THE BODY INVERSION EFFECT: THE ROLE OF VISUAL APPEARANCE ON BODY PROCESSING

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The Body Inversion Effect: The Role of Visual Appearance on Body Processing

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MASTER OF SCIENCE

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ABSTRACT

The purpose of this study was to determine if body stimuli are uniquely processed by the visual recognition system. First, my results supported past findings showing that body processing differs from object processing (e.g., cars, chairs, houses). However, body processing depended on the presence/absence of a head. Second, the nature of appearance impacted observers' performance such that discrimination was better for real than artificial bodies. Finally, I examined the impact of body appearance on event-related potential (ERP) responses, specifically the P100 and N170, and found that amplitudes elicited by real headless bodies was significantly larger than amplitudes elicited by all other variations in body appearance. In general, these results suggest the existence of a body recognition system that processes body images varying in visual appearance. However, this system may be more tuned to bodies that most resemble natural appearance and less tuned to bodies that deviate away from it.

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DEDICATION

I dedicate this project to my loving parents, Cindy Tran and Lexter Huynh, along with my siblings, Darin, Denise, and Alan. Additionally, I want to dedicate this project to my partner, Peter Phan. Thank you for always being there for me!

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INTRODUCTION

As social beings, the recognition of other humans is important for the extraction of social cues. Past research has focused extensively on the recognition of faces; however, faces are not the only objects from which social cues can be extracted. Human bodies can also provide observers with similar information, including: emotional state (Sprengelmeyer, Young, Schroeder, Grossenbacher, Federlein, Buttner, & Przuntek, 1999; De Gelder, 2006), gender (Cao, Dikmen, Fu, & Huang, 2008), and identity (Slaughter, Stone, & Reed, 2004). Moreover, research shows that the human visual system has a unique way of processing face information (Farah, 1996; Farah, Wilson, Drain, & Tanaka, 1998). By the same token, it is quite possible that body information is also processed in a distinct way. Recently, researchers have begun to examine how the visual system processes body information and whether or not this process is similar to that of faces.

Past research has used multiple techniques for understanding how observers recognize faces, and one of the most common methods is to look for the face inversion effect (FIE). The FIE refers to a general decrease in recognition performance for face images that are presented upside down compared to upright (Yin, 1969). There is evidence to suggested the presence of the FIE is an indication that observers are encoding the entire face as a whole (i.e. holistic processing) whereas the absence of the FIE is an indication of observers using a strategy that does not involve the encoding of holistic information. Thus, because past research have consistently found that faces are associated with the FIE, indicates that faces in general are unique objects because they are processed holistically (Tanaka & Farah, 1993; Bruce & Young, 1986; Diamond & Carey, 1986; Leder & Bruce, 2000).

The use of the inversion effect not only helps to distinguish face processing from non-face processing, but it can also help differentiate between images that most resemble a face from those that are less representative. This differentiation has been done using the occurrence or robustness of the FIE as a measure of "face-ness." For instance, Taubert (2009) showed that human and chimpanzee faces are similar because they both generated the FIE. However, Taubert (2009) found that gorilla, lizard, and monkey faces do not produce FIEs. These results suggest that the face mechanism does not process all faces in the same way. Rather, these results support the existence of a face "tuning curve" such that faces falling within this curve undergo a similar process (e.g., human and chimp faces) while faces falling outside of this curve (e.g., gorilla and monkey faces) undergo a different type of visual process.

Also, Balas and Nelson (2010) showed that even with conspecific faces, visual appearance, such as race-specific shape and pigmentation, could affect the encoding of faces. The authors found an enhanced inversion effect for faces belonging to the same race category as observers. This finding suggests that even within the category of human faces, visual processing can still vary depending on the degree of resemblance between face images and that of the observer's. Taken together, Taubert (2009) and Balas and Nelson (2010) showed that picture-plane inversion is an effective tool for studying face recognition. More importantly however, by using this tool these authors were able to show that observers' recognition is not the same for all faces. Rather, recognition depended on the degree to which faces are more or less representative of natural appearance, defined by observers' own experience.

The effectiveness of the inversion effect for understanding face recognition has recently been used in studies trying to understand the recognition of human bodies. Reed, Stone, Bozova, and Tanaka (2003) were the first to show that the inversion effect exists for bodies, an indication that body processing may also be holistic in nature. First, Reed et al. (2003) presented subjects with upright or upside down image pairs of computer-generated whole bodies or houses sequentially (a same/different paradigm) and had observers decide whether the items presented in each pair were the same or different. The authors found that the recognition for inverted bodies was associated with poorer performance compared to upright bodies, an outcome they called the body-inversion effect (BIE). In contrast, performance between the two orientations did not differ for houses. Secondly, the authors included computer-generated face images to compare the BIE with the FIE and found no significant difference between the two; that is, there was a similar reduction in observers' recognition performance for inverted compared to upright faces and bodies, suggesting the use of the inversion effect for investigating faces can also be used for the investigation of human bodies.

Lastly, Reed et al. (2003) compared biomechanically possible and impossible body positions and found that only possible positions produced the BIE. This result suggests there may also exist a "tuning-curve" for bodies and, like faces, the occurrence or robustness of the BIE could also be used as a measure of "body-ness." In this case, it is likely that the appearance of impossible body postures deviated significantly from how bodies are typically seen in the natural environment. As a result, impossible body postures are likely to be outside of the body recognition "tuning curve" and into the realm of non-body or less-body like objects. Together, the observed inversion effects in all three experiments led the authors to conclude that the BIE (a) does exist – an indication of holistic processing, (b) is just as robust as the inversion effect for faces and (c) is less sensitive to non-optimal bodies.

Yovel, Pelc, and Lubetzky (2010) also showed that the recognition for body images depended heavily on their appearance. These authors showed that there is a difference between the discrimination of whole faceless and headless bodies. Yovel et al. (2010) created artificial face stimuli and two different types of body stimuli that had no facial features: faceless whole bodies and headless bodies. Faceless whole bodies consisted of the head and body, while headless bodies included just the body. The authors used a same/different paradigm (Reed et al., 2006) in which pairs of images were presented sequentially in an upright or upside down orientation. Observers had to decide whether the posture of the first image was the same or different from the posture of the second image. When comparing observers' discrimination for faces and whole faceless bodies, Yovel et al. (2010) found similar inversion effects such that observers were significantly more sensitive and faster to discriminate between image pairs that were upright than upside down. More importantly, when the authors compared whole faceless with headless bodies, they found the usual BIE for whole faceless bodies but not for headless bodies. Instead, observers were just as sensitive to inverted headless bodies as bodies presented in the upright orientation. This latter comparison is relevant because neither set of stimuli had facial features but nonetheless they each produced significantly different results.

Yovel et al.'s (2010) findings suggest that head absence, but not face absence, may have placed headless bodies outside the putative body recognition boundary that separates bodies from non-body images. In contrast, faceless whole bodies may fall within this hypothetical tuning curve for processing, possibly due to observers having greater experience with perceiving complete (with heads) as opposed to incomplete human bodies (without heads). These results suggest that visual appearance (e.g., head absence, body posture), along with inversion, are determinant factors for deciding whether bodies are processed by mechanisms distinct from the mechanism used for processing other objects.

In addition to whole and headless bodies having an impact on recognition, there is evidence to suggest that the nature of bodies' appearance also impacts the manner of processing. To the best of my knowledge, there are no studies that directly compare the effects of real and artificial appearance on body recognition; however, inferences can be drawn from the available findings. Studies on body recognition have used either real or artificial body images and these studies have arrived at different conclusions regarding the recognition for headless bodies. More specifically, studies that used artificial bodies did not observe a BIE for headless bodies (Reed et al., 2003; Yovel et al., 2010). In contrast, studies using images of real bodies did (Minnebusch et al., 2008; Bauser & Suchan, 2013). Thus, there is reason to believe that some differences exist between the recognition for real and artificial images of human bodies.

In one study using real body stimuli, Minnebusch, Suchan, and Daum (2008) had participants view photographs of whole faceless and headless bodies while they performed a same/different judgment task, similar to ones used by Reed et al., (2003) and Yovel et al. (2010). However, these authors had participants make identity rather than posture judgments. In general, these authors obtained the typical BIE for whole faceless bodies such that recognition performance was better for upright than inverted images in this condition. Of greater interest however, and inconsistent with previous results (Yovel et al. 2010), was that headless bodies were also affected by inversion, but this effect was in the opposite direction; that is, performance was actually better for inverted than upright body images. As mentioned above, Minnebusch et al. (2008) used photographs of human bodies while Yovel et al. (2010) used computer-generated ones, which may have accounted for the difference in results. Thus, this finding suggests a possible distinction between real and artificial appearances such that the processing of headless bodies may also be modulated by the degree of realism. In another study, Bauser and Suchan

(2013) also provided evidence for real headless bodies producing the BIE. The authors presented image pairs of real faces, headless bodies, or houses sequentially in an upright or upside down orientation while observers performed a delayed-match-to-sample task. Subjects were shown pairs of the same type of images and had to decide whether the pairs were the same or different on a single trial. These authors found that both faces and headless bodies produced inversion effects while houses did not. Additionally, Robbins and Coltheart (2012) used the inversion effect to investigate the recognition of four different photographed stimuli: *whole body (bodies with heads), face only, body only,* or a *mix of face and body between two familiar persons* (e.g., head of one person on the body of a second person). Although the effects of inversion were not the primary goal of their investigation, the authors observed inversion effects for all four of their conditions, even headless bodies. Together, these findings support a visual system that may be more sensitive to real than artificial images of human bodies, and this was true even in the absence of a head. More specifically, studies that used artificial bodies observed a BIE for whole bodies but not for headless bodies (Reed et al., 2003; Yovel et al., 2010). In contrast, studies using images of real bodies observed BIEs for both whole and headless bodies (Minnebusch et al., 2008; Bauser & Suchan, 2013). Thus, there is reason to believe that the visual system may be more tuned to real than artificial images of human bodies.

In general, these behavioral studies show that the inversion effect is an effective tool for differentiating between types of object processing. For bodies, the evidence points to a visual system that is affected by variations in body appearance. The visual system is less sensitive to body stimuli that deviates from natural appearance and more sensitive to body stimuli closer to natural appearance. The recognition for whole bodies differs from the recognition for headless bodies because whole bodies are associated with the BIE while headless bodies are not (Yovel et al., 2010; Reed et al., 2003); however, this outcome was mostly true for studies using artificial images and not for studies using real images of human bodies. Rather, studies using real images of human bodies found that the BIE was associated with both whole and headless bodies (Bauser & Suchan, 2013; Robbins & Coltheart, 2012). Together, these findings suggest that within this hypothetical tuning curve for body recognition, real human bodies may lie well within the boundary for processing such that a missing head is accounted for by the nature of their appearance. On the other hand, artificial bodies may still lie within this “tuning curve,” however, because artificiality already deviates from natural appearance, head removal might have led to the their placement that is outside the boundary for body processing.

