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Perceptual sensitivity to changes in interpersonal distance when observing social interactions: the effects of dyad arrangement and orientation

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Abstract

In recent years, there has been growing interest in how we perceive dyadic interactions between people. It has been proposed that pairs of individuals shown upright and face-to-face recruit a form of configural processing, similar to that engaged by upright faces. This processing is thought to aid the detection and interpretation of social interactions. Dyadic arrangements shown back-to-back or upside-down are not thought to engage configural dyad processing. One of the key advantages conveyed by configural face processing is greater sensitivity to the spatial relationships between facial features when faces are viewed upright, than when viewed upside-down. If upright dyads arranged face-to-face engage similar configural processing that is not engaged by non-facing or inverted dyads, participants should therefore exhibit disproportionate sensitivity to the spatial relations between the constituent actors under these conditions. In four well-powered experiments, we find no evidence for this prediction: participants exhibited similar levels of sensitivity to changes in interpersonal distance regardless of whether dyads were shown upright or inverted, face-to-face or back-to-back. In contrast, we observe clear evidence that upright presentation affords greater sensitivity to inter-feature spatial relationships (interocular distance) when viewing faces. These results suggest that any configural processing engaged by upright facing dyads likely differs qualitatively from that engaged by upright faces.

Keywords: Social vision; Social interaction; Configural processing; Interpersonal distance

Introduction

Social perception – the study of the visual processing engaged when interacting with the social world – has been an active area of research for over fifty years. Traditionally, this line of research has sought to elucidate the visual processing of individuals. Consequently, much is known about the perceptual mechanisms engaged by the faces (Duchaine & Yovel, 2015; Tsao & Livingstone, 2008), bodies (Peelen & Downing, 2007; Slaughter et al., 2004), facial expressions (Adolphs, 2002; Frith, 2009), and actions (Blake & Shiffrar, 2007; Cook et al., 2014) of lone actors.

An influential view developed within this literature is that upright faces engage configural processing which augments the representation of inter-feature spatial relationships; for example, the distance between the eyes, or the distance between the nose and mouth (Burton et al., 2015; Freire et al., 2000; Leder et al., 2001; Lewis & Johnston, 1997; Maurer et al., 2002; Mondloch et al., 2002; Piepers & Robbins, 2013; Young et al., 1987). Some authors posit that configural face processing is 'gated' such that it is disproportionately engaged in the presence of whole upright faces (e.g., Maurer et al., 2002; Murphy et al., 2017; Tsao & Livingstone, 2008). This potentially explains why upright faces are perceived more accurately than inverted faces (McKone & Yovel, 2009; Rossion, 2008).

Recently, there has been growing interest in how we perceive dyadic interactions between people (Papeo, 2020; Quadflieg & Koldewyn, 2017). This new field of study has yielded several behavioural effects identified as putative markers of social interaction processing. For example, when two individuals are presented face-to-face (though not back-to-back), the facial and bodily expressions of one actor bias how observers interpret the expressions of the other (Abramson et al., 2021; Gray et al., 2017). Similarly, dyadic targets shown face-to-face are found faster in visual search tasks, than dyadic targets shown back-to-back (Papeo et al., 2019; Vestner et al., 2019). This search advantage for facing dyads is not seen when target and distractor dyads are shown upside-down (Vestner et al., 2019). When dyads are presented briefly (30ms) and subject to backwards masking, participants are also better able to categorise upright face-to-face arrangements, than inverted face-to-face arrangements. Conversely, the same orientation manipulation has little or no effect on the accuracy of perceptual decisions when observers view back-to-back dyads (Papeo et al., 2017).

These findings have led some authors to speculate that pairs of individuals shown upright and face-to-face recruit a form of configural processing, similar to that engaged by upright faces (Abassi & Papeo, 2022; Papeo, 2020; Papeo et al., 2017). It is hypothesised that relations among body pairs are captured automatically, aiding the detection, discrimination, and interpretation of social interactions (Abassi & Papeo, 2022; Papeo, 2020; Papeo et al., 2017). Drawing on domain-specific accounts of face processing, Papeo and colleagues propose that the configural processing engaged by dyads is gated such that it is selectively recruited when viewing upright facing dyads only: Dyads shown back-to-back or upside-down are not thought to engage configural processing (Abassi & Papeo, 2022; Papeo, 2020; Papeo et al., 2017).

Present study

Interpersonal distance is an important cue when appraising the social interactions of others. The interpersonal distance that interactants adopt can reveal a great deal about their relationships and their attitudes towards each other. For example, we tend to stand closer to those we know well, or those with whom we have intimate relationships, but stand further away from strangers or those with whom we have formal relationships (Hall, 1963, 1966; McCall, 2015). Similarly, people tend to distance themselves from members of ethnic out-groups (Dotsch & Wigboldus, 2008; McCall et al., 2009), otherwise stigmatized individuals (Bessenoff & Sherman, 2000; Worthington, 1974), and people who have recently treated us unfairly (McCall & Singer, 2015). Despite the significance of interpersonal distance for the appraisal and interpretation of dyadic displays, however, little is known about its representation within the human visual system (Bunce et al., 2021).

The aim of the present study was to assess whether observers exhibit superior sensitivity to changes in interpersonal distance when dyads are shown upright (vs. inverted) and face-to-face (vs. back-to-back). One of the key advantages conveyed by configural face processing is greater sensitivity to the spatial relationships between component features (Farah et al., 1998; Maurer et al., 2002; Piepers & Robbins, 2013). For example, participants exhibit greater perceptual sensitivity to the distances between the eyes, nose, and mouth when faces are shown upright – a condition thought to afford configural processing – than when faces are shown upside-down – a condition thought to reduce configural processing (Freire et al., 2000; Goffaux & Rossion, 2007; Le Grand et al., 2001; Leder et al., 2001). If upright dyads arranged face-to-face selectively engage a comparable form of configural processing that is not engaged by non-facing or inverted dyads, participants should exhibit greater perceptual sensitivity to the spatial relations between the constituent actors (i.e., interpersonal distance) when viewing upright face-to-face dyads, than when viewing inverted or back-to-back dyads.

A note on terminology

Throughout their work, Papeo and colleagues consistently refer to "configural processing", not "holistic processing" (Abassi & Papeo, 2022; Papeo, 2020; Papeo et al., 2017).
Although these terms are closely-related, they are used differently within the contemporary

face processing literature (Piepers & Robbins, 2013). Like configural processing, holistic processing is thought to improve representation of inter-feature spatial relationships. Unlike configural processing, however, holistic processing is additionally thought to augment the description of local features; for example, the eyes, nose, and mouth (e.g., Farah et al., 1998; Tanaka & Farah, 1993; Yovel & Kanwisher, 2008). It is unclear whether the domain-specific processing of facing dyads hypothesized by Papeo and colleagues is thought to selectively aid the representation of the actors' spatial relations ('configural processing'), or whether it is also thought to improve the representation of the constituent actors ('holistic processing'). Note, however, that both configural and holistic dyad processing would be expected to increase sensitivity to inter-feature spatial relationships; i.e., to interpersonal distance.

Experiment 1

To begin, we compared observers' ability to detect changes in interpersonal distance when pairs of boxers (Experiment 1a) or dancers (Experiment 1b) were presented face-to-face or back-to-back. All dyads were presented upright. If face-to-face dyads recruit configural processing that is not engaged by upright back-to-back dyads, then we should see greater sensitivity to changes in interpersonal distance in the face-to-face condition.

Methods

Participants

The 100 participants to complete Experiment 1a (29 males, 69 females, 2 non-binary, M_{age} = 28.21 years, SD_{age} = 8.72) included 6 replacements for participants who did not satisfy the performance requirements (criteria outlined below). The 100 participants to complete Experiment 1b (38 males, 61 females, 1 non-binary, M_{age} = 28.23 years, SD_{age} = 8.40) included 10 replacements for participants who did not satisfy the performance requirements. All participants were recruited via www.prolific.co in 2022.

Participants were required to be aged 18 to 50 years-old, to have normal or corrected-to-normal visual acuity, to have no history of psychiatric (e.g., autism, schizophrenia) or neurological illness, to reside in the United Kingdom, and to have a Prolific approval rating above 90%. Any participant who failed to achieve an overall d' of at least 0.5 (having collapsed across trial type) were excluded and replaced. These inclusion and exclusion criteria were agreed prior to data analysis. No other participants were replaced.

A power analysis conducted *a priori* using GPower 3.1 (Faul et al., 2009) revealed that a sample size of 100 yielded a 97.7% chance of detecting an effect-size of dz = .40 when conducting an matched samples t-test (α = .05, two-tailed).

Ethical clearance was granted by the Departmental Ethics Committee for Psychological Sciences, Birkbeck, University of London. The experiment was conducted in line with the ethical guidelines laid down in the 6th (2008) Declaration of Helsinki. All participants gave informed consent.

Stimuli

The stimuli used in the experiments described were derived from two stock images, one depicting a pair of dancers and one depicting a pair of boxers. The dancing couple comprised a male and female dancer. The boxers were both male. All individuals were depicted in profile against a white background. From each stock image we derived 12 stimulus images: 3 levels of interpersonal distance (~150 cm, ~180 cm, or ~210 cm) × 2 levels of dyadic configuration (face-to-face, back-to-back) × 2 levels of actor configuration (actor-1 on the left, actor-2 on the left). The estimates of interpersonal distance provided assume an actor height of 180 cm. The distances between the actors in the face-to-face and back-to-back stimulus sets were matched by fitting a minimum bounding box to each model and horizontally flipping them about the central axis. When viewed at a distance of 57.1 cm, the dancer stimuli subtended between ~17° and ~22° of horizontal visual angle and ~13° of vertical visual angle. When viewed at the same distance, the boxer stimuli subtended between ~17° and ~22° horizontally and ~13° vertically. The stimuli used can be viewed through the Open Science Framework (https://osf.io/4pqm6/).

We chose dancing and boxing interaction for two reasons. First, they represent very different types of social interaction; for example, they are associated with different kinds of body postures, and with positive and negative valance, respectively. We reasoned it would be valuable to replicate any findings across such different stimuli. Second, fighting and dancing have been used by several authors to study the visual processing recruited by facing and non-facing dyads (e.g., Abassi & Papeo, 2020; Paparella & Papeo, 2022; Quadflieg & Koldewyn, 2017) and would be widely expected to engage domain-specific dyadic processing.

