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Action's Effect on Perception

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Abstract

According to the action-specific perception account, people perceive the environment in terms of their ability to act in it. For example, softball players who are hitting better see the ball as bigger. Factors that affect ability and thus influence perception include body size, body control and coordination, energetic potential, and the challenges of the task. Acknowledging the influence of ability on perception challenges the traditional view that perception provides an objective, behaviorally independent representation of the environment. Instead, perception captures the mutual relationship between the environment and the perceiver's abilities. Consequently, these effects are potentially adaptive for helping perceivers plan future actions based on their abilities.

Keywords

spatial perception, perception–action coupling, affordances, tool use

According to the action-specific perception account, people perceive the surrounding environment in terms of their ability to act in it. For example, softball players who are hitting better than others see the ball as bigger (see Fig. 1; Witt & Proffitt, 2005). Objects beyond arm's reach look closer when perceivers intend to reach to them with a reach-extending tool than when they intend to reach without the tool (Witt, Proffitt, & Epstein, 2005). People who throw a heavy ball to a target perceive the target to be farther away compared with people who throw a light ball (Witt, Proffitt, & Epstein, 2004). These examples illustrate ways in which the perceiver's ability to act influences perception. Action abilities are dynamic, and factors that influence ability include body size, body control, energetic potential, and the demands of the task. The perceiver's abilities are then reflected in perception.

The action-specific perception account has roots in Gibson's (1979) ecological approach. According to Gibson, the primary objects of perception are affordances, which are the possibilities for action. Affordances capture the mutual relationship between the environment and the perceiver. For example, a tall wall is a barrier to me but affords jumping over to someone trained in parkour, or urban climbing. Like the ecological approach, the action-specific perception account favors the notion that perception involves processes that relate the environment to the perceiver's potential for action. Consequently, similar environments will look different to perceivers with different abilities or even to the same perceiver as his or her abilities change.

The claim that action ability influences perception is controversial, because it challenges traditional theories according to which perception provides an objective and behaviorally independent representation of the environment. To counter action-specific claims, critics have suggested that action abilities may influence judgments rather than perception (e.g., Loomis & Philbeck, 2008). As I will describe, several strategies have been used to examine this issue; but first, I outline evidence for action-specific perception.

The Body and Its Dynamic Abilities

Action abilities are dynamic. Thus, factors that influence ability will also influence perception. As reviewed below, the effects of ability are apparent in multiple aspects of perception including distance, height, slant, size, and speed. Typical measures of perception are illustrated in Figure 1.

Size

A person's ability to act is determined, in large part, by the person's body. Therefore, changes to the body will influence both physical abilities and subsequent perception. In one set of experiments, the effective size of the perceiver's body was manipulated through tool use. Targets were presented just beyond arm's reach, but they were accessible when the perceiver reached with a conductor's baton. The targets looked closer