The studies reviewed above have mostly used the inversion effect for comparing behavioral responses to different body stimuli, but the effectiveness of inversion has also been successfully shown on a neural basis (Rossion & Gauthier, 2002; Yovel & Kanwisher, 2005). One robust finding in electroencephalogram (EEG) studies is the difference in event-related potential (ERP) responses to upright and inverted faces (Rossion, Delvenne, Debatisse, Goffaux, Bruyer, Crommelinck, Guérit, 1999). A typical response elicited by faces is the N170, a negative component peaking at around 170ms post-stimulus onset. ERP responses to inverted faces enhance this N170’s negativity in comparison to ERP responses to upright faces (Rossion, Gauthier, Tarr, Despland, Bruyer, Linotte, & Crommelinck, 2000; Rossion et al., 1999). The discovery of reliable electrophysiological signatures of the FIE using EEG methods suggests that these same methods could also be used for examining human bodies and this has been confirmed by multiple studies looking at neural responses to such images.

Stekelenburg & de Gelder (2004) investigated processing differences by looking at the effect of inversion on ERP responses to emotional faces, bodies, and objects (e.g., shoe). The authors presented photographs of faces and bodies (with faces masked by a gray patch) that expressed either neutral or fearful expressions and had participants decide whether the image was upright or upside down. The authors found that both faces and bodies elicited inversion effects but objects did not. More specifically, amplitudes for both faces and bodies were significantly more negative than when they were in an upright orientation. Latencies also differed, with delayed responses to inverted faces and bodies compared to their upright counterparts. In contrast, the authors observed no response differences between upright and inverted objects suggesting inversion effects exist only for faces and bodies at the neural level.

Minnebusch et al. (2008) provided additional evidence in support of a neural BIE. The authors used EEG to demonstrate that photographs of headless bodies can also generate the BIE, a sign that the appearance of naturalistic body images could lead to the activation of body-sensitive neurons. The authors looked at the effects of inversion on images of whole faceless bodies, headless bodies, and animals. They presented pairs of upright or upside down images sequentially while subjects performed a same/different judgment task. In regards to bodies, the authors observed delayed N170 latencies for inverted compared to upright stimuli. Minnebusch et al. (2008) also observed BIEs for both whole faceless and headless bodies (i.e., amplitude differences between upright and inverted body images). However, the inversion effect for headless bodies was in the opposite pattern such that the N170 amplitude was actually larger for upright than inverted images in this condition, a result that is in accord with their behavioral data described earlier. In general, these ERP findings reflect a pattern that is similar to the pattern of findings observed in the behavioral study; that is, the perception of whole bodies differ from the perception of headless bodies. However, less clear is how neural responses differ between the perception of real and artificial body images.

Although there is limited research comparing neural responses to the nature of body appearance, inferences can be drawn from face studies using such ERP techniques. Event-related potential studies show that natural/artificial appearance impacts the encoding of faces. There are at least two studies showing a difference between the recognition of real and artificial stimuli. First, Balas and Koldewyn (2013) compared ERP responses to real and artificial human and dog faces by having subjects differentiate between species category or animacy. Overall, the authors did not observe amplitude or latency differences between real and artificial faces but they did find differences between species category (human vs. dog). Real human and dog faces elicited different N170 responses but artificial human and dog faces did not, suggesting that artificial appearance decreased the gap between these two species category. In other words, the distinction between human and dog faces became less clear when they were artificial in nature.

Second, Wheatley, Weinberg, Looser, Moran, and Hajcak (2011) conducted an EEG study that further supports the impact of stimuli appearance (e.g. real vs. artificial) on face processing. Although they did not use the method of inversion, the authors did record ERP responses to the passive viewing of real and artificial faces and clocks. First, the authors found that both real and artificial faces elicited the typical N170 while images of clocks did not suggesting that face processing differs from clock processing. Secondly, Wheatley et al. (2011) found that only real human faces sustained activity up to 400ms post-stimulus onset in the form of a positive component (a positive peak) suggesting some differences in the way real and artificial visual information gets encoded. These results led the authors to propose a two-step process. In the first stage, both types of faces (real vs. artificial) undergo a similar process followed by a second stage where they deviate from one other, as evidenced by sustained activity for real, but not artificial faces. Taken together, findings from both Balas and Koldewyn (2013) and Wheatley et al. (2011) suggest the possibility that observers' perception of face images is impacted by the nature of face appearance. Thus, it is possible that the perception of body images may also be affected by the nature of their appearance.

Besides looking at the magnitude of neural responses, Thierry, Pegna, Dodds, Roberts, Basan, and Downing (2006) provided evidence to suggest that bodies might have their own ERP component such that responses elicited by body images occur at a time period that differs from responses elicited by faces. The authors termed this component the N190 to refer to an electrical response occurring at around 190ms post-stimulus onset. In their first experiment, the authors compared ERP responses to real photographs of human faces, headless bodies, objects, and scenes while subjects performed a "1-back" task by pressing a button when an image was repeated. In their second experiment, the authors added four new categories: intact and scrambled silhouettes of human bodies and stick figures. In general, Thierry et al. (2006) observed a significant difference between ERP response to faces and bodies in both experiments. Specifically, for the first experiment, faces elicited a negative peak at 174ms while bodies elicited a negative peak at 194ms post-stimulus onset. More importantly, the amplitude observed for bodies was significantly larger than the amplitude for both objects and scenes and this finding also extended into their second experiment, suggesting that the N190 is indeed specific to bodies.

To summarize, the BIE is a useful tool for investigating how body processing works (Minnebusch, Keune, Suchan, & Daum, 2010; Yovel et al., 2010) and it is possible that bodies may have their own ERP component (Thierry et al., 2006). Furthermore, EEG studies demonstrate that the nature of appearance influences visual processing (Balas & Koldewyn, 2013; Wheatley et al., 2011; Stekelenburg & de Gelder, 2004). However, even with the success of observing the BIE in both behavioral and EEG studies, the outcomes are somewhat inconsistent. For instance, some stimuli led to the emergence of a BIE (Reed et al., 2003) while others did not (Yovel et al., 2010, Brandman & Yovel, 2012). Likewise, some studies that did observe the BIE obtained unusual results, both behaviorally and neurally (Minnebusch et al., 2008), not to mention the difference in latencies across EEG studies. There are a number of reasons for the inconsistencies but one possibility may be the type of stimuli used for testing; some used artificial bodies (Reed et al., 2003; Yovel et al., 2010; Brandman & Yovel, 2012) while others used photographs of human bodies (Stekelenburg & de Gelder, 2004; Minnebusch et al., 2008). Participants were also asked to perform different tasks (e.g., posture-discrimination, identity-judgment), which may have led to differences in the way observers were processing stimuli information (Campanella, Hanoteau, Depy, Rossion, Bruyer, Crommelinck, & Guerit, 2000). Thus, task variability may have contributed to inconsistencies among these research findings, making it challenging to draw conclusions about the representation of bodies and body appearance in the visual system.

To address some of these discrepancies, I used the BIE to define elements that determined whether a body would be processed by the visual system. In other words, I used the technique of inversion to determine whether certain variations in body appearance would impact the placement of bodies within or outside what Taubert (2009) referred to as the "tuning curve." Specifically, I used both behavioral and electroencephalogram (EEG) methods to examine the effects of head presence/absence (whole faceless vs. headless) (Yovel et al., 2010) and the nature of appearance (real vs. artificial) on body processing.

In the first experiment, I attempted to replicate previous findings for artificial whole faceless and headless bodies as a way to determine whether these two types of body images were distinct from one another (Yovel et al., 2010; Brandman & Yovel, 2012). In the second experiment, I investigated the impact of other variations in body appearance on recognition – specifically real and artificial appearances. I created and compared real and artificial human bodies by making them appear as similar to each other as possible (e.g., clothing and body position). In the last experiment, I examined whether these variations in appearance also impacted observers’ perception of body images at the neural level. Together, these comparisons helped me determine how broadly or finely tuned the visual recognition is for body processing.

EXPERIMENT 1. THE EFFECT OF INVERSION ON WHOLE AND HEADLESS BODIES

The purpose of this first experiment was to replicate the BIE result for whole faceless and headless bodies (Yovel et al., 2010). If bodies alone are indeed processed differently than other object categories, an inversion effect should emerge. Moreover, if the tuning for bodies is narrowed or has a distinct boundary, due to greater experience, then whole faceless bodies would produce an inversion effect while headless bodies would not.

Method

Participants

Twenty- six (17 females/ 9 males) undergraduate students from North Dakota State University, between the ages of 18 and 22, participated in this experiment. All students received course credit for their participation.

Stimuli

Body stimuli were provided by Brandman and Yovel (2012). All bodies were of the same identity (male) displaying poses that were biomechanically possible. These were gray-scale images that were 300 x 404 pixels in size. In addition to full bodies, I created headless bodies by removing the head in Adobe Photoshop CS4 11.0.2 (**Figure 1**). There were a total of 18 body pairs that either differed within each pair or were identical to one another. In the different condition, within each pair the position of one arm, one leg, and the head were slightly altered. In contrast, same body pairs consisted of the exact same body image. Finally, image pairs were always presented in the same orientation. For instance, if the first image was presented in an upright orientation, the second image within that same pair was also presented upright.

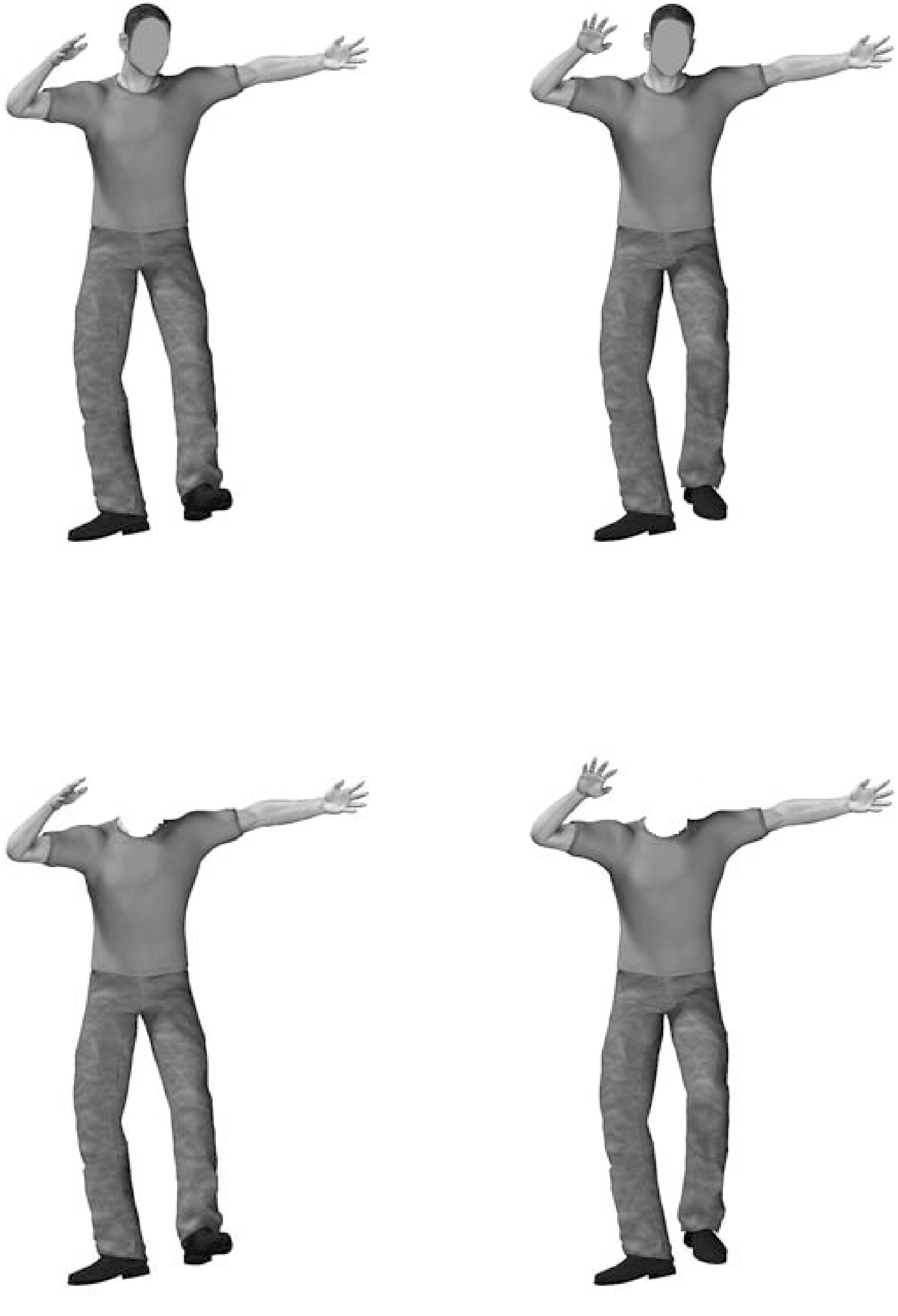

Figure 1. Examples of whole and headless bodies used in Experiment 1.

