How high can you jump?
Children's Perception of Affordances for Self and Others with Different Abilities

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Abstract

The current study investigated whether children and adults can distinguish between actions they are afforded and those afforded to an actor. Participants judged the maximum height they could reach while jumping and they judged the maximum height that the actor could reach while jumping. They did so with and without a weighted backpack, and they did so with and without walking several laps. Results show that before the addition of the weighted backpack, participants rated the actor's abilities as much closer to their own. While wearing the weighted backpack and then walking with it, participants' estimates decreased for themselves, but remained mostly unchanged for the adult.

Keywords: social perception; affordances; agency; embodiment; ecological psychology; development

Introduction

For individuals to successfully navigate their environment, they must be able to perceive when different actions are possible. How does an individual know whether they can reach a jar from a shelf, step over a barrier, or navigate through traffic without incident? The ability to perceive potential actions is not limited to the individual's actions. Daily activities are filled with social interactions, such as conversational turn-taking (Shockley, Santana, & Fowler, 2003), helping someone lift an object (Richardson, Marsh, & Baron, 2007), or detecting whether two people can fit through a doorway (Davis, Riley, Shockley, Cummins-Sebree, 2010). Because people can readily interact and coordinate with other individuals, this suggests that individuals can perceive the actions afforded others and groups of people working together.

In the case of social interaction however, the perceiver doesn't necessarily have *a priori* information about another person's action capabilities. Two approaches to this problem—the ecological and embodiment perspective—contend that minimally, perception serves the purpose of guiding action. The ecological approach focuses on the physical and spatial relationship of an observer to the environment. The embodied approach claims that individuals neurally simulate (Grush, 2004) how they or another might accomplish an action. Both theories' ability to explain social perception in a jumping estimation task was tested in the current study.

Affordances as the Object of Perception

Several researchers studying how individuals perceive possibilities for action in their environment have narrowed in on Gibson's (1979) concept of *affordances.* An affordance is meant to capture the relationship of an individual's morphology and action capabilities to the spatial layout of the environment and objects. For an individual to detect an affordance is to perceive an opportunity for action.

Affordance detection is seen in behaviors such as stair climbing (Warren, 1984) or chair sitting (Mark, 1987). Warren (1984) found that individuals selection of the tallest climbable stair is best described by a nearly, invariant ratio of leg-length to stair-riser height. Rather than focusing solely on riser height information, estimates are predicted by a ratio that exists only as a function of perceiver and stair.

Individual's daily routine rarely consist of just solo actions. For example, soccer players must decide whether their teammates are in the correct position to receive a pass. The natural tendency towards such social coordination suggests individuals readily detect what actions other people are afforded; people can accurately report what objects others can reach (Rochat, 1995), lift and move together (Richardson, Marsh, & Baron, 2007), what chairs another person can sit on (Stoffregen, Gorday, Sheng, & Flynn, 1999), and how high another person can jump and reach (Ramenzoni, Riley, Shockley, & Davis, 2008a). This detection ability suggests information is readily available regarding the perceived person and their environment. Stoffregen et al. (1999) found that observers use affordance based information to detect the possible sitting height for other individuals. They asked individuals to watch a video of an actor standing next to a chair and estimate the maximal and preferred sitting height for the actor. As long as the spatial relationship between the actor and apparatus was preserved, participants could accurately estimate the heights. Estimates were also accurate when participants only saw a kinematic display. The estimates were found to be most accurate when they were scaled by the leg length of the actor in the video, not the participant.

In this case, the estimates are based on scaling the physical morphology of the person to the spatial layout. Studies have also shown that people can perceive the capabilities for others to produce actions that are scaled by biomechanical properties such as jumping to reach an object (Ramenzoni et al., 2008a). In this case, it is less clear what information an observer might use to form a perception about another person's ability.

Simulations and the Embodied Perceiver

An alternative perspective on social perception and action rests on neurologically driven mechanisms as a basis for behavior. This approach has been brought under the banner of the *Common Coding* (Prinz, 1997) or *Embodied Simulation* (Grush, 2004) approach. This approach suggests that social behaviors are explainable by a proposed overlap in how individuals represent perceived and performed actions. In other words, if a person watches an action being performed or plans to produce an action, they *simulate* the motor program and sensory consequences underlying that action. Simulation behavior is akin to covert imitation behavior (Wilson & Knoblich, 2005).

The mirror neuron system is thought to underlie such perception and action overlap (Rizzolatti & Craighero, 2004). The finding that mirror neurons, found in the F5 area of a Macaque monkey's premotor cortex, activate similarly to the viewing and production of an action (e.g., reaching for a glass), provide a mechanism for simulations. The perception of action possibilities in the embodied stance, thus, relies on neural based representations of the observer in the environment.

