Research report

People watching: The perception of the relative body proportions of the self and others

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ABSTRACT

We have an abundance of perceptual information from multiple modalities specifying our body proportions. Consequently, it seems reasonable for researchers to assume that we have an accurate perception of our body proportions. In contrast to this intuition, recent research has shown large, striking distortions in people's perceptions of the relative proportions of their own bodies. Specifically, individuals show large distortions when estimating the length of their body parts with a corporal metric, such as the hand, but not with a non-corporal object of the same length (Linkenauger et al., 2015). However, it remains unclear whether these distortions are specific to the perception of the relative proportions of one's own body or whether they generalize to the perception of the relative proportions of all human bodies. To assess this, individuals judged the relative lengths of either their own body parts or the body parts of another individual. We found that people have distorted perceptions of relative body proportions even when viewing the bodies of others. These distortions were greater when estimating the relative body parts of someone of the same gender. These results suggest our implicit full body representation is distorted and influences our perceptions of other people's bodies, especially if the other person's body is similar to our own.

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1. Introduction

As a social species, the human body is one of the most familiar objects that we encounter in our environment. Our own body is ever present in our perceptual experience, and we are constantly interacting with other individuals whose body morphology is roughly the same as our own. Hence, we have an abundance of perceptual information specifying the relative proportions of our own bodies as well as the bodies of others. Indeed, a wealth of research has shown that we are experts in recognizing human bodies and human motion (see Shiffrar, 2011 for review). Consequently, it stands to reason that our perceptions of body proportions should be extremely accurate. However, recent research counters this intuition. Individuals have been shown to have drastically distorted

visual perceptions of their own body proportions in that people perceive less tactilely sensitive body parts such as the torso as being proportionally longer relative to more sensitive body parts, such as the hand (Linkenauger et al., 2015).

Specifically, Linkenauger et al. (2015) had individuals estimate the length of different body parts using either their hand length or a baton (matched to the length of their hand) as a metric. When people used their hand as a metric, they drastically overestimated the length of their body parts. The amount of overestimation of each body part appeared to vary inversely with the amount of area on the somatosensory cortex associated with that body part. However, when people used the baton as a metric, the overestimations were greatly reduced or even eliminated. Using another tactilely sensitive body part as a metric, the foot, produced similar results as the hand. Yet when using a less tactilely sensitive body part, the forearm, people began to *underestimate* their body parts and were unbiased with a forearm length baton. These distortions were present even when individuals viewed their body in a full-length mirror, and were not present when estimating cylinders that were the same lengths as their body parts.

Linkenauger et al. (2015) explained these effects through a hypothesis that they referred to as *reverse distortion*. Body parts that perform precise motor movements require more detailed proprioceptive and tactile feedback to execute precision movements successfully (Mountcastle, 2005). Hence, some body parts, notably the hands, have many small, dense somatosensory receptive fields to support these types of movements leading to a larger representation of that area on the somatosensory cortex than other less sensitive body parts (e.g., Powell & Mountcastle, 1959; Sur, Merzenich, & Kaas, 1980). This difference in somatosensory receptive field distribution and somatosensory cortical representation presumably accounts for the experience that tactile stimuli feel larger on more sensitive body parts (popularly known as Weber's illusion; Weber, 1834/1996). However, the actual difference in perceived size across different body parts is only a fraction of what it should be if tactile size perception derives solely from the difference in body parts' representations on the somatosensory homunculus (Taylor-Clarke, Jacobsen, & Haggard, 2004). Consequently, the perceptual system likely employs a compensatory mechanism to achieve a commensurate degree of tactile size constancy across different body parts.