Design and procedure

The experiments were conducted online via Gorilla (Anwyl-Irvine et al., 2020). Each experiment comprised 180 trials in total, split evenly into two blocks. Participants completed 90 face-to-face trials (30 no change, 30 move closer, 30 move apart) and 90 back-to-back trials (30 no change, 30 move closer, 30 move apart). The different trial types were interleaved. Stimulus order was randomized. Participants could take a break midway through each of the blocks, and between blocks.

The trial sequence is illustrated in Figure 1. Trials began with a grey fixation cross (500 ms) which was followed by the sequential presentation of two dyadic stimuli (750 ms each). A visual mask was presented in the inter-stimulus interval (1000 ms) to prevent an afterimage. The first image always depicted an interpersonal distance of ~180 cm. On signal absent trials, the same image was presented in the second stimulus interval. On signal present trials, a different image was presented: the actors appeared closer together (~150 cm) or further apart (~210 cm). Participants were asked to judge whether the distance between the actors was different in the two intervals. Participants recorded their binary decision via keypress.

The placement of each actor on the left- and right-side of the dyadic stimuli was counterbalanced across trials, but held consistent within a trial (e.g., if the female dancer appeared on the left in the first interval, she would also appear on the left in the second interval). The stimuli presented in the first and second interval would always be shown on opposite sides of the screen (left or right) in a counter-balanced fashion. On 50% of trials the stimulus presented in the first interval would appear to the left of fixation, while the stimulus presented in the second interval would appear on the right. On 50% of trials the stimulus presented first would appear on the right, while the stimulus presented second would appear on the left. The precise positioning on the left and right was jittered to discourage participants from using distance to the display edge as a cue.

Figure-1

Analysis

Performance was analysed using signal detection theory (Green & Swets, 1966). Our principal interest was perceptual sensitivity (*d′*) seen on move closer and move apart trials. For completeness, however, we also present a comparable analysis of participants' bias (*C*) in the supplementary materials. Signal detection analyses were conducted in Matlab (The MathWorks Inc., Natick, USA) using routines from the Palamedes Toolbox (Prins & Kingdom, 2009). The data for all the analyses described are available through the Open Science Framework (https://osf.io/4pqm6/).

The distributions of sensitivity (*d′*) and bias (*C*) estimates were evaluated using both traditional null-hypothesis significance testing ($\alpha = 0.05$, two-tailed) and Bayesian analysis (JASP-Team, 2022). A Bayes Factor (BF_{01}) larger than 1, 3, and 10 reflects anecdotal, substantial, and strong evidence, respectively, in favour of the null hypothesis. A Bayes Factor (BF_{01}) less than 1, 1/3, and 1/10 reflects anecdotal, substantial, and strong evidence, respectively, in favour of the alternative hypothesis. The Bayesian paired *t*-tests and Bayesian ANOVAs were conducted using the default Cauchy priors (*t*-tests: centre = 0, width = 0.707; ANOVAs: fixed effects width = 0.5, random effects width = 1). Robustness checks revealed that different prior specifications had little impact on the obtained results.

Results

The results from Experiment 1a are shown in Figure 2a. Sensitivity estimates (*d′*) were subjected to ANOVA with Dyad Arrangement (face-to-face, back-to-back) and Movement Direction (move closer, move apart) as within-subjects factors. The ANOVA revealed a significant main-effect of Movement Direction [$F(1, 99) = 18.404$, $p < .001$, $\eta^2_G = .031$, $BF_{01} = .002$], whereby participants exhibited superior sensitivity on move closer trials. Participants were more sensitive to move-closer changes on both face-to-face [$M_{clo} = 1.63$, $SD_{clo} = 0.72$, $M_{apa} = 1.44$, $SD_{apa} = 0.69$, $t(99) = 2.980$, $p = .004$, $d_z = 0.30$, $BF_{01} = .143$] and back-to-back trials [$M_{clo} = 1.74$, $SD_{clo} = 0.68$, $M_{apa} = 1.44$, $SD_{apa} = 0.67$, $t(99) = 4.442$, $p < .001$, $d_z = 0.44$, $BF_{01} = .001$]. We observed no main-effect of Dyad Arrangement [$F(1, 99) = 0.951$, $p = .332$, $\eta^2_G = .002$, $BF_{01} = 3.40$] and no Dyad Arrangement × Movement Direction interaction [$F(1, 99) = 3.324$, $p = .071$, $\eta^2_G = .002$, $BF_{01} = 1.13$]. Simple contrasts revealed no effect of Dyad Arrangement on sensitivity scores in either the move closer [$M_{F2F} = 1.63$, $SD_{F2F} = 0.72$, $M_{B2B} = 1.74$, $SD_{B2B} = 0.68$, $t(99) = 1.727$, $p = .087$, $d_z = 0.17$, $BF_{01} = 2.16$] or move apart conditions [$M_{F2F} = 1.44$, $SD_{F2F} = 0.69$, $M_{B2B} = 1.44$, $SD_{B2B} = 0.67$, $t(99) = 0.077$, $p = .939$, $d_z = 0.01$, $BF_{01} = 9.01$].

The results from Experiment 1b are shown in Figure 2b. Sensitivity estimates (*d′*) were subjected to ANOVA with Dyad Arrangement (face-to-face, back-to-back) and Movement Direction (move closer, move apart) as within-subjects factors. The ANOVA revealed a significant main-effect of Movement Direction [$F(1, 99) = 9.819$, $p = .002$, $\eta^2_G = .025$, $BF_{01} = .070$], whereby participants exhibited superior sensitivity on move closer trials. Participants were more sensitive to move-closer changes on both face-to-face [$M_{clo} = 1.69$, $SD_{clo} = 0.69$, $M_{apa} = 1.45$, $SD_{apa} = 0.71$, $t(99) = 3.336$, $p = .001$, $d_z = .33$, $BF_{01} = .053$] and back-to-back trials [$M_{clo} = 1.67$, $SD_{clo} = 0.77$, $M_{apa} = 1.47$, $SD_{apa} = 0.68$, $t(99) = 2.581$, $p = .011$, $d_z = 0.26$, $BF_{01} = .391$]. We observed no main-effect of Dyad Arrangement [$F(1, 99) < .001$, $p = .991$, $\eta^2_G < .001$, $BF_{01} = 5.73$] and no Dyad Arrangement × Movement Direction interaction [$F(1, 99) = 0.597$, $p = .441$, $\eta^2_G < .001$, $BF_{01} = 5.24$]. Simple contrasts revealed no effect of Dyad Arrangement on sensitivity scores in either the move closer [$M_{F2F} = 1.69$, $SD_{F2F} = 0.69$, $M_{B2B} = 1.67$, $SD_{B2B} = 0.77$, $t(99) = 0.368$, $p = .713$, $d_z = 0.37$, $BF_{01} = 8.46$] or move apart conditions [$M_{F2F} = 1.45$, $SD_{F2F} = 0.71$, $M_{B2B} = 1.47$, $SD_{B2B} = 0.68$, $t(99) = 0.447$, $p = .656$, $d_z = 0.05$, $BF_{01} = 8.20$].

Figure-2

Experiment 2

In our first experiment, we found that Dyad Arrangement (face-to-face vs. back-to-back) had little impact on observers' sensitivity to interpersonal distance. In our second experiment, we compared observers' ability to detect changes in interpersonal distance when pairs of facing boxers (Experiment 2a) or facing dancers (Experiment 2b) were presented upright or inverted. All dyads were arranged face-to-face. If upright face-to-face dyads recruit configural processing that is not engaged by inverted face-to-face dyads, we should see greater sensitivity to changes in interpersonal distance in the upright condition.

Methods

Participants

One hundred participants completed Experiment 2a (40 males, 60 females, M_{age} = 28.47 years, SD_{age} = 9.42), including 2 replacements for participants who did not satisfy the performance requirements. Similarly, 100 participants completed Experiment 2b (25 males, 75 females, M_{age} = 29.88 years, SD_{age} = 8.64), including 8 replacements for participants who did not satisfy the performance requirements. All participants were recruited via www.prolific.co in 2022. The same inclusion and exclusion criteria employed in the first two experiments (1a and 1b) were employed in the second two experiments (2a and 2b).

Design and procedure

The design and procedure of Experiments 2a and 2b were identical to those employed in the first two experiments (1a and 1b), with the following exception. In Experiments 1a and 1b, participants completed 90 face-to-face trials (30 no change, 30 move closer, 30 move apart) and 90 back-to-back trials (30 no change, 30 move closer, 30 move apart). In Experiments 2a and 2b, however, participants completed 90 upright trials (30 no change, 30 move closer, 30 move apart) and 90 inverted trials (30 no change, 30 move closer, 30 move apart). Once again, the experiments were conducted online via Gorilla (Anwyl-Irvine et al., 2020).

Results

The results from Experiment 2a are shown in Figure 3a. Sensitivity estimates (*d*´) were subjected to ANOVA with Dyad Orientation (upright, inverted) and Movement Direction (move closer, move apart) as within-subjects factors. The ANOVA revealed a significant main-effect of Movement Direction [$F(1, 99) = 21.162$, $p < .001$, $\eta^2_G = .038$, $BF_{01} < .001$], whereby participants exhibited superior sensitivity on move closer trials. Participants were more sensitive to move-closer changes on both upright [M_{clo} = 1.73, SD_{clo} = 0.73, M_{apa} = 1.36, SD_{apa}

= 0.75, $t(99) = 5.421$, $p < .001$, $d_z = 0.54$, $BF_{01} < .001$] and inverted trials [$M_{clo} = 1.69$, $SD_{clo} = 0.72$, $M_{apa} = 1.49$, $SD_{apa} = 0.71$, $t(99) = 2.993$, $p = .003$, $d_z = 0.30$, $BF_{01} = .139$]. We observed no main-effect of Dyad Orientation [$F(1, 99) = 0.966$, $p = .328$, $\eta^2_G < .001$, $BF_{01} = 3.71$], however, there was a significant Dyad Orientation × Movement Direction interaction [$F(1, 99) = 9.575$, $p = .003$, $\eta^2_G = .003$, $BF_{01} < .001$]. Simple contrasts revealed no effect of Dyad Orientation on sensitivity scores in the move closer condition [$M_{upr} = 1.73$, $SD_{upr} = 0.73$, $M_{inv} = 1.69$, $SD_{inv} = 0.72$, $t(99) = 0.709$, $p = .480$, $d_z = 0.07$, $BF_{01} = 7.08$]. However, participants were significantly less sensitive to move apart distance changes in the upright condition, than in the inverted condition [$M_{upr} = 1.36$, $SD_{upr} = 0.75$, $M_{inv} = 1.49$, $SD_{inv} = 0.71$, $t(99) = 2.564$, $p = .012$, $d_z = 0.26$, $BF_{01} = .407$].

