When and How Are Spatial Perceptions Scaled?

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This research was designed to test the predictions of 2 approaches to perception. By most traditional accounts, people are thought to derive general-purpose spatial perceptions that are scaled in arbitrary, unspecified units. In contrast, action-specific approaches propose that the angular information inherent in optic flow and ocular–motor adjustments is rescaled and transformed into units related to intended actions. A number of studies have shown, for example, that the apparent distance to targets is scaled by the effort required to walk the extent. Such studies can be accommodated by the traditional account by asserting that the experimental manipulations of walking effort influenced not perception itself, but rather postperceptual response processes. The current studies were designed to assess when and how action-specific influences on distance perception have their effects. The results supported the action-specific account.

Keywords: distance perception, effort, perceptual scaling, intention

For more than 100 years, researchers have attempted to delineate the informational bases for distance perception, and in so doing, they have appropriately focused primarily on optical and ocular–motor information (see, e.g., Cutting & Vishton, 1995; Proffitt & Caudek, 2002). Optical information, however, is not the content of perception. People have an awareness of the environment’s spatial layout and are, for the most part, unaware of the information on which this layout is specified. The informational bases for visual perception are unitized as angles: visual angles, changes in these angles, and ocular–motor adjustments, the latter of which can be scaled as angles as well. To achieve a perception of the environment, these angles must be transformed and rescaled into units appropriate for spatial extents.

An example of such rescaling is the use of eye height as a scaling unit. Figure 1 depicts a person standing on the ground some distance from a cone that is also located on the ground. The angular elevation of the cone relative to the horizon, \( \alpha \), can be used to specify the distance of the cone relative to the observer by the equation \( d = I / \tan \alpha \), where \( I \) is the eye’s elevation above the ground (Sedgwick, 1986). Notice that through the tangent function and an assumed eye height, the angular specification of the cone’s location has been transformed and rescaled into a specification of egocentric distance scaled in eye-height units.

Recently, we proposed that the units used to scale spatial layout are action-specific (Proffitt, 2008; Witt & Proffitt, 2008; Witt, Proffitt, & Epstein, 2004, 2005). When viewing an extent over which one intends to walk, the extent is scaled by how much walking effort would be required to traverse it, whereas viewing the same extent with the intention to throw a ball would evoke a scale based on throwing effort. When viewing extents over which one would reach, the extent is scaled by the extent of one’s reaching ability. In other words, extents are scaled by walking effort if observers are walkers but by throwing effort if they are throwers and by reaching ability if they are reachers.

The action-specific scaling of spatial perception is not a new notion. For entirely different reasons, Berkeley (1709/1975) and Gibson (1979) proposed variants of such accounts. For Berkeley, the claim emerged from the underlying assumption that perceived distance must be based on more than optical information because the projection of a single point of light onto the retina does not possess sufficient information to specify its observer-relative distance. He proposed that, in perceiving distance, optical information must be augmented by additional cues such as eye convergence and active touch. For farther distances, perception is augmented by learning the relationship between the optically specified location to a target and the associated effort required to walk to it.

Gibson (1979) argued that nonvisual information is not necessary to perceive distance because the optic information provided for moving perceivers in natural, complex environments is sufficient to specify the environment’s spatial layout. However, Gibson still emphasized the role of action-specific scaling with his notion of affordances. Affordances are the possibilities for action given the environment’s surface layout and the anatomical structure and behavioral repertoire of the organism. Affordances specify the walkability, reachability, throwability, etc., of surfaces and objects in the environment. Affordances derive from invariant relationships between perceive and environment. As such, the perceived affordance will change with variations either in the environment or in the perceiver. According to Gibson, the affordances that are noticed at any instance depend on what the organism is attempting to do. For example, an apple affords eating or throwing depending on one’s intentions.

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In agreement with Gibson (1979), we propose that perception is scaled by embodied constraints on intended action (for an expanded comparison of our approach and Gibson’s, see Witt & Proffitt, 2008). However, action-specific accounts of spatial perception have always been controversial. Many researchers, such as Loomis and Philbeck (2008), suppose that people derive general-purpose spatial perceptions that are scaled in arbitrary, unspecified units.

