

Turning Configural Processing Upside Down: Part and Whole Body Postures

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Like faces, body postures are susceptible to an inversion effect in untrained viewers. The inversion effect may be indicative of configural processing, but what kind of configural processing is used for the recognition of body postures must be specified. The information available in the body stimulus was manipulated. The presence and magnitude of inversion effects were compared for body parts, scrambled bodies, and body halves relative to whole bodies and to corresponding conditions for faces and houses. Results suggest that configural body posture recognition relies on the structural hierarchy of body parts, not the parts themselves or a complete template match. Configural recognition of body postures based on information about the structural hierarchy of parts defines an important point on the configural processing continuum, between recognition based on first-order spatial relations and recognition based on holistic undifferentiated template matching.

Keywords: configural processing, body inversion effect, face inversion effect, object recognition, body schema

A review of the literature on face recognition turns up many references to the configural processing of faces (e.g., Maurer, Le Grand, & Mondloch, 2002). Configural processing is used to refer to any phenomenon that involves perceiving spatial relations among the features of a stimulus, such as a face. It is compared against featural processing (also referred to as componential processing, piecemeal processing, and analytic processing). Unlike most other objects that can be recognized by the presence or absence of certain individual parts, the recognition of faces depends on details of the configuration of face features, that is, the specific spatial relations among face parts (e.g., Carey, 1992; Collishaw & Hole, 2000; Leder & Bruce, 2000). Recognition dependent on such configural information is termed *configural processing* in the literature (e.g., Leder & Bruce, 2000; Maurer et al., 2002). The visual system may also recognize other objects with which people have expertise by using configural processing (for a review, see Tanaka & Gauthier, 1997). Recently, the importance of configural processing for body posture recognition has also been documented (Reed, Stone, Bozova, & Tanaka, 2003). In the present article, we systematically explore the stimulus properties that affect different types of configural processing by the visual system to clarify what configural processing is for human body

postures. We focus on the human body and compare it with two stimulus classes, faces and houses.

Inversion effects (i.e., upside down objects are significantly more difficult to recognize than upright objects) are classically seen as indicators of configural processing for faces (Maurer et al., 2002; Yin, 1969). For example, inversion alters the coordinates of parts in “face space,” while preserving exact relative distances. The inversion effect is a robust finding and is sensitive to all types of configural processing, regardless of how configural processing is defined. We review what types of configural information make up the configural processing continuum to clarify how inversion has been used to investigate each type. Then we consider how these ideas might apply to human bodies as a class of stimuli. For viewers without explicit training, body postures produce inversion effects similar to those found for faces (Reed et al., 2003). These findings suggest that as for faces, a different processing mechanism is used to recognize human body postures from that used for inanimate objects such as houses. Nonetheless, it remains unclear precisely what it is about configuration that is represented and whether the configural processing used for faces is the same configural processing used for body postures.

Research on face recognition may be aggregated to construct a conceptual *configural processing continuum*, to help define what types of stimulus information contribute to configural processing (see Figure 1). Although the terms *configural processing* and *holistic processing* have sometimes been used as synonymous terms throughout the literature, we distinguish between these terms and refer to configural processing as a more general term and holistic processing as a specific type of configural processing. Objects recognized via local feature or part information, such as houses (e.g., Tanaka & Farah, 1993), are on one end of the

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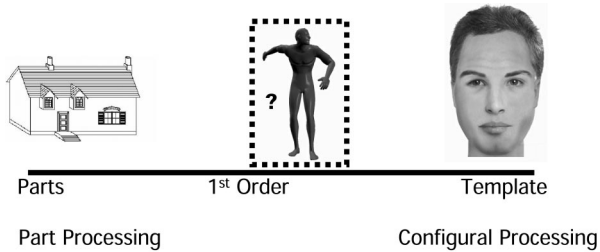


Figure 1. The configural processing continuum from part-based or feature-based processing to holistic processing. Houses are considered to be a class of objects recognized on the basis of parts and features. Faces are considered to be a class of objects recognized on the basis of holistic configuration of features. Reprinted from "Not Just Posturing: Configural Processing of the Human Body," by C. L. Reed, V. E. Stone, and J. E. McGoldrick, in *Human Body Perception From the Inside Out* (Figure 11.3, p. 236), 2005, New York: Oxford University Press. Copyright 2005 by Gunther Knoblich et al. (Eds.). Used by permission of Oxford University Press.

continuum. Objects recognized holistically as undifferentiated wholes (Farah, Wilson, Drain, & Tanaka, 1998; Gauthier & Tarr, 2002; Moscovitch, Winocur, & Behrmann, 1997; Tanaka & Farah, 1993), such as faces, are on the other extreme. Objects recognized using nonholistic configural processing or other less extreme types of holistic processing would lie in between. In this article, we operationalize various definitions of configural processing found in the face recognition literature and systematically test whether body posture recognition is affected by the same types of stimulus property manipulations that affect faces (see Figure 1).

One end of the configural processing continuum refers to recognition by presence, absence, or appearance of individual parts: Recognition of many objects does not rely on the spatial relations among parts of the object (e.g., Biederman, 1987; Cave & Kosslyn, 1993). Here we consider parts to be salient, identifiable features of an object (e.g., Biederman, 1987; Diamond & Carey, 1986; Gauthier & Tarr, 2002). Accordingly, if such part-based recognition is not based on configural processing at all, one would expect that changing part information would not interact with inversion in affecting recognition. Indeed, it does not. When nonface objects (usually human-made objects) or their isolated parts are inverted, recognition is not significantly different from when they are upright (Boutsen & Humphreys, 2003; Rhodes, Brake, & Atkinson, 1993; Tanaka & Farah, 1993). In addition, for exposure times of 1 s or less, the recognition of scrambled objects is not significantly different from the recognition of whole objects (Barton, Keenan, & Bass, 2001). Face recognition may also depend on part information but requires configural information as well. For faces, Diamond and Carey (1986) defined local feature information as the identity of a particular feature or part (e.g., eye color or mouth shape). Several studies have shown that when local feature information in faces was changed without changing configural information, these changes were equally easy to detect whether upright or inverted (Bartlett & Searcy, 1993; Diamond & Carey, 1986; Leder & Bruce, 1998; Rhodes et al., 1993; Searcy & Bartlett, 1996). For example, blackening the teeth, making the eyebrows darker, including a mustache, or swapping the mouth from a previously learned face did not increase the size of the face inversion effect.

That changing only local part information rather than configural information does not modify the inversion effect supports the idea that recognition dependent on part information does not involve configural processing.

Another point on the configural processing continuum refers to the relative spatial positions of individual features or what Carey (1992) and Diamond and Carey (1986) have defined as first-order spatial relations. More precisely, first-order relational information may be defined as the relative positions in coordinate space of constituent parts of an object, such as the placement of the eyes above the nose. First-order relationships help to define a stimulus as a face, a lamp, or a bicycle, and so forth. For example, in a bicycle the handles and seat are above the pedals, or in a face the eyes are above the nose and mouth. Humans' exceptional ability to recognize upright faces, even in the absence of normal facial features, demonstrates our exceptional sensitivity to first-order relations (Kanwisher, Tong, & Nakayama, 1998; Moscovitch et al., 1997). Evidence that first-order spatial relations are more important for faces than for many other objects comes from the fact that scrambled faces are much more difficult to categorize and recognize than are their scrambled object counterparts (Baenninger, 1994; Collishaw & Hole, 2000; Donnelly, Humphreys, & Sawyer, 1994). In other words, face recognition relies on first-order spatial relations. For familiar faces, disrupting first-order relationships by scrambling increases the inversion effect (Collishaw & Hole, 2000). Again, the inversion effect is used as an index of configural processing by looking at its interaction with another configural manipulation, disruption of first-order relational information through scrambling.

For faces, additional types of configural processing may be used for identity recognition, beyond recognition processing based on the part information and first-order spatial relations necessary to define an object as a face. Another aspect of configuration important for recognition is structural information about the connection between parts, besides just their positions in space. Marr (1982) described how recognition processes could work on the hierarchical structure of objects because particular features were embedded within an overall structure of the object. For instance, unlike many objects, faces are recognized not only by the fact that the nose is below the eyes but also from the fact that the nose is in a particular position relative to the overall structure of the face, that is, in the center. In a body, legs and arms may vary in how far above or below each other they are in space, but they are always attached to the same parts of the torso, which defines the overall hierarchical structure of the body. The position of particular parts within the overall structural hierarchy of an object specifies another type of configural information separate from first-order information, which we call *structural information*. Structural information refers to information about the organization of parts in terms of the overall object as well as the spatial relationship of each type of part relative to each other. First-order relational information is necessary, but not sufficient, to define structural information. First-order relationships provide a common visual hierarchical structure for each particular object in its class. However, defining the positions of parts within that hierarchy is a more complex kind of configural information than just first-order relationships. Objects that have a clearly defined hierarchical structure (such as faces or bodies) may elicit a kind of configural processing that lies at a point farther along on the continuum than that for objects recognized by first-

order relations. Because scrambling a stimulus disrupts first-order relational information, it also disrupts structural information.