The results from Experiment 2b are shown in Figure 3b. Sensitivity estimates (*d´*) were subjected to ANOVA with Dyad Orientation (upright, inverted) and Movement Direction (move closer, move apart) as within-subjects factors. The ANOVA revealed a significant main-effect of Movement Direction [$F(1, 99) = 36.731$, $p < .001$, $\eta^2_G = .082$, $BF_{01} < .001$], whereby participants exhibited superior sensitivity on move closer trials. Participants were more sensitive to move-closer changes on both upright [$M_{clo} = 1.77$, $SD_{clo} = 0.68$, $M_{apa} = 1.20$, $SD_{apa} = 0.74$, $t(99) = 7.389$, $p < .001$, $d_z = 0.74$, $BF_{01} < .001$] and inverted trials [$M_{clo} = 1.66$, $SD_{clo} = -0.68$, $M_{apa} = 1.38$, $SD_{apa} = 0.77$, $t(99) = 3.623$, $p < .001$, $d_z = 0.36$, $BF_{01} = .022$]. We observed no main-effect of Dyad Orientation [$F(1, 99) = 0.504$, $p = .480$, $\eta^2_G < .001$, $BF_{01} = 5.34$], however, there was a significant Dyad Orientation × Movement Direction interaction [$F(1, 99) = 20.936$, $p < .001$, $\eta^2_G = .010$, $BF_{01} < .001$]. Participants were significantly more sensitive to move closer distance changes in the upright condition, than in the inverted condition [$M_{upr} = 1.77$, $SD_{upr} = 0.68$, $M_{inv} = 1.66$, $SD_{inv} = 0.68$, $t(99) = 2.059$, $p = .042$, $d_z = 0.21$, $BF_{01} = 1.20$]. However, participants were significantly less sensitive to move apart distance changes in the upright condition, than in the inverted condition [$M_{upr} = 1.20$, $SD_{upr} = 0.74$, $M_{inv} = 1.38$, $SD_{inv} = 0.77$, $t(99) = 3.132$, $p = .002$, $d_z = 0.31$, $BF_{01} = .095$].

Figure-3

Experiment 3

In the foregoing experiments, we sought – but failed to obtain – evidence that back-to-back arrangement and inverted presentation impair observers' perceptual decisions about interpersonal distance, relative to upright face-to-face presentation. This prediction was based on i) the theoretical assertion that facing dyads engage configural processing similar to that engaged by upright faces (Abassi & Papeo, 2022; Papeo, 2020; Papeo et al., 2017); and ii) evidence that configural face processing increases observers' perceptual sensitivity to inter-feature spatial relationships (Freire et al., 2000; Goffaux & Rossion, 2007; Le Grand et al., 2001; Leder et al., 2001). The results of these experiments suggest that any configural processing engaged by facing dyads may differ qualitatively from that seen with faces. Before we accept this conclusion, however, it is necessary to show that our online sequential matching paradigm produces the expected effect with faces (i.e., greater sensitivity to inter-feature spatial relationships under viewing conditions that afford configural processing).

Previous research suggests that orientation inversion – thought to reduce configural face processing (Maurer et al., 2002; McKone & Yovel, 2009; Rossion, 2008) – impairs observers' perception of interocular distance (Leder et al., 2001). In our third experiment, we sought to confirm that we could replicate this effect using our online sequential matching paradigm. Orientation inversion is thought to impair several inter-featural judgements, including the distance between the eyes and the nose / mouth (e.g., Goffaux & Rossion, 2007). However, we opted to manipulate the distance between the eyes because this distance change was directly comparable to the distance manipulation employed in Experiments 1 and 2 (i.e., both manipulations affect inter-feature distances in the horizontal plane.

Methods

Participants

One hundred participants completed Experiment 3a (63 males, 36 females, 1 non-binary, M_{age} = 33.89 years, SD_{age} = 8.32), including 21 replacements for participants who did not satisfy the performance requirements. Similarly, 100 participants completed Experiment 3b (62 males, 38 females, M_{age} = 35.89 years, SD_{age} = 8.71), including 9 replacements for participants who did not satisfy the performance requirements. All participants were recruited via www.prolific.co in 2023. The same inclusion and exclusion criteria employed in the earlier experiments were employed in Experiments 3a and 3b.

Design and procedure

The design and procedure were identical to those employed in Experiment 2 with the exception of the stimuli and the wording of the decision prompt. The stimuli used were derived from a male (Experiments 3a) and a female (Experiments 3b) source face by increasing and decreasing the distance between the eyes by ~11%. The source faces were created and manipulated using FaceGen modeller v3.31 (Singular Inversions Inc., Toronto, Canada). Estimates of interocular distance represent pupil-to-pupil measurements. When viewed at a distance of 57.1 cm, the face stimuli subtended ~10° of horizontal visual angle and ~9° of vertical visual angle. Participants were asked to judge whether the distance between the eyes was different in the two intervals (Figure 4).

Figure-4

Results

The results from Experiment 3a are shown in Figure 5a. Sensitivity estimates (*d′*) were subjected to ANOVA with Face Orientation (upright, inverted) and Movement Direction (move closer, move apart) as within-subjects factors. The ANOVA revealed a significant main-effect of Movement Direction [$F(1, 99) = 5.619$, $p = .020$, $\eta^2_G = .012$, $BF_{01} = .407$], whereby participants exhibited superior sensitivity on move closer trials. When considered independently, however, participants were more sensitive to move-closer changes on inverted trials [$M_{clo} = 1.77$, $SD_{clo} = 0.81$, $M_{apa} = 1.51$, $SD_{apa} = 0.95$, $t(99) = 3.022$, $p = .003$, $d_z = 0.30$, $BF_{01} = .128$], but not on upright trials [$M_{clo} = 2.12$, $SD_{clo} = 0.92$, $M_{apa} = 1.95$, $SD_{apa} = 1.16$, $t(99) = 1.506$, $p = .135$, $d_z = 0.15$, $BF_{01} = 3.03$]. As expected, we observed a significant main-effect of Face Orientation [$F(1, 99) = 53.829$, $p < .001$, $\eta^2_G = .040$, $BF_{01} < .001$], whereby participants were more sensitive to distance changes in the upright condition. There was no significant Face Orientation × Movement Direction interaction [$F(1, 99) = 1.534$, $p = .218$ $\eta^2_G < .001$, $BF_{01} = 3.69$]. Participants were significantly more sensitive to move closer distance changes in the upright condition, than in the inverted condition [$M_{upr} = 2.12$, $SD_{upr} = 0.92$, $M_{inv} = 1.77$, $SD_{inv} = 0.82$, $t(99) = 5.767$, $p < .001$, $d_z = 0.58$, $BF_{01} < .001$]. Participants were also significantly more sensitive to move apart distance changes in the upright condition, than in the inverted condition [$M_{upr} = 1.95$, $SD_{upr} = 1.16$, $M_{inv} = 1.51$, $SD_{inv} = 0.95$, $t(99) = 6.021$, $p < .001$, $d_z = 0.60$, $BF_{01} < .001$].

Figure-5

The results from Experiment 3b are shown in Figure 5b. Sensitivity estimates (*d′*) were subjected to ANOVA with Face Orientation (upright, inverted) and Movement Direction (move close, move apart) as within-subjects factors. We observed no main-effect of Movement Direction [$F(1, 99) = 0.821$, $p = .367$, $\eta^2_G = .001$, $BF_{01} = 3.62$], indicating that participants did not exhibit significant differences in sensitivity on move closer and move apart trials. When considered separately, this was true of both upright [$M_{clo} = 1.91$, $SD_{clo} = 0.89$, $M_{apa} = 1.82$, $SD_{apa} = 1.05$, $t(99) = 1.005$, $p = .318$, $d_z = 0.10$, $BF_{01} = 5.54$] and inverted trials [$M_{clo} = 1.68$, $SD_{clo} = 0.90$, $M_{apa} = 1.63$, $SD_{apa} = 1.01$, $t(99) = 0.597$, $p = .552$, $d_z = 0.06$, $BF_{01} = 7.60$]. However, the ANOVA did reveal a significant main-effect of Face Orientation [$F(1, 99) = 12.115$, $p < .001$, $\eta^2_G = .012$, $BF_{01} = .025$], whereby participants were more sensitive to distance changes in the upright condition. There was no significant Face Orientation × Movement Direction interaction [$F(1, 99) = 0.300$, $p = .585$ $\eta^2_G < .001$, $BF_{01} = 5.97$].

Participants were significantly more sensitive to distance changes on move closer trials in the upright condition, than in the inverted condition [M_{upr} = 1.91, SD_{upr} = 0.89, M_{inv} = 1.68, SD_{inv} = 0.90, $t(99) = 3.457$, $p < .001$, $d_z = 0.35$, $BF_{01} < .001$]. Participants were also significantly more sensitive to distance changes on move apart trials in the upright condition, than in the inverted condition [M_{upr} = 1.82, SD_{upr} = 1.05, M_{inv} = 1.63, SD_{inv} = 1.01, $t(99) = 2.392$, $p = .019$, $d_z = 0.24$, $BF_{01} = .602$].

General discussion

It has recently been suggested that pairs of upright individuals arranged face-to-face and viewed in profile may recruit configural processing similar to that engaged by upright faces (Abassi & Papeo, 2022; Papeo, 2020; Papeo et al., 2017). Importantly, this configural dyad processing is thought to be gated, such that it is not recruited – or recruited less – when the constituent individuals are arranged back-to-back, or when facing dyads are shown upside-down. The present study sought to test a key prediction of this configural processing hypothesis. If upright facing dyads engage a form of configural processing, that is i) similar to that engaged by upright faces, and ii) not engaged by back-to-back or inverted dyads, then participants should show heightened sensitivity to the spatial relationships between the constituent individuals when dyads are arranged face-to-face and shown upright.

