NOTES AND COMMENT

Affordances matter in geographical slant perception

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We argue that the experimental conditions in the Durgin et al. (2009) study were so different from those in Bhalla and Proffitt (1999) that the results of the former study cannot be generalized to the latter. The participants in the Durgin et al. study viewed a 2-m-long ramp; those in Bhalla and Proffitt viewed expansive hills. When drawing generalizations from one study to another, equating experimental conditions is always important; moreover, from an embodied perspective on perception, equating the opportunities for action also matters.

Bhalla and Proffitt (1999) presented four studies that showed that hills appeared steeper when people were fatigued, encumbered, of low physical fitness, elderly, and in declining health. In all of these studies, the following three dependent measures were taken: a verbal report, a visual matching task, and a manual adjustment of a tilting palm board. Across these four studies, we found that the measures of explicit awareness, verbal report, and visual matching were affected by the factors listed above, whereas the implicit visual guidance of action measure, palm board adjustment, was not.

The Bhalla and Proffitt (1999) article was a follow-up to an earlier article that showed that, in general, the slant of hills is greatly overestimated in explicit awareness (Proffitt, Bhalla, Gossweiler, & Midgett, 1995). For the verbal and visual measures, 5° hills are judged to be about 20°, and 10° hills are judged to be about 30°. Indeed, participants are often incredulous when we tell them that the hill that they just judged to be 20° is, in fact, only 5°. This general overestimation is evidence of psychophysical response compression (specifically, perceived slant plotted as a function of distal slant conforms to a power function with an exponent less than 1), which has the pragmatic virtue of increasing people's sensitivity to small changes in the slant of hills shallow enough to be traversed. (I have not argued that this utility is the principal cause for the psychophysical function's form. There are important optical determinants to the form of this function [Proffitt, 2006].)

We have proposed that adjusting the palm board is a visually guided action not relying upon explicit perception. When people view a 5° hill, they do not raise their feet to accommodate a 20° incline consistent with their explicit perception. Increasingly, research is finding cases

in which the visual guidance of action relies on control heuristics that bypass the need to represent spatial layout (cf. Fajen, 2007). Visually guided actions need to accurately accommodate to the environment without necessarily representing its layout. Consistent with this notion is our finding that bioenergetic manipulations, such as wearing a backpack, never affect palm board adjustments, even though they do influence verbal and visual assessments of slant.

In Bhalla and Proffitt (1999), we began to develop a bioenergetic account of spatial perception in which the scaling of large spatial layouts is related to the bioenergetic costs associated with performing relevant actions such as walking. With respect to the backpack manipulation, we argued that climbing a hill while wearing a heavy backpack would require greater energy from the climber than would climbing a hill not wearing a backpack. Perceiving steepness in terms of the energy needed to climb hills would, thereby, cause hills to appear steeper to the climber with a heavy backpack.

In their article, Durgin et al. (2009) presented an experiment, the results of which were interpreted as showing that the influence of wearing a heavy backpack on verbal reports may be due to demand characteristics, not changes in perception. The experimental conditions in Durgin et al.'s study were so different from ours that I am unconvinced that their results generalize to our 1999 study. Figure 1 depicts the essential differences in the size of Durgin et al.'s experimental setup to the left and the hills used in our study to the right. As should be obvious, our hill would require considerable energy to ascend, whether or not a backpack was worn. A requirement in all of our studies was that the hills be of considerable length and that the hills' crests be well above eye height. That is, there had to be a real energy cost to climbing the hill. In the Durgin et al. experiment, the "hill" consisted of a 1 × 2 m ramp, which was viewed indoors. Participants were instructed to look at a fixation marker in the middle of the board and make verbal reports in the following two conditions: (1) standing in front of the ramp and looking down on it, and (2) standing on the ramp and responding on the basis of haptic feel. Durgin et al. cleverly manipulated the experimental plausibility for wearing a backpack, and found that, relative to unencumbered participants, people were inclined to report steeper values only when they felt that there was no experimental purpose to the backpack other than to affect their slant judgments. From this finding, Durgin et al. concluded that the effect of wearing a backpack on slant judgments in their study reflects a demand characteris-

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Figure 1. The left and right panels present essential differences in the sizes of the experimental setups for Durgin et al. (2009) and Bhalla and Proffitt (1999), respectively. In Durgin et al., the incline consisted of a 2-m-long ramp. By contrast to what is depicted here, in their study a 1×2 m board was placed on stairs. The right panel shows one of the hills used by Bhalla and Proffitt.

tic, not a change in perception. This conclusion seems to me warranted. What is not warranted is the conclusion that Durgin et al.'s findings generalize to our (Bhalla & Proffitt, 1999) study.