Another point on the configural processing continuum is recognition using second-order relational information, which depends on exact metric distances between parts. For faces, when the relative positions of face parts are the same and structural information is intact but the exact distances between parts vary, face recognition is affected (Carey, 1992; Frieri, Lee, & Symons, 2000; Rhodes, Byatt, Tremewan, & Kennedy, 1996). In fact, adults are able to detect minute changes in the spacing of facial features (Haig, 1984). One theory is that faces are encoded in terms of their deviation from a mentally represented average face that is abstracted from all the faces a person has encountered (Valentine, 1991). Second-order relational information refers to the deviation between the position of a particular point on a face (say, the outer edge of the eyes) and the position of that point on an average or prototype face, constructed from superimposing several faces together or averaging the positions of all face points over a set of faces (Carey, 1992). Changes to second-order spatial information in faces can be effected by moving the eyes, nose, or mouth up or down or moving the eyes closer or farther apart. Such changes in faces are more difficult to detect for inverted than for upright faces (e.g., Frieri et al., 2000). We note that recognition using second-order relational information is an important point on the configural processing continuum. Because of the methodological difficulties of defining an “average” body posture, we do not consider second-order effects on body posture recognition in this article.

The far end of the configural processing continuum, opposite from the featural recognition end, refers to recognition by holistic undifferentiated template representations (Farah, 1991; Gauthier & Tarr, 2002). In other words, the object representation is not decomposed into individual parts. Some researchers have proposed that adults process faces in a holistic fashion, much like a Gestalt pattern, so that it is more difficult to process individual features (Farah, Tanaka, & Drain, 1995; Farah et al., 1998; Tanaka & Farah, 1993). At short exposures that prevent feature-by-feature comparisons, upright, internal facial features appear to be so strongly integrated that it is difficult to parse the face into isolated features (Hole, 1994). Further, even if the internal features are the same, different external facial contours can disrupt face recognition (Sinha & Poggio, 1996). Thus, the face features, the spatial relations between these features, the respective distances between the features, and the features' relation to the facial context are not explicitly represented. Rather, all of this information is embedded in a complex pattern that is recognized as an undifferentiated template (Gauthier & Tarr, 2002). Evidence for the holistic processing of faces comes from masking studies by Farah et al. (1998) showing that whole face masks disrupt upright face recognition but part masks do not. In addition, evidence is found in learning studies by Tanaka and Farah (1993) in which face parts are better recognized within the context of whole upright faces but not inverted faces. For faces, inversion disrupts the facilitated recognition of parts within the context of the whole effect; thus inversion also interacts with the holistic level of configural processing.

Current Study

In this study, we examine where body postures fit into this configural processing continuum. The face and body inversion

effects suggest there is something about the configuration of their features in an upright orientation that is important for recognition. Although a variety of paradigms have been used to investigate holistic processing (e.g., recognition of parts in the context of wholes, mismatched composites, masking; see Maurer et al., 2002, for a review), inversion effects are empirically robust and are sensitive to all types of configural processing, regardless of how configural or holistic processing is defined. However, inversion effects per se do not demonstrate what kind of configural information observers are sensitive to that is then disrupted when the object is inverted. Maurer et al. (2002) have pointed out that for faces, inversion interacts with several kinds of configural information, not just second-order or holistic information. In previous research, manipulations of feature, first-order, and holistic manipulations influence the configural processing of faces via the presence, absence, or amplification of face inversion effects (Leder & Bruce, 1998, 2000; Leder, Candrian, Huber, & Bruce, 2001; Maurer et al., 2002). As reviewed in Maurer et al. (2002), we follow the practice of using inversion effects as an index of configural processing. In the present experiments, we used similar manipulations to those used in previous face recognition research to alter feature, first-order, structural, and holistic information in human body postures. These manipulations allowed us to determine what characteristics of the human body contribute to configural processing.

Specifically, our experiments sampled from the configural processing continuum developed for faces to determine what configural processing means for human body postures. We manipulate part, first-order spatial relations, structural, and template information. Following Maurer et al. (2002), to the extent that any of these manipulations changes the body inversion effect, we infer that such information affects configural processing. In Experiment 1, we tested the hypothesis that body postures can be recognized via their individual parts by comparing the recognition of whole body postures to the recognition of isolated body parts from those postures. In Experiment 2, we tested the hypothesis that first-order spatial relations are important for the recognition of body postures by comparing recognition of whole body postures to scrambled body postures. In Experiment 3, we tested the hypothesis that body postures and faces are recognized via an extreme version of holistic processing, namely, the holistic undifferentiated template hypothesis. We compare the recognition of whole body postures and faces to half body postures and faces. Finally, within Experiment 3, we compared two types of half stimuli that preserve visible first-order spatial relations as well as precise spatial relations among parts but differ in terms of the selected parts. Together, these experiments identify a region along the configural processing continuum between first-order spatial relations and holistic undifferentiated template processing by which body postures are processed.

Experiment 1: Configural Processing From Individual Body Parts

The purpose of Experiment 1 was to determine whether inversion effects could be found for isolated body parts. For body postures, individual components of the postures are body parts such as an arm, a leg, or a head position. Although an object may be recognized as a body by the presence of specific parts, the recognition of a body posture may require information about the

arrangement of those parts. Inversion effects are not typically found for individual parts either for objects recognized by their parts, such as houses, or for objects recognized by the configuration of their parts, such as faces (Boutsen & Humphreys, 2003; Rhodes et al., 1993; Tanaka & Farah, 1993). Rhodes et al. (1993) directly compared effects of inversion on isolated and relational features of the face. They found little effect of inversion for isolated facial features but much larger changes in inversion effects when feature relations were changed. They concluded that features alone were less important in face recognition. Extending this logic, body postures might be recognized by the spatial relations among the parts rather than by isolated features. Thus, one hypothesis is that significant inversion effects should be found only for whole body postures and not for isolated body parts. Furthermore, isolated body parts do not contain structural information about how parts fit into the whole body and thus may not be recognized using configural processing of structural information either.

However, there is an alternative hypothesis. Body parts might be recognized via local configuration information as well. For individual body parts, the biomechanical connections between the subparts might be enough to elicit structural configural processing for local parts. For example, an arm may be an individual part, but an arm contains its own internal configural information regarding the relative positions of the upper arm, elbow, lower arm, wrist, hand, and fingers. Changes in the angles between the shoulder, elbow, wrist, hand, and fingers provide significant changes in arm posture identification. This type of local configural information is not necessarily available in all face parts. Body postures that are distinguished by differences in arm position may be recognized by local configurations within a single part and may not require the whole body configuration. Thus, body parts that are distinguished by local configuration may not require the whole body posture for configural recognition. If this is true, then inversion effects should be found for these body parts.

In this experiment, we tested these two alternative hypotheses by investigating whether inversion effects would be found for whole body postures only or for both body postures and body parts. Houses were used as control stimuli because houses are a good example of objects that are not typically recognized by configuration (e.g., Tanaka & Farah, 1993). No inversion effects were expected for houses or individual house parts.

Method

Participants. Thirty-five University of Denver undergraduates participated for extra credit in psychology courses. In this and all subsequent experiments, participants had normal or corrected-to-normal vision.

Stimuli and apparatus. The body posture stimuli were black-and-white, 3-D male figures created with Poser 2.0 (Curious Labs, Santa Cruz, CA). They were approximately 14 cm × 10 cm (exact image size varied with body posture). Each figure's arms and legs were positioned to create novel poses that were visually distinguishable from each other, had no meaningful posture, and could not be easily labeled. The poses were asymmetrical with respect to both vertical and horizontal axes. All poses were physically possible. *Different* targets, or distractors, for each figure were constructed by altering the position of three body parts of the original stimulus: An arm, leg, and head of the figure were placed at a different angle or in a different position. A set of 18 upright, biomechanically possible body poses was constructed. Each pose was paired with a copy of itself and a similar appearing distractor to create 18 same-body and 18

different-body pairs. All pose pairs were then rotated 180° in the picture plane to create the inverted body stimuli.

Body-part stimuli were created from the whole body stimuli with Photoshop. Arm stimuli were created by separating the arm from the rest of the body at the shoulder. Leg stimuli were created by separating the leg from the rest of the body at the hip. Head stimuli were created by separating the head from the rest of the body at the torso. Each part was displayed in isolation.

The same number of house stimuli was created. Houses were 3-D line drawings (see Tanaka & Farah, 1993). The houses were approximately 12 cm high × 17 cm wide and shared the same external frame. A similar criterion was used for creating the house *different* distractor stimuli as for the body stimuli. The door, main window, and small window elements were altered. House-part stimuli (doors, main windows, and small windows) were created by extracting each part from the whole house stimuli with Photoshop. Each part was displayed in isolation.