These aforementioned visual distortions of one's body proportions are an aspect of this compensatory mechanism, i.e., *reverse distortion*, because they appear to inversely relate to the ratio of body parts' somatosensory representation and the body part's actual size (Linkenauger et al., 2015). Put simply, these distortions *reverse* the distortions imposed by the differences in tactile receptive field sizes across different body parts. Several previous studies have shown perceived tactile size is modulated by changes to perceived body size, such as those induced by visual magnification (Taylor-Clarke et al., 2004), proprioceptive-tactile illusions (de Vignemont, Ehrsson, & Haggard, 2005), the rubber hand illusion (Bruno & Bertamini, 2010), auditory-tactile illusions (Tajadura-Jiménez et al., 2012), and tool use (Canzoneri et al., 2013; Miller, Longo, & Saygin, 2014). The co-existence of such effects with Weber's illusion suggests that tactile size perception results from the integration of information coming from distorted

somatotopic maps with higher-order representations of body size and shape. The idea of reverse distortion proposes that distorting the representation of the body part in the opposite direction may compensate for the differences in the size of the tactile representation. For example, consider that an object may feel larger on the hand than on the forearm due to the differences in the sizes of somatosensory receptive fields on these skin regions. However, if the hand is also experienced as much smaller than the forearm, then an object placed on the hand must be relatively smaller than an object placed on the forearm. Indeed, the tactile size perception of objects increases when the rubber hand illusion is used to make individuals feel as if their hand is larger (Bruno & Bertamini, 2010) or when a part of the body is visually magnified (Taylor-Clarke et al., 2004). In support of reverse distortion, when comparing a body part to a non-corporal object, these distortions become severely reduced in magnitude (Linkenauger et al., 2015).

Although previous findings clearly show that individuals perceive distortions in their own body proportions, it is unknown if we perceive such distortions in others. Presumably, if body distortions are indeed a compensatory mechanism to achieve tactile constancy, then there is no reason to predict distortions in the perceptions of others, as there is no perceptual tactile discrepancy to be corrected. That said, presumably, one would expect individuals to notice large differences between the experience of the proportions of their own body and the body proportions of others. Nevertheless, despite the propensity for dramatic distortions of one's own body as seen in individuals with eating disorders (Bruch, 1962; Cash & Deagle, 1997) and body dysmorphic disorder (Phillips, Didie, Feusner, & Wilhelm, 2008), most individuals do not seem to notice drastic differences between their own and other's morphologies. Due to humans being a social species, perceiving commonalities between our bodies and others' was likely important to interpret and predict the actions of others as well as emphasize social and emotional bonds (Aron, Aron, & Smollan, 1992). Indeed, developmental psychologists have argued that the ability to perceive conspecifics as being "like me" is at the core not only of social development, but also our sense of self (Meltzoff, 2007). Hence, in order to achieve consistency across our bodies and those of other, it is possible that we perceptually distort other individuals' bodies in the same manner as our own. Alternatively, it is also possible that our representation of our own body is used to identify and interpret the bodies of others. This possibility is supported by the abundance of research that has shown that we use our own motor system to simulate the movements of others in order understand their actions and intentions (Jeannerod, 2001). In support of this notion, people are amazingly adept at recognizing human biological motion in point light displays (Shiffrar, 2011). People are also better at interpreting biological motion when the point light displays are of their own motion or more similar to their own motion (see Shiffrar, 2008, for a review). Hence, if we map information specifying the bodily proportions of others onto our own body representations, we should also expect similar distortions when viewing the bodies of others. If this is the case, then the distortions should be greater when estimating the body proportions of individuals whose bodies are more similar to our own body

should be more easily mapped onto the lengths of our own body representations.

Because we are looking at similarity between relative bodily proportions (the relations between the sizes of body parts), we hypothesized that gender consistency of the viewer and the viewer may modulate these distortions, because males and females bodies differ proportionally. Consider that while tall males and females may have larger limb lengths, they differ greatly on their relative bodily proportions. Yet, while a tall and short female may differ in limb length, they will have much more similar relative bodily proportions. Specifically, females' torsos are longer and legs shorter relative to their male counterparts. Women's hands are typically smaller relative to their head length (Tilley, 1993).

In order to determine how individuals perceive the body proportions of others, we adapted the paradigm developed by Linkenauger et al. (2015); however, instead of estimating one's own body, participants estimated the extent of another person's body parts using either the other person's hand or a non-corporal object as a metric. We compared their estimates to estimates made when individuals estimated their own bodily proportions. Interestingly, people perceive the bodies of other individuals to be distorted to a similar magnitude as one's own body. Body perception distortions also appear to be modulated by inter-personal similarity, as overestimations were greater when the other individual was of the gender as the participant.