The notion that perception consists of a general-purpose representation of the environment exemplifies traditional approaches to perception. By such accounts, perceptual representations are based solely on optical information and then transformed into behavioral responses by postperceptual processes (Loomis, Da Silva, Fujita, & Fukusima, 1992; Loomis, Da Silva, Philbeck, & Fukusima, 1996). In cases in which manipulations of effort or intent affect perceptual judgments, it is assumed that postperceptual processes—not perception itself—are responsible. In these cases, the perception of the environment is presumed to be the same because the underlying perception “exists independently of any of the actions to be controlled” (Loomis et al., 1996, p. 72).

An example will help illustrate this approach. Participants verbally reported the distance and blindwalked to targets presented in a hallway (Philbeck & Loomis, 1997). Verbal reports were compressed while blindwalking was accurate. However, as viewing conditions were manipulated, the correlation between verbal reports and blindwalking was high. The authors interpreted their findings of different values between the two responses as evidence for multiple, action-specific postperceptual processes that transform perception into the responses. They interpreted their finding of the high correlation between the two measures under changing viewing conditions as evidence for a single, underlying perception.

The prevalence of this traditional approach is vast, even if not explicit in its contrast to the action-specific scaling approach. Indeed, most perceptual research is conducted without manipulating the intended action. Literature searches revealed few reports beyond what has been published by the current authors that have manipulated intention (e.g., Bekkering & Negen, 2002; Vishton et al., 2007). Moreover, our thorough but not exhaustive search of introductory sensation/perception textbooks failed to find any mention of how or in what units spatial extents were assumed to be scaled.

A general-purpose account of spatial representations can be defended against counterevidence favoring action-specific perception by asserting that the effects of effort on perceptual measures are due to effort’s effects on postperceptual processes (Loomis & Philbeck, 2008). By such an account, there is a single, general-purpose spatial perception, and manipulations of action intent and associated effort influence postperceptual response processes and not perception itself. Such arguments are hard to counter. The current experiments attempted to do so.

In the current experiments, participants viewed a single target with the intention to walk or throw to the target. We increased anticipated effort for walking using a treadmill manipulation. Walking on a treadmill pairs minimal optic flow with forward walking effort. Optic flow is the systematic pattern of motion projected to a point of observation as the perceiver moves around the environment (Gibson, 1979). For instance, when the perceiver moves forward, the patterns of optical features expand outward from the point toward which the perceiver is moving. This expansion is an example of optic flow. Perceivers learn the relationship between their movements and the resulting optic flow. Thus, the treadmill provides a means for visuomotor adaptation because participants anticipate expanding optic flow as they walk. However, because the room is stationary, optic flow is minimal and specifies that they are not moving. Participants calibrate to this new relationship between forward walking effort and minimal optic flow.

This recalibration influences actions performed shortly after walking on a treadmill. Participants tend to drift forward when trying to jog or walk in place with their eyes closed (Anstis, 1995; Durbin et al., 2005; Proffitt, Stefanucci, Banton, & Epstein, 2003). Recalibration also influences blindwalking. In a clever paradigm, Rieser, Pick, Asmead, and Garing (1995) systematically manipulated the relationship between forward walking effort and resulting optic flow. They placed a treadmill on a trailer that was pulled by a tractor so that they could manipulate walking speed (the speed of the treadmill) independently from the speed of optic flow (governed by the speed of the tractor). They found that when the treadmill was set faster than the tractor, participants blindwalked past the targets. When the treadmill was set slower than the tractor, participants blindwalked short of the targets.

Proffitt et al. (2003) extended this work to demonstrate that recalibration also influences verbal reports of perceived distance. Participants verbally estimated the distance to targets before and after walking on a treadmill. During treadmill walking, participants viewed a virtual world through a head-mounted display. The world was either stationary or set to the same speed as the treadmill. Ratio scores of postwalking estimates divided by prewalking estimates revealed a larger increase for participants in the stationary world condition. Participants who experienced zero optic flow perceived targets to be farther away compared with participants who experienced normal optic flow. However, because the room is stationary, optic flow is minimal and specifies that they are not moving. Participants calibrate to this new relationship between forward walking effort and minimal optic flow.