Design

I used a 2 (pair type: same/different) x 2 (orientation: upright/inverted) x 2 (head presence: whole bodies/headless bodies) within-subjects design. Head presence varied in separate blocks while pair type and orientation were pseudo-randomized within each block. Block order was counterbalanced so that half of the participants began with the whole body condition and the remaining half began with the headless body condition. All body pairs were presented twice resulting in a total of 144 trials per block yielding a grand total of 288 trials for the entire experiment.

Procedure

Participants were seated approximately 65 cm away from the monitor in a dimly lit noise-controlled room. They viewed stimuli on a 15-inch MacBook with a 2.7 GHz Intel Core 2 Duo Processor. Stimuli were presented using PsychToolbox 3.0.11 on a MacOS 10.8.3 system. Participants' responses were recorded using buttons located on the MacBook keyboard. Specifically, they were instructed to press the "z" button if the presented body pairs were of the same posture and the "m" button if body pairs differed in posture. We asked participants to respond as quickly and accurately as possible. Following instructions, each trial began with the presentation of the first stimulus for 250ms followed by a blank screen for 1,000ms. The second stimulus then appeared and remained on the screen until a response was made. Additionally, the presentation of body images within each pair randomly differed in location and size. Specifically, body images were randomly offset between 0 to 20 pixels to the right or left from the center of the screen and/or varied in size from 90 to 110%. The purpose of these random manipulations was to prevent the retina from retaining the initial image, which could potentially assist participants in the detection of changes within a given trial. Short breaks were offered in between blocks and the experiment resumed only when participants indicated they were ready to continue.

Results

Sensitivity (d')

I computed estimates of sensitivity (d') using hits and false alarms in each condition and submitted them to a 2 (image orientation) x 2 (head presence) repeated measures ANOVA and found main effects for all factors: head presence, ($F(1,25) = 13.40$, $p = .001$, $\eta^2_p = .35$) and orientation, ($F(1,25) = 31.54$, $p < .001$, $\eta^2_p = .56$). Overall, the ability to discriminate between body images was better when images were presented upright (M= 1.23, SE= .12) than upside down (M= .88, SE=.10) as well as for images of whole faceless bodies (M= 1.21, SD= .11) than headless bodies (M= .90, SE= .11). Head presence and orientation also interacted, ($F(1,25)$ = 10.72, $p = .003$, $\eta^2_p = .30$), indicating that picture-plane inversion disrupted discrimination but only for whole faceless bodies. In contrast, inversion had no effect on headless bodies (**Figure 2**).

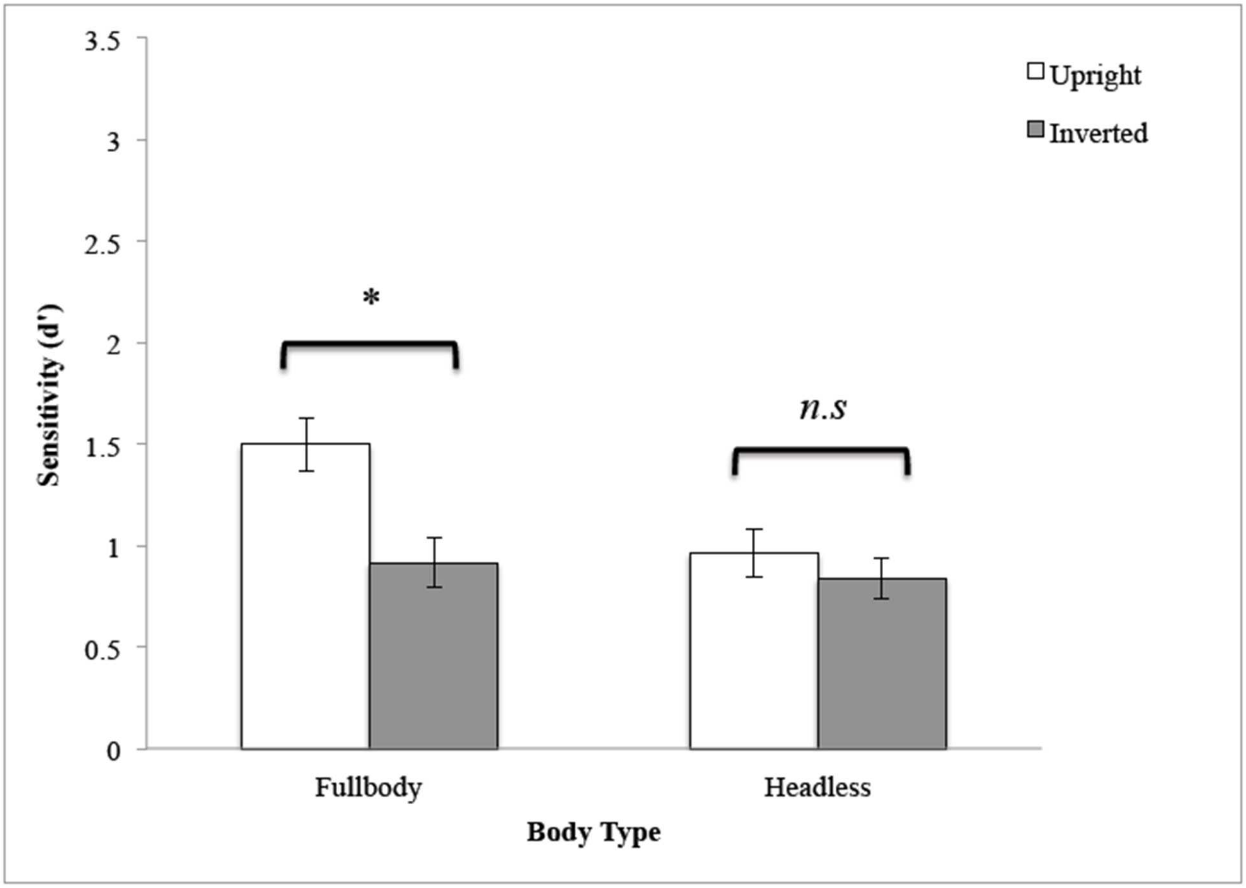

Figure 2. Sensitivity measures for responses in Experiment 1. We find that only whole bodies (with heads) produced the inversion effect. Error bars represent +/- 1 standard error of the mean.

Response time

I performed a 2 (image orientation) x 2 (head presence) repeated measures ANOVA of median correct response latencies and found a main effect of image orientation, ($F(1,25) = 6.32$, $p = .02$, $\eta^2_p = .20$). Overall, observers were much quicker to respond when images were presented upright (M= 1.20, $SE = .01$) than upside down ($F(1,25) = 13.40$, $p = .001$, $\eta^2_p = .35$). No other factors reached significance, head presence, ($F(1,25) = .02$, $p = .90$, $\eta^2_p = .00$).

Response bias, C

I ran a 2 (image orientation) x 2 (head presence) repeated measures ANOVA on response bias, C, and found no significant effects, body type, ($F(1,25) = .85$, $p = .37$, $\eta^2_p = .03$), image orientation, ($F(1,25) = .20$, $p = .695$, $\eta^2_p = .01$), suggesting no significant biases in the way participants were responding in each condition.

Discussion

My results largely replicated those obtained by Yovel et al. (2010). My findings suggest that human bodies are uniquely processed and involve the encoding of holistic information, a process that is said to be active during the perception of upright whole bodies (Reed et al., 2003). Through the process of inversion then, observers' ability to discriminate between body images becomes disrupted, as indicated by both the decrease in performance and an increase in response latency for inverted compared to upright whole bodies (Brandman & Yovel, 2010; Stekelenburg & de Gelder, 2004). Also, the lack of an inversion effect for headless bodies suggests the utilization of a separate processing mechanism that is more comparable to ones used for processing other object categories that do not involve the encoding of holistic information. Overall, these results suggest that the appearance of body stimuli affects the encoding process such that observers are encoding whole and headless bodies differently. This difference could be associated with this hypothetical tuning curve encompassing some (e.g. whole bodies), but not all forms of human bodies (e.g. headless bodies).

In the following section, I extended the current findings on body processing by examining the nature of visual appearance. More specifically, I compared observers' discrimination performance for whole and headless bodies that were real and artificial in nature.

EXPERIMENT 2. THE BIE IN REAL VS ARTIFICIAL HUMAN BODIES

The purpose of Experiment 2 was to determine whether the nature of visual appearance impacts body processing. I compared the BIE for real versus artificial body images. I hypothesized that if visual appearance had an influence, then observers' performance would differ between real and artificial bodies. Furthermore, I expected performance to be better for real as compared to artificial human bodies. On the other hand, if the nature of appearance does not have an influence, then this would be an indication that the body system may be more broadly tuned, incorporating both real and artificial body images.

Method

Participants

There were 28 participants; however, seven were excluded due to either missing conditions or achieving accuracy scores below 20%. This yielded a total of 21(10 females/11 males) students, between the ages 18 and 38, from North Dakota State University who participated in this study. Students received either course credit or monetary compensation for their participation.

Stimuli

There were two types of body stimuli. Artificial body stimuli were created using Poser 8.0 software^{TM}. These images consisted of eight (4 females/4 males) different individuals portraying six different biomechanically possible body postures. Additionally, there were two versions of the same pose with the second differing slightly from the first by an arm movement; thus, creating pairs for each poses. All individuals wore a black t-shirt and black pants to reduce the level of variation between individuals that might otherwise affect observers' perception for them. Real body stimuli were created by taking photographs of actual people's bodies exhibiting postures similar to those of the artificial stimuli. I began by using a NEC WT600 projector that displayed the artificial bodies onto a screen on the wall. I then photographed individuals as they positioned themselves to resemble as close as possible to the position of the artificial body images. Each individual modeled six different poses. Each pose also consisted of two versions with the second version differing slightly from the first by a single arm movement. Heads were removed using Adobe Photoshop CS4 11.0.2. All stimuli were presented in gray scale measuring 400 x 500 pixels in size. There were a total of eight (4 males/4 females) different artificial body images (**Figure 3**) and eight (4 males/ 4 females) natural photographs of people (**Figure 4**). Finally, image pairs were always presented in the same orientation.