Because all the part stimuli and their *different* distractor stimuli were taken directly from the whole stimuli versions, the difficulty of the discrimination between stimuli and targets was similar for whole and part stimuli. The inverted stimulus pairs were created by rotating all upright stimulus pairs 180° in the picture plane. Example body posture and house stimuli are illustrated in Figure 2.

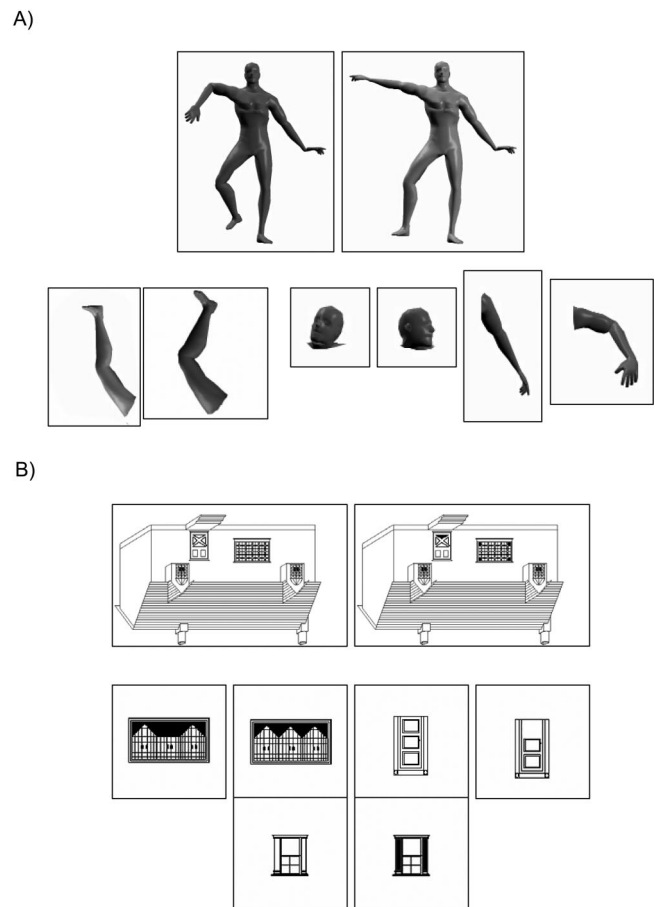


Figure 2. Stimuli for Experiment 1. A: Whole and part body postures. The whole body posture pair illustrates an example of an upright *different* trial. Body parts are arms, legs, and head postures. B: Whole and part houses. The whole house pair illustrates an example of an inverted *different* trial. Each part pair illustrates an example of *different* stimulus–target pairs. House parts are bay windows, doors, and windows.

Procedure. Each participant was seated 70 cm from a 13-in. (33-cm) Macintosh computer monitor. Chair height was adjusted so that each participant's eyes were level with the center of the computer screen. Participants were informed that the experiment had four parts during which they would determine whether two similar objects, depicted in the same orientation, were the same or different: (a) whole body postures, (b) body parts, (c) whole houses, and (d) house parts. For all types of stimuli, the first stimulus was presented for 250 ms, followed by a blank screen for 1,000 ms, and then a second stimulus was presented until the participant responded. Both stimuli were presented at the same orientation, either both upright or both inverted (i.e., no mental rotation was required). Participants pressed the *S* key using their left index finger to indicate that the two stimuli were the same or the *L* key using their right index finger to indicate that the stimuli were different. The *S* and *L* keys were labeled with *S* or *D* stickers, indicating same or different, respectively. For all trials, participants were asked to respond as fast and accurately as possible. Response time and accuracy were recorded. The basic paradigm is illustrated in Figure 3.

Whole and part house stimuli and whole and part body stimuli were presented in four separate blocks, with block order counterbalanced across participants. Each of the four blocks contained 72 trials, for a total of 288 trials. Each block started with 12 practice trials, 3 *same* and 3 *different* in each orientation. The entire testing session lasted approximately 45 min.

Results

To measure visual sensitivity to configuration, we computed $d' = z(\text{hit rate}) - z(\text{false alarm})$ for each condition and participant. Hit and false alarm rates of 0 or 1 were adjusted to eliminate infinite z values (Macmillan & Creelman, 1991). Large d' values indicate greater discriminability. Thus, inversion effects are indicated by larger d' values for upright stimuli than for inverted stimuli. Preliminary analyses revealed no main effect or interactions for block order ($p > .05$). Order was not considered further.

To test the hypothesis that only whole body postures would produce an inversion effect, a repeated measures analysis of variance (ANOVA) with factors part-whole (part vs. whole), object (body postures vs. houses), and orientation (upright vs. inverted) was conducted. If body parts do not elicit configural processing, then a three-way interaction should be found such that inversion effects will be found only for whole bodies. The three-way interaction, $F(1, 33) = 7.31$, $MSE = 1.57$, $p = .011$, confirmed that an inversion effect was found only for the whole body posture condition and not the body parts or either of the house stimuli (see Figure 4). All main effects and interactions were significant. Overall, upright objects were easier to discriminate than were upside down objects: main effect for orientation, $F(1, 33) = 4.32$, $MSE = 1.31$, $p = .046$ (upright, $M = 1.85$, $SE = 0.14$; inverted, $M = 1.71$, $SE = 0.12$). Also, parts were more discriminable than wholes: main effect for part-whole, $F(1, 33) = 114.05$, $MSE = 28.10$, $p < .0001$ (parts, $M = 2.10$, $SE = 0.14$; wholes, $M = 1.46$, $SE = 0.12$). Body postures were easier to discriminate than were houses: main effect for object, $F(1, 33) = 154.26$, $MSE = 62.69$, $p < .0001$ (body posture, $M = 2.26$, $SE = 0.14$; house, $M = 1.30$, $SE = 0.12$). The main effects as well as the Part-Whole \times Object, $F(1, 33) = 10.92$, $MSE = 3.72$, $p = .002$; Part-Whole \times Orientation, $F(1, 33) = 6.98$, $MSE = 0.87$, $p = .012$; and Object \times Orientation, $F(1, 33) = 5.41$, $MSE = 1.57$, $p = .025$, interactions were mediated by the three-way interaction.

Given that inversion effects are indicators of configural processing, post hoc analyses examined each condition for an inversion

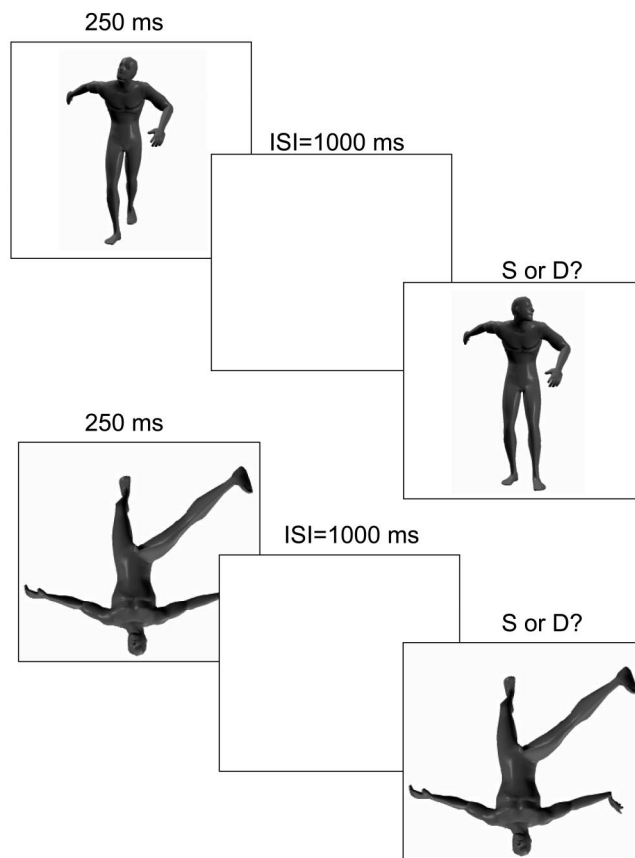


Figure 3. The basic body inversion paradigm. In any trial, a stimulus (e.g., a whole body posture) in either an upright or inverted orientation was presented, followed by a blank screen, and then a target in the same orientation was presented. Participants determined whether the two stimuli were the same (*S*) or different (*D*). The top series illustrates an upright *different* trial. The bottom series illustrates an inverted *same* trial. ISI = interstimulus interval. Reprinted from "Not Just Posturing: Configural Processing of the Human Body," by C. L. Reed, V. E. Stone, and J. E. McGoldrick, in *Human Body Perception From the Inside Out* (Figure 11.4, p. 238), 2005, New York: Oxford University Press. Copyright 2005 by Gunther Knoblich et al. (Eds.). Used by permission of Oxford University Press.

effect. Confirming the interpretation of the three-way interaction, the only significant inversion effect was found for whole body postures, $F(1, 33) = 30.17$, $MSE = 5.71$, $p < .0001$. Body parts, $F(1, 33) < 1$, *ns*; house parts, $F(1, 33) < 1$, *ns*; and whole houses, $F(1, 33) < 1$, *ns*, did not show inversion effects. Although combined body parts and combined house parts do not produce inversion effects, individual body parts may evoke local configural processing and thereby produce inversion effects. Nonetheless, no significant inversion effects were found for arms, $F(1, 33) < 1$, *ns*; legs, $F(1, 33) = 2.04$, *ns*; or the head, $F(1, 33) = 2.30$, *ns*. As expected, no inversion effects were found for doors, windows, or bay windows (all $ps > .19$).