2. Methods

2.1. Participants

Sixty students (44 female) at Lancaster University participated in return for course credit in an introductory psychology course or through opportunity sampling. Participants' ages ranged from 18 to 32 years old (M = 19.55, SD = 1.96). Handedness was assessed through self-report (53 right-handed, 7 left-handed). All participants provided informed consent, had normal or corrected to normal vision, and had no visible morphological abnormalities.

2.2. Procedure

Prior to beginning the experiment, participants' hand lengths (from the intersection of the palm and wrist to the longest fingertip) were measured using a tape measure, but they were told these would be used for a later experiment. We used a 2 × 2 between subjects factorial design with estimates of the self versus other being one factor and the metric used, hand verses baton, as the other factor. We used a between subjects design in order to prevent participants from intuiting the commonality between the baton length and their hand. Participants were randomly assigned to one of four groups. In one group, participants estimated the lengths of another person's body parts (who hereafter we will refer to as "the model") using the model's hand as a metric. We had participants use the model's hand as a metric, because we wanted the task to be entirely about their perceptions of the relative proportions of another's body, not about the relationship between the

perceiver's body and another body. In the second group, participants estimated the lengths of the model's body parts using an adjustable metal baton as a metric. Unknown to the participant, the length of the baton was adjusted to be the same as the length of the model's hand. The third group estimated the lengths of their own body parts using their own hand as a metric. The final group estimated the lengths of their own body parts using a metal baton as a metric. Unbeknownst to the participant, the length of the metal baton was adjusted to be the same as the length of the participant's hand.

In all groups, participants were instructed they were to use the length of the metric (either the length of the baton or the hand, as defined by the palm-wrist intersection to the longest fingertip) to estimate the lengths of various body parts by saying how many multiples of the metric they were. Participants were instructed to estimate the length of the leg (as defined by the hipbone and the heel's bottom), torso (as defined by the top of the shoulder and the hipbone), arm length (on an outstretched arm, as defined by the bone protrusion on their shoulder to the longest fingertip), head (as defined by the chin bottom to the top of their head), the entire body (as defined by the top of head to heel's bottom), and foot (as defined by the back of the heel to the tip of the longest toe).

To investigate whether similarity between the model and perceiver influenced the perception of body proportions, we used two models: one male and one female. In the conditions in which the proportions of the model were estimated, gender of the model was counterbalanced across participants so that half of the participants estimated a male model and half of the participants estimated a female model. In the model conditions, the model stood in front of the participants with his or her hand length/baton length visible. In the baton condition, the model held the baton in a similar orientation and same distance from the participant as in the hand condition. The model also placed a fingertip on his or her hipbone to make it salient. The participant was allowed to instruct the model to adjust his or her position so that they could have a better view of the body part that he or she was estimating. The participant was also allowed to move and look at the model from various viewpoints. The participant was encouraged to feel comfortable in estimating the model. In the self conditions, participants were encouraged to look at their different body parts while making their estimates. In all conditions, participants were prevented from physically measuring their own or the models' body parts with the hand or the baton.

3. Results

Individuals' estimates were transformed into centimeters by multiplying hand length by the body part estimate. Accuracy ratios were computed by dividing their estimate by the actual length of the body part. Thus, if participants' estimates were perfectly accurate, then the accuracy ratio should be 1. Accuracy ratios over 1 indicated overestimation, and accuracy ratios under 1 indicated underestimation. The degree to which the ratio was above or below 0 could be considered the percentage of over/underestimation (e.g., 1.5 would be overestimated by 50%; whereas, .5 would be underestimated by 50%). While in some of our previous studies, we have used

percent overestimation as a dependent measure (e.g., Longo & Haggard, 2010, 2012), it is important to note that the difference between that and the present measure is essentially stylistic, and does not affect the conclusions drawn.