Behavioral support is found in stimulus-response incompatibility studies and action perception studies. For example, Brass, Bekkering, Wohlschlager, & Prinz (2000) showed that finger movement reaction times are slower after watching a video of a hand performing the opposite of the instructed movement. They propose this is due to neural interference. Upon seeing the stimulus cue to respond, participants automatically simulate the action they saw; this creates a delayed response due to the overlap between the intended and observed action.

Researchers have suggested that such overlap between perception and action may provide a basis for understanding many social behaviors (Gallese, Keysers, & Rizzolatti, 2004; Sebanz & Knoblich, 2009). Knoblich and Jordan (2002) postulate that the mirror neuron system and embodied simulations support the ability to predict potential actions and their outcomes for perceivers and other people. Simulations are derived through a perceiver detecting or representing the actions they are afforded. These simulations are also used to judge the action capabilities of other individuals.

Results supporting a simulation theory of social perception have drawn on behavioral and physiological data. Calvo-Merino, Glaser, Grezes, Passingham, and Haggard (2005) found greater activity in cortical regions containing mirror neurons when participants watched videos containing dance movements they were trained to perform. Individuals watching point-light displays are also more sensitive to movements produced by themselves than the movements of other people (Loula, Prasad, Harber, & Shiffrar, 2005). These findings suggest that an observer's perception of another person's ability is derived from the observer's own capacity for action.

The proposal by Knoblich and Jordan (2002), regarding social action perception, suggests that the perceiver's estimation of other person's capacity to produce actions should be scaled to the perceiver's ability. Interestingly, Ramenzoni et al (2008a) found that putting weights on a participant reduced jump and reach estimates for themselves and an actor even though the actor was not wearing weights. This finding suggests that people may use simulations to estimate others, but use themselves as a frame of reference. It is not clear however, whether such estimates are really based on one's own ability to act per se, or are scaled by another relationship. Ramenzoni, Riley, Shockley, & Davis (2008b) manipulated observer eye-height in another study as well. They found significant changes in the participants' estimates for themselves and the actor. These findings suggest that eye-height scaled information and embodied simulations both contribute to determining the ability to judge actions for others. Simulation behavior may provide a template for judgments while detection of eye-height or other optically specified information is used to tune those judgments.

Study Overview

The current study examined whether a person's inherent and manipulated jumping ability affect their judgments of their own and another person's ability equivalently. Specifically, we tested whether individuals' judgments are based solely on their own ability to jump and reach an object or whether estimates are underpinned by simulations tuned by detecting optically specified information. In this case, the detectable information is the eye-height difference between the participant and another person. Thus, we predicted that an observer's estimation accuracy for another person should be related to the difference in eye-height of the perceiver and actor and the similarity of their inherent jumping abilities. If individuals only use simulations to make judgments, reducing observer's abilities should significantly reduce estimates for themselves and the actor. If estimates for the actor remain mostly unchanged, we predict that participants are using simulations tuned by differences in the eye-height between participant and actor.

To test the current predictions, we asked children and adults to estimate the maximum jumping abilities for themselves and an actor. Past studies (Ramenzoni et al., 2008a) have only used adult participants. This population doesn't discriminate between groups who possess naturally different abilities and potentially different simulation capabilities. Both groups were used under the assumption that children naturally have lower jumping abilities then adults. Thus, they should have inherently different action capabilities to simulate. Participants had never seen the actor walk, jump, or reach for anything, removing any cues regarding the actor's biomechanical abilities, which has been shown to improve individual's judgments of other's (Ramenzoni, Riley, Davis, Shockley, & Armstrong, 2008c). We manipulated participant's perception of their own jumping abilities and potentially the actors jumping abilities (Ramenzoni et al., 2008a) by increasing their weight. This was accomplished by having participants wear a backpack containing weights. Weighted estimates were provided before and after walking with the backpack.

Methods

Participants

Participants were 15 children between 4.5 and 5 years old (M =4.9, SD = 0.32) and 15 adults between 18 and 24 years old (M =21, SD = 2.5). Children ranged in weight from 30 to 55 lbs (M =48.6, SD = 7.3), in height from 94 to 130 cm (M =112, SD =9.3), and in eye-height from 85 to 123 cm (M =104, SD = 9.6). Adults ranged in weight from 141 to 210 lbs (M =159, SD =30.2), in height from 162 to 195 cm (M = 171, SD = 7.7), and in eye-height from 152 to 185 cm (M =162, SD = 8.6). The actor had a weight of 140 lbs, height of 166 cm, and eye-height of 152 cm. All participants were either undergraduate students at the University of Cincinnati or children of undergraduates.