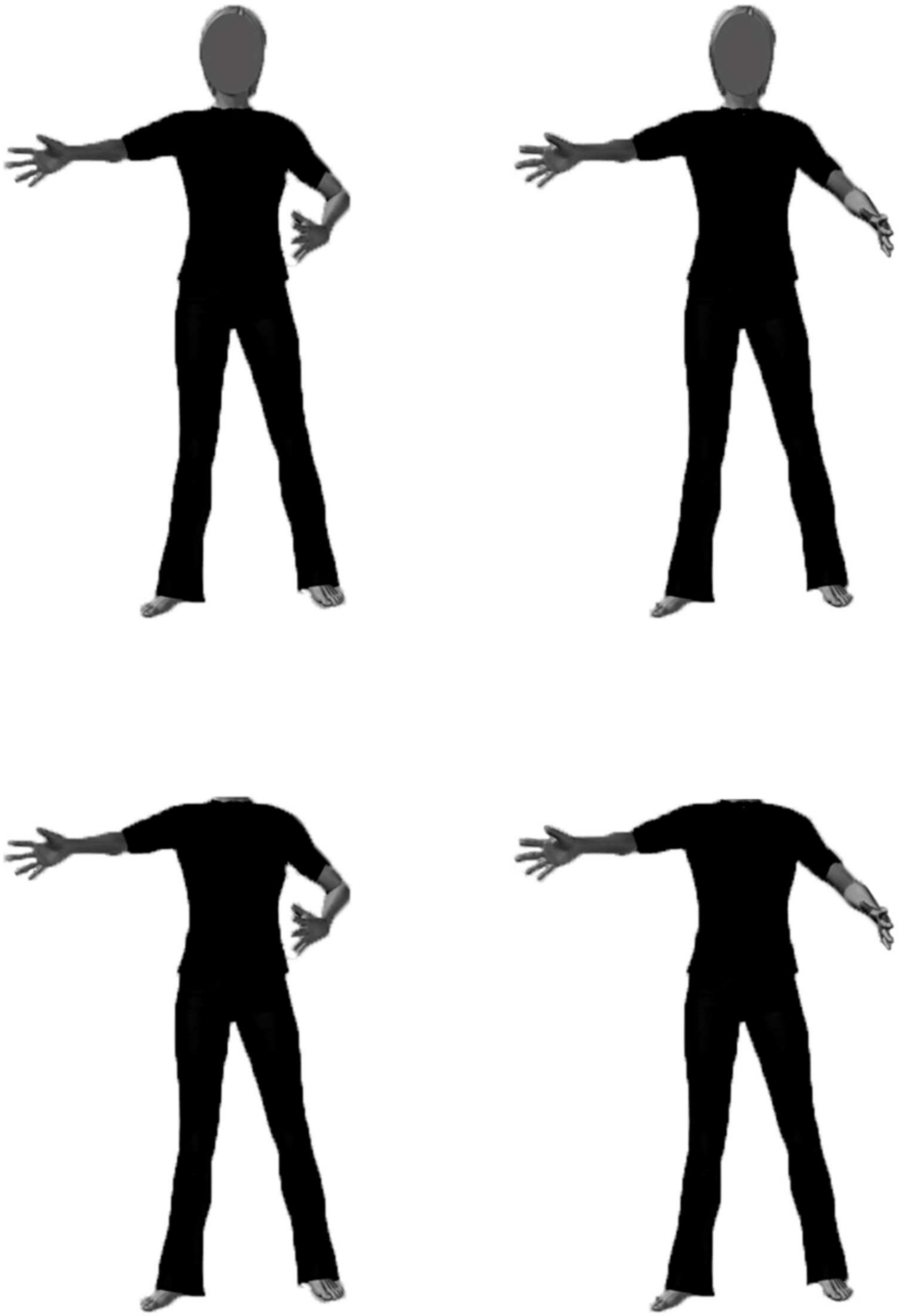

Figure 3. Examples of artificial whole and headless bodies used in Experiment 2.

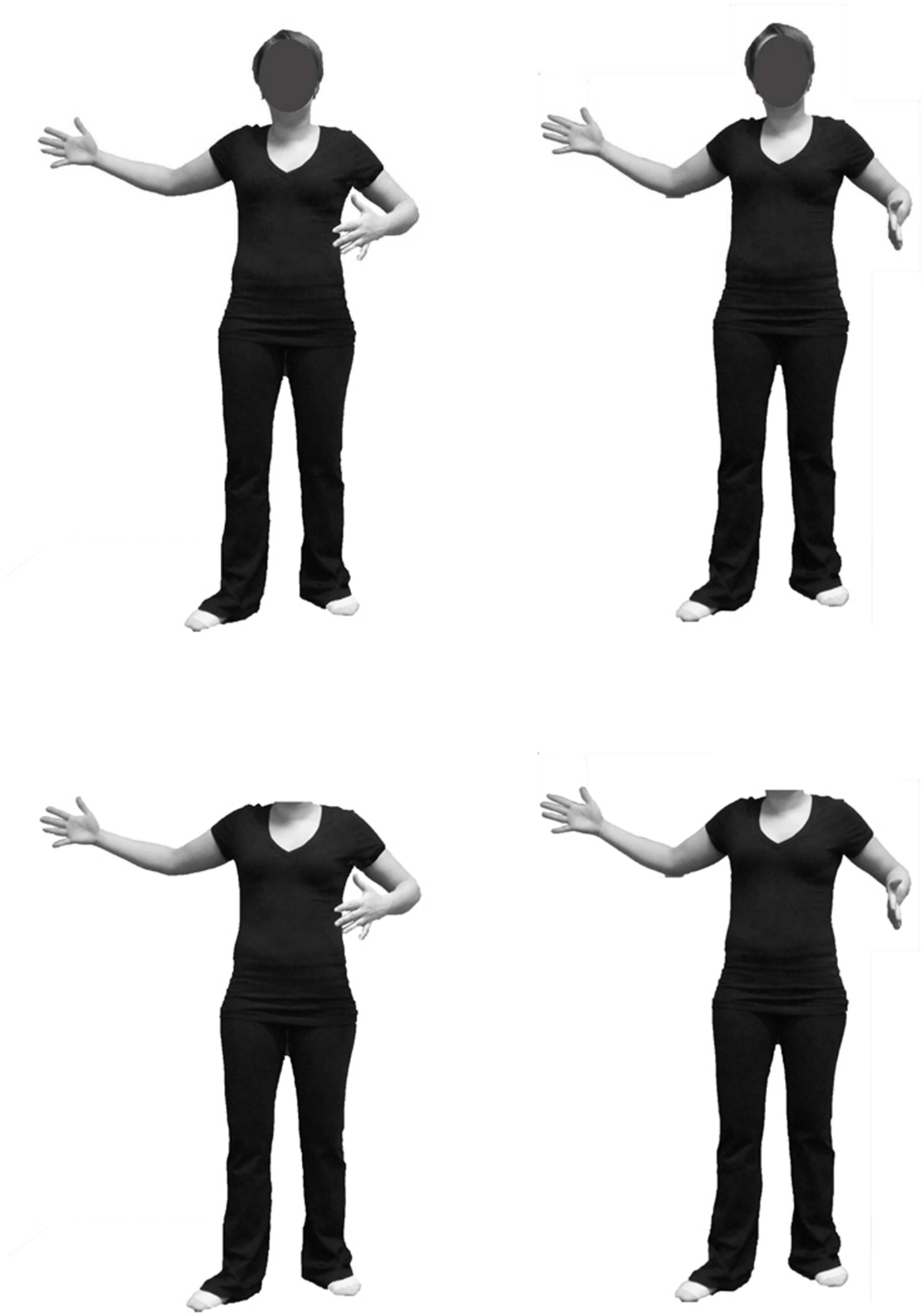

Figure 4. Examples of real whole and headless bodies used in Experiment 2.

Design

I used a 2 (orientation: upright/inverted) x 2 (head presence: whole faceless bodies/headless bodies) x 2 (body type: real vs. artificial) within-subjects design. Body type and head presence varied in separate blocks while image orientation was pseudo-randomized within each block. Block order was also counterbalanced so that not all participants began with the same condition. Finally, body pairs were presented three times for a total of 96 trials per block and a total of 384 trials for the entire experiment.

Procedure

Participants sat approximately 65cm away from the monitor in a dimly lit noise-controlled room. They viewed stimuli on a 15-inch MacBook with a 2.7 GHz Intel Core 2 Duo Processor. Stimuli were presented using PsychToolbox 3.0.11 on a MacOS 10.8.3 system. Participants' responses were recorded using buttons located on the MacBook keyboard. I had participants perform a same/different discrimination task for each pair of the same stimuli (i.e., version one and version two). Each trial began with the first version of a model appearing for 250ms followed by 1,000ms of a blank screen. The second version of this same model then appeared and remained on the screen until a response was made by pressing one of two keys on the keyboard corresponding to one of the two choices (i.e., same or different). Additionally, the presentation of body images within each pair randomly differed in location and size. More specifically, body images were randomly offset between 0 to 20 pixels to the right or left from the center of the screen and/or varied in size from 90 to 110%. I asked participants to respond as quickly and accurately as possible.

Results

Sensitivity (d')

I computed estimates of sensitivity (d') using hits and false alarms in each condition and submitted them to a 2 (image orientation) x 2 (body type) x 2 (head presence) repeated measures ANOVA and found a main effect of body type, ($F(1,20) = 39.59$, $p < .001$, $\eta^2_p = .66$). Overall performance was better for real (M= 2.28, SE=. 18) than artificial (M= 1.78, SE=. 10) images of human bodies and this was true in both upright, ($t(41) = 4.72$, $p < .001$), and upside-down orientations, ($t(41) = 6.84$, $p < .001$) (**Figure 5**). Body type and image orientation interacted, ($F(1,20) = 6.17$, $p = .02$, $\eta^2_p = .24$), such that inversion increased the magnitude of the difference already observed between real and artificial bodies, ($t(41) = -2.78$, $p < .01$) (**Figure 6**). In other words, the difference between real and artificial bodies in the upright condition significantly differed from the difference for real and artificial bodies in the inverted condition. No other factors reached significance, head presence, ($F(1,20) = .19$, $p = .67$, $\eta^2_p = .01$), image orientation, ($F(1,20) = .03$, $p = .87$, $\eta^2_p = .00$). Unlike my results from Experiment 1, the presence or absence of a head did not affect discrimination performance and this was true for both real and artificial bodies. Picture-plane inversion also had no effect on performance since no inversion effect emerged for either type of body.