Discussion

The results of Experiment 1 support the hypothesis that isolated body parts, like isolated facial features, do not evoke configural

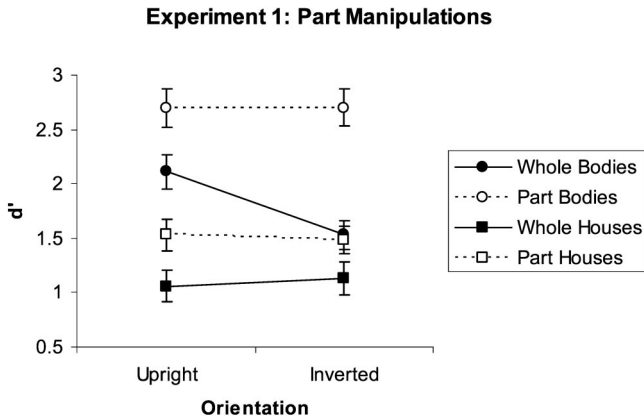


Figure 4. Experiment 1: Part manipulations. d' data are shown for whole and part body postures and houses in upright and inverted orientations. Only whole body postures produced an inversion effect. Error bars represent standard error.

processing. Only whole body postures produced a significant inversion effect. No inversion effects were found for isolated human body parts, nor were they found for isolated house parts or whole houses. Subsequent analyses produced no significant inversion effects for any of the individual body parts. The whole body inversion effect and lack of inversion effect for whole houses replicated the results of Reed et al. (2003). It appears that the body context is necessary to elicit configural processing, but the local configural information available in isolated arm or leg postures was not sufficient. Participants saw only one body part at a time, and that body part provided no explicit information about how it was connected to the rest of the body. The presentation of isolated body parts eliminated information regarding the hierarchy or context of body space, that is, the overall framework within which the parts are organized. Similar findings are found for isolated face parts. Without the context of the face, no inversion effects are found for face features (Rhodes et al., 1993). In the next experiment, we further explore the importance of intact body structure (i.e., body parts in their correct positions relative to the trunk) for the recognition of body postures.

Experiment 2: Disrupting First-Order Spatial Relations

Experiment 2 examined the importance of body context and first-order spatial relations for recognition of body postures. At one point on the continuum of configural processing, recognition relies on the relative position of parts within the general space of the object. All faces share first-order spatial relations among facial features (Carey, 1992). Thus, the relative position of the nose, eyes, and mouth in face space (i.e., the area defined by the outer contour of the head) is important. When a visual object is scrambled, all the parts are present within the object space in positions that parts are typically located, but they have new spatial locations relative to one another. For example, scrambled faces have two eyes, a nose, and mouth, but the eyes can be located where the mouth usually is, the nose where the eyes are, and so on. Such changes also disrupt structural information. In objects for which recognition is based on these first-order spatial relations, scrambling or changing these relations among parts changes the identity

of the object. Empirically, scrambled faces are much more difficult to recognize than normal faces, and for familiar faces, scrambling magnifies the inversion effect (Baenninger, 1994; Collishaw & Hole, 2000; Valentine & Bruce, 1986). If body postures are recognized like faces, then human body posture recognition may also depend on the relative positions of body parts within “body space.” For body postures, body space refers to the space taken up by the head, torso, arms, and legs.

We investigate the importance of first-order information for configural body posture recognition. Changing first-order spatial relations necessarily changes structural information as well. For body postures, first-order spatial relations refer to the relative positions of the parts relative to the torso. For example, the head is connected to the torso, relatively above the arms. To determine whether the disruption of first-order relations interferes with the inversion effect, we compared whole body postures with scrambled body postures. Scrambled body postures maintained the general space of the body, the typical locations of body parts with respect to the torso, and included all body parts. However, they change the relative position of body parts within the context of the upright torso. The torso is the center of symmetry for the body and is the anchor for which body parts are connected. As such, an upright torso is a clear indicator of the central component of orientation. In this case, the trunk provides information regarding upright orientation in the same way that the face contour does in scrambled face studies. Also in keeping with the scrambled face studies, all body parts were relocated to positions typically held by other body parts (e.g., the head is placed in the arm’s location).

If the recognition of body postures relies on intact first-order spatial relations, then inversion effects should be found for intact but not scrambled body postures. In addition, scrambled upright body postures should be slower and more difficult to recognize than intact upright body postures. Intact and scrambled houses are used as control stimuli because the disruption of first-order relational information does not affect their recognition (e.g., Tanaka & Farah, 1993) in upright or inverted orientations.

Method

Participants. Fourteen undergraduates from the University of Denver participated for extra credit in psychology courses.

Stimuli. The intact body posture and house stimuli were the same as the whole stimuli used in Experiment 1. An equal number of upright and inverted scrambled body posture and house stimuli were created from modifications of the whole stimuli with Photoshop. When faces are scrambled in face recognition studies (e.g., Baenninger, 1994), the outline of the face, or face space, is preserved and all the other face parts are rearranged in terms of which face part is put in which face part location. For this study, we constructed the scrambled body postures and house stimuli in a similar way. Parts from intact body and house stimuli were rearranged within the body space and house outline space, respectively. For scrambled body postures, the torso was considered to be the core of body space. The limbs were then scrambled with respect to the upright torso: The arms were put where heads and legs are typically located; legs were placed where heads and arms are typically located; and heads were placed where arms and legs are typically located. Similarly, for houses, the outline of the upright house defined “house space.” The house parts were then scrambled with respect to the upright house outline: The main windows, small windows, and doors were placed in positions where the other features are typically located. The preservation of the upright torso or the upright house outline and general

part locations provided visually available cues as to the upright orientation of the scrambled stimulus.

Scrambled *different* distractor stimuli were constructed by using the corresponding intact *different* stimuli as the starting points and then changing the location of the parts to be consistent with the scrambled member of the pair. Thus, the discrimination requirements were constant for scrambled and intact stimuli because the same position changes and part changes were made for both scrambled and intact stimuli. Examples of these stimuli are illustrated in Figure 5.

Procedure. The same procedure was used as in Experiment 1 with the intact body posture, scrambled body posture, intact house, and scrambled house stimuli.

Results

For each participant, d' was calculated for each condition. Preliminary analyses revealed no main effect or interactions for block order ($p > .05$). It was not considered further.

To test whether inversion effects would be found only for upright intact body postures, we conducted an Object (body posture vs. house) \times Scrambled (scrambled vs. intact) \times Orientation (upright vs. inverted) ANOVA. We predicted that an inversion effect would be found only for intact body postures and not for intact houses, scrambled houses, or scrambled body postures, thereby demonstrating the importance of first-order spatial relations. The significant three-way interaction, $F(1, 13) = 6.83$, $MSE = 6.39$, $p = .021$, indicated that this was the case (see Figure 6). Post hoc analyses testing for inversion effects in each condition confirmed the interpretation of the three-way interaction: Inversion effects were found for intact body postures only, $F(1, 13) = 17.24$, $MSE = 5.35$, $p < .0001$, but not for scrambled body postures, $F(1, 13) = 2.81$, $p < .12$; intact houses, $F(1, 13) < 1$, ns ; and scrambled houses $F(1, 13) < 1$, ns .

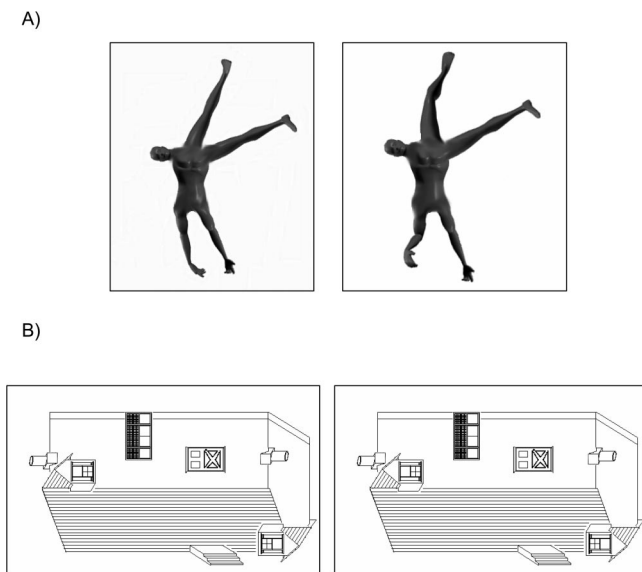


Figure 5. Experiment 2 stimuli: Example of a (A) *different* stimulus-target pair for an upright scrambled body posture and a (B) *same* stimulus-target pair for an inverted scrambled house. Intact body postures and houses were the same as in Experiment 1.