I would not predict that the bioenergetic costs of ascending the ramp in Durgin et al.'s study would influence people's slant perceptions. At most, participants could take a step or two on the board. Effort is not relevant. The experimental setup in Durgin et al.'s study and the one in ours do not generalize one to the other. Durgin et al. induced demand characteristics in their situation, in which bioenergetics was irrelevant; however, this does not imply that encumbrance always induces demand characteristics, whether or not bioenergetics is relevant. More importantly, the theoretically interesting question is not whether wearing a backpack can, in some circumstances, induce a demand characteristic; rather, it is whether bioenergetics plays a role in scaling perceived space.

The notion that efforts' influence on spatial perceptions could be due to a response bias—especially for verbal reports—is not new to the Durgin et al. experiment. I raised this possibility before.

A very reasonable objection would be that these manipulations might have created a response bias, so that the results might not reflect an influence on perception itself. After all, if people are asked to wear a heavy backpack while making distance judgments, they might well suspect that the backpack is supposed to have an effect on their judgments—why else are they being asked to wear one? (Proffitt, 2006, p. 115)

I then wrote that this is why we have used converging measures and manipulations, in which the anticipated outcome would not be intuited by participants.

In the third experiment reported in Bhalla and Proffitt (1999), we assessed physical fitness using a cycle ergometer test, and found that fitness was negatively correlated with slant judgments for the two explicit de-

pendent measures, verbal reports and visual matching, whereas the visually guided action, the palm board, was unaffected. There was no experimental manipulation, all participants were treated the same, and the experimenter was blind to the participants' fitness status. We again took an individual-differences approach in the fourth experiment, which looked at the elderly and assessments of their health. We found that slant overestimations increased with age and declining health, although only for the steepest hills. Recently we have begun to investigate the mechanisms that underlie bioenergetics and have focused on blood glucose. Schnall, Zadra, and Proffitt (2009) found that hills appear steeper to those with depleted levels of blood glucose.

It is important to note that across all of our studies, effort manipulations and individual differences in physiology affected the explicit dependent measures of slant, but not the visually guided action. We employed the visual matching task because such tasks tend to be more immune to demand characteristics than do verbal reports. Moreover, the palm board adjustment was never affected by energetic manipulations. If our effects were the result of demand characteristics, all of the dependent measures should have been affected. It is important to note that, in cases in which we predict an influence on the palm board, such as adjustments made from memory, the palm board adjustments are affected (Creem & Proffitt, 1998). This shows that the null effect on the palm board is not just due to a lack of statistical power. Durgin et al. employed neither the visual matching nor the palm board measure; their inclusion would have been good indicators of whether the induced demand characteristic was pervasive.

Finally, it is worth pointing out that wearing a backpack does not always result in a change in spatial perception due to induced demand characteristics. Lourenco and Longo (2009) found that wearing wrist weights caused a contraction of perceived near space, whereas in a control condition, wearing a backpack did not.

To summarize my approach, I have suggested that spatial layout is scaled by that aspect of the individual's ever-changing phenotype—morphology, physiology, and behavior—that is relevant for the action opportunities that currently exist in the environment. In our lab, we have found that, within near space, distances are scaled to an aspect of morphology—the extent of the actor's reach (Linkenauger, Witt, Bakdash, Stefanucci, & Proffitt, in press; Linkenauger, Witt, Stefanucci, Bakdash, & Proffitt, in press; Witt & Proffitt, 2008; Witt, Proffitt, & Epstein, 2005). For large environments, such as fields and hills, spatial layout has been shown to be scaled by “how much walking” would be required to traverse it. Further, I have proposed that “how much walking” is biologically realized by changes in physiology—the bioenergetic costs of walking relative to the bioenergetic resources currently available (Proffitt, 2006). From this perspective, spatial perceptions are affordance or action specific (Proffitt, 2008). For example, near spaces are scaled by reachability, objects of the appropriate size are scaled by their graspability, and far spaces are scaled by the bioenergetic costs associated with walking long distances.

The action opportunities available in a 2-m-long ramp do not generalize to those afforded by geographical hills. That wearing a backpack induced a demand characteristic in the Durgin et al. study does not support the conclusion that such influences were also present in our study; it could equally well be argued that the lack of a demand characteristic influence for wearing a backpack in the Lourenco and Longo study implies that demand characteristics were not present in Bhalla and Proffitt (1999). From an embodied perspective on visual perception, equating experimental conditions—and thereby equating the opportunities for action—matters.

Finally, whether and in what conditions wearing a backpack may induce a response bias is not a very critical question. The more conceptually interesting issue is whether spatial layout is scaled to those aspects of the individual's phenotype that are relevant for the action opportunities available in the situation. Although there are many interesting questions about visual perception that can be investigated with reduced displays, studying embodied perception cannot be achieved in experimental contexts in which the opportunities for action are virtually nonexistent.

AUTHOR NOTE

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