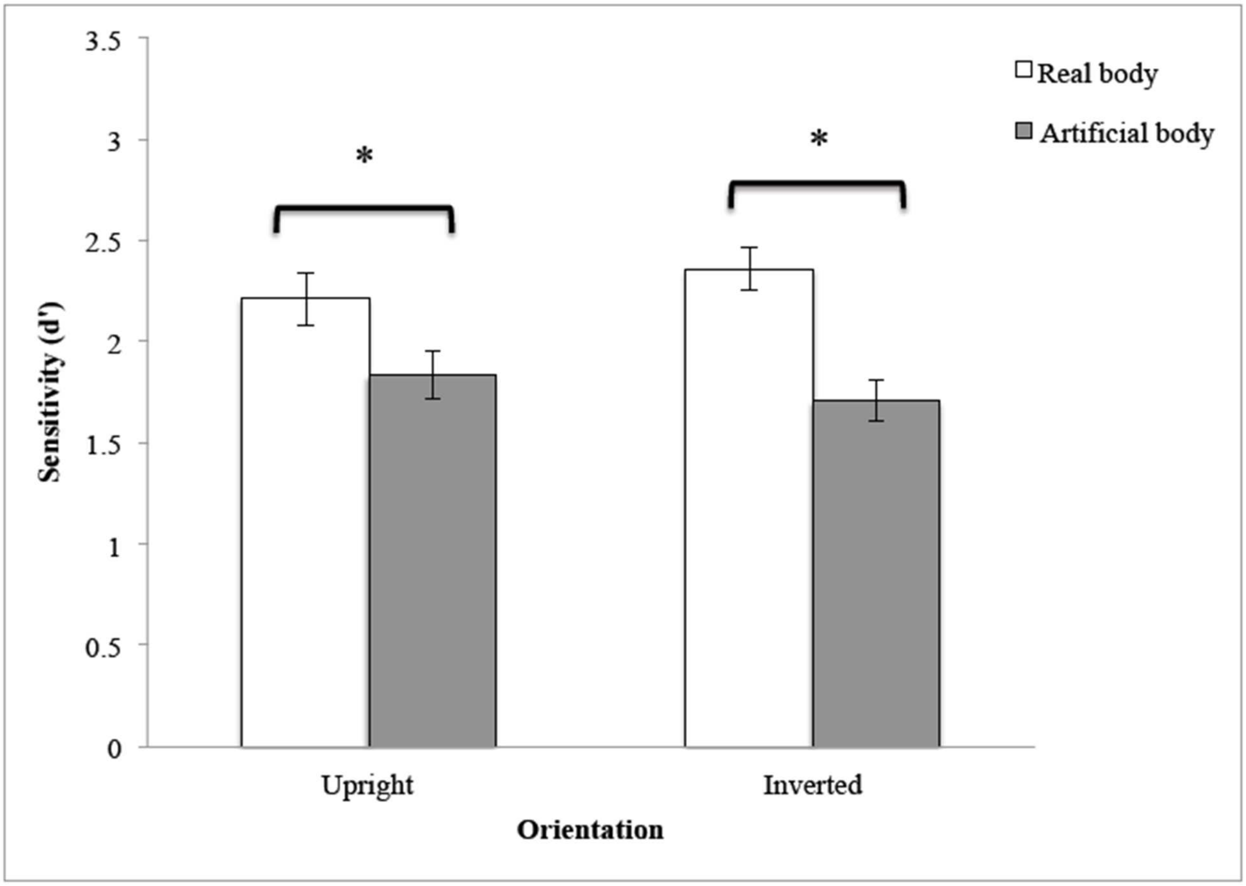

Figure 5. Sensitivity measures for responses in Experiment 2. Discrimination performance was better for real than artificial body images in either orientation. Error bars represent +/- 1 standard error.

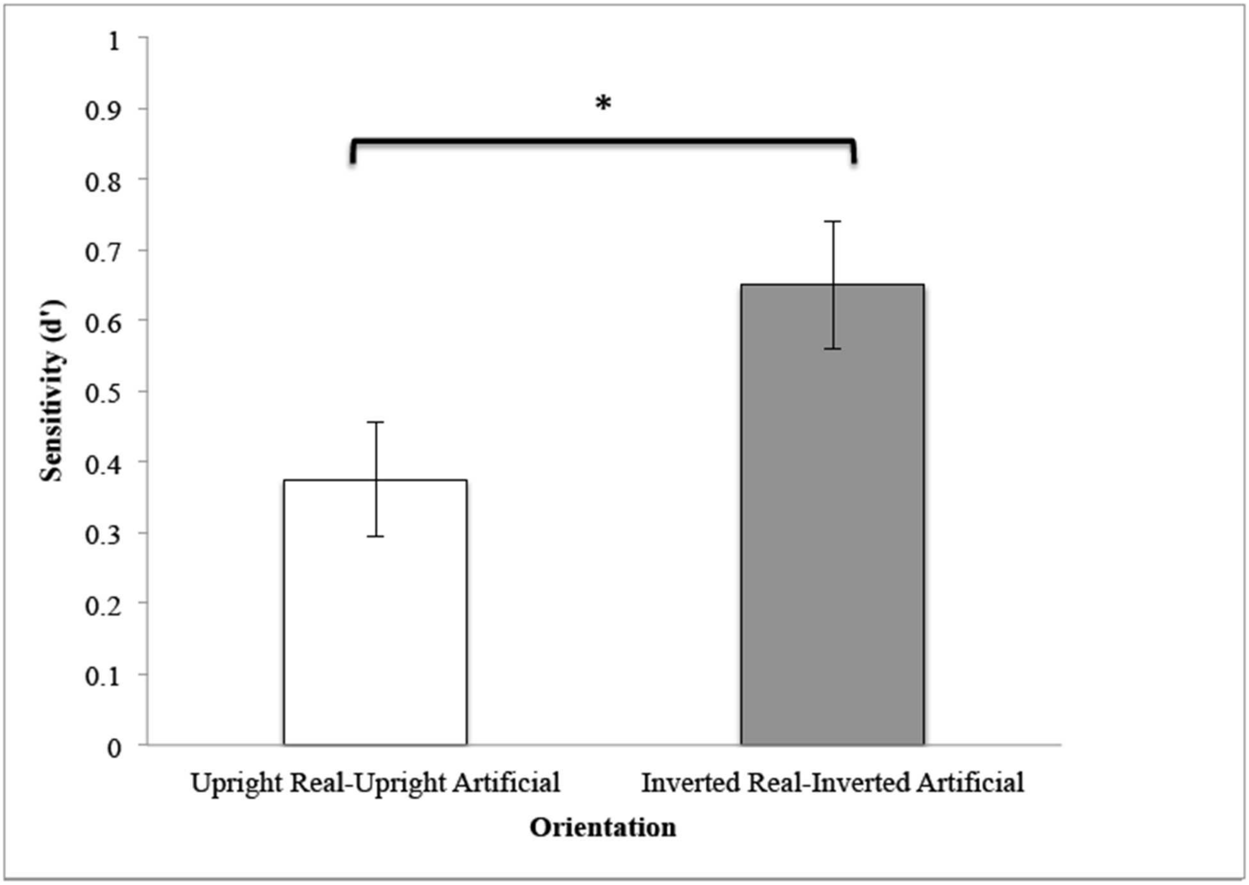

Figure 6. The difference of scores between real and artificial bodies in either orientation. We find that inversion increased the difference between real and artificial bodies. Error bars represent +/- 1 standard error of the mean.

Response time

I performed a 2 (image orientation) x 2 (body type) x 2 (head presence) repeated measures ANOVA of median correct response latencies and found no significant differences in reaction time among all conditions, image orientation, ($F(1,20) = 1.86$, $p = .19$, $\eta^2_p = .09$), body type, ($F(1,20) = 2.2$, $p = .16$, $\eta^2_p = .10$), head presence, ($F(1,20) = 2.55$, $p = .13$, $\eta^2_p = .11$). None of the factors interacted ($p > .05$).

Response bias, C

I ran a 2 (image orientation) x 2 (body type) x 2 (head presence) repeated measures ANOVA on response bias, C, and found significant main effects of image orientation, ($F(1,20) = 16.68$, $p = .001$, $\eta^2_p = .46$) and head presence, ($F(1,20) = 27.87$, $p < .001$, $\eta^2_p = .58$). Body type was only marginally significant, ($F(1,20) = 3.96$, $p = .06$, $\eta^2_p = .17$). I also obtained two-way interactions between body type and head presence, ($F(1,20) = 42.15$, $p < .001$, $\eta^2_p = .68$), body type and image orientation, ($F(1,20) = 13.79$, $p = .00$, $\eta^2_p = .41$), and head presence and image orientation, ($F(1,20) = 70.79$, $p <.001$, $\eta^2_p = .78$). These two-way interactions were qualified by a three-way interaction, ($F(1,20) = 59.11$ $p <. 001$, $\eta^2_p = .75$) showing that for upright images, the factor of head presence affected the way subjects were responding. For real images of human bodies, subjects were more biased towards responding "same" than "different" when heads were absent. In contrast, subjects exhibited no head biases for artificial human bodies. For inverted images, subjects were more biased towards responding "same" than "different" for real human bodies with than without heads. In contrast, there were no differences between head presence/absence for artificial human bodies (**Table 1**).

Table 1

Response Bias, C, for Experiment 2

	Upright		Inverted	
	Head	No Head	Head	No Head
Real Bodies	-.18	-.27	-1.27	-.01
Artificial Bodies	-.31	-.31	-.30	.30

Discussion

Unlike Experiment 1, the presence or absence of a head had no effect on either type of body, whether upright or upside down. One possibility for this discrepancy in results is the difference in stimuli used in both experiments. In the first experiment, whole body stimuli had varied in an arm, leg, and head positions. In contrast, the headless body stimuli varied only by an arm and a leg, resulting in less cues made available to observers. On the other hand, the stimuli in Experiment 2 varied only by a single arm position, and this was true for both whole and headless bodies. With less cues available to assist observers, the task assigned in the second experiment may have been more challenging when they were trying to detect changes within each pair of stimuli. As a result, observers may have also used a processing strategy that did not involve a holistic approach. Instead, observers may have used a feature-based strategy, which involves the encoding of individual features (Bruce & Young, 1986; Tanaka & Farah, 1993).

The use of this separate strategy could also explain why neither stimulus produced the body-inversion effect. According to Yovel et al. (2010), the lack of variation in head position can reduce the likelihood of observing an inversion effect. Yovel et al. (2010) compared inversion effects for bodies with and without fixed heads (i.e., heads that do not vary within a pair of stimuli) on a similar task, and found that the inversion effect for the latter group was significantly reduced compared to the former group of bodies. In regards to my results, the whole body stimuli used in the "different" condition in my first experiment had body pairs with heads that differed in position from the first and second image. Observers could have used this variation in head movement as an additional cue in deciding whether pairs were similar or not. In contrast, stimuli used in my second experiment consisted of fixed heads for all conditions, making them particularly uninformative and more similar to the headless body condition. As a result, observers may have learned to focus their attention elsewhere on the body rather than the head. Thus, it is possible that these result differences were due to the adoption of two separate processing strategies that were based on the demands of the task.

