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# Perceived distance and obesity: It's what you weigh, not what you think☆

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ABSTRACT

Action abilities are constrained by physical body size and characteristics, which, according to the action-specific account of perception, should influence perceived space. We examined whether physical body size or beliefs about body size affect distance perception by taking advantage of naturally-occurring dissociations typical in people who are obese but believe themselves to weigh less. Normal weight, overweight, and obese individuals made verbal distance estimates. We also collected measures of beliefs about body size and measures of physical body size. Individuals who weighed more than others estimated distances to be farther. Furthermore, physical body weight influenced perceived distance but beliefs about body size did not. The results illustrate that whereas perception is influenced by physical characteristics, it is not influenced by beliefs. The results also have implications for perception as a contributing factor for lifestyle choices: people who weigh more than others may choose to perform less physically demanding actions not as a result of how they perceive their bodies, but as a result of how they perceive the environment.



According to the action-specific account of perception, a person's ability to perform an action influences spatial perception (Witt, 2011a). For example, softball players who are hitting better than others see the ball as bigger (Gray, 2013; Witt & Proffitt, 2005), archers shooting better than others see the target as bigger (Lee, Lee, Carello, & Turvey, 2012), and tennis players who are playing better than others perceive the ball to be moving slower (Witt & Sugovic, 2010). There are many factors that influence a person's ability to perform an action, and previous research has documented that many of these factors also influence perception. These factors include body size (e.g. Linkenauger, Witt, & Proffitt, 2011; Van der Hoort & Ehrsson, 2014; van der Hoort, Guterstam, & Ehrsson, 2011), task difficulty (e.g. Kirsch, Herbort, Butz, & Kunde, 2012; Kirsch & Kunde, 2013a, 2013b; Witt & Sugovic, 2010; Witt & Sugovic, 2012), and the energetic costs associated with performing the action (e.g. Bhalla & Proffitt, 1999; Eves, Thorpe, Lewis, & Taylor-Covill, 2014; Taylor-Covill & Eves, 2013, 2014). However, despite the growing literature demonstrating these action-specific effects, little research has examined the role of beliefs about action. In the current study, we examined whether beliefs about abilities influence perception, and if so, if this effect of beliefs is in addition to or is responsible for previously reported effects of physical abilities on perception.

Resolving which factors contribute to spatial perception will have implications for theories of vision. On one hand, it is irrelevant whether action-specific effects are driven by physical characteristics versus beliefs because both would show non-optical, and therefore top-down, influences on vision. Bottom-up influences refer to information detected by the eye itself, namely optical information, and all other non-optical sources are considered to be top-down influences. Regardless of whether physical characteristics or beliefs about the body are the relevant factor, either would demonstrate a top-down influence on perception. On the other hand, the determination between physical characteristics and beliefs is critical because it would resolve the nature of these top-down, non-visual influences. Beliefs about the body are of a similar category to classic conceptions of top-down influences such as knowledge and expectations. A finding that beliefs influence spatial vision would challenge models of vision that considered spatial vision to be immune to top-down influences (see Cavanagh, 1999; Firestone & Scholl, 2014, in press). In contrast, an effect based on physical characteristics rather than beliefs might reveal a different kind of top-down influence for spatial vision. For example, an effect based on unconscious physical abilities rather than on conscious beliefs would preserve the idea that spatial vision is cognitively impenetrable because what is known (or thought or believed) would not exert an influence on vision (Fodor, 1983; Pylyshyn, 1999, 2003). In addition, the source of the information that feeds back to visual areas would differ depending on if the influential factor were beliefs or physical factors. Thus, in order to determine what kind of top-down effect is supported by action-specific effects, we set out to determine the unique contributions of beliefs versus physical characteristics.

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Prior research on action-specific effects is consistent with both interpretations. Beliefs could play a role in spatial perception because even though physical abilities are typically manipulated, people's beliefs about their abilities often highly coincide with their physical abilities (e.g. Mark, 1987; Warren, 1984). Consequently, previous effects of a person's ability to act on perception could in fact be the result of effects based on beliefs about action. In some experiments, researchers measured beliefs as a way to assess ability. For example, in a study on the relationship between Parkour and perceived wall height, the participants rated the ease with which they could climb each wall, and no physical measurements were taken (Taylor, Witt, & Sugovic, 2011). The goal was to assess physical abilities, not specifically beliefs about abilities, with the notion that people tend to be accurate so their judgments could be used as a proxy for their abilities.

In an experiment on golfers, the researchers measured both physical performance and subjective measures of performance (Witt, Linkenauger, Bakdash, & Proffitt, 2008). Physical performance was assessed as course score after playing a round of golf. Participants were asked to rate their performance by indicating, on a scale of 1 to 7, their putting abilities in comparison to similarly-skilled players, their putting abilities on that day relative to their own typical abilities, and their overall play on that day relative to their own typical play. None of these measures (nor the composite score) related to perceived golf hole size, whereas course score (i.e. physical performance) was significantly correlated with perceived hole size. In this case, participants' assessments or beliefs about their own abilities were only moderately correlated with physical performance ($r = .14$, $r = .15$, $r = .48$; respectively). This discrepancy between physical and believed performance allowed for the assessment of the independent contributions for each, and the evidence favored the significant role of physical abilities, but not believed abilities.