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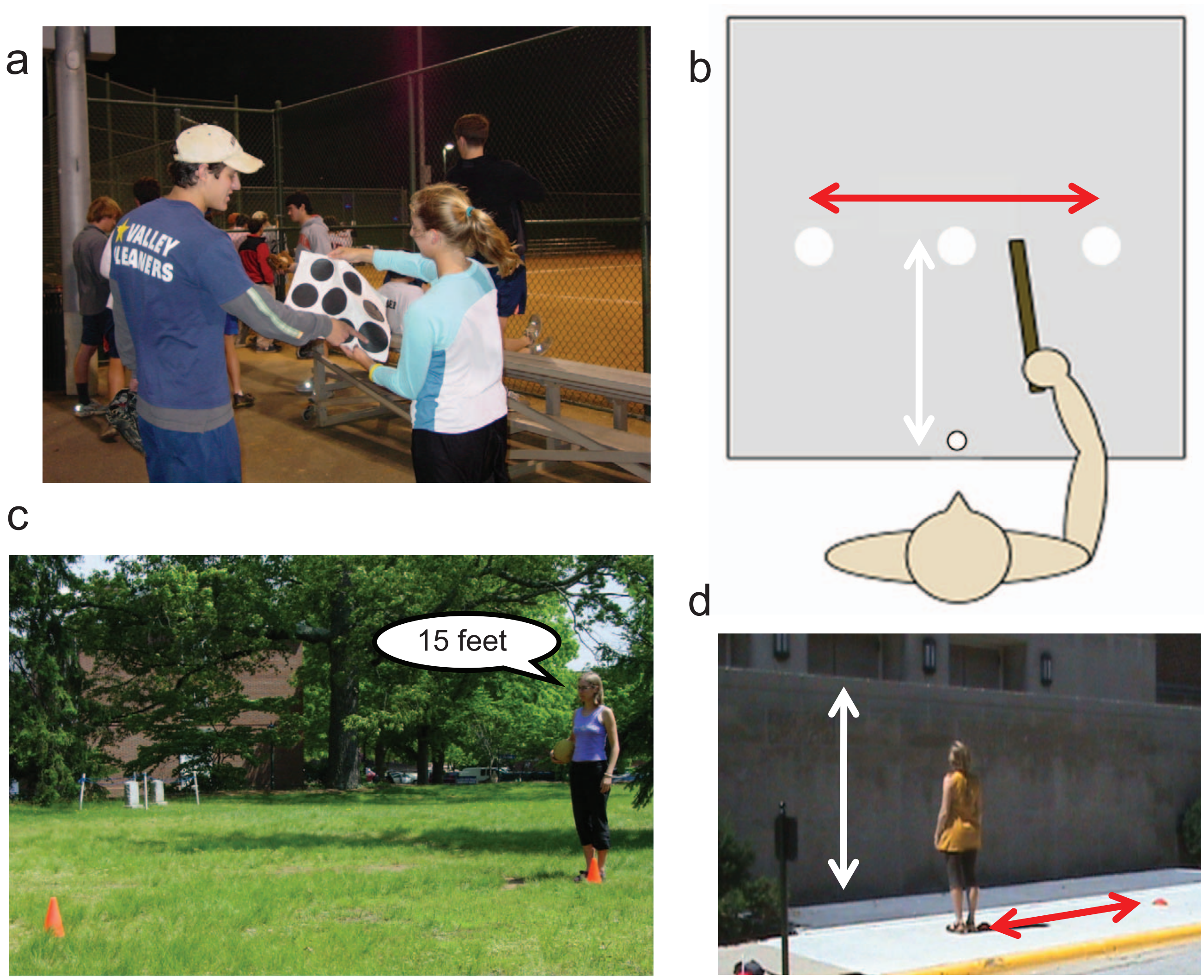

Fig. 1. Examples of perceptual measures of softball size (a), distance to an object (b, c), and height of a wall (d). For many visual-matching tasks, participants adjusted one extent (red arrows) to match the target extent (white arrows).

when participants intended to reach to them with the tool than when they intended to reach without the tool (Witt et al., 2005). When perceivers' ability to reach increased, the targets looked closer.

The size of the body determines which actions are possible and the ease with which actions can be performed. For example, someone with narrow shoulders will be able to pass through a narrow doorway more easily than someone with broad shoulders. Consequently, perceivers with narrow shoulders perceive doorways to be wider compared with perceivers with wide shoulders (Stefanucci & Geuss, 2009).

Control and coordination

While size of the body is relevant for physical ability, it is not the only determinant. Even when people are the same height, for example, those with better jumping abilities will see vertical targets as lower because they will have the ability to jump to the target. Parkour experts, who are trained to kick off of walls in order to jump higher, and height-matched novices estimated the height of walls. Parkour experts perceived the walls to be shorter compared with novices when the wall afforded climbing for parkour experts but not the novices (Taylor, Witt, & Sugovic, 2010). Thus, action ability is dynamic and can be developed through training.