Consistent with my hypothesis, observers' performance for real bodies differed from artificial bodies. More specifically, observers' performance was better for the former than the latter group of stimuli. This distinction between observers' performance for real and artificial appearance could be explained by studies showing a difference between faces based on viewing experience. Observer's recognition performance for faces they have more experience with tends to be better than when faces deviate from how they typically appear (Malpass & Kravitz, 1969; Kuefner, Macchi, Picozzi, & Bricolo, 2008). For instance, studies have shown the existence of an other-race effect (Herrmann, Schreppel, Jager, Koehler, Ehlis, & Fallgatter, 2007) as well as an other-age effect (Anastasi & Rhodes, 2005), in which observers were better at recognizing faces that were of similar race and/or age as the observer. Thus, it is possible that the distinction between the two body types observed in this current experiment is a reflection of observers having a much greater experience viewing bodies that were real than artificial in nature.

Moreover, this difference in observers’ performance for the two types of bodies was further highlighted by the interaction observed between body type and orientation. More specifically, inversion significantly increased the disparity already observed between observers’ performance for the two body types. This result suggests not only sensitivity of the body system to the nature of visual appearance but that the level of sensitivity is a function of orientation. In the following section, I sought to determine whether real and artificial appearances also differed at the neural level.

EXPERIMENT 3. EVENT-RELATED POTENTIALS IN RESPONSE TO REAL VS ARTIFICIAL HUMAN BODIES

The purpose of Experiment 3 was to further the results of Experiment 2. I used the BIE to determine how variations in body appearance impact perception at the neural level. In other words, this experiment tested for possible differences in regards to whole and headless bodies, and real and artificial appearances that may occur at the neural level.

I compared ERP responses for real and artificial body images by manipulating the factors described in the previous two experiments: head presence and orientation. I examined whether these body images would produce responses similar to the behavioral responses observed in the previous experiment. Furthermore, if the nature of visual appearance dictated where a body lies within the body recognition boundary, then ERP responses would also differ between real and artificial body stimuli. Thus, I expected to see differences between the two orientations for body stimuli that were perceptually closest to natural appearance (i.e., photographs as opposed to computer-generated) but not much difference for bodies furthest away (Taubert, 2009). Specifically, I predicted larger amplitudes and longer latencies for inverted relative to upright bodies for all conditions with the exception of artificial headless bodies because this condition has been previously shown not to produce a behavioral BIE (Yovel et al., 2010). Additionally, Thierry et al. (2009) suggested that bodies might have their own ERP component (i.e., N190) that is distinct from the N170 component for faces. Based on Thierry et al.'s (2009) findings, I expected to see differences in ERP responses around 190ms post-stimulus onset for upright and upside down body images.

Method

Participants

Twenty-five participants ages 18-35 participated in this study. Those with less than half usable trials were rejected in the analysis process. The final sample of participants consisted of 16 undergraduate students (10 females/6 males) from North Dakota State University. All participants indicated they were right handed except for one, who was left-handed. Students received either course credit or monetary compensation for their participation.

Stimuli & Design

The stimuli used in this experiment were the same as those described in Experiment 2. However, for simplicity all body images were restricted to one pose such that observers saw the same pose being exhibited by all body images. I used a 2 (body type: real/artificial) x 2 (head presence: whole faceless/headless) x 2 (orientation: upright/inverted) within-subjects design for a total of eight conditions. Head presence varied between blocks while body type and orientation varied within blocks.

Procedure

I applied a 64- channel Hydrocel Geodesic Sensor Net (Electrical Geodesics Inc., Eugene, OR) on participants' heads prior to seating them in a soundproof, darkened room. Participants were situated approximately 60cm away from the monitor where images were presented. I provided participants with two buttons, one on the right and one on the left, which were counterbalanced across participants. I presented images using E-Prime v2.0. Prior to the start of the experiment, I instructed participants to press one button if the image displayed on the screen was upright and a different button if the image was upside down. Unlike the behavioral task, I had participants perform this orientation task so they could actively engage most of their attention to the two orientations rather than having to possibly shift their attention towards detecting subtle differences between pairs of body images. Trials began with the display of a single image for 500ms followed by an inter-stimulus interval (ISI) ranging from 800ms to 1500ms to reduce anticipation of the next image. The ISI was randomized across all trials. Since my stimuli consisted of 16 different individuals (8 real/8 artificial), there were a total of eight conditions that were repeated 10 times, for a grand total of 640 trials for the entire experiment.

I recorded EEG responses while referencing the vertex electrode (Cz). Raw signals were amplified with an EGI NetAmps 200 amplifier that uses a band-pass filter of 0.1-100 Hz and a sampling rate of 250 Hz. Prior to the start of the experiment, I checked impedances online and advanced to the actual experiment only when impendences were below the threshold of 100 kΩ.

Results

Upon completion of each experimental session, I analyzed each participant's data individually using NetStation v4.3.1 (Eugene, OR). First, I applied a 30-Hz low pass filter and segmented each trial in order to define a window that began 100ms pre-stimulus onset to 900ms post-stimulus onset. Secondly, I baseline-corrected these segments by taking its entire baseline period and subtracting from it the average voltage. Third, I applied an automated artifact detection tool provided in NetStation to exclude any muscle movements, eye movements, eye blinks, as well as any sensors that had lost connection. I also removed entire segments showing any signs of widespread drifts as well as replacing any bad channels using spherical spline interpolation. Fourth, I calculated every individual's average for each of the eight conditions and re-referenced their data to the global average reference. I rejected nine participants due to their data having less than half usable trials (< 40 of 80 trials) in each category, yielding a total of 16 participants in the final sample for analysis. I chose sensors located just over the occipital – temporal area from the right (sensors 43, 44, and 45) and left (sensors 27, 30, and 32) hemisphere (**Figure 7)**. I based my selection of electrodes on both previous reports and the location of where components were visually maximal. For the analysis of the P100 and N170, I chose the time window of 90 – 150 ms post-stimulus onset and the time window of 131 – 219 ms post-stimulus onset. These ranges accounted for variations across participants and because they capture the entire component of interest.

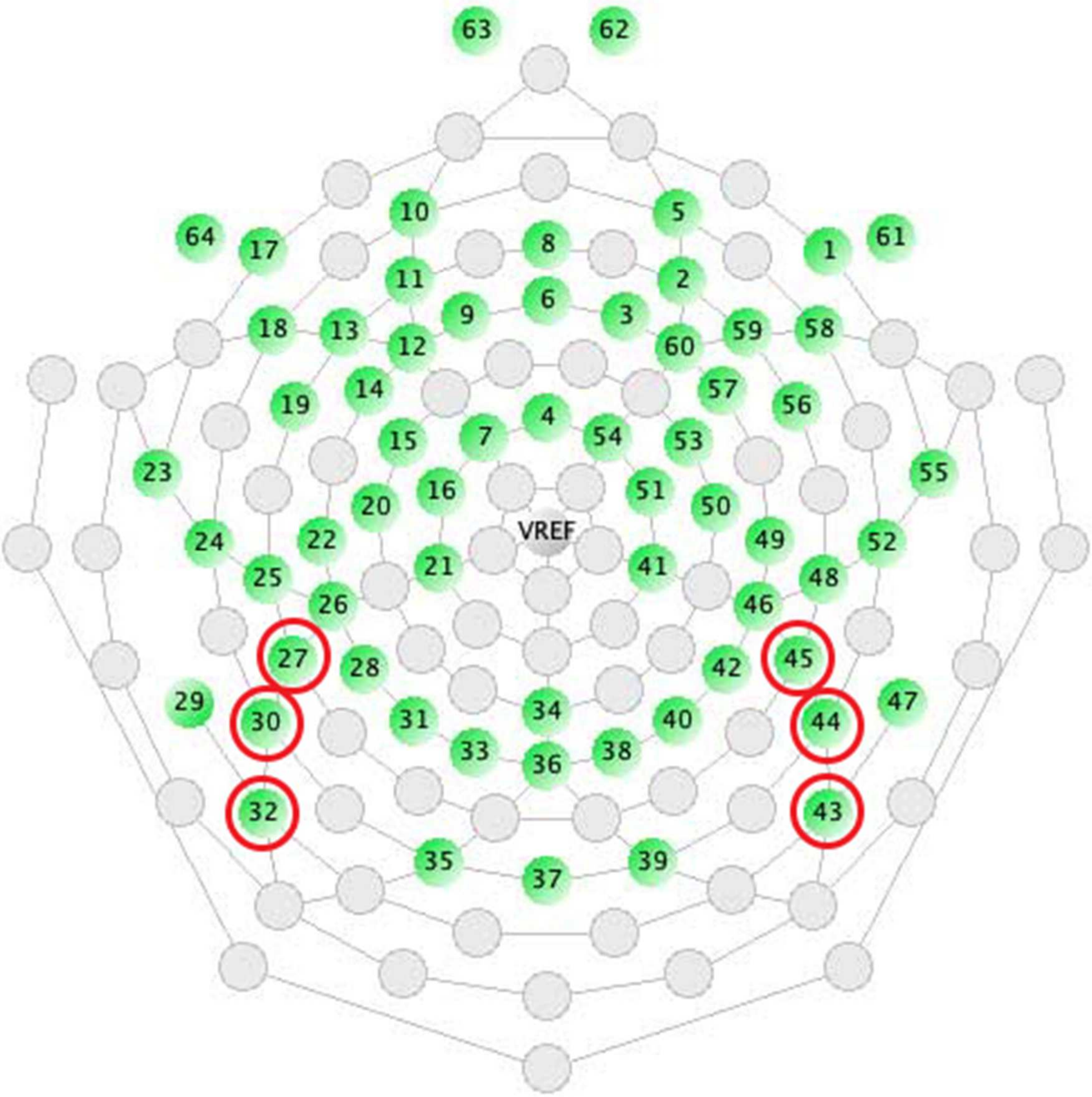

Figure 7. Example of sensors located on a 64- channel Hydrocel Geodesic Sensor Net (Electrical Geodesics Inc., Eugene, OR). Specifically, sensors 27, 30, and 32 from the left and sensors 43, 44, and 45 from the right hemisphere were selected for analysis in Experiment 3.

To analyze latencies and peak amplitudes of the P100 and N170, I submitted all conditions to a 2 x 2 x 2 x 2 repeated-measures ANOVA with body type (real/artificial), head presence (with head/without head), orientation (upright/inverted), and hemispheres (right or left) as within-subject factors.

P100 mean amplitude

I observed main effects of body type, ($F(1,15) = 3.02$, $p = .02$, $\eta^2_p = .33$), and orientation, ($F(1,15) = 28.13$, $p < .00$, $\eta^2_p = .65$). The mean amplitude for real bodies, ($M = 3.23$, $SE = .41$), was significantly more positive than the mean amplitude for artificial bodies, ($M = 3.01$, $SE = .42$), and the mean amplitude for inverted bodies, ($M = 3.37$, $SE = .42$), was significantly more positive than the mean amplitude for upright bodies, ($M = 2.87$, $SE = .41$). No other factors or interactions reached significance, ($p > .05$).

