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Abstract

The current study aimed to examine how the recognition of grey-scale photos of fearful or angry female bodies would be affected by three conditions: social situation (single person vs. facing vs. nonfacing dyad) the orientation of figures (upright vs. inverted); emotion complementarity (same vs. complementary). We hypothesized that the recognition of emotions would be the most accurate when either single or facing body pairs were presented, while the inversion would impair the perception of affective expressions. Facing bodies in fact had an advantage over nonfacing ones, same emotion condition also had higher accuracy than complementary, as well as the overall accuracy was higher for anger than fear, thus context was an important factor in differentiating between these two negative emotions. Inversion effect was not confirmed for emotions conveyed by bodies, therefore our results demonstrated that not only configural, but part-by-part analysis is also required for emotion recognition.

Keywords: body inversion effect, social interactions, bodily emotional expressions

Introduction

In everyday life we are surrounded by people in multiple situations, therefore information conveyed by bodies needs to be addressed as rapidly and accurately as possible to give a proper reaction to each signal. Therefore, our perceptual system is adapted to process bodily information effectively (Aviezer, Trope, & Todorov, 2012; de Borst & deGelder, 2016).

Previous studies have investigated how faces (i.e.Valentine, 1988; Yin, 1969) and bodies (Reed, Tanaka & Bozova, 2003) are considered special stimuli to our visual system, as their perception is holistic, configural, while non-face objects like houses, are processed by their isolated parts (Maurer, Le Grand & Mondloch 2002; Reed et al., 2003). To indicate the importance of configural processing, face and body inversion effect (BIE) has been confirmed multiple times in the past. It means bodies are processed the most accurately in their common upright position, however, recognition is disrupted when they are presented upside down (e.g. Reed et al., 2003; Reed, Grubb & McGoldrick, 2006). This effect is absent or disrupted for objects (Reed et al., 2003; Papeo et al., 2017), headless bodies (Arizpe et al., 2017; Minnebusch et al., 2009; Reed et al., 2003; Yovel, Pelc & Lubetzky, 2010) as well as for biomechanically impossible body postures, joint positions or scrambled body parts (Reed et al., 2003; Soria Bauser & Suchan, 2013; Tao & Sun, 2013; Tao, Zeng & Sun, 2014). These observations apply to bodies presented as isolated stimuli, however, in everyday life social and affective signals are often conveyed by more people at the same time rather than people being surrounded by no one else, or no environmental context.

When there is a visible interaction between two people or objects, they are prone to be processed as one entity (Green & Hummel, 2004; Alvarez, 2011; Papeo, Stein & Soto-Faraco, 2017) similarly to individuals depicted alone. The visual system is driven by the relative positioning of bodies; therefore, a grouping mechanism works when two bodies appear to be related to each other. Some previous studies investigating two-body interactions (Papeo, et al., 2017, 2019; Vestner et al., 2019, 2020, 2021) revealed that bodies perceived as unrelated (not facing each other) are processed part-by-part rather than configural, therefore, their perception differs from visibly facing pairs and single bodies, as facing body dyads had advantage over nonfacing dyads in visual search tasks. It has also been reported that inversion did not disrupt the detection of unrelated body pairs to the same extent as for interacting bodies, providing evidence for the presence or lack of configural processing of bodies based on social context (Papeo et al., 2017; Vestner et al., 2021).

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People are naturally professional at reading bodily information regardless the context they are presented at, yet recognition appears to be dependent by the surrounding objects, especially when bodies convey emotions (Hortensius, de Gelder, & Schutter, 2016; Kret & de Gelder, 2010).