Even with training, abilities vary from day to day. Such variance is apparent in athletes who alternate having good days and bad days. On good days, targets look bigger, and on bad days, targets look smaller. Softball players who are hitting better than others see the ball as bigger (Witt & Proffitt, 2005, see Fig. 1). Children who throw balls more successfully to a target perceive the target as bigger (Cañal-Bruland & van der Kamp, 2009). Tennis players who return more balls successfully than others see the net as lower (Witt & Sugovic, 2010); because the net is an obstacle to be avoided, better performance leads to the net looking shorter. Furthermore, tennis balls appear to be moving slower on returns in which players successfully hit the ball in-bounds compared with returns in which they hit the ball out-of-bounds (Witt & Sugovic, 2010). Golfers who are playing better than others see the hole as bigger (Witt, Linkenauger, Bakdash, & Proffitt, 2008). Interestingly, whereas golf performance on that day related to perceived size, overall golf skill—as measured by handicap—did not relate to perceived size, suggesting that perception is affected by moment-to-moment ability rather than overall skill.

These studies raise the issue of causality. Did the athletes play well and then see the target as bigger or did they initially see the target as bigger and consequently played better? One study speaks directly to this issue. Athletes judged the size of an American football goalpost both prior to and after attempting to kick the ball through it. The number of successful kicks related to post-kicking perceptual estimates. However, if this relationship was due to initially seeing the goalpost as bigger, then pre-kicking perceptual estimates should also be related to kicking success, but they were not (Witt & Dorsch, 2009). Therefore, this suggests a causal link in which performance influences perception.

Task-related challenges and energetic potential

Ability is also a function of the level of difficulty of a task. Golfers tasked with making more difficult putts perceived the hole to be smaller compared with golfers who attempted easier putts (Witt et al., 2008). In a modified version of the computer game Pong, the ball looked to be moving slower when participants played with larger paddles than when they played with smaller paddles (Witt & Sugovic, 2010). Common tools that are positioned such that they are easy to grasp look closer than when the tools are oriented such that they require an awkward twisting of the arm to be grasped (Linkenauger, Witt, Stefanucci, Bakdash, & Proffitt, 2009). Thus, more difficult tasks have consequences for perception.

The energetic demands of a task also influence action ability and therefore perception. Perceivers who are burdened by a heavy load, and thus have reduced ability to walk, see hills as steeper and distances as farther (Bhalla & Proffitt, 1999; Proffitt, Stefanucci, Banton, & Epstein, 2003). Targets placed uphill look farther away than targets placed on flat ground (Stefanucci, Proffitt, Banton, & Epstein, 2005). Targets also look farther away to perceivers who throw heavy balls to them compared with perceivers who throw light balls (Witt, Proffitt, & Epstein, 2004). For tasks that are more physically demanding, and thus restrict the perceiver's ability, targets look farther away and hills look steeper.

The difficulty of a task can also vary across perceivers. For example, walking down a short hallway is a relatively easy task for a healthy adult, but a task dreaded by people with chronic pain in their legs and back. Consequently, chronic pain patients perceive targets to be farther away compared with age-matched controls (Witt et al., 2009).

Even when task constraints are the same, energy levels also influence action ability and thus influence perception. Physically fit perceivers see hills as shallower than less fit perceivers, and fatigued runners perceive hills as steeper after running than before running (Bhalla & Proffitt, 1999). Energy-depleted perceivers see hills as steeper than do energy-depleted perceivers who had just consumed a sugary drink (Schnall, Zadra, & Proffitt, 2010).

In summary, many factors influence action ability and thus have subsequent effects on perception. These factors include body size, coordination, and energetic potential, as well as the demands of the task. As ability increases, hills look less steep, objects look closer, targets look bigger, obstacles look smaller, and target speeds look slower.

Alternative Explanations?