P100 max amplitude

I observed main effects of body type, ($F(1,15) = 5.52$, $p = .03$, $\eta^2_p = .27$)), and orientation, ($F(1,15) = 22.54$, $p < .001$, $\eta^2_p = .60$)). The maximum amplitude for real bodies, ($M = 5.23$, $SE = .43$), was significantly more positive than the maximum amplitude for artificial bodies, ($M = 5.06$, $SE = .40$) and the maximum amplitude for inverted bodies, ($M = 5.48$, $SE = .45$), was also more positive than the maximum amplitude for upright bodies, ($M = 4.81$, $SE = .39$). The interaction between orientation and hemisphere was also significant, ($F(1,15) = 4.61$, $p = .05$, $\eta^2_p = .24$). Bonferroni-corrected pairwise comparisons revealed amplitude differences between upright and inverted bodies in both the left ($p = .02$) and right ($p <. 001$) hemisphere but no hemisphere differences within either orientation ($p > .05$). No other factors or interactions reached significance, ($p > .05$).

P100 latency

I observed a main effect of body type, ($F(1,15) = 6.75$, $p = .02$, $\eta^2_p = .31$), indicating that artificial bodies, ($M = 119.13$ ms, $SE = 1.87$ ms), elicited a response significantly earlier than the response elicited by real bodies, ($M = 120.80$ ms, $SE = 1.98$ ms). No other factors reached significance, ($p > .05$).

N170 mean amplitude

I observed main effects of orientation, ($F(1,15) = 4.93$, $p = .04$, $\eta^2_p = .25$), and head presence, ($F(1,15) = 8.35$, $p = .01$, $\eta^2_p = .36$) indicating that the mean amplitude for inverted bodies ($M = 1.01$, $SE = .56$) was more negative than the mean amplitude for upright bodies ($M = 1.47$, $SE = .43$). Additionally, the mean amplitude for headless bodies ($M = .82$, $SE = .49$) was more negative than the mean amplitude for whole faceless bodies ($M = 1.66$, $SE = .53$). The main effect of head presence was qualified by an interaction between body type and head presence, ($F(1,15) = 6.33$, $p = .02$, $\eta^2_p = .30$). Paired sample t-test showed that head presence had the greatest impact on the perception of real human bodies ($t(63) = 3.94$, $p < .001$) but only a marginal effect on artificial human bodies ($t(63) = 1.98$, $p = .052$) (**Figure 8**). No other factors or interactions reached significance, ($p > .05$).

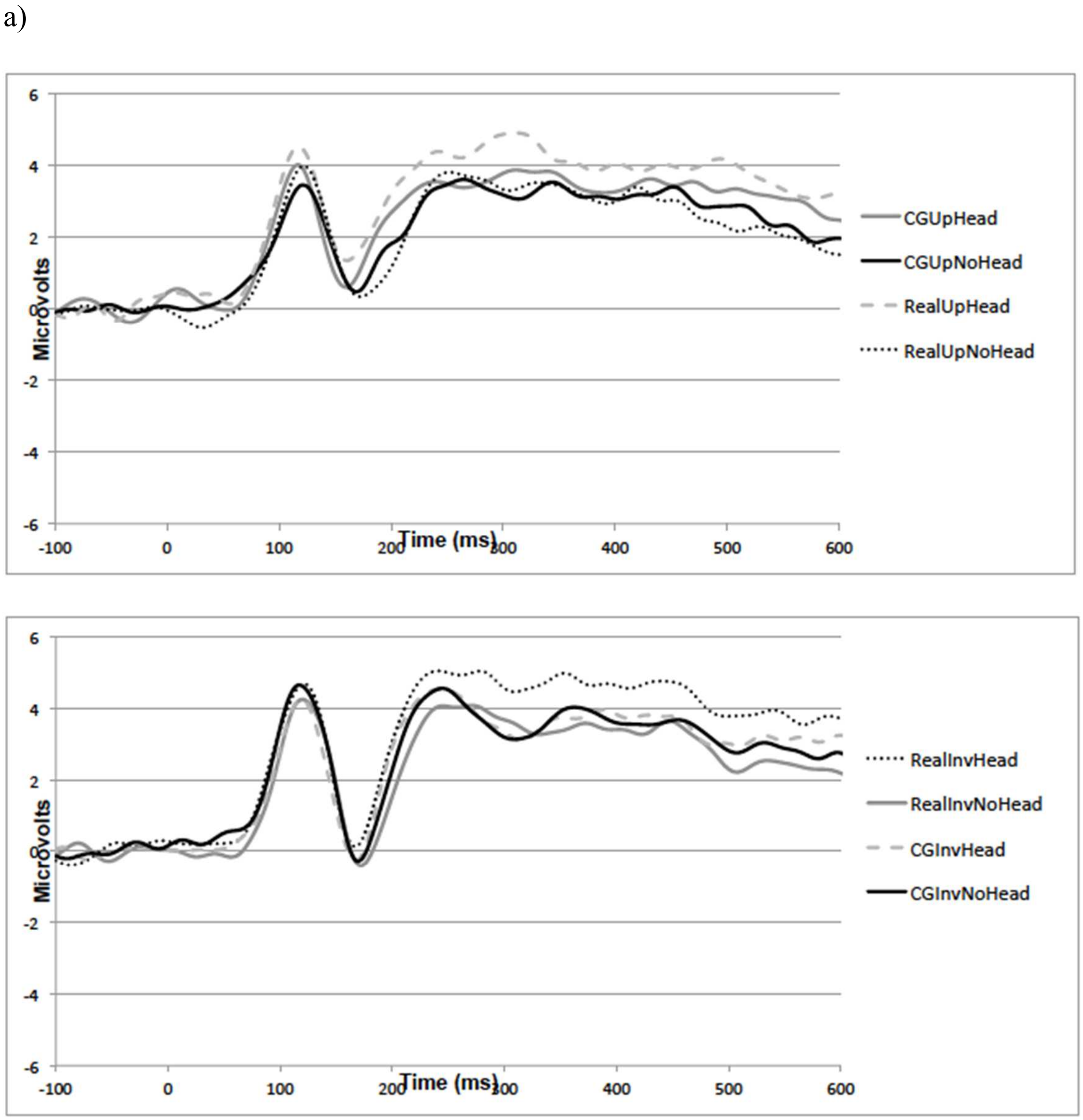

Figure 8. Grand averages for the left (a) and right (b) hemispheres measured for real and artificial bodies during the completion of the orientation task. Measurements were recorded over the occipito-temporal area. Overall, head absence had the greatest impact on perceptions of real human bodies.

b)

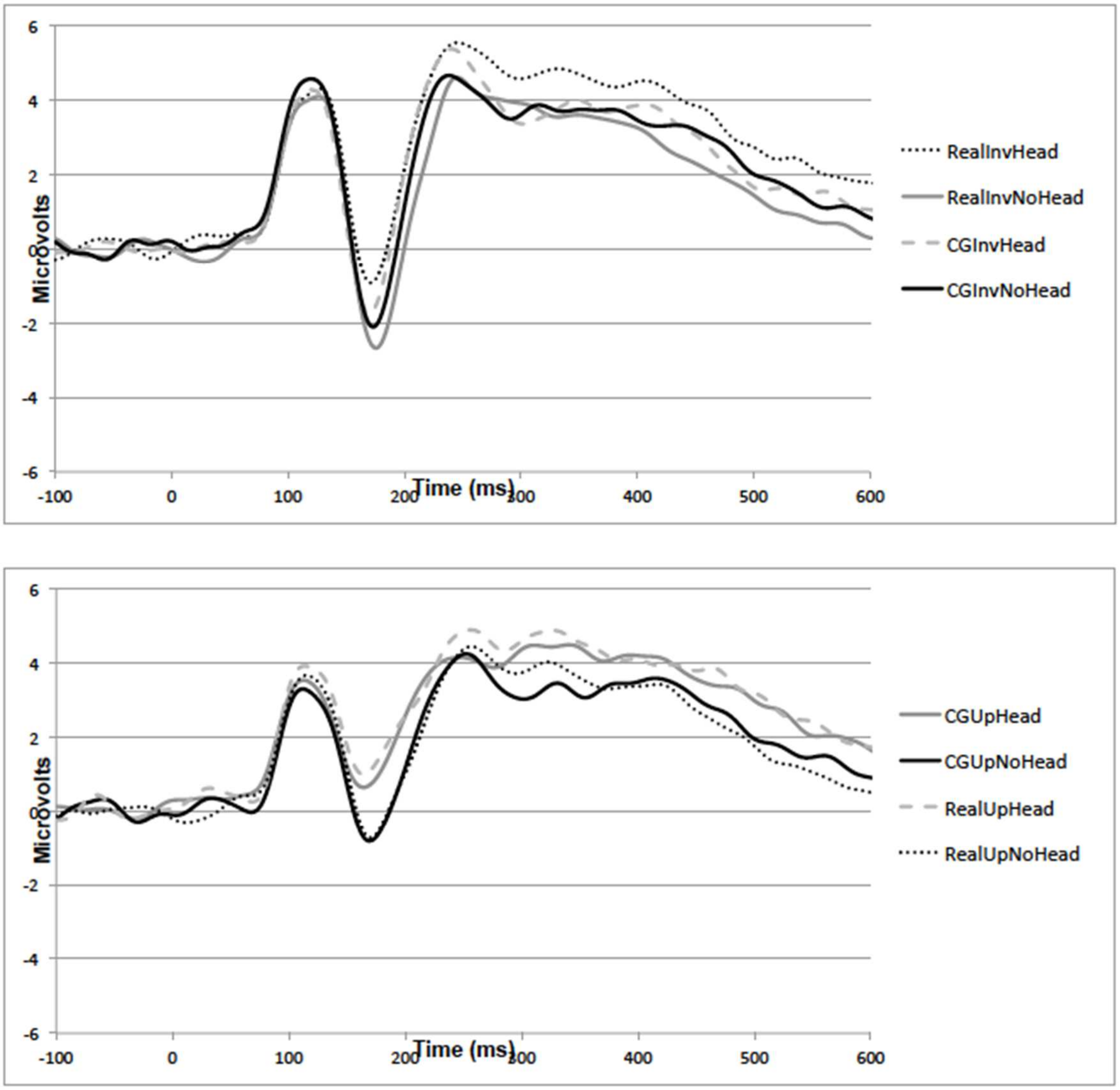

Figure 8. Grand averages for the left (a) and right (b) hemispheres measured for real and artificial bodies during the completion of the orientation task (continued). Measurements were recorded over the occipito-temporal area. Overall, head absence had the greatest impact on perceptions of real human bodies.

N170 minimum amplitude

I obtained main effects of orientation, ($F(1,15) = 13.66$, $p < .01$, $\eta^2_p = .48$), and head presence, ($F(1,15) = 5.74$, $p = .03$, $\eta^2_p = .28$). These main effects were driven by more negative peaks for inverted, ($M = -1.86$, $SE = .69$) than upright bodies, ($M = -.66$, $SE = .55$), and headless bodies, (M = -1.66, SE = .64), than whole faceless bodies, (M = -.86, SE = .62). I also obtained two-way interactions between body type and head presence, ($F(1,15) = 7.00$, $p = .02$, $\eta^2_p = .32$), as well as head presence and hemisphere, ($F(1,15) = 4.76$, $p = .05$, $\eta^2_p = .24$). Bonferroni-corrected pairwise comparisons revealed that the former interaction was driven by amplitude differences between whole and headless bodies for real ($p = .01$) but not artificial bodies ($p = .19$) and the latter interaction was driven by amplitude differences between whole and headless bodies in the right ($p = .01$) but not left ($p = .22$) hemisphere. No other factors or interactions reached significance, ($p > .05$).