According to previous findings, body expressions contribute to the recognition of some affective states more than facial expressions (Ekman & Friesen, 1969; Ekman & Friesen, 1974; Meeren, Heijnsbergen & deGelder, 2005; Van den Stock, Righart & deGelder, 2005), especially if the emotions displayed by the body and face were different (Kret et al., 2013a; Meeren et al., 2005; Van Heijnsbergen, Meeren, Grezes & deGelder, 2007). Body posture has been found to be important in the recognition of fear as it indicates both an existing threat and an action tendency as well (de Gelder, 2006). Similarly, aggressive body cues are perceived as a direct threat to the observer, more than faces alone (de Gelder et al., 2010). Fearful postures can be labeled as high arousal, low valence with a negative or neutral-negative action tendency. Angry postures, on the other hand, are labeled by observers as high arousal, neutral valence with a positive action tendency, hence these two emotions are easily distinguishable from each other (Kleinsmith, De Silva & Bianchi-Berthouze, 2005).

Previous studies have also concluded that two bodies or faces conveying congruent (same), or incongruent (different) emotional expressions are processed differently (Abramson et al., 2021; de Borst and deGelder, 2016; Kret et al., 2013a, Kret et al., 2013b). A study by Abramson and colleagues (2021) showed that fear presented as a target stimulus next to an angry body was recognized better compared to when another fearful body served as context, and this context effect was stronger for facing bodies, than for nonfacing ones. These findings further prove the notion that anger is a threatening social signal, while fear is a reaction to a threatening environment (de Borst & deGelder, 2016) making them complementary emotions, as fear is a natural reaction to expressions of anger. The complementarity of these two basic emotions enhances the contextual relevance of their perception, hence evaluating the interaction of fear and anger is different from understanding emotion incongruency (e.g., fear with happy or neutral body expressions), or two bodies conveying the same affective state (like two fearful bodies). Complementarity can be even more pronounced if fearful and angry bodies face each other, as these threatening bodies may not be that alarming from third person-perspective, when there is no apparent relation between them.

In this study, we focus on the understanding of configural or piecemeal processing of emotional bodies when not only the social situation of bodies (single, facing non facing) but also the effect of complementarity (same emotions or complementary emotions) is involved as contextual cues. Also, to date there are no studies investigating the inversion effect when two emotional bodies are presented in a facing or nonfacing social context.

We predict that the recognition of emotions conveyed by female bodies is affected by the perceived social situation (single bodies, facing dyads or nonfacing dyads), the complementarity of emotions (same or complementary emotion conditions) as well as the orientation (upright, inverted) of the presented stimuli. Based on previous literature (Papeo et al., 2017, Vestner et al., 2019, 2020, 2021), we assume that facing social context will have an advantage over nonfacing bodies. Also, inversion may disrupt the perception of emotions more in facing condition than in nonfacing. We also consider that results may vary based on the complementarity of emotions, as fearful bodies may be detected more accurately if the adjacent body is angry, rather than fearful (Abramson et al., 2021). We solely rely on the perception of fearful and angry bodies this time, and single bodies serve as controls for understanding the mere perception of emotions without any contextual or social information.

Materials and methods

Participants

31 healthy adults (17 females, 14 males, mean age = 23,7, SD = 2.33) with normal or corrected-to-normal vision volunteered to take part in the experiment, they were recruited at the University of Pécs. All participants were right-handed. All gave informed consent prior to participation. Previously, five participants were excluded from the analysis as their overall accuracy rates were below the group's average performance. Power analysis was run to justify the sample size required for the experiment (26-34 participants) and our initial sample size was eligible for the criteria.

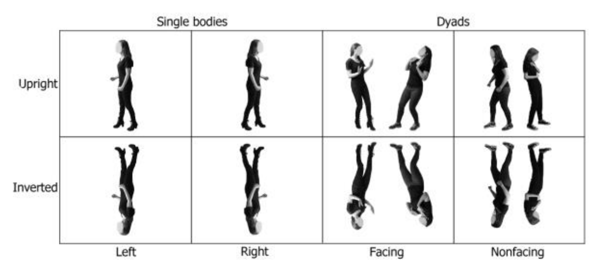

Figure 1: Examples of single body and dyad conditions in upright and inverted orientation.

