The Influence of Perceptual-Motor Experience on Skill-Relevant Action Capabilities

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Abstract

The role of perceptual-motor experience in affordance perception is fundamental in understanding the reciprocity of perception and action and their relevance to cognition. An experiment investigating perception of the maximum height to which actors could reach, jump to reach, and sit was conducted. The role of perceptual-motor experience was investigated by evaluating the performance of basketball players and non-basketball players. Reaching, reaching-with-jump and sitting height estimates were compared to the actual action capabilities. Basketball players more accurately perceived a skill-relevant affordance (maximum height another could reach by jumping) than non-basketball players, but perceived a non-skill-relevant affordance (the maximum height of a surface upon which one could sit) with the same accuracy as non-basketball players. These results demonstrate the role of specific action experience in perception of affordances for others.

Keywords: Affordance; experience; expertise; basketball; perception-action.

A natural part of ordinary perception is the perception of affordances. Affordances are invariant (e.g. unchanging) combinations of surface/substance properties of our environment taken with reference to an animal's action capabilities; in other words, affordances are possibilities for action (Gibson, 1986). Affordances change with changes in one's action capabilities, and affordance perception changes accordingly in real time. For example, Mark (1987) demonstrated what is sit-on-able for a person corresponds to a rigid surface that is 45% of the person's eye height and, importantly, that perception changes with experience. Moreover, he showed that if a perceiver wears blocks on their feet, changing the maximum sit-on-able height to 50% of their eye height, they will initially make inaccurate judgments based on their previous fit to the environment. However, perceivers re-calibrate to this new scaling relation extremely quickly, and accurately judge the maximum height of what is sit-on-able with their new legs.

Previous research has also demonstrated that humans can perceive affordances for others (i.e., what the environment affords another person). For example, Ramenzoni, Riley Shockley and Davis (2008a) have shown that observers are able to perceive how high another can reach overhead at a similar level of accuracy as perceiving the affordance for themselves and how high another person can reach while jumping both for themselves and for another person. Likewise, Stoffregen, Gorday, Sheng and Flynn (1999) found observers can differentiate the maximum height at which different sized people could sit.

Moreover, perception of affordances is a function of our own perceptual-motor experience. For example, Hove, Riley, and Shockley (2006) demonstrated that hockey players perceive which hockey sticks are better for power versus precision shots differently than non-hockey players. This perceptual sensitivity may indicate a type of perceptual learning via attunement—that is, perceptual-motor experience in a sport aids the discovery of information that is specific to a sport-relevant affordance (Hove, Riley & Shockley, 2006; Abernethy, Gill, Parks & Packer, 2001). The implication is that experts in a particular sport may have over-developed capacities for perception and may, therefore, be more sensitive to perceiving affordances related to their skill domain as compared to non-experts (Fajen, Riley & Turvey, 2008).

Given the fact that humans can perceive affordances for others and that athletes may be differentially sensitive to perceptual information about affordances related to their domain of sports, the present study evaluated whether basketball players were more accurate at perceiving basketball-relevant affordances than non-basketball players. Basketball was selected as the sport of interest because prior research has shown that affordances that are related to basketball playing, namely reaching and reaching-with-jump (e.g. shooting, rebounding, passing, etc.), can be accurately reasonably accurately for self and for others (Ramenzoni et al., 2008a; Ramenzoni, Riley, Davis, Shockley & Armstrong, 2008b). Basketball players were hypothesized to be more accurate at perceiving basketball-relevant affordances (the maximum height another can reach overhand and the maximum height another can reach overhand by jumping) than non-basketball players both for self and for another. Basketball players were hypothesized to be no more accurate than non-basketball players at perceiving a non-basketball-related affordance (the maximum height at which one can sit upon a surface) both for self and other.

Method

Twenty-two undergraduate students at the University of Cincinnati participated in this study. Eleven participants had never played on a basketball team (non-basketball players; mean height = 174.70 cm) and 11 had played on a basketball team within two years prior to participating in this study (basketball players; mean height = 179.05 cm). Non-basketball players spent an average of 1.05 hours/week playing and practicing basketball, while basketball players spent an average of 8.64 hours/week playing and practicing basketball. With the exception of one basketball player who was also a cheerleader, no participants from the basketball group played a sport other than basketball. No participants from the non-basketball group played other sports.