In our first two experiments, we compared observers' ability to detect changes in interpersonal distance when pairs of boxers (Experiment 1a) or dancers (Experiment 1b) were presented face-to-face or back-to-back. In our second two experiments, we compared observers' ability to detect changes in interpersonal distance when pairs of facing boxers (Experiment 2a) or facing dancers (Experiment 2b) were presented upright or inverted. Contrary to the predictions of the configural processing hypothesis (Abassi & Papeo, 2022; Papeo, 2020; Papeo et al., 2017), observers' sensitivity to distance changes was not influenced by dyad arrangement (front-to-front vs. back-to-back; Experiment 1) or dyad orientation (upright vs. upside down; Experiment 2). These results argue against the configural processing hypothesis which predicts main-effects of dyad arrangement (face-to-face > back-to-back) and orientation (upright > inverted) on sensitivity to distance changes. Note, the two main-effects of Dyad Arrangement (Experiments 1a and 1b) and the two main-effects of Orientation (Experiments 2a and 2b) yielded associated Bayes Factors ranging from 3.4 to 5.7 – substantial evidence for the null hypothesis (Jeffreys, 1961).

In Experiments 1 and 2, we failed to observe superior sensitivity to changes in interpersonal distance when dyads were viewed in an upright facing condition relative to an upright back-to-back condition (Experiment 1) or an inverted facing condition (Experiment 2). In Experiment 3, however, we observed superior sensitivity to changes in interocular distance when faces were shown upright than when they were shown inverted, replicating previous reports (Leder et al., 2001). This finding is important as it confirms that the sequential matching paradigm used in all three experiments produces the expected effect with faces. As such, the null effects seen in Experiments 1 and 2 are unlikely to reflect features of the paradigm, such as the presence of a working memory load, or the use of an online procedure.

In Experiments 2a and 2b, our analyses revealed an unexpected Orientation × Movement Direction interaction. In both experiments, we observed diminished sensitivity to distance changes on move apart trials when dyads were presented upright, relative to the inverted condition. In Experiment 2b we also observed greater sensitivity to distance changes on move closer trials when dyads were presented upright, relative to the inverted condition, however, we did not observe this effect in Experiment 2a. Once again, these findings are hard to reconcile with the configural processing hypothesis. The observation of diminished sensitivity to distance changes on move apart trials when dyads are upright, does not accord with the recruitment of configural processing which ought to augment the representation of interpersonal distance when viewing upright dyads.

The observation of superior sensitivity in the inverted condition may at first appear counter-intuitive. However, one possible explanation is that participants experience a perceptual bias whereby actors appear closer together when viewed upright, but not when viewed inverted (see also: Vestner et al., 2019). This kind of bias might hinder the detection of distance changes in the move apart condition when stimuli are shown upright. When stimuli are shown inverted, however, participants – free from the interfering bias – may exhibit superior sensitivity. Such a bias might arise from perceptual priors acquired through previous visual experience of social interactions. It is also conceivable that a bias might arise from attention cueing; i.e., stimuli that cue attention might appear to drift in the direction implied. Given that attention cueing is greatly attenuated by inversion (Langton & Bruce, 1999; Vestner et al., 2022; Vestner, Gray, et al., 2021), this might manifest as an orientation-sensitive bias.

The pattern of *C* effects (described in the supplementary materials) closely mirrors that seen in the *d′* analyses. In all experiments, participants exhibited greater sensitivity on move closer trials (than on move apart trials), and a corresponding bias to report more distance changes in the move closer trials (than on move apart trials). Similarly, greater sensitivity on move apart trials when facing dyads were shown inverted (relative to upright presentation) was accompanied by a greater bias to report distance changes. As described above, it is possible that the presence of a perceptual bias sometimes undermines sensitivity to distance changes

– in particular, when facing dyads move apart. However, the interpretation of criterion measures under conditions where sensitivity is known to differ is notoriously difficult. Although sensitivity measures are generally regarded as meaningful across conditions that differ in bias, the reverse is not necessarily true (e.g., Wixted & Stretch, 2000).

According to the configural processing account of dyadic perception, pairs of individuals presented upright and face-to-face, engage a form of configural processing similar to that recruited by upright faces. The present results argue against this account in its strongest form. Nevertheless, it may be possible to sustain a weaker version of this hypothesis. It has been proposed that configural processing exists along a continuum (Reed et al., 2006). At one end, the configural processing recruited by upright whole faces may be the strongest form reported to-date. However, there is considerable evidence that a range of other stimuli recruit configural processing to some degree, including inverted faces (Murphy et al., 2020; Susilo et al., 2013), bodies (Aviezer et al., 2008; Reed et al., 2006), unfamiliar Chinese characters (Hsiao, 2009), words and letter strings (Anstis, 2005; Wong et al., 2010), maps (Johnston et al., 2014), compound letter arrays (Navon, 2003), musical notation (Wong & Gauthier, 2010), finger prints (Busey & Vanderkolk, 2005; Vogelsang et al., 2017), and synthetic objects (Gauthier & Tarr, 1997; Wong et al., 2009). While the processing engaged by facing dyads may not be strictly comparable to that engaged by upright faces, it remains possible that facing dyads selectively engage some form of configural processing, albeit one that does not augment the representation of inter-feature spatial relations.

A different perspective is that putative markers of configural dyadic processing are products of domain-general attentional phenomena, not 'true' configural processing (Vestner et al., 2020; Vestner, Over, et al., 2021). When viewed in profile, faces and bodies cue observers' visuo-spatial attention leftwards or rightwards, in accordance with their directionality (Langton & Bruce, 1999; Vestner, Gray, et al., 2021). The arrangement of these attention cues is very different when viewing face-to-face and back-to-back dyadic arrangements (Vestner et al., 2020). In face-to-face arrangements, these attention cues form an 'attention trap': the face / body on the left of the dyad directs observers' attention to the face / body on the right, which in turn re-directs observers' attention back to the face / body on the left. When dyads are arranged back-to-back, however, the same face / body cues direct observers' attention toward the display periphery.

There is now compelling evidence that the differential arrangement of attention cues present in face-to-face and back-to-back dyads is responsible for the search advantage for facing dyads; i.e., the finding that observers locate facing dyads in search displays faster than non-facing dyads (Vestner et al., 2020; Vestner, Over, et al., 2021). Consistent with this explanation, the same search advantage is seen for non-social stimuli that also cue attention – including arrows (Vestner et al., 2020), desk fans, desk lamps, power drills, cameras, and cars (Vestner, Over, et al., 2021) – when exemplar pairs are arranged front-to-front. It is quite possible that the differential arrangement of attention cues present in face-to-face and back-to-back dyads, may explain other behavioural effects produced by the facing vs. non-facing manipulation, including higher rates of detection for upright facing dyads in backwards masking procedures (Papeo et al., 2017).

In Experiments 1a and 1b, 2a and 2b, and 3a, participants exhibited greater sensitivity on move closer trials than on move apart trials. Where observed, this advantage was unaffected by dyad arrangement (Experiments 1a and 1b), dyad orientation (Experiments 2a and 2b), or face orientation (Experiment 3a). Moreover, a similar effect has been reported when observers are tasked with detecting changes in the distance between two grandfather clocks (Bunce et al., 2024). Superior detection of move-closer changes therefore appears to be a non-specific feature of distance-change detection tasks. The discriminability of two stimuli is known to vary as a function of the relative difference when the absolute difference is held constant – see Weber's Law (e.g., Algom, 2021; Pardo-Vazquez et al., 2019). For example, a difference in height of 3 cm is more obvious when viewing two short individuals, than when viewing two tall individuals. For a similar reason, a reduction in the distance between two objects may be more salient than an increase of the same amount. For example, in Experiments 1 and 2, the distance change was always the same on move closer and move apart trials (e.g., a decrease or increase of ~30 cm, relative to a starting distance of ~180 cm). When expressed as a fraction of the larger of the two distances shown, however, the distance change was greater in the move closer conditions (~30 cm / ~180 cm) than in the move apart conditions (~30 cm / ~210 cm). This may have rendered the move closer distance changes more salient.

Conclusion

In summary, we have described four experiments that sought to test whether upright facing dyads recruit a form of configural processing similar to that engaged by faces (Abassi & Papeo, 2022; Papeo, 2020; Papeo et al., 2017). A key hallmark of this processing is heightened sensitivity to the spatial relationships between constituent features (Maurer et al., 2002; Piepers & Robbins, 2013). Although we clearly replicate this effect with face stimuli using judgements of interocular distance, we find no evidence for heightened sensitivity to spatial relations (interpersonal distance) in upright face-to-face dyadic arrangements. If upright facing dyads do recruit some form of configural processing, it seems likely to differ qualitatively from that engaged by upright faces.

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References

Abassi, E., & Papeo, L. (2020). The representation of two-body shapes in the human visual cortex. *Journal of Neuroscience*, *40*(4), 852-863.

Abassi, E., & Papeo, L. (2022). Behavioral and neural markers of visual configural processing in social scene perception. *NeuroImage*, *260*, e119506.

Abramson, L., Petranker, R., Marom, I., & Aviezer, H. (2021). Social interaction context shapes emotion recognition through body language, not facial expressions. *Emotion*, *21*(3), 557-568.

Adolphs, R. (2002). Recognizing emotion from facial expressions: psychological and neurological mechanisms. *Behavioral and Cognitive Neuroscience Reviews*, *1*(1), 21-62.

Algom, D. (2021). The Weber–Fechner law: A misnomer that persists but that should go away. *Psychological Review*, *128*(4), 757–765.

Anstis, S. (2005). Last but not least. *Perception*, *34*(2), 237–240.

Anwyl-Irvine, A. L., Massonnié, J., Flitton, A., Kirkham, N., & Evershed, J. K. (2020). Gorilla in our midst: An online behavioral experiment builder. *Behavior Research Methods*, *52*, 388–407.

Aviezer, H., Hassin, R. R., Ryan, J., Grady, C., Susskind, J., Anderson, A., . . . Bentin, S. (2008). Angry, disgusted, or afraid? Studies on the malleability of emotion perception. *Psychological Science*, *19*(7), 724-732.

Bessenoff, G. R., & Sherman, J. W. (2000). Automatic and controlled components of prejudice toward fat people: evaluation versus stereotype activation. *Social Cognition*, *18*(4), 329–353.

Blake, R., & Shiffrar, M. (2007). Perception of human motion. *Annual Review of Psychology*, *58*, 47-73.

Bunce, C., Gehdu, B. K., Press, C., Gray, K. L. H., & Cook, R. (2024). Autistic adults exhibit typical sensitivity to changes in interpersonal distance. *Autism Research*.

Bunce, C., Gray, K. L. H., & Cook, R. (2021). The perception of interpersonal distance is distorted by the Muller-Lyer illusion. *Scientific Reports*, *11*(1), 494.