Stimuli

A new stimulus set was created for the current experiment. For the stimulus set five male and five female students in their twenties were recruited at the University of Pécs as nonprofessional models in exchange for course credit or out of personal interest. Participants were instructed to wear dark trousers and dark tops (a t-shirt or a long-sleeved shirt) for photography. They posed in front of a white wall lit by natural light and all models were asked to display each emotion (fear, anger, happiness, sadness and neutral) as naturally as possible, and they were photographed from both frontal and lateral views. The photos were taken with a digital camera, and they were edited in Adobe Photoshop CC and Clip Studio Paint. All figures were turned gray-scaled, cut out, and placed on a white background (512 x 768 pixels), and their faces were masked by a grey oval shape.

The validation of the selected 54 photographs of male models involved 31 participants (22 females, 9 males; mean age = 26.6, SD = 5.78) while the validation of the 53 images of female models involved 33 participants (28 females, 5 males; mean age = 28.4, SD = 7.94). All stimuli were presented in a random order. Participants had to choose the emotion each photo conveyed, and they also rated their reliability on a 9-point Likert-scale.

For the current experiment, three female identities were chosen from the original stimulus set. Photographs of males were not used in this experiment to provide less conditions. Previous studies also used female stimuli only (see Geangu & Vuong, 2020). We also took into consideration women tend to be better at expressing affective states (Brody & Hall, 1993, Wood et al., 1989). This time only fearful, angry and neutral expressions were used, and all figures were seen from a lateral view. All stimuli had a recognition rate of at least 90%.

The images were vertically mirrored so that half of the stimuli were looking leftwards and half of them were looking rightwards which yielded twelve pictures. The twelve figures were flipped upside down to measure the body inversion effect. In both upright and inverted orientations stimuli were used twice which resulted in 24-24 experimental trials. Dyads were also created in Clip Studio Paint. The two bodies were arranged as either facing or facing away from each other before a white background (1061 x 768 pixels large). For combining expressions, pictures of the previous female identities were used. Eight dyads either displayed same (two fearful or two angry bodies) or complementary (one fearful and one angry body) emotions, while the other eight figures were paired with neutral emotion which was used as control. The sixteen dyads were also inverted and repeated twice during trials, comprising 32 upright and 32 inverted pairs.

Procedure

Participants were seated 60-80 cm away from a laptop screen (screen resolution = 1366 x 768, frame rate = 60 Hz) at university. The experiment was coded in PsychoPy version 3. The experiment comprised 4 blocks (112 trials in total). Stimuli were presented in different blocks depending on two main conditions, orientation (upright, inverted) and social situation (single bodies or dyads). The order of trials was randomized.

Before each experimental block participants performed practice trials to get familiar with each task. Between blocks, participants were allowed to take breaks if needed. In all blocks, participants were instructed to decide whether fear or anger was depicted. To respond, they used the left and right arrow buttons with their right hand. Participants were asked to press a button as rapidly and accurately as possible after the appearance of the stimulus. Trials with single body stimuli began with a central fixation cross (500 ms) then a stimulus appeared for 300 ms followed by blank space until response (with a 5s limit). Body dyads were presented similarly. Following the center fixation cross (500 ms) a red square appeared on either the left or the right side of the screen (500 ms) indicating which figure of the two had to be evaluated.

Participants were instructed to neglect the adjacent body (distractor stimulus) next to the target stimulus in each trial as they were used for providing a social context (Abramson et al., 2021). Neutral expressions were only used as controls so that they only appeared as distractor stimuli but never as targets. During the experiment reaction times (RTs) and recognition accuracy were measured.

Results

For each participant, the average recognition accuracy rates (correct responses/performance), as well as reaction times (RTs) were calculated for every condition. Accuracy and RT means were examined separately depending on whether body dyads were displayed in normal or inverted orientation. However, controls with neutral expressions were not investigated. Prior to the analysis, each accuracy value and RTs were checked, and outlier data were deleted.