It is important to note that this visuomotor adaptation only influences perceived distance if the perceiver intends to walk to the target (Witt et al., 2004). In this study, participants initially made verbal estimates of the distance to targets in a hallway. After each estimate, one group of participants closed their eyes and walked to the target, so for each target, they viewed the target with the
intention to walk. Another group of participants threw a small beanbag at the target, so this group viewed each target with the intention to throw. These different pretest manipulations established an anticipation by one group that, after making distance estimates, they would walk to the target, whereas the other group viewed the target with the anticipation of throwing to it. After making several distance estimates, all participants walked on the treadmill. Because the room was stationary, walking on the treadmill paired forward walking effort with minimal optic flow; therefore, all participants adapted to this new relationship. After walking on the treadmill, both groups were told that they would perform the same task as they had prior to walking on the treadmill. The walkers would estimate the distance and then blindwalk to the target, and the throwers would estimate the distance and then throw to the target. We found that participants who intended to walk perceived the targets to be farther away relative to participants who intended to throw. Effort for walking influenced participants who intended to walk but not those who intended to throw.

According to an action-specific scaling approach, walking on the treadmill recalibrates anticipated effort to walk to a target. After learning that it takes a lot of effort to go nowhere, participants anticipate having to exert more effort to walk to a specified target. If participants intend to walk to the target, the optical information specifying the target’s distance will be scaled according to walking effort, which has increased. Therefore, the target looks farther away. On the other hand, if participants intend to throw to the target, the optical information is scaled according to throwing effort, which has not increased. Thus, the targets look farther away to participants who intend to walk compared with participants who intend to throw (Witt et al., 2004).

In contrast, according to a general-purpose perceptual account, the intended action does not influence perception. To explain the differences in verbal responses, proponents of a general-purpose perception claim that effort and intention must have affected the postperceptual processes that generate the verbal response (Loomis & Philbeck, 2008).

Therefore, the issue is when intention exerts its influence. This could happen during perceptual processing of the target, which is consistent with the action-specific approach. Or this could happen during postperceptual processes that generate the response, consistent with a general-purpose perceptual approach.

The current experiments assessed whether the action-specific effects that were obtained occurred at a perceptual or postperceptual stage of processing. One group of participants was told that after walking on a treadmill, they would view a target, and then after donning a blindfold, they would attempt to walk to its location (walkers). The other group was told that after walking on a treadmill, they would view a target, be blindfolded, and would attempt to throw a beanbag to its location (throwers). We assessed what would happen, if after looking at the postadaptation target, the throwers were told to close their eyes, but instead of throwing the beanbag as anticipated, they were told to walk to the target (see Figure 2 for procedural overview). This design allowed us to get at when the effects of effort exert their influence in the perception/action cycle. If the effects occur within perception itself, then the manipulation of walking effort can only exert its influence when perceivers are actually viewing the target, and thus, the throwers-turn-walkers should be uninfluenced by the treadmill-walking adaptation because when viewing the target as throwers, the treadmill adaptation of walking effort was irrelevant. However, if effort exerts its influence on a postperceptual process, then the throwers-turn-walkers should adjust their blindwalking response to accommodate for the treadmill-walking adaptation, which evokes an increase in the amount of effort required to walk to a target location.

The purpose of the current experiment was to provide evidence supporting one or the other of these two alternatives by investigating when effort and intention exert their effects. If their influence does not occur during perception, but rather during the planning and execution of the response, then perception may well be of a general-purpose nature and thus be immutable to action-specific scaling influences. But if the effects are truly perceptual, then these findings support an action-specific account of spatial perception.