Burton, A. M., Schweinberger, S. R., Jenkins, R., & Kaufmann, J. M. (2015). Arguments against a configural processing account of familiar face recognition. *Perspectives on Psychological Science*, *10*(4), 482-496.

Busey, T. A., & Vanderkolk, J. R. (2005). Behavioral and electrophysiological evidence for configural processing in fingerprint experts. *Vision Research*, *45*(4), 431–448.

Cook, R., Bird, G., Catmur, C., Press, C., & Heyes, C. (2014). Mirror neurons: from origin to function. *Behavioral and Brain Sciences*, *37*(2), 177-192.

Dotsch, R., & Wigboldus, D. H. J. (2008). Virtual prejudice. *Journal of Experimental Social Psychology*, *44*(4), 1194–1198.

Duchaine, B., & Yovel, G. (2015). A revised neural framework for face processing. *Annual Review of Vision Science*, *1*, 393-416.

Farah, M. J., Wilson, K. D., Drain, M., & Tanaka, J. N. (1998). What is "special" about face perception? *Psychological Review*, *105*(3), 482-498.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149-1160.

Freire, A., Lee, K., & Symons, L. A. (2000). The face-inversion effect as a deficit in the encoding of configural information: Direct evidence. *Perception*, *29*(2), 159-170.

Frith, C. (2009). Role of facial expressions in social interactions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1535), 3453-3458.

Gauthier, I., & Tarr, M. J. (1997). Becoming a “Greeble” expert: exploring mechanisms for face recognition. *Vision Research*, *37*, 1673–1681.

Goffaux, V., & Rossion, B. (2007). Face inversion disproportionately impairs the perception of vertical but not horizontal relations between features. *Journal of Experimental Psychology: Human Perception and Performance*, *33*(4), 995-1002.

Gray, K. L. H., Barber, L., Murphy, J., & Cook, R. (2017). Social interaction contexts bias the perceived expressions of interactants. *Emotion*, *17*(4), 567–571.

Green, D. M., & Swets, J. A. (1966). *Signal detection theory and psychophysics*. Wiley.

Hall, E. T. (1963). A system for the notation of proxemic behavior. *American Anthropologist*, *65*(5), 1003–1026.

Hall, E. T. (1966). *The Hidden Dimension*. Doubleday.

Hsiao, J. H., & Cottrell, G. W. (2009). Not all visual expertise is holistic, but it may be leftist: The case of Chinese character recognition. *Psychological Science*, *20*(4), 455-463.

JASP-Team. (2022). JASP (Version 0.16.3)[Computer software]. *Amsterdam, The Netherlands.*

Jeffreys, H. (1961). *Theory of probability (3rd ed.)*. Oxford University Press.

Johnston, P., Baker, D. H., Stone, R., & Kaufman, J. (2014). Thatcher's Britain: A new take on an old illusion. *Perception*, *43*(12), 1400-1403.

Langton, S. R., & Bruce, V. (1999). Reflexive visual orienting in response to the social attention of others. *Visual Cognition*, *6*(5), 541-567.

Le Grand, R., Mondloch, C. J., Maurer, D., & Brent, H. P. (2001). Early visual experience and face processing. *Nature*, *410*(6831), 890-890.

Leder, H., Candrian, G., Huber, O., & Bruce, V. (2001). Configural features in the context of upright and inverted faces. *Perception*, *30*(1), 73-83.

Lewis, M. B., & Johnston, R. A. (1997). The Thatcher illusion as a test of configural disruption. *Perception*, *26*(2), 225-227.

Maurer, D., Le Grand, R., & Mondloch, C. J. (2002). The many faces of configural processing. *Trends in Cognitive Sciences*, *6*(6), 255-260.

McCall, C. (2015). Mapping social interactions: the science of proxemics. In M. Wöhr & S. Krach (Eds.), *Social Behavior from Rodents to Humans* (pp. 295-308). Springer.

McCall, C., Blascovich, J., Young, A., & Persky, S. (2009). Proxemic behaviors as predictors of aggression towards Black (but not White) males in an immersive virtual environment. *Social Influence*, *4*(2), 138-154.

McCall, C., & Singer, T. (2015). Facing off with unfair others: introducing proxemic imaging as an implicit measure of approach and avoidance during social interaction. *PLoS One*, *10*(2), e0117532.

McKone, E., & Yovel, G. (2009). Why does picture-plane inversion sometimes dissociate the perception of features and spacing in faces, and sometimes not? Toward a new theory of holistic processing. *Psychonomic Bulletin & Review*, *16*(5), 778-797.

Mondloch, C. J., Le Grand, R., & Maurer, D. (2002). Configural face processing develops more slowly than featural face processing. *Perception*, *31*(5), 553-566.

Murphy, J., Gray, K. L. H., & Cook, R. (2017). The composite face illusion. *Psychonomic Bulletin & Review*, *24*(2), 245-261. https://www.ncbi.nlm.nih.gov/pubmed/27488558

Murphy, J., Gray, K. L. H., & Cook, R. (2020). Inverted faces benefit from whole-face processing. *Cognition*, *194*(104105), 1-9.

Navon, D. (2003). What does a compound letter tell the psychologist's mind? *Acta Psychologica*, *114*(3), 273-309.

Paparella, I., & Papeo, L. (2022). Chunking by social relationship in working memory. *Visual Cognition*, *30*(5), 354-370.

Papeo, L. (2020). Twos in human visual perception. *Cortex*, *132*, 473-478.

Papeo, L., Goupil, N., & Soto-Faraco, S. (2019). Visual search for people among people. *Psychological Science*, *30*(10), 1483-1496.

Papeo, L., Stein, T., & Soto-Faraco, S. (2017). The two-body inversion effect. *Psychological Science*, *28*(3), 369-379.

Pardo-Vazquez, J. L., Castiñeiras-de Saa, J. R., Valente, M., Damião, I., Costa, T., Vicente, M. I., . . . Renart, A. (2019). The mechanistic foundation of Weber's law. *Nature Neuroscience*, *22*(9), 1493-1502.

Peelen, M. V., & Downing, P. E. (2007). The neural basis of visual body perception. *Nature Reviews Neuroscience*, *8*(8), 636-648.

Piepers, D. W., & Robbins, R. A. (2013). A review and clarification of the terms "holistic," "configural," and "relational" in the face perception literature. *Frontiers in Psychology*, *3*(559), 1-11.

Prins, N., & Kingdom, F. A. A. (2009). Palamedes: Matlab routines for analyzing psychophysical data. http://www.palamedestoolbox.org.

Quadflieg, S., & Koldewyn, K. (2017). The neuroscience of people watching: how the human brain makes sense of other people's encounters. *Annals of the New York Academy of Sciences*, *1396*(1), 166-182.

Reed, C. L., Stone, V. E., Grubb, J. D., & McGoldrick, J. E. (2006). Turning configural processing upside down: part and whole body postures. *Journal of Experimental Psychology: Human Perception and Performance*, *32*(1), 73-87.

Rossion, B. (2008). Picture-plane inversion leads to qualitative changes of face perception. *Acta Psychologica*, *128*(2), 274-289.

Slaughter, V., Stone, V. E., & Reed, C. (2004). Perception of faces and bodies: Similar or different? *Current Directions in Psychological Science*, *13*(6), 219-223.

Susilo, T., Rezlescu, C., & Duchaine, B. (2013). The composite effect for inverted faces is reliable at large sample sizes and requires the basic face configuration. *Journal of Vision*, *13*(13), 1-14.

Tanaka, J. W., & Farah, M. J. (1993). Parts and wholes in face recognition. *Quarterly Journal of Experimental Psychology*, *46*(2), 225-245.

Tsao, D. Y., & Livingstone, M. S. (2008). Mechanisms of face perception. *Annual Review of Neuroscience*, *31*, 411-437.

Vestner, T., Gray, K. L., & Cook, R. (2022). Sensitivity to orientation is not unique to social attention cueing. *Scientific Reports*, *12*(1), e5059.

Vestner, T., Gray, K. L. H., & Cook, R. (2020). Why are social interactions found quickly in visual search tasks? *Cognition*, *200*, 104270.

Vestner, T., Gray, K. L. H., & Cook, R. (2021). Visual search for facing and non-facing people: the effect of actor inversion. *Cognition*, *208*, 104550.

Vestner, T., Over, H., Gray, K. L. H., & Cook, R. (2021). Objects that direct spatial attention produce the search advantage for facing dyads. *Journal of Experimental Psychology: General*, *151*(1), 161–171.

Vestner, T., Tipper, S. P., Hartley, T., Over, H., & Rueschemeyer, S. A. (2019). Bound together: Social binding leads to faster processing, spatial distortion, and enhanced memory of interacting partners. *Journal of Experimental Psychology: General*, *148*(7), 1251–1268.

Vogelsang, M. D., Palmeri, T. J., & Busey, T. A. (2017). Holistic processing of fingerprints by expert forensic examiners. *Cognitive research: principles and implications*, *2*, e15.

Wixted, J. T., & Stretch, V. (2000). The case against a criterion-shift account of false memory. *Psychological Review*, *107*(2), 368–376.

Wong, A. C. N., Palmeri, T. J., & Gauthier, I. (2009). Conditions for facelike expertise with objects: Becoming a Ziggerin expert—but which type? *Psychological Science*, *20*(9), 1108-1117.

Wong, Y. K., & Gauthier, I. (2010). Holistic processing of musical notation: Dissociating failures of selective attention in experts and novices. *Cognitive, Affective, & Behavioral Neuroscience*, *10*, 541-551.

Wong, Y. K., Twedt, E., Sheinberg, D., & Gauthier, I. (2010). Does Thompson's Thatcher effect reflect a face-specific mechanism? *Perception*, *39*(8), 1125-1141.

Worthington, M. E. (1974). Personal space as a function of the stigma effect. *Environment & Behavior*, *6*, 289–294.

Young, A. W., Hellawell, D., & Hay, D. C. (1987). Configurational information in face perception. *Perception*, *42*(11), 1166-1178.

Yovel, G., & Kanwisher, N. (2008). The representations of spacing and part-based information are associated for upright faces but dissociated for objects: Evidence from individual differences. *Psychonomic Bulletin & Review*, *15*(5), 933-939.