RT means and accuracy rates were analysed separately for both upright and inverted stimuli. Therefore, four repeated measures analysis of variance (RM ANOVAs) with 2 emotions (fear or anger) x 2 social situation (facing or nonfacing body pairs) x 2 emotion complementarity (same or complementary emotions) was conducted in a within-subject design in the case of emotional body pairs. As we used single body stimuli as control, 2 emotion (fear or anger) x 2 orientation (normal or inverted) RM ANOVAs were also run for RT means and accuracy rates. The alpha level of significance was set at 0.05. All data were analysed in Jamovi version 2.3.28.

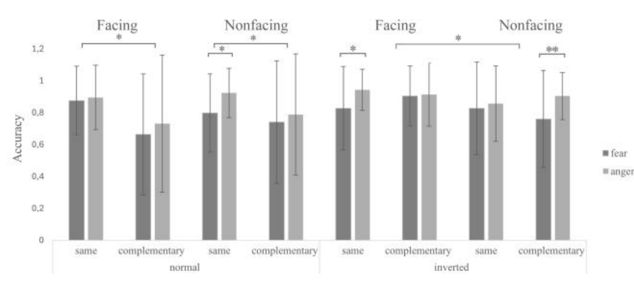

Figure 2: Main accuracy rates depicted separately based on three conditions: emotion (fear or anger), social situation (facing or nonfacing) and emotion complementarity

(complementary or same emotions) of body dyads. Asterisks represent significant differences between stimulus groups (*$p < 0.05$, **$p < 0.01$).

Examining accuracy rates for emotional body pairs presented in upright orientation, a significant main effect emerged for *emotion* ($F(1,25) = 6.205$, $p = 0.020$, $\eta_p^2 = 0.199$), accuracy rates were significantly higher for anger (M = 0.834, SD = 0.216) than fear (M = 0.769, SD = 0.223). Another main effect for *emotion complementarity* ($F(1,25) = 4.707$, $p = 0.040$, $\eta_p^2 = 0.158$) was also found, target stimuli presented next to emotionally complementary distractors were identified less accurately (M = 0.731, SD = 0.356) compared to when they were presented with a same emotion body (M = 0.873, SD = 0.128). No significant main effect was revealed for *social situation* ($p > 0.05$) as well as there were no interactions (all *p*s > 0.05).

Another RM ANOVA for accuracy rates of inverted body pairs revealed a significant main effect for *emotion* ($F(1,25) = 7.187$, $p = 0.013$, $\eta_p^2 = 0.223$), anger (M = 0.913, SD = 0.125) was identified better than fear (M = 0.829, SD = 0.176). There was a significant main effect for *social situation* ($F(1,25) = 4.325$, $p = 0.048$, $\eta_p^2 = 0.147$) as well, similarly to previous findings bodies in facing (M = 0.897, SD = 0.126) social situation were recognized better than the ones presented as nonfacing (M = 0.846, SD = 0.160). For e*motion complementarity,* there was not a significant main effect ($p > 0.05$), but we found a three-way interaction of *emotion x emotion complementarity x social situation* ($F(1,25) = 4.301$, $p = 0.049$, $\eta_p^2 = 0.147$).

Student's t-tests revealed that in in facing, same emotion condition ($t(25) = 2.065$, $p = 0.049$) accuracy for anger (M = 0.942, SD = 0.129) was higher than for fear (M = 0.827, SD = 0.262). Similarly, in nonfacing, complementary emotion condition ($t(25) = 3.058$, $p = 0.005$) anger (M = 0.942, SD = 0.147) had higher accuracy rates than fear (M = 0.760, SD = 0.304). Also, fear depicted next to anger was recognized better ($t(25) = 2.161$, $p = 0.041$) when bodies were facing (M = 0.904, SD = 0.188) compared to nonfacing social situation (M = 0.760, SD = 0.304).

Analysing RTs for upright, paired body stimuli, the only significant main effect was *social situation* ($F(1,25) = 5.069$ $p = 0.040$, $\eta_p^2 = 0.033$), interestingly, facing bodies (M = 0.809, SD = 0.211) had longer RT means compared to nonfacing social situation (M = 0.769, SD = 0.173). There were no interactions (all *p*s > 0.05). Comparing RTs in inverted orientation, no main or interaction effect emerged (all *p*s > 0.05).