Experiment 1: Changing Intention—Target at 6 m

To determine when effort and intention exert their effects, we divided participants into two groups: throwers and walkers. Both groups walked on a treadmill with minimal optic flow and then viewed a target in a hallway. The walkers viewed the target with the intention to walk, and consequently, donned a blindfold and blindwalked to the target. The throwers viewed the target with the intention to throw, but after putting on the blindfold, they were instructed to blindwalk to the target instead.

Method

Participants. Forty volunteers (21 women, 19 men) participated in exchange for credit for a psychology course.

Materials and stimuli. Participants walked on a motorized treadmill (Precord 9.1). A blindfold occluded vision during blindwalking. We put duct tape in the shape of an x on the floor to mark a target at 6 m. A small beanbag was shown to the throwers as the object to be thrown.

Procedure. Participants were assigned to one of two groups: walkers or throwers. The main difference between the two groups was the initial instruction of the experiment. The walkers were told that they would walk on a treadmill for a few minutes and then blindwalk to a target in the hallway. The throwers were told that they would walk on a treadmill and then blindthrow to a target in the hallway.
After these initial instructions, both groups walked on the treadmill with their eyes open for 3 min at 3 mph. Because the room itself was stationary, forward walking effort was paired with minimal optic flow. Participants lowered a blindfold before the experimenter stopped the treadmill and were led—still blindfolded—into the hallway. The hallway was located just outside the room with the treadmill, and the treadmill was located approximately 8 m from the door. Participants had walked through this hallway to get to the experiment. They were told the target would be in that hallway, and they did not view the target until after walking on the treadmill. Once they were at the start position, they were told to raise the blindfold and look at the target, which was placed 6 m away. As a result of the initial instructions, the walkers viewed the target with the intention to walk, and the throwers anticipated throwing to the target. Both groups lowered the blindfold again, and the throwers were told to walk to the target instead of throwing. Instructions were approximately to the effect of “actually, we want you to walk to the target instead. Walk until you think you are standing on top of the target. I will walk behind you to ensure that you do not run into anything.” The walkers were also instructed to walk to the target and stop when they thought they were standing on the target, and they were also told that the experimenter would walk behind to ensure that they did not run into anything. Neither group was given a second chance to look at the target following these instructions. The experimenter followed closely behind all participants to prevent them from walking into the walls.

Results and Discussion

An independent samples t test revealed a significant effect of intention on blindwalked distance, \( t(38) = 1.88, p < .05 \) (one-tailed), \( d = 0.59 \). Participants who viewed the target with the initial intention to walk blindwalked farther than participants who viewed the target with the initial intention to throw (see Figure 3). One-sample t tests with 6 m as a test value revealed a significant effect for intend-to-walk group, \( t(19) = 2.124, p < .05, d = 0.47 \). Walkers blindwalked past the target. However, the intend-to-throw group’s walking distance did not differ significantly from the target distance, \( t(19) = -0.37, p > .71 \).

The walkers walked farther than the throwers. This result is consistent with the action-specific scaling approach. Because the groups viewed the target with different intentions, and because only effort for walking had increased but not effort for throwing, the two groups would have perceived the target to be at different distances. As a result, the groups walked to different distances. The alternative view of a general-purpose perception cannot explain this result. Because effort for walking had increased for both groups, and because both groups blindwalked to the target, both groups should have walked the same distance according to the general-purpose perceptual approach.

Experiment 2: Changing Intention—Target at 8 m

Because of the constraints of the design, we could only access walking distance to one target. Once we changed the intention for the throwers, we did not think we could trick them again. Therefore, we used a separate group of participants to verify that these results generalize to another, although similar, distance.

Experiment 3: Changing Intention Without the Treadmill Adaptation

In the previous experiment, we manipulated intention by giving the groups different instructions. We found that the throwers...
walked a shorter distance than the walkers, which is consistent with previous findings using verbal estimates (Witt et al., 2004). However, it is possible that this group was more uncomfortable walking because they were not prepared to walk. Being uncomfortable or other procedure differences between the walkers and throwers could explain why the walkers blindwalked farther than the throwers. In Experiment 3, we controlled for these alternative explanations by using the same intention manipulation but without the effort for walking manipulation. Therefore, both groups should perceive the target to be in the same place because effort for neither action had increased. If just changing the intention in and of itself affects blindwalked distance, we should see a difference in blindwalked distance between the two groups when there is no effort manipulation.