Experiment 2: 1st-order Manipulations

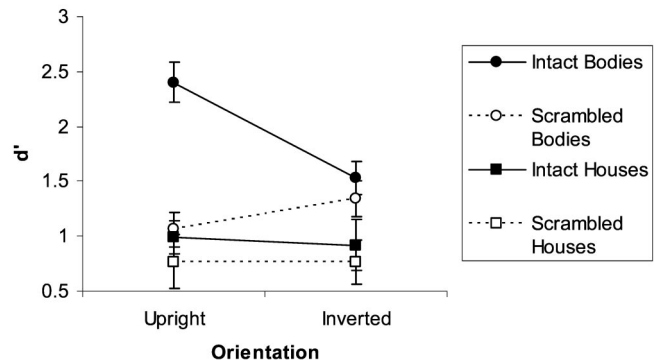


Figure 6. Experiment 2: First-order manipulations. d' data are shown for intact and scrambled body postures and houses in upright and inverted orientations. Only intact body postures produced an inversion effect. Error bars represent standard error.

Further, some main effects were significant. Body postures were easier to recognize than were houses: main effect of object, $F(1, 13) = 22.05$, $MSE = 14.67$, $p = .0001$ (body posture, $M = 1.58$, $SE = 0.12$; house, $M = 0.86$, $SE = 0.15$). Scrambled objects were more difficult to recognize than were intact objects: main effect of scrambled, $F(1, 13) = 17.22$, $MSE = 6.39$, $p = .001$ (scrambled objects, $M = 0.98$, $SE = 0.12$; intact objects, $M = 1.46$, $SE = 0.13$). Upright objects were marginally easier to recognize than inverted objects: marginal main effect of orientation, $F(1, 13) = 3.57$, $MSE = 0.76$, $p = .081$ (upright objects, $M = 1.30$, $SE = 0.13$; inverted objects, $M = 1.14$, $SE = 0.11$). A significant Scrambled \times Orientation interaction was found, $F(1, 13) = 8.08$, $MSE = 2.66$, $p = .014$, as well as an Object \times Orientation interaction, $F(1, 13) = 5.80$, $MSE = 0.51$, $p = .032$. All effects and interactions were mediated by the three-way interaction.

In addition, to test the hypothesis that for upright stimuli, intact body postures would be better recognized than scrambled ones, we conducted a one-way ANOVA comparing recognition performance for upright scrambled and intact body postures. A significant effect was found, $F(1, 13) = 60.92$, $MSE = 12.54$, $p < .0001$, indicating that when first-order relations were disrupted by scrambling the locations of the parts, upright scrambled body postures ($M = 1.06$, $SE = 0.16$) are more difficult to recognize than are upright intact body postures ($M = 2.40$, $SE = 0.18$). In contrast, houses do not show differential recognition for scrambled over intact houses, $F(1, 13) < 1$, ns . Thus, first-order spatial relations are important for body posture recognition but not for house recognition.

Discussion

In Experiment 2, inversion effects were found for only one condition—intact body postures. Disrupting first-order spatial relations by scrambling part positions affected the recognition of body postures, but not houses. In addition, the scrambling of body parts impaired recognition of upright body postures, even though all stimulus components were identical for both conditions. These findings suggest that the configural processing of body postures

requires more than the presence of all body parts within body space. Intact first-order spatial relationships between parts appear to be critical for the recognition of body postures. This corresponds to what is found for faces as well.

In addition, structural information may be important. Because scrambling disrupts both first-order and structural information, the tests conducted in Experiment 2 conflate first-order information with the hierarchy of the body and the degrees of freedom in which the body moves. Typically, the head is above the shoulders, which are above the hips, but it is body topology in the sense of what parts are connected to what other parts that is important for the body. Spatially, we can put our legs over our heads when lying down and thereby put our hips over our heads, but we cannot change the fact that our heads are connected to the spine that is connected to the hips and the legs, and so forth. The question then becomes whether the complete body hierarchy is necessary for configural body posture recognition or whether partial but spatially correct body hierarchies can be used for configural processing. This idea is explored in Experiment 3.

Experiment 3: Disrupting Structural and Holistic Template Information

The face recognition literature presents a pluralistic picture of holistic mechanisms (Carey & Diamond, 1994; Gauthier, Williams, Tarr, & Tanaka, 1998). Some face recognition theories suggest that recognition via holistic processing relies not only on the relative positions and precise metric distances among object features but also on the presence of all features and complete spatial-relation information (e.g., Farah, 1991; see Gauthier & Tarr, 2002, for a review). In the face recognition literature, a number of studies have investigated the extent to which complete spatial-relation information is used. Despite some research that suggests that face recognition does not require holistic processing (e.g., Leder & Bruce, 2000; Rakover & Teucher, 1997), other research supports this view (Farah, 1991; Farah et al., 1998; Tanaka & Farah, 1993). These different findings have led researchers to refine the definition of holistic processing (e.g., Gauthier & Tarr, 2002).

In Experiment 3, we tested the far end of the configural processing continuum in which holistic processing is defined as the recognition of objects on the basis of undifferentiated templates (i.e., parts are not explicitly represented). In this sense, holistic undifferentiated template processing is analogous to recognizing objects by comparing them to a single mental representation in which all the parts and details are matched. We compared inversion effects for whole and half body postures to determine whether complete holistic template information is necessary for configural processing. Half stimuli do not provide all of the parts, or a complete template, required for holistic undifferentiated template processing. Thus, if the recognition of faces and body postures is based on the undifferentiated whole or requires template-like information for configural processing, then only whole stimuli will evoke inversion effects. The control stimuli were faces because faces are the paradigm example of stimuli that appear to be processed holistically in the strictest sense.

Although it is important to define the ends of the configural processing continuum, this extreme type of configural processing is unlikely for body postures because we are able to recognize

postures even if we do not see the whole body posture. Perrett and colleagues (Perrett, Oram, & Ashbridge, 1998) have demonstrated that in the superior temporal sulcus, populations of neurons fire more strongly for human bodies viewed from a particular angle, but that graded responses are observed for other views. This also holds for faces. As a result, it is important to investigate two less extreme hypotheses about holistic processing. By examining two types of half stimuli that contain different information, we can distinguish between two alternative hypotheses regarding holistic processing by comparing two different types of half stimuli: horizontal axis divisions and vertical axis divisions. Both types of half stimuli preserve appropriate first-order spatial relations and precise spatial relations among the visible parts. They differ, however, in terms of which parts are visible and how salient different parts may be. In other words, we determine whether the configural processing of human body postures lies somewhere between recognition based on first-order relational properties and recognition based on holistic undifferentiated templates.

The part-saliency hypothesis focuses on the presence of inversion effects for stimuli divided along the horizontal axis. Certain parts of a figure are more diagnostic of a figure (Chambers, McBeath, & Schiano, 1999). If configural recognition relies on first-order spatial information and spatial relationships among specific salient features, then inversion effects should be found for the half of the stimulus that contains the salient features. In this case, having information about the whole mouth, both eyes, both leg postures, or both arm postures may provide precise spatial relations among like parts, creating a potentially distinctive and meaningful configuration (i.e., “those are John’s eyes” or “that body posture means ‘stop’”). Some research has shown that for faces, inversion effects can be found with eye stimuli because the more salient differences among faces occur in the spatial relations involving the eyes (e.g., Rakover & Teucher, 1997). Likewise, for body postures, arm positions may be more salient than leg positions, as arms are often used for gesturing whereas legs are needed for postural support. Legs have fewer options for position variations. Thus, for both faces and bodies the upper portions may provide more distinguishing features than the lower portions. If part saliency contributes to holistic processing, then inversion effects may occur for upper face and body halves but not for lower face and body halves. In contrast, inversion effects would not occur for vertically divided halves because the spatial relationships among the salient feature types are not visible.

An alternative hypothesis is the partial-template matching hypothesis. Faces and bodies have bilateral structural symmetry along the vertical axis. Long-term normalized face or body representations contain first-order relation and structural description information (e.g., Buxbaum & Coslett, 2001; Schwoebel, Buxbaum, & Coslett, 2004; Sirigu, Grafman, Bressler, & Sunderland, 1991), which may facilitate the configural processing of incomplete stimuli. In other words, long-term representations may be used to fill in the template or at least partially activate the template for partial body or face information as long as sufficient characteristic structural information is provided. In contrast, no inversion effects would be predicted for body posture stimuli divided along the horizontal axis separating upper and lower halves because dividing the body along the horizontal axis does not preserve full structural information.

Method

Participants. Twenty-four University of Denver undergraduates participated for extra credit in psychology courses.