In order to assess the differences between conditions, we conducted a repeated-measures analysis of variance (ANOVA) with body part as a within subjects factor, metric type (hand vs baton) and person (self vs model) as between subjects factors, and accuracy ratios as the dependent measure. We found a significant effect of body part, $F(5, 280) = 27.43$, $p < .001$, $\eta_p^2 = .33$. As found in Linkenauger et al. (2015), the torso was the most overestimated body part, $M = 1.53$, $SE = .06$, and the foot was overestimated the least, $M = .98$, $SE = .02$, see Fig. 1.

We also found that individuals overestimated significantly more when using the hand as a metric, $M = 1.29$, $SE = .05$, than when using the stick as a metric, $M = 1.10$, $SE = .05$, $F(1, 55) = 7.93$, $p = .007$, $\eta_p^2 = .12$. We also found a significant interaction between body part and person, $F(5, 280) = 3.26$, $p = .007$, $\eta_p^2 = .06$. Based on visual inspection, this difference appears to be driven by accuracy ratios of the torso being much larger in the self than in the other body condition. Whereas in the other body condition, the torso remained the most overestimated part, but it did not differ drastically from the other body parts as in the self condition, see Fig. 1. Fuentes, Longo, and Haggard (2013) found that individuals severely misperceive the location of their own hipbone. Hence, this difference could result from the hipbone being more clearly specified on the model than on their own body (the model placed his or her finger on the hipbone).

Interestingly, there was no significant difference between the estimates of the self and the model, $F(1, 56) = 1.87$, $p = .18$, nor was there a significant interaction between metric and the person, $F(1, 56) = .03$, $p = .87$, suggesting that individuals perceived distortions in the body proportions of others, $M = 1.24$, $SE = .05$, as similar in magnitude as they perceived distortions in the body proportions of their own body, $M = 1.15$, $SE = .05$, see Fig. 2. There were no other significant interactions. Clear overestimation of body part size was found when the hand was used as a metric in both the self condition, $t(14) = 6.19$, $p < .001$, $d = 3.27$, and the other condition, $t(14) = 4.84$, $p < .001$, $d = 2.59$. In contrast, no such distortion was apparent when the baton was used, either in the self condition, $t(14) = 1.84$, $p = .09$, $d = .98$, or the other condition, $t(14) = .79$, $p = .45$, $d = .42$. Post-hoc tests reveal that there was no significant difference between self-other in the baton conditions ($p = .48$) or the hand conditions ($p = .18$).

If morphological similarity influences these distortions, we should expect individuals to overestimate more when their bodies are more similar to the model. In order to assess this possibility, we conducted another analysis, including only the data from the 'other' condition. Because we counterbalanced the gender of the model, we were able to create a gender congruency variable, in which we labelled participants as either having estimated a model of the same or of different gender. Due to the higher number of female participants, this resulted in 18 participants in the gender incongruent and 12 participants in the gender congruent condition. We conducted a repeated-measures ANOVA with body part as the within
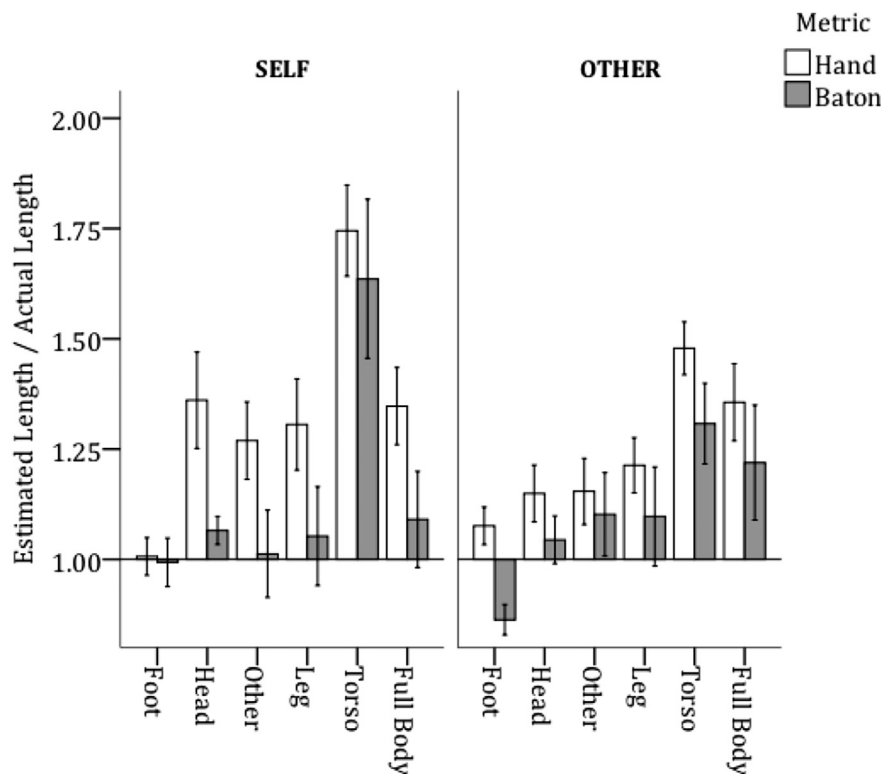