Method

Participants. Twenty-four volunteers (12 men, 12 women) participated in the experiment in exchange for payment or for course credit.

Materials and stimuli. The materials and stimuli were the same as in Experiment 2 except that we did not use the treadmill.

Procedure. As in the previous experiments, different instructions were given to two groups. The walkers were told they would view a target, put on a blindfold, and walk to the target. The throwers were told they would view a target, put on a blindfold, and throw to the target. Both groups were blindfolded and led into the hall, viewed a target at 8 m, and then put on the blindfold again. The throwers were then told to walk to the target instead. Both groups walked to the target blindfolded, and the experimenter followed the participants to prevent them from walking into the walls.

Results and Discussion

The throwers walked just as far as the walkers, \( t(22) = 0.29, p > .38 \) (see Figure 5). Both groups walked short of the target, \( t(11) = -2.59, p < .05; t(11) = -3.89, p < .01 \) (throwers and walkers, respectively). Previous research has demonstrated that blindwalking tends to be accurate (e.g., Philbeck & Loomis, 1997), so it is unclear why these participants walked short of the target. However, participants in our study did not get any practice blindwalking, which may account for why their blindwalking estimates were so short of the target. Most experiments on blindwalking give the participants practice prior to the test trials (e.g., Loomis et al., 1992; Philbeck & Loomis, 1997; Rieser et al., 1995; Witt et al., 2004). Given our paradigm, we could not give the participants practice ahead of time without the concern that the throwers would have the intention to walk instead of throw.

The design of this experiment was similar to the previous experiments except that neither group walked on the treadmill. Thus, both groups should have perceived the target to be the same distance away because neither effort for walking nor effort for throwing increased. That both groups perceived the target to be at the same distance is verified by the result that they walked the same distance. This experiment demonstrates that changing the perceiver’s intention after donning the blindfold did not influence blindwalking in and of itself. Thus, the difference in walked distance between throwers and walkers found in Experiments 1 and 2 is, therefore, due to differences in perceived distance and not because one group was uncomfortable walking without prior knowledge of the task or because of procedural differences between the two groups.

General Discussion

We investigated whether effort and intention influence perception directly, or whether they exert their effects during postper-
ceptual processes that are involved in generating a response. In the first two experiments, two groups of participants walked on a treadmill, which increased the anticipated effort associated with walking an extent because their perceptual–motor system had adapted to a circumstance in which forward walking effort was paired with minimal optic flow. Afterwards, one group looked at a target with the intention to blindwalk to it, and another group looked at the target with the intention to blindthrow to it. After donning a blindfold, we instructed both groups to walk to the target; therefore, for both groups, our measure of perceived distance was a blindwalking estimate. We found that the walkers blindwalked farther than the throwers in both experiments.

The only difference between the groups occurred when they were viewing the target (see Figure 2). The throwers viewed the target with the intention to throw and the walkers viewed the target with the intention to walk. Once vision was occluded, we told both groups to walk to the target; thus, both groups had the intention to walk at the time that the walking response was generated and executed. This result demonstrates that effort and intention affect perception directly. If effort and intention had exerted their effects during postperceptual processes, both groups would have walked equally far because both groups experienced the same effort manipulation and both groups intended to walk at the time that their response was generated.

We attempted another experiment that replicated the design of Experiment 1 except that two additional conditions were added in which, after donning the blindfold, all participants were all asked to throw a beanbag to the target location. It was anticipated that the walkers-turned-throwers would throw the beanbag farther than the throwers who remained throwers. Unfortunately, blindthrowing proved to be too inaccurate and imprecise to be a useful dependent measure without prior practice. We could not give participants prior practice with blindthrowing because that would alert them to the possibility that they would likely be asked to perform this task in the future. Recall that providing prior practice with either blindthrowing or blindwalking served as a robust manipulation of intentional expectations in the Witt et al. (2004) study. In that study, we also adapted participants to treadmill walking, after which they made verbal distance judgments with the expectation that they would either throw a beanbag or blindwalk to a target location.