Stimuli. The same whole body stimuli were used as in Experiments 1 and 2. The half body stimuli were created in several steps. First, the whole body stimuli were coded as to whether the distractors had changes in the upper, lower, left, or right portions of the body. Upper and lower body halves were defined by the body's horizontal axis, that is, body parts located above and below the waistline. Left and right body halves were defined by the body's vertical axis, that is, body parts located to the left and right of the center of the body. Second, on the basis of where the position changes occurred in the whole stimuli, five postures with changes in the upper half were selected to be upper half stimuli, five postures with changes in the lower half were selected to be lower half stimuli, five postures with changes in the left half were selected to be left half stimuli, and five postures with changes in the right half were selected to be right half stimuli. Third, Photoshop was used to eliminate the nonrelevant portions of the half postures from the whole postures for the targets and the distractors. Last, inverted versions were made for each of the half posture pairs.

The face stimuli were 20 male black-and-white photographic images created using FACES 3.0 (Thomas Investigative Publications, Austin, TX) software. They were approximately 8 cm × 12 cm. All faces shared the same facial outline (hair and hairline, ears, chin, and shoulders); only the internal features (eyes, nose, and mouth) differed between faces. Face distractors differed by all three internal features. Inverted faces were created for each of the stimulus pairs.

The half face stimuli were created by using the same basic steps as the half body postures. The upper and lower halves of the face were based on the face's horizontal axis, that is, face parts located above and below the tip of the nose. The left and right halves of the face were based on the face's vertical axis, that is, face parts located to the left and right of the center of the face. Five upper half, five lower half, five left half, and five right half faces were created with Photoshop from the original whole face stimulus pairs. Inverted half faces were created for each of the half face pairs. The stimuli are illustrated in Figure 7.

Procedure. The same procedure was used as in Experiment 1 with the whole face, whole body, half face, and half body stimuli.

Results

For each participant, d' was calculated for each condition. Preliminary analyses revealed no main effect or interactions for block order ($p > .05$). Order was not considered further.

Evidence of holistic template matching. If holistic templates were required for recognition of body postures and faces, one would predict that inversion effects would be found only for whole stimuli. We looked for this effect by conducting a repeated measures ANOVA with three factors: orientation (upright vs. inverted), half-whole (half vs. whole), and object (body postures vs. faces). Our lack of a three-way interaction, $F(1, 23) < 1$, ns , suggested that orientation and wholeness manipulations affected body postures and faces similarly (see Figure 8). Nonetheless, the inversion effect was greater for whole stimuli than for half stimuli overall: Half-Whole × Orientation interaction, $F(1, 23) = 6.80$, $MSE = 1.45$, $p = .016$. All upright objects ($M = 2.21$, $SE = 0.12$) were easier to recognize than inverted objects ($M = 1.71$, $SE = 0.10$): orientation, $F(1, 23) = 37.78$, $MSE = 4.73$, $p < .0001$. Further, collapsing across half and whole stimuli, body postures ($M = 2.12$, $SE = 0.12$) were more discriminable than faces ($M = 1.80$, $SE = 0.12$): object, $F(1, 23) = 6.75$, $MSE = 0.23$, $p = .016$. Finally, the Object × Orientation interaction was not significant, $F(1, 23) < 1$, ns .

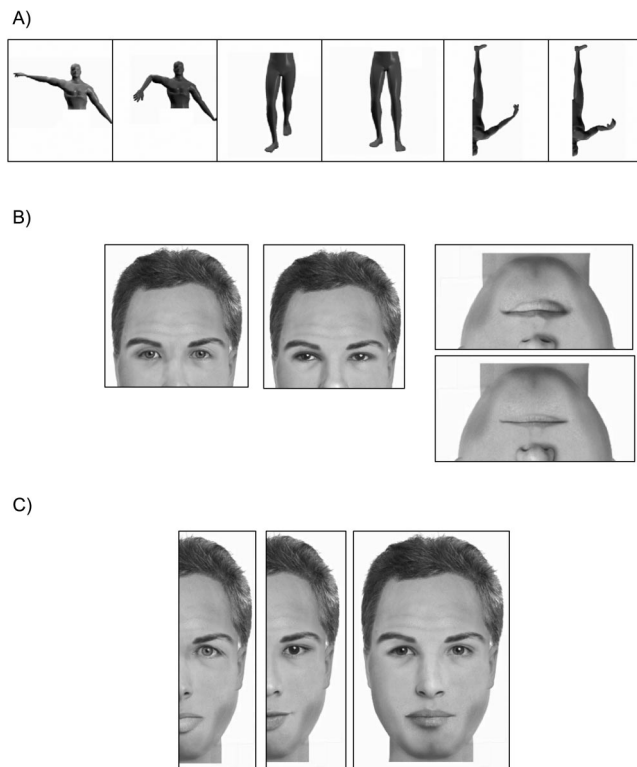


Figure 7. Experiment 3 stimuli. A: Examples of half body postures divided along horizontal (lower–upper) and vertical (right–left) axes. The right–left pair is an example of an inverted left-side *different* pair. B and C: Examples of whole and half faces. The half faces are divided along horizontal (lower–upper) and vertical (right–left) axes. The lower face pair is an example of an inverted *different* pair.

In support of the idea that half stimuli also produce inversion effects, inversion effects were demonstrated for all conditions with post hoc analyses (see Figure 7). Significant inversion effects (i.e., orientation effects) were found for half body postures, $F(1, 23) = 4.49$, $MSE = 1.03$, $p = .045$, and whole body postures, $F(1, 23) = 27.99$, $MSE = 5.29$, $p < .0001$. Similarly, significant inversion effects were found for half faces, $F(1, 23) = 5.75$, $MSE = 1.47$, $p = .025$, and for whole faces, $F(1, 23) = 25.64$, $MSE = 5.45$, $p < .0001$. Overall, these results suggest that holistic templates are not necessary for either face or body recognition. The significant inversion effects for the half body postures and the half faces suggest that configural recognition processes for both body postures and faces may not require complete feature information (i.e., template information).

Investigating the importance of structural information. We next considered whether there are differences of processing for the two types of preserved information contained in the two types of half stimuli—right–left halves and upper–lower halves—and the above analysis cannot distinguish between them. The right–left division along the vertical axis preserves structural information plus spatial relations information among each part type. The upper–lower division emphasizes part saliency. To test whether the two types of halves differed in terms of inversion effects, we conducted a repeated measures ANOVA with factors object (face

Experiment 3: Template Manipulations

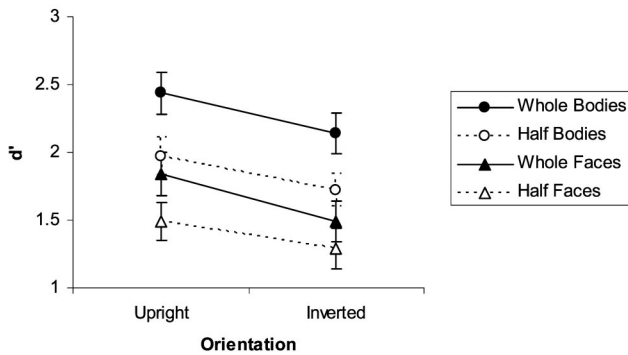


Figure 8. Experiment 3: Template manipulations. d' data are shown for whole and half body postures and faces in upright and inverted orientations. All conditions produced inversion effects. Error bars represent standard error.

vs. body posture), half type (right–left vs. upper–lower), and orientation (inverted vs. upright). Inversion effects occurred only in the right–left condition for both faces and body postures (see Figure 9): Half Type \times Orientation interaction, $F(1, 23) = 9.98$, $MSE = 1.60$, $p = .004$. As expected from the previous analyses, significant effects were found for object, $F(1, 23) = 24.83$, $MSE = 10.78$, $p = .0001$, and orientation, $F(1, 23) = 15.94$, $MSE = 2.92$, $p = .001$, but not half type, $F(1, 23) < 1$, ns .

Investigating the importance of part salience. Finally, we conducted an analysis to determine whether the presence of certain stimulus features were important to configural processing of faces and body postures. For this analysis, the important conditions to analyze were those involving upper and lower portions of the face and body stimuli. Region (upper vs. lower) \times Orientation (upright vs. inverted) ANOVAs were conducted separately for faces and body postures. For body postures, a significant effect was found for region, $F(1, 23) = 10.12$, $MSE = 2.01$, $p < .004$, indicating that upper body postures ($M = 2.01$, $SE = 0.11$) were easier to recognize than were lower body postures ($M = 1.72$, $SE = 0.09$). Neither the orientation effect, $F(1, 23) = 1.69$, ns , nor the Region \times Orientation interaction was significant, $F(1, 23) < 1$, ns . For faces, no main effects, $F(1, 23) < 1$, ns , or the Region \times Orientation interaction, $F(1, 23) = 2.75$, ns , were significant.