Another area in which beliefs do not always align with physical characteristics is with respect to body size. Many people who are obese believe that their body is physically smaller than its actual size (Kuchler & Variyam, 2003; Truesdale & Stevens, 2008). This dissociation between physical body size and believed body size allowed us to determine the independent contributions of beliefs and physical characteristics on the perception of distance.

A person's ability to perform an action is naturally influenced by his or her physical body size. An organism's morphology, or somewhat permanent body structure, places a constraint on what the organism is capable of doing (see Proffitt & Linkenauger, 2013). For example, a person's arm length determines the range of objects that can be reached. A person's leg length determines the maximum step height they can take, and a person's body height determines what barriers they can walk under without bending. Different body sizes naturally permit some actions and hinder other actions. As a result, body size determines which actions are possible.

Consequently, according to recent research, body size also influences perception of the environment. For example, shoulder width affects perception of aperture widths (Stefanucci & Guess, 2009). Participants with broader shoulders who would have more difficulty passing through constricted doorway widths perceived the doorway widths to be narrower than did those with narrow shoulders. Modifications to the body also result in changes in perception. In a series of experiments, participants were asked to judge the distance to a target placed just beyond arm's reach. Arm length was functionally extended via use of a reach-extending tool. When using a tool, the objects appeared closer than when the tool was not used or when a short tool was used (Bloesch, Davoli, Roth, Brockmole, & Abrams, 2012; Osiurak, Morgado, & Palluel-Germain, 2012; Witt, 2011b; Witt & Proffitt, 2008; Witt, Proffitt, & Epstein, 2005).

Another technique to manipulate body size has been to render the body as being different sizes in a virtual environment. In one series of studies, the entire body was rendered as twice or half its size (Van der Hoort & Ehrsson, 2014; van der Hoort et al., 2011). In another series of experiments, the hand was rendered as larger or smaller (Linkenauger, Leyrer, Buelthoff, & Mohler, 2013) or the arm was rendered as longer or shorter (Linkenauger, Bulthoff, & Mohler, 2015). These studies found significant effects of rendered body size on perceived distance to and size of external objects. Objects looked smaller or closer when the body or hand was rendered bigger and the arm was rendered smaller.

Virtual reality allows for a dual-reality: participants can know that their bodies appear bigger even if their bodies are not actually bigger. Thus, it is unclear how results using virtual reality fit into the discussion about beliefs versus physical attributes. Certainly physical body size was not manipulated, but beliefs about one's own (physical, not virtual) body are also unlikely to be influenced. After experiencing a virtual body that is bigger, participants do not believe their own bodies to be any different in size than after experiencing a virtual body that is smaller (Piryankova et al., 2014). While virtual reality is a wonderful tool for some research questions, the results with studies using virtual reality do not directly address the current question of interest.

In addition to structural constraints, the size of the body also places energetic constraints on action. Those who weigh more than others must carry a heavier load, so walking incurs a higher energetic cost. Energetic costs influence spatial perception. Hills appear steeper and distances appear farther to people who carry a heavy backpack (Bhalla & Proffitt, 1999; Proffitt, Stefanucci, Banton, & Epstein, 2003). Staircases appear steeper to perceivers who weigh more than others (Eves et al., 2014) or who are fatigued (Taylor-Covill & Eves, 2013). Distance across a gap appears farther to observers wearing ankle weights compared with observers who do not carry the extra weight (Lessard, Linkenauger, & Proffitt, 2009). Objects on a ground appear farther to observers who intend to throw a heavy ball compared with observers who throw a light ball (Witt, Proffitt, & Epstein, 2004). Walking specified distances presented up a hill requires more energy, and also appears farther, compared to distances presented on flat ground (Stefanucci, Proffitt, Banton, & Epstein, 2005; White, Shockley, & Riley, 2013). These studies show that the energetic costs associated with traversing a space influences perception of that space.

In order to test the separate effect of beliefs and physical abilities on perceived distance, we took advantage of a naturally occurring dissociation often found in people who are obese. Based on the previous research on energetic costs and distance perception, we expect that people with body sizes bigger than others will see distances as farther. To the extent that physical body size and beliefs about body size differ, we can determine the unique contribution of each factor.

## 1. Method

### 1.1. Participants

Seventy-six people participated in the experiment. Participants were community members who were recruited outside of a local superstore. Two participants had a problem understanding the task and two were excluded due to experimenter data logging errors. One participant was deemed a statistical outlier because his mean distance judgment was more than three standard deviations from the group mean, and another was excluded because one estimate was so much farther than her other estimates, even though it was not for the farthest target, and excluding her was necessary to fit statistical models. Four participants were also excluded because they classified morbidly obese. People who are morbid obesity also tend to have cognitive impairments (Smith, Hay, Campbell, & Trollor, 2011).

The final sample included sixty-six people (30 female, 36 male) between the age of 18–50 ($M = 24.4$ years old, $SD = 6.53$). According to the standard Body Mass Index (BMI) classification system, 23 were at a normal weight ($18.5 \leq \text{BMI} < 25$; 8 female, 15 male), 21 were overweight ($25 \leq \text{BMI} < 30$; 11 female, 10 male), and 22 subjects were obese ($\text{BMI} \geq 30$; 11 female, 11 male). Participants were naïve to the purpose of the experiment and received a bag of chips for participation.