Participants made three types of perceptual estimates for themselves and for a model actor. These estimates included the maximum height that could be reached overhand vertically while standing on the floor (reach), the maximum height than could be reached overhand vertically by jumping from the floor (reach-with-jump), and the maximum height of a sitting plank upon which one could sit without lifting the heels of the feet (sit). These instructions were explained to all participants before starting the study, however participants' actual reaching/reaching with jump/sitting heights were not determined until after all estimates had been made (cf. Mark, 1987). All participants were asked to remove their shoes for the duration of the study. A large wooden apparatus (325 cm high × 95 cm wide) was used as the backdrop for the moving object. Consistent with previous affordance studies of this type (Ramenzoni et al., 2008a; Ramenzoni et al., 2008b), participants stood 3 m from the front of the apparatus. The model stood directly beside the apparatus while observers made judgments for the model, allowing participants to see the model clearly while making all types of judgments. For reach and reach-with-jump judgments, the target was a small cylindrical object (5 cm × 4 cm) suspended from the ceiling and attached to a pulley in front of the wooden apparatus perpendicular to the floor (see Figure 1). For sitting judgments, the target was a seating plank (85 cm long × 35 cm wide) attached to the same pulley.

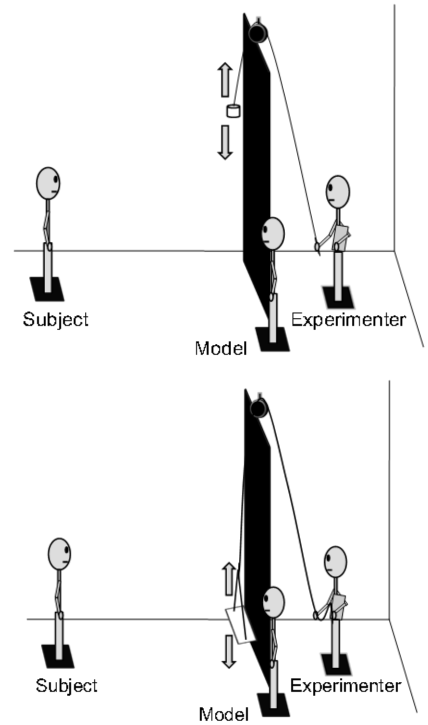

Figure 1. Apparatus and position of subject, model and experimenter for reach, reach-with-jump and sitting conditions.

Each type of judgment was obtained in one of three blocks of trials, randomized by block across participants within each type of report (self or other) and counterbalanced across participants. For reachability and reachability-while-jumping, perceivers made their judgments by directing the experimenter (who was standing out of sight, behind the apparatus) to stop moving the small cylindrical object, which started at either a low height and moved up or a high height and moved down, with the starting position randomized across trials. For sit-on-ability judgments, participants were asked to judge the maximum height of the plank upon which the affordance target (perceiver or model actor, depending on self or other condition) could sit without lifting the heels of the feet using the same procedure. After informing the experimenter to stop moving the target on the apparatus, the participant was allowed to make fine adjustments to the position of the target. The height corresponding to the participant's judgments (in cm) as indicated by occluded measuring tape attached to the apparatus was recorded by the experimenter. After completing three blocks of eight trials each, the participant approached the apparatus to determine his actual reaching and reaching-with-jump heights. Reaching height was defined as the height at which the participant could reach and touch the object with their fingertips. Reaching-with-jump height was defined as the height at which participants could touch the object with their fingertips while performing a vertical jump. Actual sitting height was determined using Mark's (1987) proportion of eye height to maximum sit-on-ability.