The current pattern of results matches our previous findings that used verbal reports as the dependent measure (Witt et al., 2004; see Figure 6). In those studies, we demonstrated specificity of intention where effort for walking influenced perceived distance—as assessed with verbal reports—when intending to walk but not when intending to throw, and effort for throwing influenced perceived distance when intending to throw but not when intending to walk. Given that effort and intention influence perception, both indices of perceived distance—blindwalking and verbal reports—were affected. Thus, we have demonstrated an effect of effort and intention using converging measures of perceived distance.

Provided that blindwalking and verbal reports tap into the same underlying perception (Philbeck & Loomis, 1997), then it is not surprising that the blindwalking results exactly mirror the verbal reports found earlier (Witt et al., 2004; see Figure 6). However, the current results go beyond all prior data because they rule out alternative explanations that the effects of effort and intention were postperceptual.

Our account of perceptual recalibration complements earlier studies by Rieser and colleagues (1995), which also used a treadmill manipulation. Participants first walked on the treadmill while the tractor pulled it and then attempted to blindwalk to targets placed in a field. Rieser et al. found that when the treadmill speed was set faster than the tractor speed, participants blindwalked past the target; when the treadmill was set slower than the tractor, participants blindwalked short of the target. They interpreted these results as a visuomotor adaptation; however, their results are also consistent with our account of action scaling of perception; in this case, the scaling would be in units of walking effort. When the treadmill was faster than the tractor, participants would recalibrate the relationship between walking effort and resulting optic flow such that more walking effort would be required to produce an amount of optic flow necessary to reach the target. Consequently, they would perceive the targets to be farther away and would blindwalk farther. When the treadmill was slower than the tractor, participants would learn that less walking effort would be required to produce an amount of optic flow needed to walk to the target, and consequently they would perceive the targets to be closer and walk short of the target. However, if the effects of recalibrating on the treadmill are purely visuomotor, then participants in the present study should have all blindwalked past the target because they all underwent the treadmill adaptation. Instead, we found that participants who intended to throw to the target blindwalked shorter than participants who intended to walk to the target.

That effort influences perception has also been demonstrated with perceived slant. Hills look steeper to those wearing a heavy backpack, who are fatigued from a long run, who are of low physical fitness, and who are elderly and of declining health (Bhalla & Proffitt, 1999). It is interesting that increased effort influences verbal reports and visual matching tasks of hill slant, but not haptic measures. When participants placed their hand on a

Figure 6. The effect of effort for walking on verbal estimates when intending to walk versus when intending to throw (taken from Witt et al., 2004). The y-axis represents ratio scores of participants’ post–treadmill-adaptation verbal estimate of a target at 8 m divided by their pre–treadmill-adaptation verbal estimate of a target at 8 m. Error bars represent 1 standard error.
wooden platform and adjusted the platform to match the slant of hill, which they did without looking at their hand, their estimates were quite accurate and uninfluenced by manipulations of effort. Thus, there seems to be a contradiction in that effort influences the action measure of blindwalking (as demonstrated here) but not the action measure of haptic responses to perceived slant (as demonstrated by Bhalla & Proffitt, 1999). One possible resolution to this contradiction is to suppose that the haptic measure taps into visual processing in the dorsal visual pathway (cf. Goodale & Milner, 1992; see also Witt & Proffitt, 2007), whereas blindwalking relies on the same visual information as verbal reports (Philbeck & Loomis, 1997). Thus, the haptic measure could be immune to biases arising from increased effort, whereas verbal and blindwalking measures reflect explicitly perceived distance.