N170 latency

I observed a main effect of head presence, ($F(1,15) = 13.02$, $p < .01$, $\eta^2_p = .47$), such that headless bodies, (M = 175.33 ms, SE = 3.44 ms), elicited a response that was significantly later than the response elicited by whole faceless bodies, (M = 170.79 ms, SE = 4.09 ms). No other factors or interactions reached significance, ($p > .05$).

Discussion

Results from this experiment showed that the visual system is sensitive to deviations from bodies' natural appearance. Amplitudes at both the P100 and N170 component differed between real and artificial body stimuli. At the N170, responses were more negative for real than artificial bodies. This real and artificial distinction is consistent with results obtained by Balas and Koldewyn (2013) who demonstrated sensitivity of the visual system to the nature of appearance at the N170 component. These authors compared neural responses to real and artificial human and dog faces and found that responses to the two differed but only when observers viewed real but not artificial human and dog faces. Their findings suggest that the nature of appearance modulates observers' perception for different species categories. In regards to the current findings, real and artificial appearances appeared to also play a role in the perception of complete vs. incomplete human bodies. First, similar to previous reports showing a difference between neural responses to whole and headless bodies (Minnebusch et al., 2010; Minnebusch et al., 2008), my results showed that head removal was associated with a delayed and enhanced N170 response to body images. More importantly, at the N170, responses to headless bodies were more negative for real compared to artificial bodies, suggesting that the perception of bodies is also modulated by deviations from natural appearance.

It is important to note, however, that I did not obtain this same effect in my second experiment. Such a discrepancy is likely due to differences in task demands. In Experiment 2, I asked observers to perform a same/different posture discrimination task whereas in this third experiment, I had observers perform an orientation task. The former task likely required observers to focus their attention towards subtle differences between features of the body (e.g., arms) when comparing the first and second image. Consequently, this shift in attention could have resulted the utilization of a less efficient processing strategy that does not involve the encoding of bodies as a whole. Thus, although body images were the same for Experiment 2 and 3, it is likely that result differences were due to a shift in their focus.

Also consistent with past research is the enhanced negativity of the N170's amplitude to upside down vs. upright human bodies (Stekelenburg & de Gelder, 2004; Minnebusch et al., 2010). Such a response has often been observed for the viewing of upright vs. inverted faces (Rossion & Gauthier, 2002; Itier & Taylor, 2004; Rossion et al., 2000). These results were possibly due to the recruitment of additional resources for visual processing since inversion often leads to greater difficulty in recognition (Rossion et al., 2000). In general, the inversion effects observed in this experiment supports a visual system that encodes body information in a way that is similar to the encoding system for faces.

In addition to the N170, I also detected differences at the P100 between perceptions of the two body types (real or artificial) and two orientations (up or inverted). There are studies suggesting that the P100 is sensitive to the perception of low-level features (e.g., contrast and luminance) (Itier & Taylor, 2004); however, Herrmann, Ehlis, Ellgring, and Fallgatter (2005) showed that this component is also sensitive to the perception of faces. These authors compared neural responses to faces vs. buildings, and faces vs. scrambled faces and found that the P100 amplitude for faces was significantly (a) larger and longer for faces than the amplitude for buildings, and (b) larger than the amplitude for scrambled faces. Herrmann et al. (2005) argued that these P100 responses were a reflection of an early face detection process; that is, an initial stage where faces are being categorized as a face (Liu et al., 2002) with little regards to facial structure. Herrmann et al. (2005) also argued that it is not until later in the visual process that face structure gets encoded. In regard to my results, it is possible that amplitude differences between real and artificial bodies are also a reflection of an early detection process such that real and artificial body appearances are being categorized into separate groups.

Furthermore, observers' ERP responses at the P100 elicited by real bodies and bodies presented upside down were significantly more positive than responses elicited by artificial bodies and bodies presented in the upright orientation (**Figure 8**). The larger response to real as compared to artificial stimuli is inconsistent with that obtained by Balas & Koldewyn (2013) who found the opposite to be true for faces. However, other studies on the perception of faces have shown more positive amplitudes at the P100 for faces than other non-face categories (e.g. houses) (Itier & Taylor, 2004; Rossion et al., 2000), suggesting that to some degree, more positive ERP responses reflect greater levels of familiarity for the perceived object. Thus, the difference between real and artificial bodies could be a reflection of greater familiarity with real versus artificial human bodies.

Finally, the effect of orientation obtained for bodies in this experiment suggest that perhaps all body images were being placed within the same object category, even though they may differ along various dimensions of visual appearance. In other words, body images were not necessarily grouped as either “bodies” or “non-bodies” but instead, were grouped as either real or artificial at this early stage of processing. As mentioned earlier, Herrmann et al. (2005) also argued that the encoding of structural information does not occur until later in the visual process, most likely at the N170 component, which would explain why the presence or absence of heads did not matter at the P100 component, but did at the N170 component. Overall, my findings suggest that the encoding of human bodies follow a process that is very similar to the encoding of human faces and, like faces, variations in appearance greatly impact the processing of body information.

GENERAL DISCUSSION

Human bodies can provide important social cues (e.g., gender, age, and emotional state) for successful interactions. Therefore, it is imperative that bodies be quickly recognized for the extraction of these cues. Overall, the findings from this study showed that variations in body appearance affected the visual process. First, discrimination of complete bodies (with heads) was better than that of incomplete bodies (without heads). Second, observers' ability to discriminate between images was better when bodies were real than artificial in nature. Finally, these performance differences were also observed at the neural level.

Experiment 1 results replicated those obtained by Brandman & Yovel (2012) showing that observers' discrimination of human bodies depended on the presence or absence of a head because whole bodies, but not headless bodies, led to the BIE. This result suggests that observers were using two separate processing strategies for the task. For whole bodies, it is likely that observers used a holistic approach that involved the encoding of body information as one whole unit. In contrast, for headless bodies observers may have used an approach that involved the encoding of featural information, a processing strategy that involves focusing on individual body parts (Tanaka & Farah, 1993).

Experiment 2 results showed that body processing also depended on the nature of appearance. Observers' performance for artificial bodies was lower than that for real bodies. However, the degree to which real and artificial bodies differed depended on bodies' orientation. When observers viewed bodies upside down, the nature difference was significantly larger than when observers viewed bodies in the upright orientation. In other words, the perceived difference in observers' performance between the two bodies increased when bodies were turned upside down. This difference is likely due to observers having considerably greater experience viewing the former than the latter type of body. Additionally, similar to results on headless bodies in Experiment 1, the lack of a BIE in the current experiment is possibly due to the limited amount of cues available in Experiment 2's body stimuli. Consequently, observers may have used a strategy that also does not involve a holistic approach. However, on a neural basis, when observers no longer had to rely on these cues, the BIE emerges.

Experiment 3 extended the findings from Experiment 1 and 2 by showing that variations in body appearance also impacted observers' perception of bodies at the neural level. First, real and artificial appearances did not have a direct impact on the N170 because there were no amplitude differences between the two types of bodies. However, head removal had the greatest effect on observers' perception for real human bodies suggesting that deviations from natural appearance may modulate the perception for certain forms of human bodies (complete vs. incomplete). More specifically, the N170 was significantly larger for real headless compared to real whole bodies. This result was in the opposite direction of my original hypothesis. I predicted that head presence/absence would have no effect on perceptions of real human bodies because a missing head would be compensated by observers having greater familiarity to real, as opposed to artificial, human bodies. Instead, this finding is more in line with past studies showing greater sensitivity to changes made to objects that observers are more familiar with (e.g. faces) (Bruce & Young, 1986; Diamond & Carey, 1986). In regards to the current results, it is likely that observers' perception of real bodies became much less familiar when heads were removed. Thus, the processing of headless bodies appears to be somewhat modulated by the degree of realism and the more realistic the body, the more susceptible the body system is to certain visual changes.

Second, P100 amplitudes also differed between real and artificial bodies but not between whole and headless bodies, suggesting that information related to the nature of visual appearance might actually be detected before structural information and the latter of which, might not occur until later in the visual process (Herrmann et al., 2005).

Past studies suggest there are at least 2 separate stages for processing face information; the initial stage is associated with face categorization followed by a second stage, where information such as faces' identity gets encoded (Liu, Harris, & Kanwisher, 2002). Based on the current and past findings (Reed et al., 2003), the human visual system appears to process body information similarly to the way it processes face information. Therefore, it is likely that these two stages are also being applied towards the encoding of bodies. The initial stage is reflected by ERP responses appearing as early as 100 ms post-stimulus onset. At this stage, body information is automatically detected and categorized (e.g., real or artificial). Additionally, the second stage is likely reflected by the behavioral results where information that is most relevant to observers is attended to and encoded (e.g. body posture).

Finally, contrary to the results obtained by Thierry et al. (2006), I did not observe a negative peak around 190 ms post-stimulus onset and this was consistent with other studies (Stekelenburg & de Gelder, 2004; Minnebusch et al., 2008) that also did not obtain a response within this time window. Thierry et al. (2006) have proposed this time window, which they termed the N190, is specific to human bodies, just as the N170 is known to be specific to faces (Rossion et al., 2000; Eimer, 2000). However, the current data indicates that responses are actually occurring closer to around 170 ms post-stimulus onset, which is most similar to the component for faces. Based on the current findings, it is more likely that the N170 encompasses not just faces but bodies as well. This result is less surprising if one considers that faces and bodies are often visually linked together.

Although my results showed that body appearance affects the processing of body information, they provided little information on how the demands of the task could also influence this process. In this study, the amount of cues available within each body pair could have affected the way observers approached the task and consequently, the way they encoded body information. Unfortunately, variations in task demands were not directly tested in this study but future research should examine the effects of task on body processing. Observers performed similar tasks in Experiment 1 and 2 but the occurrence of the BIE was not consistent across both experiments. Thus, future research should vary the actual task and/or variations in stimuli (e.g., adding or subtracting the number of cues available in stimuli pairs) in order to determine how these manipulations might influence the processing strategy that observers eventually use for processing. Also, this study only included body stimuli that were faceless (i.e. had no facial features). The purpose of using faceless bodies in this current study was to reduce the amount of influence that faces might have on body processing. However, faces and bodies are typically seen together; therefore, future research should examine the impact of both face and body information on observers' recognition.

Taken together, my study not only support past studies showing that bodies are a unique class of object because they are processed holistically (Reed et al., 2003), but it also suggest that the encoding of body information can be affected by (a) deviations from natural appearance and (b) the amount of available cues in pairs of body stimuli. The impact that deviations from natural appearance have on observers' ability to discriminate between images is likely due to these variations in body appearance lying on different locations within this hypothetical tuning curve for body recognition. In other words, the manner of processing depended on the degree to which body images are more or less “body-like.” The system’s sensitivity is greatest for bodies that are visually closest to natural appearance (e.g. complete and real) and least for bodies furthest away (e.g., headless and artificial). Being able to identify factors that can increase or decrease such sensitivity can better our understanding on how observers recognize other humans. Additionally, understanding this sensitivity can help us learn how the visual system’s boundary separate bodies from non-bodies based on observers’ own experiences.

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