According to the action-specific-perception account, perceivers literally see the world in terms of their abilities and intentions. However, some critics have countered that these effects may be due to differences in postperceptual processes rather than in perception (e.g., Loomis & Philbeck, 2008). The current studies are susceptible to such criticism because they rely on perceptual judgments, which are a function of both the processes underlying perception and the processes that generate the response, and ability could affect either.

For example, one alternative explanation is a response-bias account. According to this account, participants guessed the experimenter's hypothesis and adjusted their responses accordingly. Consistent with this account, one study revealed that wearing a heavy backpack influenced judgments of a short ramp but not when a cover story was used to explain relevance of the backpack (Durgin et al., 2009). From this finding, the authors concluded that ''backpack effects, and other reported effects of effort, are judgment biases'' (p. 964). This claim goes well beyond their data. Furthermore, their ramp was only 2 m long, and participants were instructed to look only 1 m up the ramp. Participants were not instructed to walk up the ramp, but even if they had been, the relative difference in the amount of energy required to walk 1 m up a ramp with and without the backpack is probably not enough to produce a reliable change in perception. A manipulation of energetic potential needs to be of a sufficient change in order to produce effects that can be observed in perception. In addition, participants in the cover-story condition recalled the backpack to be only 19 lb while those who were not given a cover story recalled the backpack to weigh 30 lbs. If those in the cover-story condition did not anticipate having to exert more effort because the backpack seemed to weigh less, this too would reduce the perceived steepness of the ramp. Also, the elaborate cover story may have created a response bias in the opposite direction to report the ramp as less steep. Concerns such as these call into question whether this study provides solid evidence for a response-bias account.

Despite issues with this study, many researchers are drawn to the response-bias account or other alternative accounts for various reasons, and there is much resistance to accept the claim that ability influences perception. In response to this resistance, three strategies have been used to examine if the effects are perceptual.

One strategy has been to demonstrate functional specificity. We have found that the direction of the effect is specific to the goal of the task, and only ability for the intended action influences perceptual judgments. For example, better sports performance does not always lead to judging everything as bigger. Better batting performance leads to judgments that the ball looks bigger (Witt & Proffitt, 2005), but better returns in tennis leads to judgments that the net, which is an obstacle rather than a target, is lower (Witt & Sugovic, 2010). Furthermore, the effects of ability are also modulated by intention. Wielding a tool increases one's ability to reach, but the act of holding this tool only influences judged distance when the perceiver intends to reach with the tool. If the perceiver simply holds the tool but does not intend to reach, the targets look the same distance away as when the perceiver does not hold the tool (Witt et al., 2005). Also, if the perceiver views a target that is beyond reach but intends to pick up the tool and use it to reach, the targets are judged to be closer compared with perceivers who intend to reach without the tool (Witt & Proffitt, 2008). With respect to effort, targets are reported to be farther away after throwing a heavy ball but only if the perceiver intends to throw again and not if the perceiver intends to walk instead (Witt et al., 2004). It is difficult to account for these results with a nonperceptual explanation. For example, why would participants have adjusted their distance judgments when holding and reaching the tool but not when just holding the tool? To date, no alternative explanation has been presented that can explain the effect of intention in modulating these effects.

Another strategy has been to use opaque manipulations of ability so that participants cannot anticipate the experimental hypothesis. For example, several experiments have used treadmill manipulations to increase effort for walking: After walking on a treadmill (and exerting a lot of effort to go nowhere), targets are reported to be farther away (Proffitt et al., 2003; Witt et al., 2004). A response-bias account might predict the opposite effect. Given that most people's experience after walking on a treadmill is that they seem to move especially quickly, it would be reasonable to predict that the target should look closer, not farther. Indeed, informal questioning of students revealed predictions in opposite direction than what was found in the data. Similarly, the effect that drinking juice with sugar makes hills look less steep than they do after drinking juice with fake sweeteners is not obvious, especially given that participants could not detect if sugar or fake sweeteners had been added (Schnall et al., 2010). Studies such as these also undermine response bias as a plausible explanation.