Discussion

In Experiment 3, we investigated first whether the inversion effects found for faces and body postures depended on holistic undifferentiated template processing. Our results showed overall inversion effects for both half and whole stimuli. Thus, these results did not support the most stringent template processing theory because the inversion effect did not depend on complete information for either faces or body postures. We then investigated two less stringent holistic processing hypotheses: the part salience hypothesis and the partial-template hypothesis. A further analysis of the half face and body stimuli was particularly informative in distinguishing between them. To examine the part-salience hypothesis, we divided stimuli into upper and lower halves that contained salient parts such as eyes or arms but only partial

structural information. However, no inversion effects were found for these horizontally divided stimulus halves, for either faces or body postures. In addition, the upper portions of the stimuli that potentially contained more diagnostic information (i.e., eyes and arms, respectively) did not differ from the lower portions in terms of the inversion effect; neither showed the effect. Contrary to some previous research for faces (e.g., Rakover & Teucher, 1997), the part-salience hypothesis was not supported. To examine the partial-template hypothesis, we divided stimuli into left and right halves that preserved both first-order spatial relations and structural information. Inversion effects were found for vertically divided halves of both faces and body postures. It appears that the preserved first-order relations and structural information may facilitate a partial-template match because they provide enough information to activate long-term representations that can fill in what is not provided in the actual stimulus. In summary, these additional analyses of half stimuli permit us to define another point on the configural processing continuum between first-order spatial relations and extreme holistic template matching. Recognition based on structural information is an important aspect of configural processing.

General Discussion

Recently Reed et al. (2003) presented evidence that body postures were processed configurally. Comparable inversion effects were found for body postures and faces but not for houses. However, the inversion effect per se does not address what information in the stimulus evokes configural processing. On the basis of the configural processing continuum developed by Leder and Bruce (2000), we conducted three experiments to explore different ways to operationalize configuration: local subcomponent relationships with an isolated part, first-order spatial relations, and holistic information. The purpose was to sample from the two ends of the configural processing continuum and points in between. Then, we examined what stimulus information was critical to the inversion effect when first-order spatial relations were preserved but the distribution of parts varied.

Experiment 3: Horizontal vs. Vertical Axis Halves

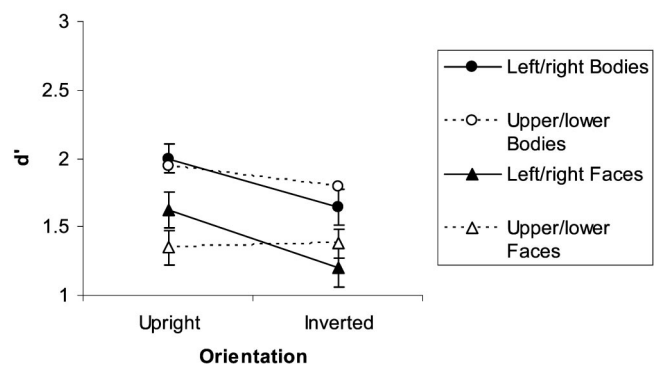


Figure 9. Experiment 3: Horizontal and vertical axis halves. d' data are shown for left–right and upper–lower halves of body postures and faces in upright and inverted orientations. Only vertical axis divisions produced inversion effects for both faces and body postures. Error bars represent standard error.

In Experiment 1, we sampled from the “recognition by parts” end of the continuum to determine whether local configural information available in the subcomponents of isolated parts could evoke configural processing. Using the inversion effect as an indicator of configural processing, we compared recognition of whole body postures and isolated body part postures. The control comparison stimuli were whole houses and isolated house parts because houses are a known class of stimuli that are recognized via their parts (Farah et al., 1998; Tanaka & Farah, 1993). Isolated parts contain no explicit information regarding the overall object structure or relative spatial relations among object parts. Our results showed that only whole body postures produced inversion effects. Local configural information found in isolated arm, leg, and head positions was not sufficient. No inversion effects were found for any house stimuli.

In Experiment 2, we sampled from the “first-order spatial relations” part of the continuum. We determined whether the presence of all the objects’ parts was sufficient to elicit an inversion effect or whether those parts had to be in specific positions with respect to each other. We compared intact and scrambled body parts with intact and scrambled houses. Scrambled stimuli contained all the same parts as the complete objects, and they were located in typical part locations; however, in scrambled stimuli, all the parts were relocated relative to the upright object space. For bodies, parts were scrambled relative to an upright torso (e.g., an arm was located off the neck). For houses, parts were scrambled relative to the outline of the house (e.g., a door was located on the roof). Thus, the scrambled body posture stimuli disrupted the first-order spatial relations, or the structural hierarchy, of the human body. Our results showed inversion effects only for intact body postures and not for scrambled body postures. No inversion effects were found for any house stimuli. For the configural processing of body postures, one part cannot just be attached to any other part. The specific spatial relations between parts are critical in the sense that the location of one body part constrains the location of another. Thus, first-order spatial relations and structural information appear to be necessary for the type of configural processing used for body postures.

In Experiment 3, we sampled from the extreme “holistic processing” end of the continuum in which objects are recognized via undifferentiated holistic templates. We compared whole and half bodies with whole and half faces. Faces were selected as control stimuli because some evidence has suggested that faces are recognized holistically (Farah, 1991; Farah et al., 1998; Tanaka & Farah, 1993). The half stimuli preserved the presence of some of the parts, some of their shapes, and some of the first-order relations but did not include the complete information required for undifferentiated template recognition. Our results showed inversion effects for both whole and half body postures and faces. This suggested that holistic configural processing of complete template information is not necessary for recognition of either body postures or faces. The inversion effect did not seem to depend on the most strict interpretation of holistic processing.

Instead, our results support a more restricted partial-template matching process based on what information is contained in the partial stimulus. We compared inversion effects for two types of half stimuli: (a) left- and right-half stimuli based on a vertical-axis division that preserved first-order spatial relations and structural information—that is, precise spatial relations

among each part type (i.e., head, arm, and leg or eye, nose, and mouth)—and (b) upper- and lower-half stimuli based on a horizontal-axis division that preserved first-order spatial relations but preserved structural information only for like object parts (e.g., spatial relations between two arms or two eyes) to emphasize specific salient relationship among some parts. Partial-template matching for holistic processing did not occur for just any partial stimulus. For horizontally divided face and body posture stimuli, any partial-template matching was either not evoked or was not strong enough to lead to significant inversion effect. Thus, preserved first-order spatial relations and salient features were not enough. Particular parts or regions of the face and body did not appear to contribute to the type of configural processing used for body posture or face recognition, because no inversion effects were found for either upper or lower portions of the face or body. Surprisingly, inversion effects were restricted to stimuli divided along the vertical axis into left and right halves. Because bodies and faces are symmetric along the vertical axis, this symmetry may permit a long-term template representation of a face or body to supplement configural processing. For both faces and bodies, providing one half of the stimulus may allow a reconstruction of the other half from long-term, visual knowledge of faces and bodies in general. In fact, long-term spatial representations of bodies and faces are said to include structural information as well as first-order relations (e.g., Buxbaum & Coslett, 2001; Schwoebel et al., 2004; Sirigu et al., 1991), both of which seem to define the type of configural processing used for recognition of body postures and faces alike.

Although we are hesitant to postulate behavioral mechanisms from neuronal response, our findings are consistent with those of Perrett et al. (1998) on recognizing images from different views. It is possible that the long-term body representation is in a canonical orientation and contributes strongly to the neural response of the upright partial half stimulus. Thus, the rate of accumulation of activity from neurons selective for the upright half body postures would be faster than those for the inverted counterparts. This explanation is consistent with our data showing better performance for whole upright body postures than for inverted body postures. It is also consistent with our data for half body posture stimuli that preserve first-order spatial relations and structural information. Thus, this type of process may facilitate our exceptional ability to recognize body postures when people are not facing us directly.

For body posture recognition, the importance of structural information—that is, the spatial relations among body parts—corresponds nicely with what we know about long-term, body-specific, spatial representations of the body that are multimodal and used for the self and others. This representation has been referred to in a number of ways—the body schema, the body image, and so on (e.g., Buxbaum & Coslett, 2001; Ogden, 1995; Reed & Farah, 1995; Schwoebel et al., 2004; Sirigu et al., 1991; see Reed, 2002, and Slaughter & Heron, 2004, for reviews). Regardless of the specific term used, this long-term representation contains information regarding the spatial organization of body parts in the context of the whole body. Specifically, it has been defined as a hierarchical topological representation that preserves the local relationship among parts and provides a spatial map specifying first-order relations among body parts. The present

findings make an interesting connection with the neurological syndrome of autotopagnosia in which brain-injured patients lose the ability to localize body parts on their body or even on someone else's body when required to do so in the context of the body structure. In other words, they cannot make use of structural information to locate body parts. However, they have no difficulty locating parts of other complex objects (Ogden, 1995). Autotopagnosia not only documents existence of a spatial body representation that can be selectively disrupted but also gives us hints as to how that information is organized. The fact that errors occur only when the whole body is present and that these errors tend to be within the general region of the correct body part location suggest that the representation contains information regarding the specific spatial relations among body parts (Ogden, 1995).