Fig. 1 — **Accuracy ratios for each body part in the self and other conditions and in the hand and baton conditions. Error bars represent ± 1 SE of the mean.**
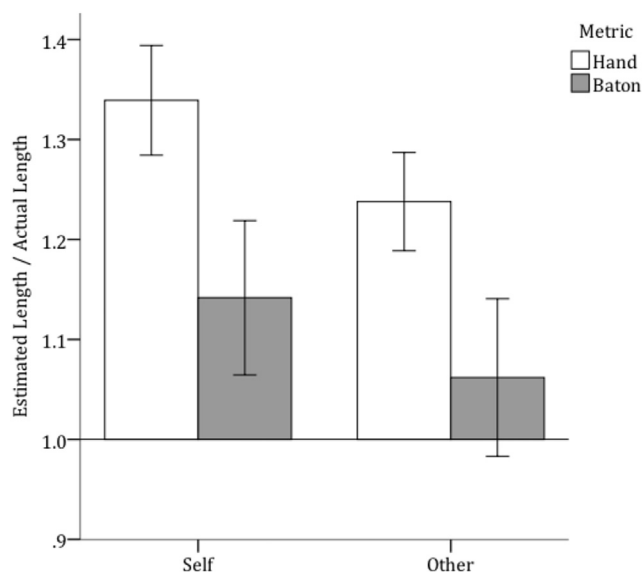
Fig. 2 — Accuracy ratios between the metric and person conditions collapsed across body part. Error bars represent ± 1 SE of the mean.

subjects variable, gender congruency as the between subjects variable, and accuracy ratios as the dependent measure. Body part was significant with the torso being overestimated the most, $M = 1.40$, $SE = .06$, and the foot the least, $M = .97$, $SE = .04$, $F(5, 140) = 14.52$, $p < .001$, $\eta_p^2 = .34$. Congruency of gender was significant, $F(1, 28) = 8.03$, $p = .008$, $\eta_p^2 = .22$, with individuals in the gender congruent condition, $M = 1.30$, $SE = .07$, overestimating body lengths more than individuals in the gender incongruent condition, $M = 1.05$, $SE = .06$, see Fig. 3.

In order to assess whether these findings were a result of the gender of the participant or the gender of the model rather than gender similarity, we conducted two ANOVAs similar to the previous, except that instead of gender congruency as the between subjects variable, we used either participant gender or model gender as the between subjects variable. Neither the gender of participant, $p = .30$, $\eta_p^2 = .04$, nor the gender of the model, $p = .48$, $\eta_p^2 = .02$, had a significant effect on accuracy ratios suggesting that the difference as a result of gender congruency was not driven by either the participants' or the models' gender.