After analysing accuracy rates for body pairs, RM ANOVAs (2 (emotion: fear or anger) x 2 (orientation: normal or inverted) were run for single body stimuli. Looking at accuracy rates there was a significant main effect of emotion ($F(1,25) = 10.87$, $p = 0.003$, $\eta_p^2 = 0.303$), as in previous results, angry bodies (M = 0.905, SD = 0.117) had higher recognition accuracy rates than fearful bodies (M = 0.853, SD = 0.109). Unlike paired bodies a significant main effect for orientation also emerged ($F(1,25) = 4.61$, $p = 0.042$, $\eta_p^2 = 0.156$), but unexpectedly accuracy was higher for inverted bodies (M = 0.910, SD = 0.077) compared to ones in normal orientation (M = 0.848, SD = 0.166). However, the interaction of emotion x orientation was not significant ($p > 0.05$), so that the previous result indicating a reversed inversion effect was independent from emotions (fear or anger). For RT means we found no significant main or interaction effect regarding single bodies (all *p*s > 0.05).

Discussion

In our current experiment, we aimed to examine the role of social situations (facing, nonfacing or single bodies as control stimuli) and the body inversion effect in the recognition of complementary emotions (fear and anger) or same emotions (two fearful or two angry bodies) conveyed by female bodies. We hypothesized that when two bodies appear to be in face-to-face orientation, it tends to attract more attention (i.e Papeo et al., 2017, Vestner et al., 2019, 2020) that improves the accuracy and speed of emotion recognition compared to the single and nonfacing body conditions. We also expected that the configural perceptual processing of human bodies would be disrupted when the bodies are inverted (see Papeo et al., 2017; Reed et al., 2003, 2006; Tao, Weidong & Sun, 2013; Vestner et al., 2021) and the effect is higher for facing body dyads than for nonfacing dyads.

We could confirm that both social situation (facing vs nonfacing body dyad) and emotion complementarity had effects on emotion recognition. In terms of the social situation, the results varied depending on whether participants viewed the stimuli in an upright or inverted presentation. In inverted orientation, facing bodies had advantage over nonfacing bodies, but in upright orientation there were no significant differences between facing and nonfacing conditions. Surprisingly, the recognition time for facing bodies was longer compared to nonfacing ones, but only in upright orientation. We found no significant differences between facing and nonfacing body conditions in inverted orientation.

Facing bodies are perceived as functional units by the visual system (Alvarez, 2011; Green & Hummel, 2004; Papeo et al., 2017, Vestner et al., 2019, 2020, 2021), hence such social situation could elicit more attention. However, previous studies did not investigate the social meaning of body postures in two-body perception conditions. With the inclusion of emotional body, our results showed that the perceived interaction between the two bodies affected the recognition of anger and fear in both complementary and same emotion conditions differently.

We revealed that the overall recognition of angry bodies was significantly higher compared to fearful bodies, regardless their orientation, social situation or the emotion conveyed by the distractor stimulus. In upright orientation, both fear and anger had the highest accuracy rates when the distractor conveyed the same emotion, while complementary emotion condition had lower accuracy in general. The concurrent presence of two distinct emotions tends to have impact on each other (de Borst & deGelder, 2016). Even when instructed to disregard the nearby body, participants struggled to ignore that information.

Results in inverted orientation showed that fear had higher accuracy rates in facing social situation compared to nonfacing, but only when the distractor body showed anger (complementary emotion condition), two fearful bodies were not distinguished differently in the two social conditions. In nonfacing, complementary emotion condition, anger was recognized better than fear, but in facing condition, complementary emotions (fear and anger) had similar accuracy rates. In facing, same emotion condition, anger had advantage over fear, but in nonfacing social situation there was no difference between these emotions.

Based on these findings, perceived facing social interaction facilitates the recognition of fear next to anger, while anger was recognized better in same emotion condition. Abramson and colleagues (2021) showed comparable results, fearful target figures were categorized more accurately when they were presented next to interacting angry figures, but in upright orientation.