The current results are consistent with recent findings demonstrating other aspects of action-specific spatial perception. For example, the efficacy with which one can reach targets influences perceived distance. Targets within reach when using a tool looked closer than did targets that were beyond reach when no tool was available even when distance was held constant (Witt et al., 2005; Witt & Proffitt, 2008). Participants reached and estimated the distance to targets that were beyond reach without a tool but were within reach when wielding a tool. Distance estimates were in the form of a visual matching task. When participants reached with the tool, they estimated the targets to be closer compared with when they reached without the tool. Thus, their ability to reach the targets affected their perception of the distance to the targets. However, holding a tool only influenced perceived distance when the perceiver intended to reach with it. Perceived distance was not affected when the participants simply held the tool but never reached with it.

Additional studies have demonstrated effects of efficacy on other aspects of spatial perception as well. The ability to hit softballs affected the apparent size of the softball (Witt & Proffitt, 2005). We found a positive correlation between batting average for a softball game and the judged size of the softball immediately after that game. Batters who were hitting better perceived the ball to be bigger than batters who were not hitting well. Similarly, golfers who are playing better perceive the hole as bigger (Witt, Linkenauger, Bkadash, & Proffitt, 2008). In a recent study, participants attempted to kick field goals on an American football field. Those who made more successful kicks perceived the goal to be bigger than those who made fewer successful kicks (Witt & Dorsch, 2009). Also, participants who were better at dropping darts onto a target perceived the target to be bigger than participants who had more difficulty hitting the target (Wesp, Cichello, Gracia, & Davis, 2004). In addition, the ability to ascend or descend a hill affects the perceived slant of the hill (Proffitt, Bhalla, Gossweiler, & Midgett, 1995). Slants are judged to be the same whether viewing the hill from the bottom or the top. However, at 25°, hills look steeper from the top than from the bottom. This is also the angle at which it is still possible to ascend the hill, but it becomes biomechanically difficult to descend it. In other words, a 25° hill offers different affordances from the top and the bottom. The difference in the affordance for walking may account for the difference in perceived slant. Thus, there are several demonstrations that the perceiver’s intention to act, physiological potential, and behavioral abilities play a role in scaling the perceived environment.

When studying perception, researchers typically want to know the degree to which perception is accurate. Yet, to many researchers, accuracy means geometrical accuracy relative to the objective physical world. Research from this perspective seeks to understand perception, without concern for who the perceiver might be or what he or she is trying to do. In contrast, we propose a pragmatic definition for accuracy in which perception relates the physical world to the perceiver’s purposes and abilities. A sprinter sees the world as a sprinter. A child sees the world as a child. A person confined to a wheelchair sees the world as a wheelchair driver. The perceived world reveals different affordances to each of them, and what they see is scaled by their intended actions and individual abilities. What is the perceptual “truth” to one need not be the same perceptual “truth” to another.

Moreover, it may be advantageous to scale the perceived world in terms of its energetic costs (Proffitt, 2006, 2008). To survive, more energy needs to be consumed than expended; therefore, regulating energy expenditure is a survival imperative. Perception is useful for planning long-term actions in energy-efficient ways because the energetic costs associated with intended actions are inherent in the scaling of perception. For example, by seeing a hill as being steeper when wearing a heavy backpack or after going for a long run, perceivers can plan to walk more slowly and thereby avoid exhaustion.

Given that we propose that these effects are adaptive, it is curious that participants were not able to adjust their blindwalking estimates to account for the change in anticipated walking ability. The throwers adapted to the new relationship between forward walking effort and minimal optic flow, so when they were told to walk to the target instead of throwing to it, they could have adjusted their walking response to account for the recalibration. Yet, it appears that they did not. To some extent, not using the available information on recalibration seems maladaptive. However, except in laboratory settings, perceivers can generally resample the environment in order to generate an appropriate response. Thus, if a perceiver changes her mind about what action to perform, she will likely look at the target again before generating her response. Thus, effort and intention can influence perception in an adaptive way, even if the contrived setup used in our experiments reveals that the system does not take into account all known information.

In summary, we propose that spatial perceptions are scaled by a wide variety of action-specific influences. This scaling occurs during the time when the target is viewed, not during postperceptual processes when a response is being generated. The current findings provide support for our contention that optical and ocular–motor information is scaled and transformed by action-specific influences into perceptions of spatial layout.

References


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