the effects were not driven by the inclusion of a wide age range. The results from this subgroup were very similar to the overall sample, showing that the inclusion of older adults in this study did not substantially alter our results.

Discussion

The present results provide further evidence for automatic integration of emotional information from faces and bodies. The results from the full-body condition provide a clear replication of the finding that emotion recognition from seen faces is slower and less accurate when faces are presented in the context of a body posture displaying a different emotion (Aviezer et al., 2008, 2011, 2012b; Meeren et al., 2005; Mondloch, 2012; Van den Stock et al., 2007). More critically, a similar pattern was found when faces were presented together with isolated hands.

This demonstrates that emotion from faces and hands is automatically integrated, in a similar way as from full bodies. More broadly, these results emphasize the important role of the hands in social perception and communication (Longo, 2025).

These results provide further evidence that emotional perception from bodies does not depend only on the global configuration of the entire body. Removing the hands from images disrupts the ability to classify emotion from the rest of the body (Ross & Flack, 2020), emotion can be classified from isolated images of hands (Blythe et al., 2023), and the presence of emotional information in hands disrupts perception of facial emotion even when irrelevant to the task (this study). Together, these results indicate that the hands are a rich source of information about the emotions of others, which are automatically integrated with information from other sources, such as facial expressions. More generally, these results complement broader findings that the hands are a rich communicative channel, as seen, for example, in cospeech gestures, which are known to increase comprehension in observers (Berger & Popelka, 1971; Graham & Argyle, 1975; Riseborough, 1981), memory for the content of speech (Woodall & Folger, 1981, 1985), and learning both in classroom settings (Cook et al., 2013; Valenzeno et al., 2003) and in vocabulary acquisition in young children (Mumford & Kita, 2014; Wakefield et al., 2018).

The automatic processing of emotional information from hands in the present study has an interesting resemblance to automatic processing of information from deictic hand gestures, such as points. Langton et al. (1996; Langton & Bruce, 2000) used a Stroop-type paradigm to show that attention is automatically oriented in the direction of a seen point. Similar results have been found even in young infants (Bertenthal et al., 2014; Daum et al., 2013; Rohlfling et al., 2012), indicating that automatic perceptual processing of hand gestures is present from early in life. The present results indicate that this automatic processing is not only specific to imperative, deictic gestures such as points but also arises from hand gestures reflecting emotional states.

Larger congruency effects were found for angry faces than for fearful faces. This indicates that incompatible fearful body postures had a larger influence on judgments than did angry body postures. This effect was not predicted and its significance is uncertain. A large literature on face perception has shown that both fearful and angry faces capture attention even when task irrelevant (e.g., Bradley et al., 1997; Eimer & Kiss, 2007; Fenker et al., 2010). The same has been found to be true for angry and fearful body expressions (e.g., Bannerman et al., 2009; Borgomani et al., 2025; Tamietto et al., 2007). Although angry and fearful stimuli are frequently grouped together as “threatening” stimuli, some previous studies have found differences in responses to fearful and angry body expressions (de Valk et al., 2015; Pichon et al., 2009). Pichon et al. (2009), for example, used fMRI to compare neural responses with body expressions of anger and fear. Although similar activations were found in many brain areas, angry expressions elicited larger responses in the anterior temporal lobe, the premotor cortex, and the prefrontal cortex. In contrast, fearful expressions produced larger activations in the temporoparietal junction. This latter effect is interesting in relation to the known involvement of temporoparietal junction in understanding the mental states of other people (e.g., Samson et al., 2004; Saxe & Kanwisher, 2003) and might be linked to the larger influence of fearful than angry bodies on facial emotion recognition in the present study.

The finding that similar automatic integration of emotional information from faces and bodies occurs for whole bodies and isolated hands also provides insight into the underlying perceptual integration mechanisms underlying such effects. Some studies have manipulated whether the emotional face is presented in its anatomically correct position on top of the body or in a misaligned position (Aviezer et al., 2012b; Mondloch, 2012), finding that such misalignment reduces the magnitude of face/body integration. In the present study, faces in the hands condition were aligned with where the torso and neck would be, but are also not physically contiguous with the actual portions of the body shown in the image. Despite this lack of contiguity, strong integration between the face and hands was nevertheless found. This suggests that physical contiguity is not a critical aspect of this integration.

The nature of integration in this paradigm, whether from whole bodies or from faces, remains uncertain. One interpretation is that the bodily emotion and facial emotion undergo a type of Bayesian integration to produce a single percept of facial emotion that is intermediate between the two stimuli. This form of integration could be analogous to the optimal integration of visual and haptic information described by Ernst and Banks (2002), in which signals from each modality are integrated with weights proportional to their precision. Alternatively, it may be that on some proportion of trials, the body stimuli capture attention such that on those trials, the participant responds based on the body stimulus *instead of* the face. On this interpretation, the effects reflect something more like Stroop interference than true integration. Because responses in this paradigm are dichotomous, there is no way to differentiate between these interpretations, which is an important topic for future research.

The present behavioral study provides clear evidence for automatic integration of emotion information from faces and hands. The neural mechanisms underlying this integration, however, remain unclear. Discussing integration of face and body information more

generally, Hu et al. (2020) contrasted hypotheses of “early integration” at perceptual stages of processing (e.g., Aviezer et al., 2011) and “late integration” at decision-making stages (e.g., Carroll & Russell, 1996). In this study, we cannot determine whether the integration we observe occurs at early or late stages. Meeren et al. (2005) took advantage of the temporal resolution of electroencephalography to show that integration between emotional information between faces and full bodies occurred rapidly, not much more than 100 ms after stimulus presentation, suggesting integration at the perceptual level. It would be interesting in future research to similarly measure the time course of integration between faces and hands, which could help determine whether the effects in the present study reflect integration at the perceptual level rather than the decisional level. Harry et al. (2016) found using fMRI that the anterior temporal lobe showed strong integration between faces and full bodies but weaker integration between faces and individual body parts. Future research should use similar fMRI paradigms to investigate which brain regions integrate emotional information from faces and bodies or body parts.

There are several constraints on the generality of our results. We tested participants in the United Kingdom using face and body stimuli that depict White European models. It will be important in future research to test participants from a wider range of cultures using more diverse stimuli. Our study also focused specifically on just two emotions, and it would be interesting to test a broader range of emotional displays. Our study also focused on the relation between the face and the hands, but we know from previous research that body parts other than the hands also carry information about emotion (Blythe et al., 2023).

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