4. Discussion

These results display clear distortions in the perception of the relative lengths of the human body. These distortions are systematic in that certain body parts are consistently over-estimated more than others. Surprisingly, these distortions persist not only when perceiving the self, but also when perceiving others. When perceiving others, distortions were more pronounced when the observed individual was of the same gender as the perceiver, suggesting that morphological and/or social similarity plays a role in these distortions. Hence, even in the event that we have sufficient visual information to accurately perceive other people's bodies, we do not see the morphology of the human body as it is, but rather we see the human body as being systematically dysmorphic.

These findings replicate and extend those of Linkenauger et al. (2015) as here we found that participants over-estimated their body parts by roughly 30% on average when using their hand as a metric. As in previous research, individuals overestimated their relative body proportions more when using their hand than when using a non-corporal object
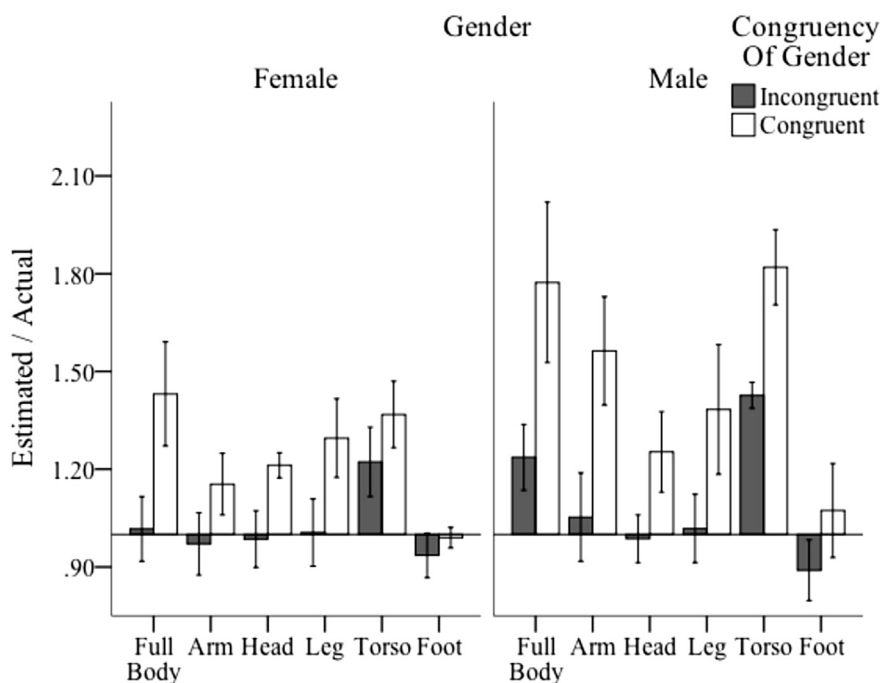

Fig. 3 — Accuracy ratios for each body part when the model was gender congruent and gender incongruent across female and male participants. Error bars represent ± 1 SE of the mean.

of the same length. This difference between the hand and baton is consistent the notion of reverse distortion in which less sensitive skin surfaces are perceived as smaller than body parts with larger somatosensory receptive fields. Possibly, reverse distortion acts to counteract tactile distortions inherent in the organization of the somatosensory system to achieve some degree of tactile size constancy (Linkenauger et al., 2015). Consequently, these distortions are most apparent when perceiving the relationships between body parts (e.g., measuring with the hand) than when perceiving the relationship between a body part and non-corporal object (e.g., measuring with the baton). Regardless of the metric, across all individuals in all conditions, certain body parts were systematically more overestimated than others; the less tactilely sensitive torso was usually the most overestimated body part and most tactilely sensitive foot was the usually most underestimated body part. This pattern in over-estimation is also consistent with the notion of reverse distortion.

Though not significant, the distortions in others appear to be slightly smaller in magnitude than distortions in oneself. This trend is possibly a result of the gender consistency effect; specifically, when estimating the bodies of others, the distortions are lessened when estimating the bodies of individuals whose gender is different from one's own. Because 18 out of 30 individuals in the 'other' condition estimated a body of a different gender, this trend is not surprising. Most importantly, however, we found the same pattern of results across body parts for one's self and others. Additionally, we found significant distortions between when using the hand in both the self and other conditions, but no evidence of distortions when using the baton. With these results, we can be reasonably sure that perceptions of others bodies are distorted in a similar manner as our own bodily perceptions.