Our findings indicate that complementary affective information facilitates the recognition of fear when significant social interaction is perceived from a third person-perspective while angry bodies, regardless the context in which they were embedded were identified better than fearful bodies. These results validate the complementary nature of these two negative emotions, as angry bodies are a direct threat to the observer, hence attracting more fixations on the body (Kret et al., 2013b), as well as leading to a positive action tendency (Kleinsmith et al., 2005), while fearful bodies indicate a threatening environment (Hortensius et al., 2016) which leads to negative action tendency (Kleinsmith et al., 2005), meaning less accurate responses in the case of our study. This time we did not show bodies from frontal view, thus we can only assume that from a third person-person perspective, angry bodies appeared as stronger threatening objects toward the adjacent bodies, hence eliciting more accurate reactions compared to fearful bodies.

However, the fact that we found little to no differences between conditions in upright orientation supports existing literature is that people expertise in the perception of emotions (Aviezer, Trope, & Todorov, 2012; de Borst & deGelder, 2016), therefore the distinction of anger from fear appeared to be a simple task, even when bodies were presented next to a distractor stimulus in different emotional and social contexts.

Surprisingly, we did not find significant inversion effect for body pairs as in previous studies (see Papeo et al., 2017; Vestner et al., 2019, 2020, 2021), we only found reversed inversion effect for single body stimuli, inverted bodies were recognized better than upright ones.

Evidence for reversed BIE has been found by Minnebusch, Suchan and Baum (2009) for headless bodies, highlighting the importance of the presence of the head when observing human bodies. Body perception require configural processing, but it is disrupted when bodies are not presented in their normal configuration (see Arizpe et al., 2017; Minnebusch et al., 2009; Reed et al., 2003,2006; Soria Bauser & Suchan, 2013; Tao et al., 2013, 2014; Yovel, Pelc & Lubetzky, 2010). As the models used in our experiments had their faces blurred, only the body conveyed relevant information of their emotional state, so that participants had to gaze mostly on the bodies, especially their parts.

It raises the question whether part-by-part analysis of body stimuli may play a more significant role in the perception of body affective states, rather than configural processing. To support this, several studies have reported the recognition of emotionally expressive body postures strongly relies on each body part that contribute to the affective state (e.g., Calbi et al., 2021, Fridin et al., 2009; Geangu & Vuong, 2020; Kret et al., 2013a; Kret et al., 2013b; Ross & Flack, 2020), therefore configural processing may be less relevant for understanding body affective states than analysing the information based on certain expressive parts of the body.

In our current experiment we solely collected behavioral data, but in the future this question can be re-examined by using eye tracking, so that we can give a proper analysis how part-by-part and configural processing contributes to perception of emotional bodies either alone or in embedded social situations. whether emotional bodies are processed part-by-part, rather than configural. Also, all stimuli were seen from lateral view, from a third person-perspective, therefore in upcoming experiments the effects of movement directionality (Hortensius, deGelder & Schutter, 2016; Poyo-Solanas et al., 2020), gaze direction (Sanders et al., 2007), frontal or lateral presentation (Coulson, 2004) could be investigated by including emotional bodies presented from frontal view as well. Analysing gender differences could also enrich future results.

To summarize, our results revealed that contextual cues (social situation and emotion complementarity) affected the discrimination of angry and fearful bodies more significantly in inverted orientation than in upright orientation. On the other hand, no significant inversion effect found, and facing bodies had no overall advantage over nonfacing dyads. Therefore, our results indicate the importance of examining the underlying perceptual mechanisms (such as gaze patterns) of emotional body perception in social contexts in the future. The body inversion effect on emotional bodies needs more investigation as well.

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Adorján and Gy. B. Lázár edited the photographs for the stimulus set. T.Z. Ferencz took part in the validation of the stimulus set. Gy. B. Lázár and B. Lábadi contributed to writing the draft of the manuscript. All authors approved the final version of the manuscript for submission.

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