A third strategy is to use indirect and converging measures of perception. As proposed by Loomis and Philbeck (2008), "converging evidence using . . . perceptual variables like size, shape, and motion . . . and action-based measures . . . is needed to establish that perceived distance is truly being affected by manipulation of nonoptical variables such as energetic state and intent" (p. 33). If ability influences perception, the effect should be apparent in all measures that are driven by the percept. To date, convergence has been demonstrated in two ways. First, effects of energetic potential are apparent in multiple types of distance measures including verbal reports, visual matching, and blind walking (Witt et al., 2004; Witt, Proffitt, & Epstein, 2010). Second, the effect of reachability is apparent in measures of multiple aspects of perceived spatial layout including distance, shape, and parallelism (Witt, 2011). In these experiments, targets were presented just beyond reach, and participants reached to the targets with or without a reach-extending tool. In one experiment, for example, the target was the far corner of a triangle, and participants had to adjust the shape of another triangle to match the target triangle. If participants who reached with a tool perceived the target to be closer, they would have to adjust the comparison triangle to be shorter in order for it to look the same as the target triangle (see Fig. 2). This is exactly what they did. Thus, convergence has been demonstrated with action-based measures and shape, suggesting that ability influences perception itself.

Other methods such as signal detection theory and neuroimaging techniques have been developed to distinguish perceptual and response-based effects. Because the issue of whether these effects are perceptual or not has not yet been resolved, both of these techniques are currently being pursued in my lab. To date, however, no alternative accounts that can explain the entire body of work that provides evidence for action-specific effects have been proposed, and growing evidence suggests that the effects are indeed perceptual.

Adaptive Advantages?

A bias to see balls as bigger or targets as closer than their objective size and distance might seem like an error in perception that could lead to errors in subsequent performance. However, these potential perceptual errors could be corrected with continuous on-line visual feedback during the movement. So the question becomes whether these biases have any adaptive advantages.

Perceiving the environment in relation to the perceiver's own abilities—rather than in behaviorally irrelevant metrics—could prove to be useful, particularly for planning future actions. Novices are unlikely to attempt to climb a wall that seems impossibly high. The perceptual bias to see the wall as taller will lead to fewer false alarms in which the perceiver thinks the wall can be climbed. This, in turn, will lead to fewer attempts to climb the wall, which would certainly expend needless energy and would possibly lead to injury from falling. People who are out of shape might choose an alternative route to climbing up a steep hill or select to walk at a slower speed, thereby better regulating their energy expenditure, which is imperative for survival (see Proffitt, 2006). Athletes who are struggling to play well might devote extra concentration because they will be trying to hit a (perceptually) smaller target. The effects found in sports could be applied to a hunting scenario, which is clearly more relevant for survival and is the historical foundation upon which many sports are based. A hunter who is not performing well will see the target as smaller. This might encourage the hunter to get closer in order to be