Individuals also have distorted perceptions of other people's body proportions, which seems on the surface, quite surprising, as we have an abundance of visual information specifying our perceptions of other individuals, even more so than our own bodies. Additionally, vision is typically considered more spatially accurate, and many of the distortions in body perception are thought to originate from differences in somatosensory acuity across different body parts (see Longo, 2015, for a review). Yet, the relative distortion of each body part of other individuals follows the same pattern as when viewing oneself, which seemingly varies inversely with the size of the body part's representation in the somatosensory cortex.

We can interpret these results in several different ways. Firstly, individuals could project distortions on to their perceptions of other's body in order to maintain some form of morphological similarity between one own body and those of others. However, having a distorted perception of others' body proportions lacks utility in this context. Additionally, this explanation does not explain why gender congruency would modulate distortions.

Alternatively, individuals could use their own body representations in order to identify and interpret the bodies of others (Meltzoff, 2007). This explanation is similar how biological motion from point light displays is identified and interpreted. Seemingly, we map biological motion from point light displays onto our own bodily representation using our own egocentric motor system (Saygin, Wilson, Hagler, Bates, & Sereno, 2004). By using our own body representations, we are able to gain a better understanding of other people's actions (Shiffrar, 2011). This assertion is supported by research showing that the same areas of the brain associated with overtly performing an action, such as the premotor and intraparietal cortices, become activated merely when viewing another person perform that same action (Decety & Grezes, 2006; Grezes et al., 2001; Roth et al., 1996; Saygin, 2007). Additionally, performing an overt action simultaneously interferes with the identification of biological motion in a point light display, but only if the overt action being performed is similar to the action being presented in the point light display (Jacobs & Shiffrar, 2005). Presumably, performing a similar action engages the motor areas required to identify the biological motion, which consequently, inhibits the perceptual system from recruiting those resources to identify the biological motion.

The findings in this experiment suggest that it is possible that we recognize the human body by using our own body representation leading to distortions in the perceptions of other's body proportions. This explanation also fits in quite nicely with the finding that overestimations of body parts lengths were in part modulated by gender congruency. If the morphological structure of the perceiver is more similar to the individual who they are viewing, it is easier to map the visual information specifying their body onto one's own body representation, and thereby, increasing the perceived distortions in their body proportions.

It remains uncertain, however, at what level of abstraction similarity between self and other is modulating estimation of bodily proportions. Research in social cognition has revealed widespread modulation of perception and neural processing by similarity in racial or ethic background (e.g., Serino, Giovagnoli, & Làdavas, 2009) and even characteristics such as political affiliation (e.g., Mitchell, Macrae, & Banaji, 2006; Serino et al., 2009).

One could argue, then, that the gender consistency effect may be due to gender consistency leading to different patterns of looking when viewing someone of the same gender versus someone of the opposite gender. Evidence from point light walker displays illustrates that what people attend to varies on the task goal (Johnson & Tassinary, 2005). For example, if the goal of the task is to disambiguate gender, people viewing point light displays of walkers, naturally fixate on the same morphological aspects of the walker (i.e., waist to hip ratio), but this pattern is greatly attenuated when the gender the walker has been prespecified (Johnson & Tassinary, 2005). When looking patterns do differ, in the above instance when gender is prespecified, it could be due to individuals extracting different information in order to fit their body model onto the other person. Consequently, different looking patterns between viewing inconsistent and consistent gender could be a mechanism as to how the body model is fitted to one's own.

These results fit into a larger body of work showing that, contrary to our intuitions, our perceptions of our body are quite distorted (see Longo, 2015, for a review). However, most of our knowledge of distortions in body perception stem from atypical populations (e.g., body dysmorphia) or are limited to

perceived distortions in one isolated body part (example). Here, we extend this research by showing large distortions across the whole body and distortions in the relative proportions of our body parts, and surprisingly, also we show that these distortions also extend to our perceptions of the relative proportions of other individuals' bodies as well.

Acknowledgments

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