Figures

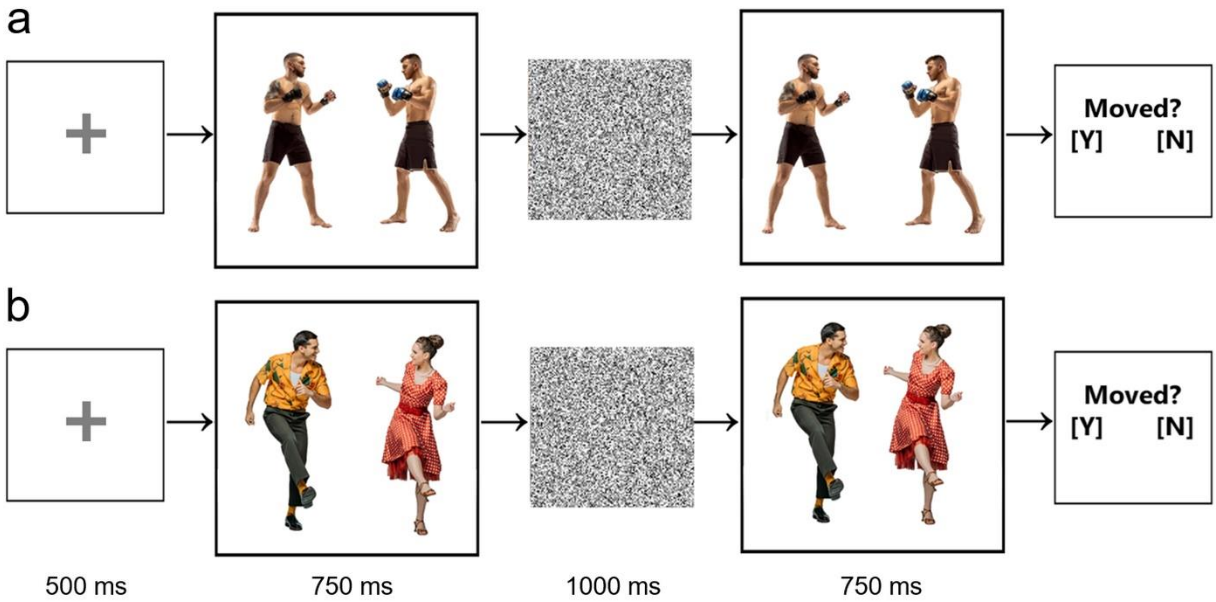

Figure 1. Overview of task sequence for Experiment 1. Schematic illustration of (a) a move apart trial from Experiment 1a, and (b) a move closer trial from Experiment 1b.

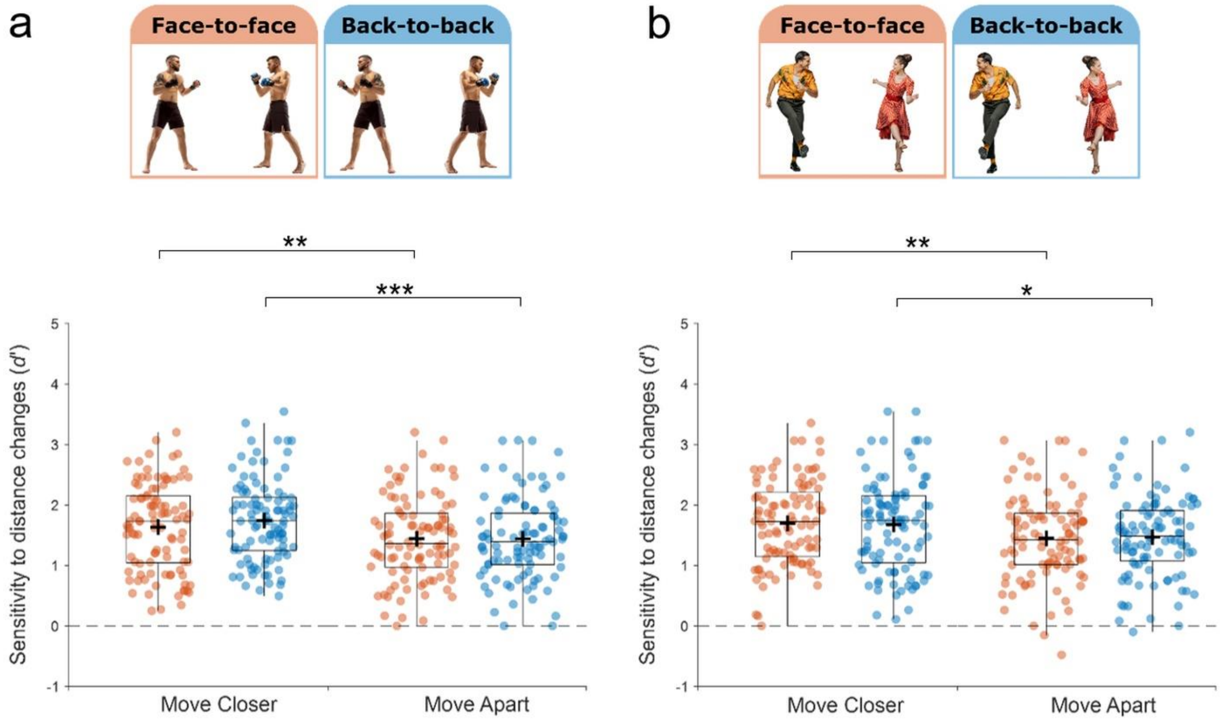

Figure 2. Results of Experiment 1. (a) Results for Experiment 1a obtained with boxing dyads. (b) Results for Experiment 1b obtained with dancing dyads. Boxes show the median and interquartile range, crosses show the mean. No significant effects of Arrangement (face-to-face vs. back-to-back) were observed in either experiment. * denotes $p < .05$, ** denotes $p < .01$, *** denotes $p < .001$.

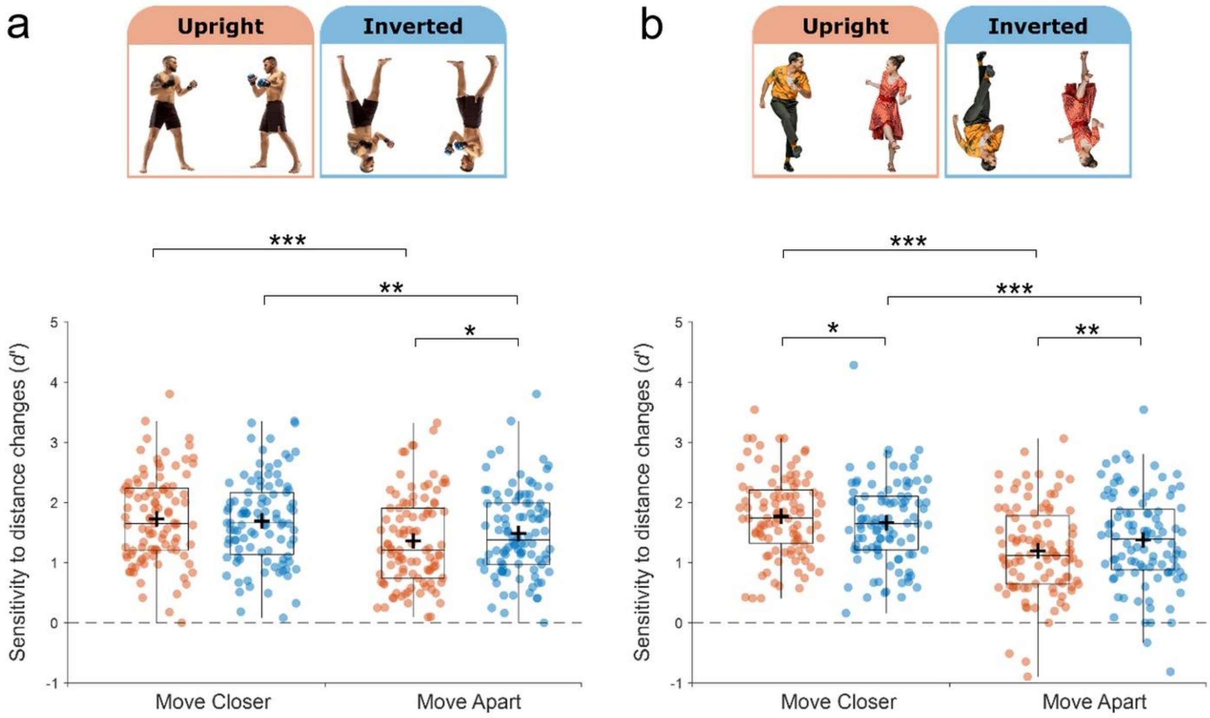

Figure 3. Results of Experiment 2. (a) Results for Experiment 2a obtained with boxing dyads. (b) Results for Experiment 2b obtained with dancing dyads. Boxes show the median and interquartile range, crosses show the mean. * denotes $p < .05$, ** denotes $p < .01$, *** denotes $p < .001$.

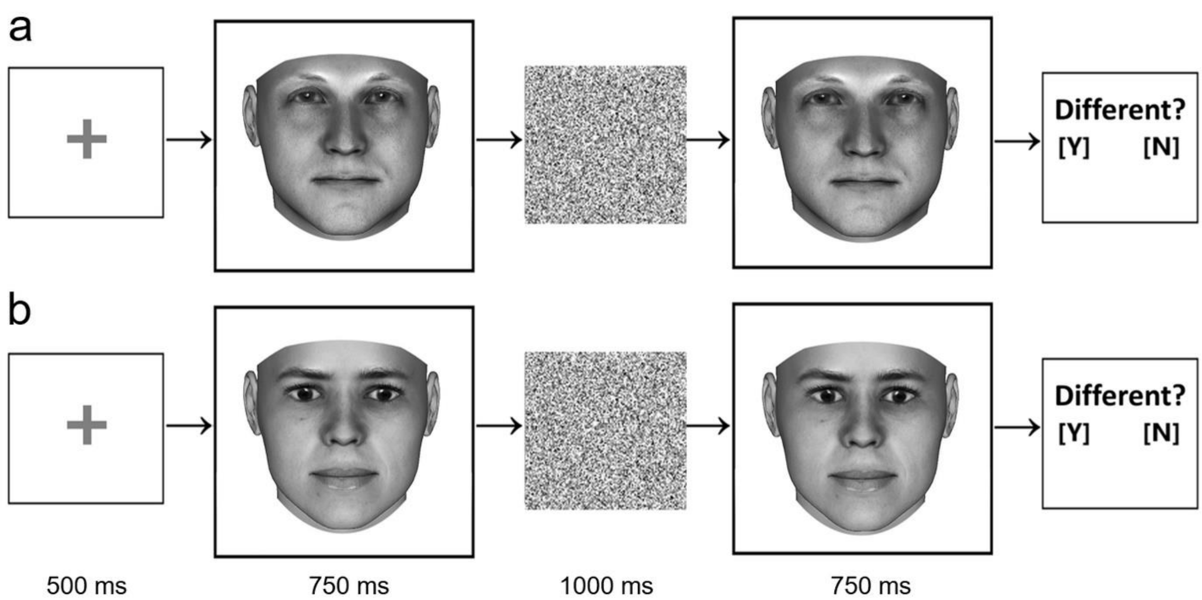

Figure 4. Overview of task sequence for Experiment 3. Schematic illustration of (a) a move apart trial from Experiment 3a, and (b) a move closer trial from Experiment 3b.