Results and Discussion

Accuracy of the participants' estimates was evaluated using the error in judgments of the three affordances (reach, reach-with-jump, sit) as a function of judgment type (self, other) and perceiver type (basketball player, non-basketball player). An average perceptual judgment for each judgment type was obtained from the eight trials. We had no basis to predict whether participants would over- or under-estimate height judgments, thus absolute error (absolute error = |actual height – mean perceived height|) was used as the dependent measure. Basketball players exhibited similar error in reach judgments both for self (mean error = 4.83 cm) and other (mean error = 8.65 cm) when compared to non-basketball judgments for self (mean error = 8.64) and other (mean error = 9.86 cm). Basketball players exhibited less error in reach-with-jump estimates as well, both for self (mean error = 13.29) and other (mean error = 11.15), when compared to non-basketball judgments for self (mean error = 19.70) and other (mean error = 26.86). Basketball players ranged in height from 168.5 to 191.5 cm (mean = 179.1 cm, *SD* = 9.1cm) and ranged in eyeheight from 154.5 to 181.0 cm (mean = 166.9 cm, *SD* = 9.7 cm). Non-basketball players ranged in height from 163.5 cm to 184.0 cm (mean = 174.7 cm, *SD* = 6.5 cm) and ranged in eyeheight from 152.0 cm to 168.5 cm (mean = 161.5 cm, *SD* = 5.9 cm). The model had a height of 182 cm and an eyeheight of 170 cm.

Actual sitting height was calculated using Mark's (1987) ratio of what is sit-on-able for a person (actual sitting height = eyeheight (EH) × 0.45). Basketball players exhibited similar error in sitting judgments for self (mean error = 14.16) and other (mean error = 15.53) when compared to non-basketball judgments of self (mean error = 15.33) and other (mean error = 19.46) (see Figure 2 below).

Accuracy of reaching and reaching-with-jump judgments was determined by the difference between actual and estimated reach and reach-with-jump heights, however this was not how accuracy was determined for sitting judgments. The increase in error for sitting judgments for both groups of participants may have been due to the use of a body-scaled measurement instead of actual sitting height measurements, possibly making it more difficult for differences to emerge between groups.

Mean absolute error in affordance judgments for each condition were submitted to a 2 (perceiver type) × 2 (affordance target) mixed analysis of variance (ANOVA) for each affordance type with perceiver type (basketball vs. non-basketball) as a between subjects factor and judgment target (self vs. other) as a within subjects factor. For reaching judgments, neither perceiver type, $F(1, 20) = 1.38$, $p > .05$, $1 - \beta = .19$, $\eta_p^2 = 0.06$, nor affordance target, $F(1, 20) = 1.55$, $p > .05$, $1 - \beta = .21$, $\eta_p^2 = 0.07$, significantly influenced error and there was no significant interaction, ($F < 1$, $1 - \beta = .09$, $\eta_p^2 = 0.02$) ($1 – \beta$ refers to the observed power of the test). For reach-with-jump judgments, there was a significant main effect for perceiver type, $F(1, 20) = 10.97$, $p < .005$, $1 - \beta = .87$, $\eta_p^2 = 0.33$, with basketball players exhibiting less error than non-basketball players. There was no significant influence of affordance target ($F < 1$, $1 - \beta = .14$, $\eta_p^2 = 0.04$) and no significant interaction, $F(1, 20) = 2.99$, $p > .05$, $1 - \beta = .36$, $\eta_p^2 = 0.13$. For sitting judgments, there was no significant influence of perceiver type, $F(1, 20) = 1.14$, $p > .05$, $1 - \beta = .17$, $\eta_p^2 = 0.05$. There was, however, a significant influence of affordance target, $F(1, 20) = 11.10$, $p < .005$, $1 - \beta = .90$, $\eta_p^2 = 0.36$, with judgments for self being more accurate than judgments for other. There was no significant interaction, $F(1, 20) = 2.79$, $p > .05$, $1 - \beta = .34$, $\eta_p^2 = 0.12$.