Materials

To estimate jumpability, a figurine was suspended by a pulley and rope from the ceiling (see Figure 1). It could be lowered down a wall. Participants stood on a flat surface (100 cm x 100 cm), 7 feet from the suspended object. The actor was positioned one foot to the left of the apparatus, facing the participant. The room was covered in black felt, including the background of where the figurine was suspended. Two adjustable backpacks, one adult-sized and one child-sized, were used to add weight to the participants. The weights used in the bag weighed 15 g each. The amount of weight used per person was approximately 5% of their body weight (±15g). Participants were given help to put on the bags during the experiment.

Procedure and Design

Participants were asked to play a guessing game. They were instructed to accurately estimate their own and another person's maximum ability to jump for the figurine. Prior to a trial, the figurine was lifted to the ceiling and then lowered down slowly. This was accomplished by an experimenter standing behind the wall and using the pulley system. The instruction was to tell the experimenter to stop lowering the figurine when it was at the reachable height. Participants were allowed to have the experimenter adjust the apparatus, if the figurine was lowered too much. Estimates were coded using a tape measure drawn onto the wall. The figurine was then lifted to the top of the wall and a new trial started. Participants closed their eyes between each trial, preventing the usage of any spatial cues provided by resetting the apparatus. When estimates were made for the participant's own abilities, the actor was not in the room. When estimates were made for the actor, the actor stood next to the apparatus. A trial started by giving a verbal "go" signal, upon which the participant opened her/his eyes and the figurine was lowered.

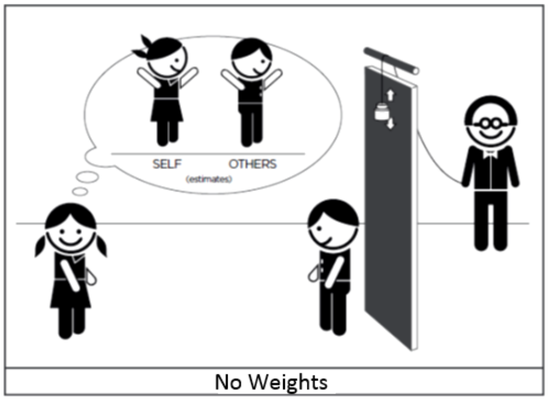

Figure 1: Experimental setup. The girl represents the participant making a judgment about herself as well as the actor (the boy in front of the wall). The person behind the wall represents the experimenter lowering the figurine.

The experiment consisted of six types of trials, dependent on whether the participant was making estimates for themselves or the actor, and whether the participant had no weights (no-weights trial), had weights (weights-before-walking trial), or had walked with weights (weights-after-walking trial). In the no-weights condition, individuals made estimates from the designated spot. Participants were then given a backpack to wear (pre-weighed to approximately 5% body weight), but were not allowed to move from the spot. After making their judgments, they were asked to walk 10 circular laps around the room. They then made the two remaining estimates. Two estimates were made for each trial type. The average of the two was used for the dependent variables. After all of the judgments, participants were asked to perform two jumps with the backpack on and two jumps without the backpack. The average across the two jumps of each kind was used to measure actual jumping abilities.

Because we wanted to examine the effects of going from a non-manipulated (no-weights) to a manipulated, but unadjusted (weights before walking), and adjusted (weights after walking) scenario, we did not counterbalance the order of trial type. We did however, counterbalance the order of the Person factor (self vs. other). Combining all of the factors, we utilized a mixed-design of Age Group (Child vs. Adult) x Person (Self vs. Actor) x Trial Type (no-weights, weights-before-walking, and weights-after-walking).

Results

The following analyses present variables, described below, to analyze the actual jumping abilities, the mean estimated jumping height for the participant and actor (per trial type), and the estimation error (calculated as $\text{actual}_{\text{jump-height}} - \text{estimated}_{\text{jump-height}}$). To examine whether optical information is related to jumpability estimates, the relationship of eye-height difference to estimation error is also considered.

