Body-based perceptual rescaling revealed through the size–weight illusion

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Received 20 June 2011, in revised form 15 August 2011

Abstract. An embodied approach to the perception of spatial layout contends that the body is used as a ‘perceptual ruler’ with which individuals scale the perceived environmental layout. In support of this notion, previous research has shown that the perceived size of objects can be influenced by changes in the apparent size of hand. The size–weight illusion is a well known phenomenon, which occurs when people lift two objects of equal weight but differing sizes and perceive that the larger object feels lighter. Therefore, if apparent hand size influences perceived object size, it should also influence the object’s perceived weight. In this study, we investigated this possibility by using perceived weight as a measure and found that changes in the apparent size of the hand influence objects’ perceived weight.

To determine whether actions can be performed across a given extent, visual information specifying the extent must be scaled to the action capabilities of the body. Recent perspectives on perceiving spatial layout have proposed that action capabilities serve as perceptual rulers to scale visual information (Proffitt and Linkenauger, in press). Accordingly, the environment is perceived relative to the possibilities for action.

Specific studies have examined the influence of hand size and/or the maximum grasping ability of the hand and its influence on the perception of object size. According to embodied perceptual-scaling perspectives, by increasing the ability of the hand to grasp larger objects—through increases in the perceived size or action capabilities of the hand—the size of the perceptual ruler used to scale the optical information specifying the sizes of graspable objects increases as well. If this is the case, then when the action capabilities of the hand are larger, then objects are perceived to be smaller, because they measure as smaller on the larger perceptual ruler.

A recent study demonstrated a phenomenally noticeable change in size perception resulting from hand-based rescaling. Specifically, when globally enlarging the environment by wearing magnifying goggles, individuals perceive objects as smaller when their hand is visible next to the objects than when their body is not visible (Linkenauger et al 2010; hereafter referred to as the rescaling effect). Participants reported that the size of the object appeared to visibly shrink when they placed their hand next to the object. Presumably, when the object was viewed in the absence of the hand, perceivers scaled optical information specifying the size of the object to the known, unmagnified size of the hand. As a result, the magnified optical information measured as larger on one’s known hand size. However, when individuals place their hands next to the object and the hand is magnified as well, the optical information specifying the size of the object is rescaled to the magnified hand, thereby making the object appear smaller. By including objects of known size in this experiment, it was shown that the sight of one’s hand is not simply an instance of scaling via familiar size.
To investigate the rescaling effect more closely, we utilized a well documented, reliable illusion in the literature, known as the size–weight illusion. The size–weight illusion can be described as a phenomenon in which large objects of the same weight feel lighter than objects that are smaller (Charpentier 1891). Therefore, if rescaling really influences perceived size, then by virtue of the size–weight illusion, objects should feel heavier if the hand is visible, because the object is perceived as smaller.

To test this possibility, forty-nine participants were randomly assigned to one of two conditions: visible hand or nonvisible hand. Participants sat at a table while wearing magnifying goggles. Participants were asked to close their eyes while one of eight bean bags (ranging from 45 g to 150 g) was placed in front of them. Participants in the visible-hand condition placed their right hand next to the bean bag, whereas individuals in the nonvisible-hand condition kept their right hand in their lap out of view. Individuals placed their left hand into a box, which occluded the hand. Inside the box, there were two levers, each attached to a pulley. One pulley lifted the visible bean bag and the other lifted an unseen basket into which weights could be placed. Using this device, participants could lift both the visible bean bag and comparison weights, and thereby experience their felt weights. Participants instructed the experimenter to place weights in the unseen basket until they thought that the weight in the basket matched the weight of the bean bag. The starting weight in the basket was always half the weight of the bean bag that the participant was presently estimating. Participants were allowed to request two different types of increases in weight: large, which corresponded to an increase in ~10 g, and small, which corresponded to an increase in ~3 g.

Data from three participants were excluded because their mean-weight estimates varied ±2.5 standard deviations from the group mean. A repeated-measures ANOVA was conducted with actual bean bag weight as the within-subjects factor and hand visibility as the between-subjects factor, and with estimated weight as the dependent variable. As predicted, individuals in the visible-hand condition \((M = 98.00 \, \text{g}, \, \text{SE} = 2.09 \, \text{g})\) estimated the weight of the bean bags to be more than those in the nonvisible-hand condition \((M = 90.98 \, \text{g}, \, \text{SE} = 2.09 \, \text{g}, \, F_{1, 44} = 5.67, \, p = 0.02, \, \eta^2 = 0.11 — \text{see figure 1})\).

**Figure 1.** Difference in weight estimates between hand visibility conditions. Error bars represent ±1 SE of the mean.
Interestingly, we found a negative correlation between hand width and mean object weight ($r = -0.31$, $p = 0.04$, two-tailed test—see figure 2). This suggests that individuals with smaller hands likely perceived the object to be larger and, therefore, heavier; this finding also supports body-based scaling accounts. This is not due to differences in the larger hands’ better lifting ability, because this would have affected both the perceived weight of the basket and the perceived weight of the bean bag in a similar manner.

These results provide support for the notion that the perceived sizes of graspable objects are scaled to the apparent size of the hand through the indirect measure of weight perception. This result is also supported by similar findings that increases in perceived hand size via the rubber-hand illusion can influence perceived object weight (Haggard and Jundi 2009). Indirect measures of perception have the virtue of being less susceptible to intrusions of knowledge or beliefs into participants’ judgments (Loomis and Philbeck 2008). Similarly, not only do changes in the visual perception of size of self influence size-judgments of other objects, they also change the expectation of how heavy those objects will be.

References
Charpentier A, 1891 “Experimental study of some aspects of weight perception” Archives de Physiologie Normale et Pathologique 3 122–135
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