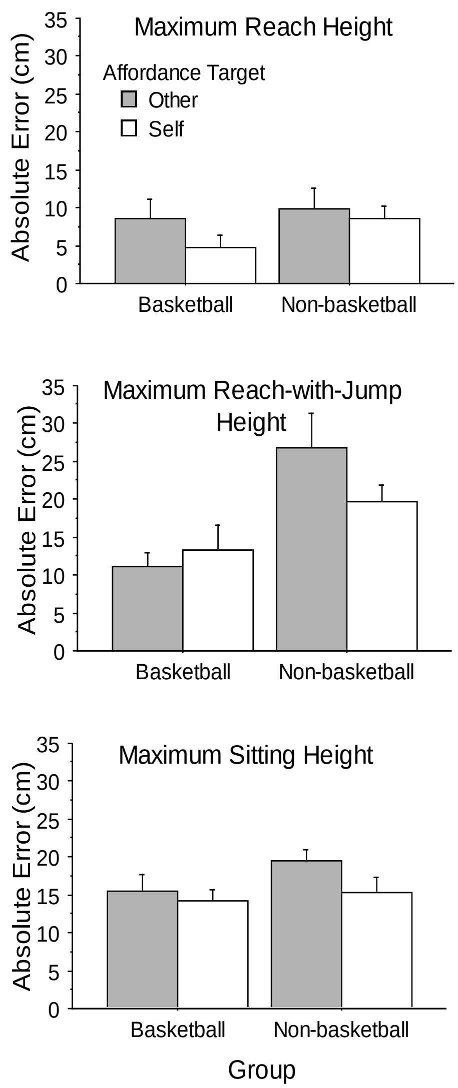

Figure 2. Mean perceived error for reach, reach-with-jump, and sitting tasks.

In partial support of our hypotheses, basketball players were more accurate at perceiving the experience-relevant affordance, maximum reach-with-jump height, than the non-experience-relevant affordance, maximum sitting height.

This finding suggests that expertise in playing a sport that relies on highly accurate affordance perception for self and for others enables athletes to better perceive skill-related affordances for themselves and others than those without a background in sports. Such a finding extends our understanding of how our own perceptual-motor experience and skills influence our perceptual capabilities. Athletes know how to perceive and act in contexts relevant to their skill domain because they are coupled with their sport environment; their specific perception and action experiences regulate their sports performance by attuning them to relevant perceptual information (Araújo & Davids, 2009).

Unexpectedly, athletes were no more accurate than non-basketball players at perceiving another experience-relevant affordance, maximum overhand reach height while standing. This may indicate that perceiving the maximum overhand reach height of another is not an affordance judgment skill unique to basketball players. It could be that reachability is a common affordance encountered by all people who make reaching judgments during activities in their daily lives. Alternatively, this finding, in comparison to the finding for reach-with-jump judgments, may offer an additional insight regarding the type of information to which athletes exhibit greater sensitivity. Fajen, Riley, and Turvey (2008) identified two classes of affordances—body-scaled affordances (e.g., step-on-ability, sit-on-ability, pass-under-ability) and action-scaled affordances (e.g., braking distance, jumping to reach) (see Fajen, Riley & Turvey, 2008, for a review). Body-scaled affordances have been shown to be a function of the geometric fit between the dimensions of the environment and the perceiver/actor (e.g., the proportion of eye height to something in the environment; Mark, 1987; Ramenzoni et al., 2008a), while action-scaled affordances have been shown to be a function of the relation between the dimensions of the environment relative to the force-production capabilities of the perceiver/actor (e.g., Fajen, 2007; Ramenzoni et al., 2008b). Accordingly, action-scaled affordances for others may be specified by different perceptual information than body-scaled affordances, namely information in the movement patterns (i.e., kinematic information) of the actor in question (Runeson, 1977/1983). For example, Ramenzoni et al. (2008a) demonstrated that perception of reach-with-jump height for another becomes more accurate after observing the actor walk. Thus, the present finding of greater sensitivity by athletes to an action-scaled, experience-relevant affordance (reaching while jumping) as compared to a body-scaled affordance (reaching) may reflect greater sensitivity of athletes to kinematic information that captures the force production capabilities of others.

Athletes have been found to be superior in perceiving affordances relevant to their experience in their particular sport. Presumably, for basketball players, this reflects their specific experience observing others jumping to reach basketballs or nets. However, if greater sensitivity to kinematic information is the basis for this superiority, then the present results do not rule out the possibility that athletes, generally, may be more sensitive to kinematic information, generally, and not necessarily to kinematic information relevant to their particular sport (Abernethy et al., 2001; Oudejans et al., 1996). For example, basketball players might be superior at perceiving maximum ball-kicking distance as well as reaching-with-jump heights. Therefore, experience-specific sensitivity needs to be disambiguated from kinematic-specific sensitivity in future research.

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