Actual Jumping Abilities

First, we analyzed the actual jump height for the child and adult participants in a normal and weighted scenario. This measure was used to determine whether the weight manipulation actually affected jumping ability. Mean jumping height was analyzed with a 2 (Age Group: child, adult) x 2 (Condition: non-weighted, weighted) mixed-design ANOVA. As expected, there was a main effect of the between-group variable of Age Group, $F(1,28) = 80.30$, $p < .05$, $\eta_p^2 = .74$. Overall, there were differences in the jumping abilities of the children (*M* = 160.96, *SD* = 23.66 cm) and adult (*M* = 227.80, *SD* = 17.98 cm) group. The main within-group effect of Conditions was also significant, $F(1,28) = 33.10$, $p < .05$, $\eta_p^2 = .54$. In general, both groups exhibited similar changes in jumping without weights (*M* = 195.70, *SD* = 40.88 cm) and with weights (*M* = 191.96, *SD* = 39.42 cm). The two-way interaction was not significant, suggesting both groups were similar in changes between non-weighted and weighted jumping ability (*M* = 7.2, *SD* = 2.34 cm). The effect of Condition and lack of interaction reveals that the weights reduced participant's abilities similarly, regardless of Age Group.

Estimated Jumping Abilities

To determine whether participants jumpability estimates for themselves and the actor were equivalently affected by the weight manipulation, we analyzed the participants' mean jumpability estimates using a 2 (Age Group: child, adult) x 2 (Estimated Person: participant, actor) x 3 (Condition: no-weights, weights before walking, and weights after walking) mixed-design ANOVA.

The analysis revealed a significant three-way interaction of Age Group x Estimated Person x Condition, $F(1.69,47.57) = 4.94$, $p < .05$, $\eta_p^2 = .74$. Follow-up analyses were performed by splitting the Age Group (child and adult) factor into two separate 2 (Estimated Person: participant, actor) x 3 (Condition: no-weights, weights before walking, and weights after walking) repeated-measures ANOVAS. The results for the adult group yielded a significant interaction between Estimated Person and Condition, $F(1.62,22.71) = 27.64$, $p < .05$, $\eta_p^2 = .66$. Simple effects compare estimates for the participant versus the actor at each level of Condition revealed no significant effects. The analysis for child participants yielded a two-way interaction between Estimated Person and Condition, $F(1.69,23.76) = 32.78$, $p < .05$, $\eta_p^2 = .70$. Simple effects analyses comparing the participant and actor, across each level of Condition, yielded a significant effect for the weights before walking, $F(1,28) = 5.63$, $p < .05$, $\eta_p^2 = .17$, and after walking condition, $F(1,28) = 9.70$, $p < .05$, $\eta_p^2 = .26$. The mean estimates provided by both age groups for the participant and actor are displayed in Figure 2.

Table 1. Mean jumping estimates and estimation error in cm. All values are rounded to whole integers. Standard deviations are in parentheses.

Group	Condition	Person	Estimate	Error
Adult	No-weights	Self	222 (7)	8 (13)
		Actor	219 (9)	16 (10)
	Before walking	Self	218 (8)	7 (14)
		Actor	218 (9)	17 (10)
	After walking	Self	210 (11)	-7 (2)
		Actor	216 (8)	19 (10)
Child	No-weights	Self	179 (13)	-14 (17)
		Actor	185 (11)	45 (11)
	Before walking	Self	170 (12)	-11 (16)
		Actor	187 (10)	47 (10)
	After walking	Self	157 (12)	-12 (7)
		Actor	188 (11)	47 (12)

Estimation Accuracy

The accuracy of estimates were analyzed by examining the mean estimation error ($\text{actual}_{\text{jump-height}} - \text{estimated}_{\text{jump-height}}$) using a 2 (Age Group: child, adult) x 2 (Estimated Person: participant, actor) x 3 (Condition: no-weights, weights before walking, and weights after walking) mixed-design ANOVA. Analyses revealed a significant three-way interaction of Age Group x Estimated Person x Condition, $F(1.42,39.77) = 11.86$, $p < .05$, $\eta_p^2 = .29$.

Follow-up analyses were performed by splitting the age groups into two separate 2 (Estimated Person: participant, actor) x 3 (Condition: no-weights, weights before walking, and weights after walking) repeated-measures ANOVAs. The two-way interaction was significant in the adult group, $F(1.28,18.03) = 23.25$, $p < .05$, $\eta_p^2 = .62$. Simple effects were used to compare estimation error for the participant versus the actor at each level of Condition. Results yielded a significant difference in the weights before walking condition, $F(1,28) = 4.60$, $p < .05$, $\eta_p^2 = .31$, and in the weights after walking condition, $F(1.28,18.03) = 108.79$, $p < .05$, $\eta_p^2 = .62$. Analyses for the child age group were analyzed similarly. In this case, only the main effect of Estimated Person was significant, $F(1,14) = 150.77$, $p < .05$, $\eta_p^2 = .92$.