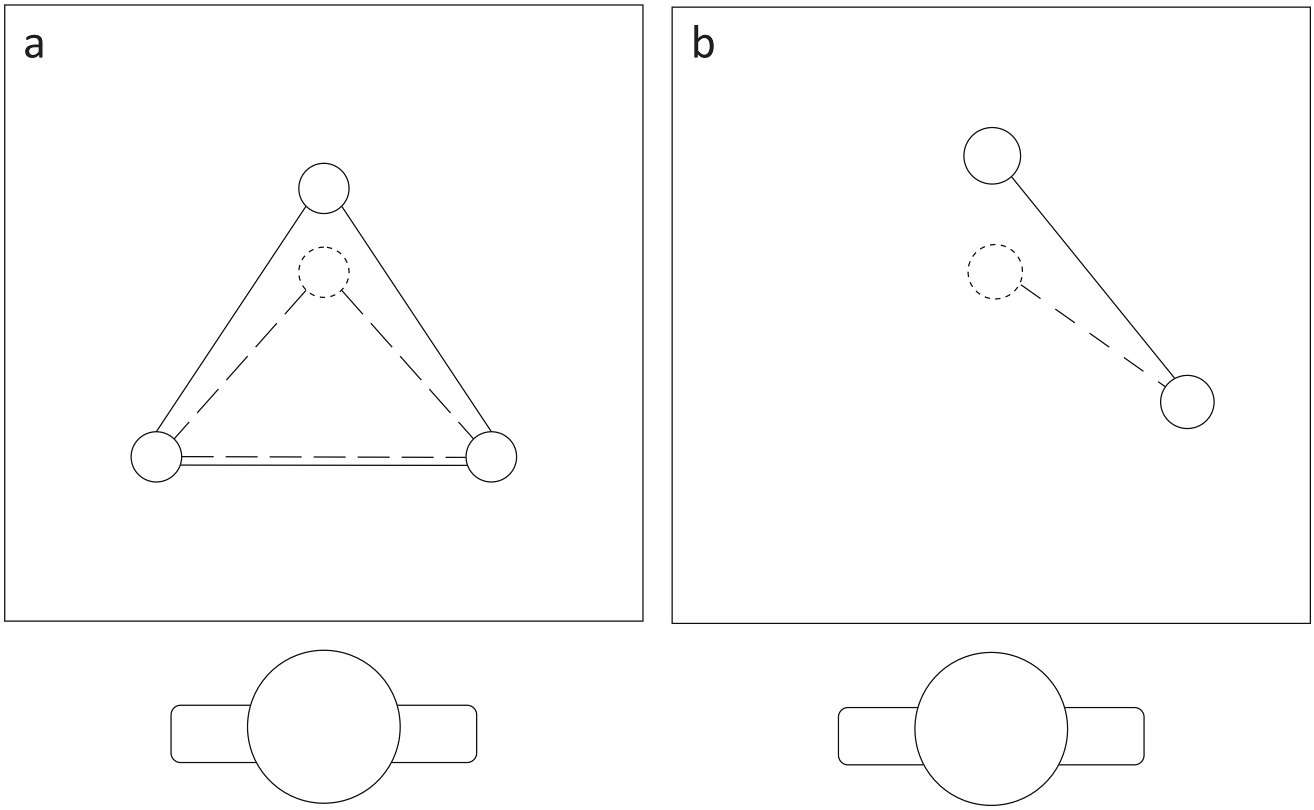

Fig. 2. Illustrations of how perceiving a target as closer would influence (a) perceived shape and (b) perceived parallelism (Witt, 2011).

more precise in the attack—which, on a bad day, will promote more hunting success. On the other hand, a hunter who is performing well will see the target as bigger and might be more likely to attempt to hit it from his or her current location rather than risk detection by trying to get closer. Thus, perceptual biases generated by action capabilities could be adaptive and promote survival by encouraging appropriate behavioral decisions.

Conclusions

In summary, the action-specific perception approach asserts that perception is a function of the perceiver's abilities. Athletes who are playing better see their sports–related targets as bigger. Perceivers who can reach farther see objects as closer. Perceivers who have to exert more energy to walk to a target see it as farther away. Perception is not an objective representation of the environment but instead reflects the relationship between the environment and the perceiver's ability to act within it.

Recommended Reading

Proffitt, D.R. (2006). (See References). A wonderful article that describes the effects of energetic potential on perception in greater detail; also includes nonhuman references and references to effects of emotional state (mood, fear) on perception.

Gibson, J.J. (1979). (See References). A historical classic—Gibson's most thorough treatment of affordances.

Bekkering, H., & Neggers, S.F.W. (2002). Visual search is modulated by action intentions. *Psychological Science*, 13, 370–374. A striking study that demonstrates the influence of intention on visual search processes.

Witt, J.K., & Proffitt, D.R. (2008). (See References). An article on the possible mechanisms underlying action-specific-perception effects; proposes and provides evidence that motor simulation is necessary for the effects of ability on perception.

Declaration of Conflicting Interests

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