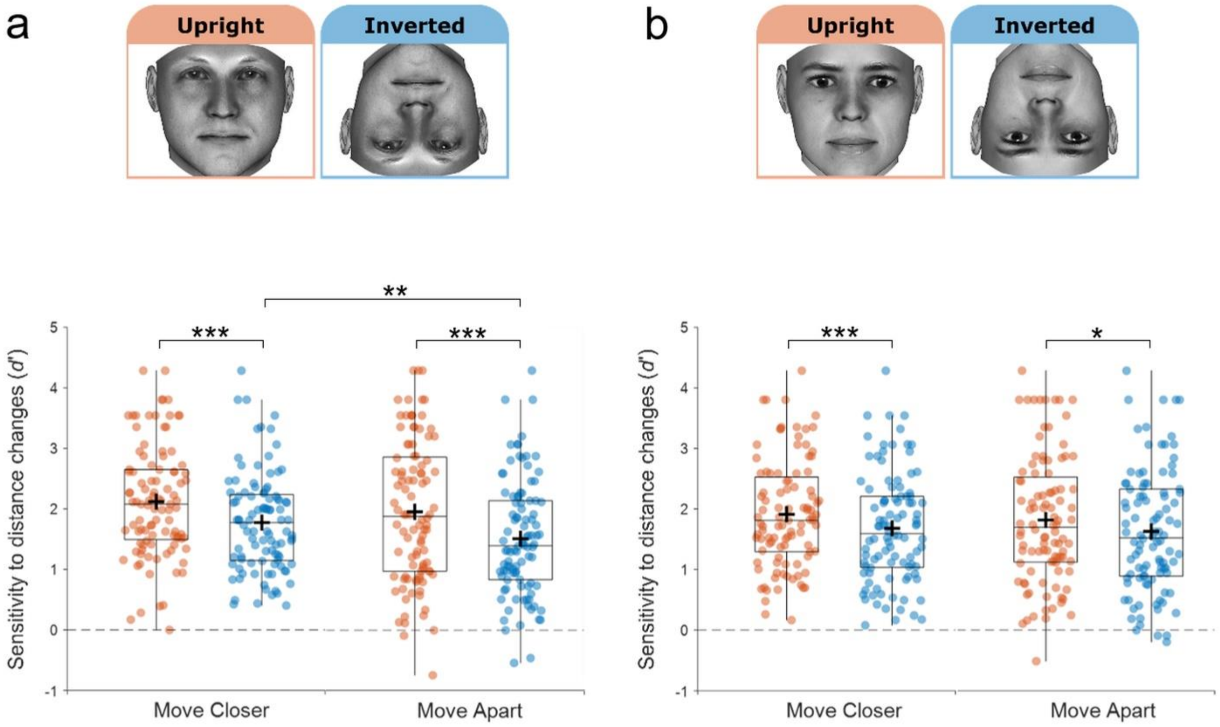

Figure 5. Results of Experiment 3. (a) Results for Experiment 3a obtained with a male face. (b) Results for Experiment 3b obtained with a female face. Boxes show the median and interquartile range, crosses show the mean. * denotes p < .05, ** denotes p < .01, *** denotes p < .001.

Supplementary Material

Experiment 1

Experiment 1a

Bias estimates (*C*) were subjected to ANOVA with Dyad Arrangement (face-to-face, back-to-back) and Movement Direction (move closer, move apart) as within-subjects factors. The ANOVA revealed a significant main-effect of Movement Direction [$F(1, 99) = 18.238$, $p < .001$, $\eta^2_G = .028$, $BF_{01} = .002$], whereby participants were more likely to report a distance change on move closer trials. We observed no main-effect of Dyad Arrangement [$F(1, 99) = 0.83$, $p = .489$, $\eta^2_G = .002$, $BF_{01} = 4.478$] and no Dyad Arrangement × Movement Direction interaction [$F(1, 99) = 3.235$, $p = .075$, $\eta^2_G = .002$, $BF_{01} = 1.556$]. Simple contrasts revealed no effect of Dyad Arrangement on bias scores in either the move closer [$M_{F2F} = -0.17$, $SD_{F2F} = 0.32$, $M_{B2B} = -0.12$, $SD_{B2B} = 0.39$, $t(99) = 1.369$, $p = .174$, $d_z = 0.14$, $BF_{01} = 3.66$] or move apart conditions [$M_{F2F} = 0.270$, $SD_{F2F} = 0.34$, $M_{B2B} = 0.27$, $SD_{B2B} = 0.39$, $t(99) = 0.270$, $p = .788$, $d_z = 0.03$, $BF_{01} = 8.72$].

Experiment 1b

Bias estimates (*C*) were subjected to ANOVA with Dyad Arrangement (face-to-face, back-to-back) and Movement Direction (move closer, move apart) as within-subjects factors. The ANOVA revealed a significant main-effect of Movement Direction [$F(1, 99) = 9.819$, $p = .002$, $\eta^2_G = .020$, $BF_{01} = 0.065$], whereby participants were more likely to report a distance change on move closer trials. We observed no main-effect of Dyad Arrangement [$F(1, 99) = 0.046$, $p = .830$, $\eta^2_G < .001$, $BF_{01} = 5.676$] and no Dyad Arrangement × Movement Direction interaction [$F(1, 99) = 0.597$, $p = .441$, $\eta^2_G < .001$, $BF_{01} = 6.780$]. Simple contrasts revealed no effect of Dyad Arrangement on bias scores in either the move closer [$M_{F2F} = -0.09$, $SD_{F2F} = 0.40$, $M_{B2B} = -0.10$, $SD_{B2B} = 0.37$, $t(99) = 0.209$, $p = .835$, $d_z = 0.02$, $BF_{01} = 8.841$] or move apart conditions [$M_{F2F} = -0.22$, $SD_{F2F} = 0.41$, $M_{B2B} = -0.20$, $SD_{B2B} = -0.42$, $t(99) = 0.572$, $p = .569$, $d_z = 0.06$, $BF_{01} = 7.71$].

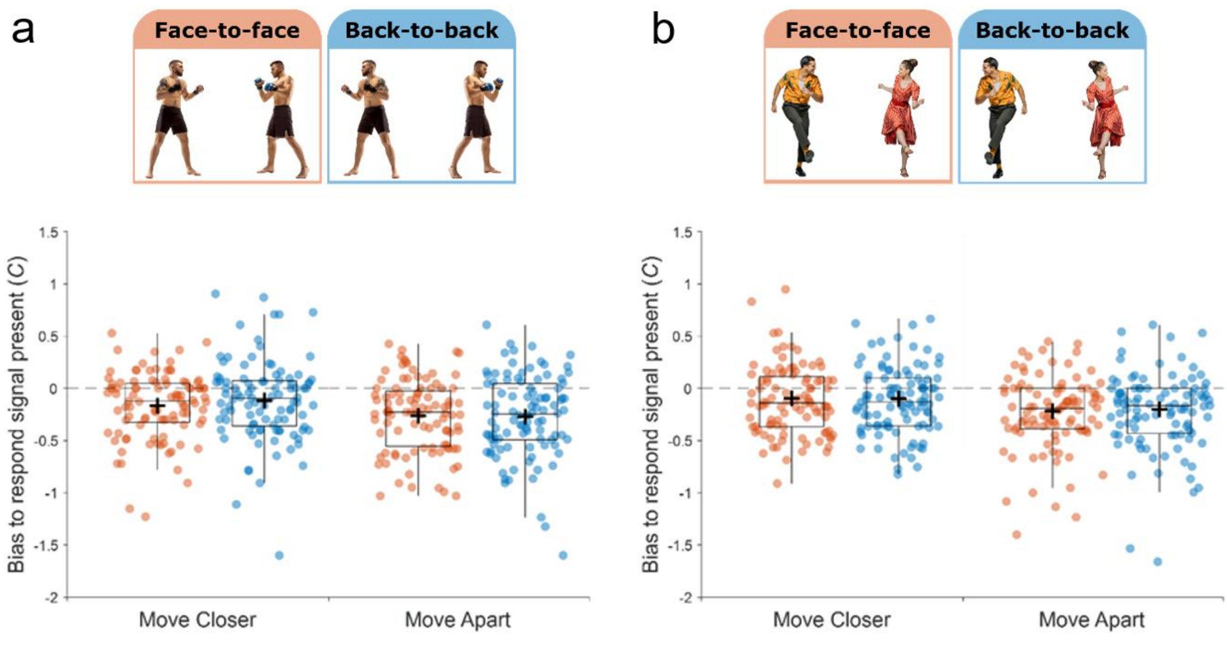

Figure S1. Distributions of C estimates obtained in (a) Experiment 1a and (b) Experiment 1b. * denotes $p < .05$, ** denotes $p < .01$, *** denotes $p < .001$.

Experiment 2

Experiment 2a

Bias estimates (*C*) were subjected to ANOVA with Dyad Orientation (upright, inverted) and Movement Direction (move closer, move apart) as within-subjects factors. The ANOVA revealed a significant main-effect of Movement Direction [$F(1, 99) = 21.162$, $p < .001$, $\eta^2_G = .034$, $BF_{01} < .001$], whereby participants were more likely to report a distance change on move closer trials. We observed a significant main-effect of Dyad Orientation [$F(1, 99) = 6.331$, $p = .013$, $\eta^2_G = .009$, $BF_{01} = 0.305$], whereby participants were more likely to report a distance change in the inverted condition. The analysis also revealed a significant Dyad Orientation × Movement Direction interaction [$F(1, 99) = 9.575$, $p = .003$, $\eta^2_G = .003$, $BF_{01} < .001$]. Simple contrasts revealed no effect of Dyad Orientation on bias scores in the move closer condition [$M_{upr} = -0.13$, $SD_{upr} = 0.41$, $M_{inv} = -0.10$, $SD_{inv} = 0.37$, $t(99) = 0.895$, $p = .373$, $d_z = 0.09$, $BF_{01} = 6.124$]. However, participants were significantly less likely to report a move apart distance change in the upright condition, than in the inverted condition [$M_{upr} = -0.31$, $SD_{upr} = 0.39$, $M_{inv} = -0.20$, $SD_{inv} = 0.36$, $t(99) = 3.818$, $p < .001$, $d_z = 0.38$, $BF_{01} < .001$].