We view this study as a starting point for more intensive study of holistic processing using other paradigms. For example, Gauthier and Tarr (2002), Maurer et al. (2002), and others have specified various types of holistic processing. The inversion paradigm can investigate the extreme holistic processing end of the continuum and provide some evidence for a less stringent form of holistic processing that is similar to that used to recognize faces, but it can only tell us so much. To fully test the hypothesis that body postures are processed holistically, different paradigms are needed. Tanaka and Farah (1993) proposed that if the representation of faces were embedded in a complex template-type face pattern, then the recognition of an isolated face part should be facilitated when in the context of the rest of the face versus when that same part is recognized in isolation. Using this definition of holistic processing, Seitz (2002) asked participants to view a whole body or face for a 5-s inspection period and, following a 500-ms interstimulus interval, to determine which of two alternatives in a recognition-test display matched the original. The recognition test presented either face or body parts in isolation or within the context of the whole face or body. She found that participants were better at recognizing both face and body parts within the context of the whole face or body. Seitz concluded that bodies as well as faces were recognized holistically.

A more direct test of the undifferentiated template hypothesis was conducted by McGoldrick (2003; McGoldrick & Reed, 2005). This study modified two of Tanaka and Farah's (1993) paradigms designed to directly test for holistic processing for bodies relative to faces. For the first part of the study, participants learned the names of isolated face and body part postures (e.g., "Joe's face" or "Joe's arms"). After an initial self-paced learning session to associate a person's name with a particular face or body part, participants then were given a two-choice alternative recognition test to answer the on-screen question regarding which one was a previously learned part (e.g., "Which arm is Joe's?"). The recognition tests included upright and inverted isolated parts and upright and inverted whole faces and bodies. If body postures were processed holistically, then like faces, upright body parts should be better recognized in the context of the whole body. Further, the inversion condition created a stronger version of holistic processing: The whole-versus-part recognition advantage should disappear when the faces and body postures were inverted. McGoldrick replicated Tanaka and Farah's (1993) face results as well as Seitz's (2002) results in that body posture parts and face parts were better recognized upright in whole bodies and faces. Nonetheless, the inversion effect was different for faces and bodies: The whole-

versus-part recognition advantage remained for inverted bodies but disappeared for inverted faces. These results suggest that body postures are processed holistically, but not necessarily in an undifferentiated template processing manner.

In the second part of the study, McGoldrick (2003) pursued potential holistic configural processing differences between faces and body postures by creating a body posture version of a masking study conducted by Farah et al. (1998). Participants performed a sequential same-different matching task. A stimulus (i.e., an upright face, an inverted face, an upright body, or an inverted body) was presented briefly, followed by a pattern mask and a target stimulus of the same type and orientation. The critical manipulation was whether the type of mask disrupted object recognition. The intervening mask was either a *whole mask* (a novel but complete stimulus object such as a whole face, house, or word) or a *part mask* consisting of parts of the stimulus (a scrambled face or body in which the parts were rearranged but positioned where other parts would normally exist). If upright faces and body postures were recognized as undifferentiated wholes, so that part representation played a relatively small role in their recognition, then whole masks should be more disruptive on performance than part masks. In addition, both types of masks should have equivalent effects on inverted stimuli because inversion disrupts configural spatial relations and the pattern is no longer recognized as a face or body posture. Replicating Farah et al. (1998), McGoldrick found that for faces, whole masks but not part masks disrupted only upright face recognition and a face inversion effect. Although an inversion effect was found for body postures, there was no difference between part and whole masking. Thus, manipulations that disrupted holistic face recognition did not have the same disruptive effect on body posture recognition. Again, body postures were not recognized in a holistic, undifferentiated manner, despite evidence of configural processing.

In summary, the present experiments investigated which stimulus properties in body postures affect configural processing, as indexed by presence, absence, or changes in the inversion effect observed for whole bodies. Configural recognition processes used for body postures and faces take as crucial input information about both first-order spatial relations and structural information. We have confirmed that local configural information from a body part does not produce the same effects on recognition as structural information about the whole body. Furthermore, the type of configural processing used for recognition of bodies and faces does not seem to require complete holistic template information.

In terms of the configural processing continuum, we now can determine approximately where body postures fit in. We can define another point on the configural processing continuum between first-order spatial relations and holistic processing. The recognition of body postures can be positioned close to faces between first-order spatial relations and holistic processing. For an object to be processed configurally at this point on the continuum, the visual system must maintain structural information: information about the organization of parts in terms of the overall object as well as the spatial relationship of each type of part relative to each other. For body postures, such information would allow the visual system to make use of the underlying spatial body repre-

sentations by providing information regarding the ways that parts are connected to each other, not just their spatial placement.

To this level, recognition of faces and body postures both appear to use similar configural processing by the visual system. Using the inversion paradigm and stimulus manipulations to change the inversion effect, we can see that similar changes to stimulus information in faces and bodies evoke similar changes to the inversion effect. The intermediate points on the configural processing continuum between first-order relations and holistic processing have not been well explored for nonface stimuli, and it is not clear how to define all of these points on the continuum for body postures. For face recognition, second-order spatial relations among object parts have been defined as a type of configural processing between first-order relations and extreme holistic processing (e.g., Carey, 1992; Leder & Bruce, 1998, 2000). Second-order spatial relations describe how the exact metric distances among parts for a particular exemplar of a category differ from the prototypical distances for that category. In the face recognition literature, these second-order spatial relations are determined from a spatially averaged prototype of the face. However, second-order relationships are difficult to define for body postures because compared with faces, the human body has more degrees of freedom for part positions within object space. It is not clear what an “average body position” would be. Thus, differences in the configural processing of faces and bodies may emerge at this point on the continuum, with configural recognition processes for faces depending on second-order properties and for bodies depending more on structural information.

To put our study of body posture recognition into the bigger theoretical picture of object recognition, we next consider possible differences in the different types of objects that are recognized and their connection to the spatial-action system. The long-term spatial body representation, in addition to representing body parts within the context of the body, is also multimodal in that it receives visual and proprioceptive inputs. Further it represents not only our own body but also the bodies of other people (Reed & Farah, 1995). The fact that we have a body and can use it to represent other people’s bodies makes body representations different from other, inanimate object representations. Parsons (1987a, 1987b) and others have documented that we often use our own bodies to determine the orientation of other people’s bodies. Reed and Farah (1995) demonstrated that personal movement can influence the memory for other people’s body postures. Rosenbaum and Chaiken (2001) have shown that for tasks involving the body, an intrinsic body centered coding system is used; in contrast, for tasks not involving the body, extrinsic egocentric coding is used. Thus, this ability to act with bodies as well as perceive bodies has implications for the spatial frames of reference used to represent bodies. Body postures can be represented by egocentric spatial reference frames, so that the body and/or its parts are coded relative to the viewer. They can also be represented by allocentric frames, such that the body and/or its parts are coded relative to one another, without respect to where a viewer may be. What may separate the recognition of body postures different from other stimuli is that they are encoded both by body-centered, egocentric spatial processing, as well as body-independent, allocentric spatial perception. In other words, body posture representations involve the coding of extrinsic (spatial coordinates) as well as intrinsic (postural or body movement) information.

These differences between body postures and other objects not only have implications for divisions of processing within the visual–cognitive processing stream for part-based versus configural processing mechanisms but also have implications about interactions between them. The difference in the configural processing of human body postures could potentially arise from the multimodal aspect of the body representation in which spatial and motor systems interact with object recognition systems. Recent neuroimaging studies have demonstrated that static pictures of the body activate not only the object recognition systems but also parts of the motor planning systems and movement perception systems (MT/V5; e.g., Kourtzi & Kanwisher, 2000). The spatial organization of the human body may be part of conceptual organization of perceptive action knowledge. Thus, the need for action in face and body may lead to configural processing as well as integration of visual–cognitive and visuomotor processing systems.

In conclusion, our study demonstrates that changes to similar types of information in faces and body postures affect configural processing. We have systematically established what types of configural processing may be used for recognition of static body postures and defined more precisely the types of stimulus information necessary to evoke such recognition processing. Our results indicate that this essential information corresponds closely to information associated with the long-term spatial body representation. Parts alone are not sufficient to evoke configural processing, but on the other hand, complete holistic template information is not required either. By identifying the stimulus properties of body postures that affect configural recognition processes, we can clarify how different objects make use of different kinds of configural processing and more precisely delineate how different object recognition streams might fit on the configural processing continuum.

This study shows that to some point faces and bodies share a recognition processing stream. However, inherent differences in the stimuli suggest that the recognition streams may diverge further in processing (Slaughter, Stone, & Reed, 2004). Thus, the more precise delineation of different types of configural processing allows us to move beyond a simple conception of “faces are processed configurally and other objects are not” to ask questions about the nature of representations and recognition processes in the visual system for a variety of object categories. Are faces special? Maybe. If so, are bodies special too? Probably. More important, recognition of any class of object that depends on certain types of information may make use of various types of configural processing in the visual system.

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