Experiment 2b

Bias estimates (*C*) were subjected to ANOVA with Dyad Orientation (upright, inverted) and Movement Direction (move closer, move apart) as within-subjects factors. The ANOVA revealed a significant main-effect of Distance Direction [$F(1, 99) = 36.731$, $p < .001$, $\eta^2_G = .076$, $BF_{01} < .001$], whereby participants were more likely to report a distance change on move closer trials. We observed a significant main-effect of Dyad Orientation [$F(1, 99) = 13.254$, $p < .001$, $\eta^2_G = .014$, $BF_{01} < .001$], whereby participants were more likely to report a distance change in the inverted condition. The analysis also revealed a significant Dyad Orientation × Movement Direction interaction [$F(1, 99) = 20.936$, $p < .001$, $\eta^2_G = .010$, $BF_{01} = 0.001$]. Simple contrasts revealed no effect of Dyad Orientation on bias scores in the move closer condition [$M_{upr} = -0.08$, $SD_{upr} = 0.38$, $M_{inv} = -0.06$, $SD_{inv} = 0.37$, $t(99) = 0.495$, $p = .622$, $d_z = 0.05$, $BF_{01} = 8.019$]. However, participants were significantly less likely to report a move apart distance change in the upright condition, than in the inverted condition [$M_{upr} = -0.37$, $SD_{upr} = 0.37$, $M_{inv} = -0.20$, $SD_{inv} = 0.36$, $t(99) = 5.656$, $p < .001$, $d_z = 0.57$, $BF_{01} < .001$].

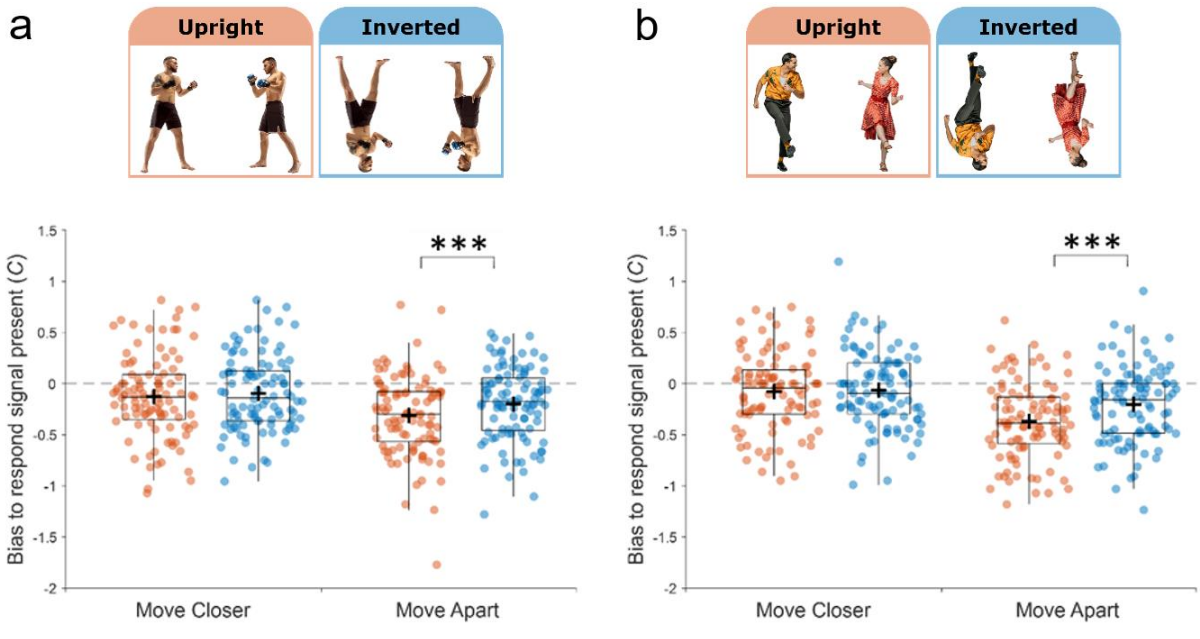

Figure S2. Distributions of C estimates obtained in (a) Experiment 2a and (b) Experiment 2b. * denotes $p < .05$, ** denotes $p < .01$, *** denotes $p < .001$.

Experiment 3

Experiment 3a

Bias estimates (C) were subjected to ANOVA with Face Orientation (upright, inverted) and Movement Direction (move closer, move apart) as within-subjects factors. The ANOVA revealed a significant main-effect of Movement Direction [$F(1, 99) = 5.615$, $p = .020$, $\eta^2_G = .015$, $BF_{01} = 0.463$], whereby participants were more likely to report a distance change on move closer trials. We observed no main-effect of Face Orientation [$F(1, 99) = 2.267$, $p = .135$, $\eta^2_G = .004$, $BF_{01} = 2.346$] or a Face Orientation × Movement Direction interaction [$F(1, 99) = 1.530$, $p = .219$, $\eta^2_G < .001$, $BF_{01} = 3.000$]. Simple contrasts revealed participants were significantly less likely to report a move closer distance change in the upright condition, than in the inverted condition [$M_{upr} = -0.23$, $SD_{upr} = 0.47$, $M_{inv} = -0.14$, $SD_{inv} = 0.44$, $t(99) = -1.991$, $p = .049$, $d_z = -0.20$, $BF_{01} = 1.361$]. However, there was no effect of Dyad Orientation on bias scores in the move apart condition [$M_{upr} = -0.31$, $SD_{upr} = 0.46$, $M_{inv} = -0.28$, $SD_{inv} = 0.36$, $t(99) = -0.714$, $p = .477$, $d_z = -0.07$, $BF_{01} = 7.050$].

Experiment 3b

Bias estimates (C) were subjected to ANOVA with Face Orientation (upright, inverted) and Movement Direction (move closer, move apart) as within-subjects factors. The ANOVA revealed no main-effect of Movement Direction [$F(1, 99) = 0.821$, $p = .367$, $\eta^2_G = .002$, $BF_{01} = 3.166$], indicating participants were equally likely to report a distance change on move closer and move apart trials. We also did not observe a significant main-effect of Face Orientation [$F(1, 99) = 1.823$, $p = .180$, $\eta^2_G = .005$, $BF_{01} = 2.248$] or a Face Orientation × Movement Direction interaction [$F(1, 99) = 0.300$, $p = .180$, $\eta^2_G = .005$, $BF_{01} = 6.250$]. Simple contrasts revealed no effect of Face Orientation on bias scores in the move closer condition [$M_{upr} = -0.19$, $SD_{upr} = 0.33$, $M_{inv} = -0.15$, $SD_{inv} = 0.38$, $t(99) = -1.078$, $p = .284$, $d_z = -0.11$, $BF_{01} = 5.150$] and the move apart condition [$M_{upr} = -0.24$, $SD_{upr} = 0.41$, $M_{inv} = -0.17$, $SD_{inv} = 0.37$, $t(99) = -1.309$, $p = .194$, $d_z = -1.13$, $BF_{01} = 3.952$].

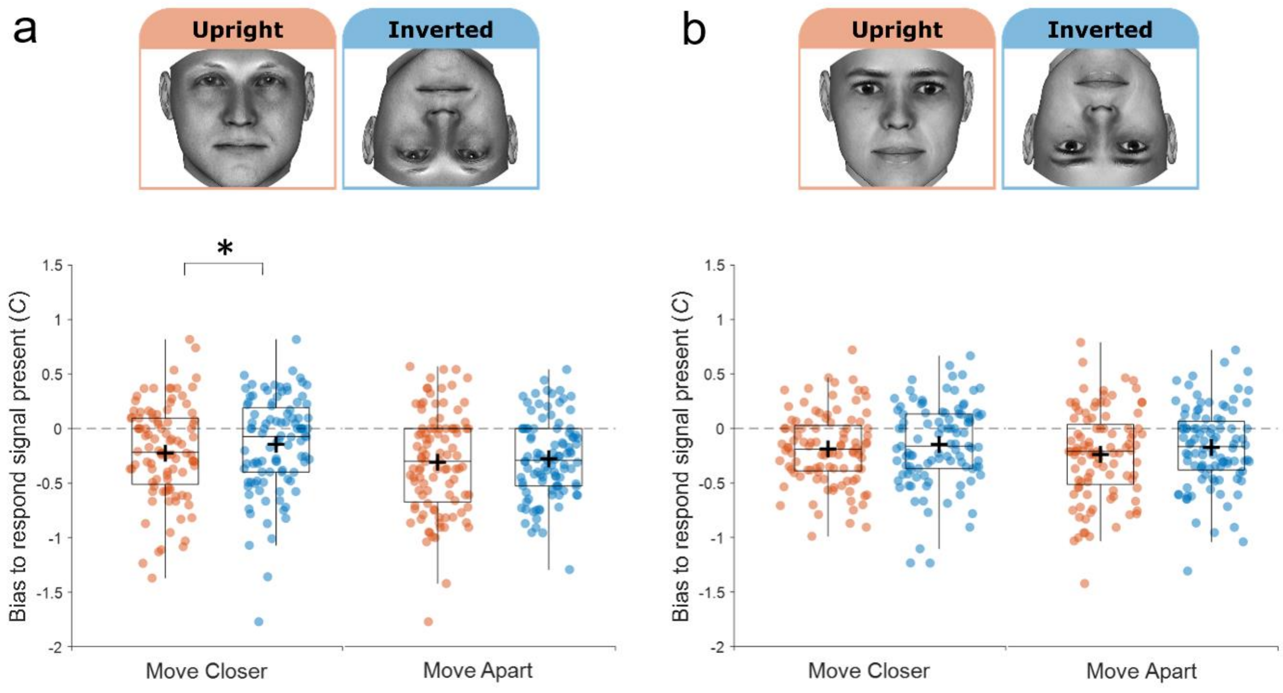

Figure S3. Distributions of C estimates obtained in (a) Experiment 3a and (b) Experiment 3b. * denotes $p < .05$, ** denotes $p < .01$, *** denotes $p < .001$.