Accuracy and Eye-Height Scaling

Lastly, we examined whether a relationship between the perceiver's and actor's eye-height explains the accuracy of estimates made for the actor. The focus on actor estimates was chosen because participants provided a consistent level of accuracy for themselves, but varied in their accuracy for the actor.

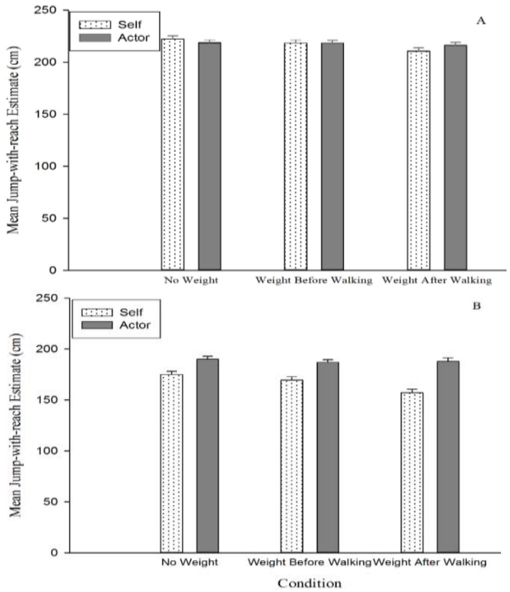

Figure 2: Mean jumping estimates by condition, for the participant and the actor. Estimates for the adult (panel A) and child participants (panel B) are shown separately.

Analyses were accomplished using a linear regression to predict the mean estimation error for the actor from the difference in eye-height between participant and actor ($\text{eye-height}_{participant} - \text{eye-height}_{actor}$). Separate regressions were used for each condition (no-weights, weights before walking, and weights after walking). For simplicity, analyses were not split between age group.

The results showed that eye-height difference accounted for a substantial amount of the variance in the no-weights ($R^2 = .70$, $F(1,28) = 63.83$, $p < .05$), weights before walking, ($R^2 = .73$, $F(1,28) = 76.75$, $p < .05$), and in the weights after walking condition ($R^2 = .65$, $F(1,28) = 52.72$, $p < .05$). The results for the three separate analyses are displayed in Table 2, and the data is in Figure 3.

Table 2: Results of regression analyses of estimation error for the actor predicted by the eye-height difference between actor and participant.

Variable	β	SE(β)	t	Sig. (*p*)
No-weights	.834	.104	7.98	*P < .01*
Before walking	.856	.098	8.76	*P < .01*
After walking	.808	.111	7.26	*P < .01*

Discussion

The present study examined what information observer's use when estimating another person's ability to jump for an object.

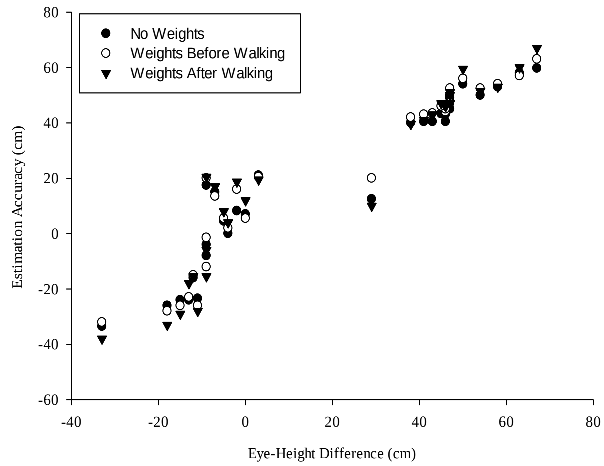

Figure 3: Scatterplot showing the relationship of the participant's estimation accuracy for the actor with the difference in eye-height.

Like previous findings (Ramenzoni et al., 2008a and 2008b), we anticipated individuals could detect the actor's ability with some accuracy. Some studies (Ramenzoni et al., 2008a) have shown that changing the participant's ability to jump by adding weights alters a perceiver's estimate of their own and an actor's ability, despite not changing the actor's abilities. This has been taken as support that an observer's perceptual judgment is driven by a simulation mechanism. Other studies have shown that estimates of another person's abilities are better described by some physical relationship of the actor (e.g., leg-length) to the environment (Rochat, 1995; Stoffregen et al., 1999) or the physical relationship between two people (Richardson et al., 2007).

Based on the current line of theorizing, we predicted that participant estimates for themselves should decrease when weights were initially added and more so after walking with them on. Additionally, if participants were utilizing eye-height information, then the estimates for the actor should not decrease significantly. Examining the mean jumpability estimates (Figure 2. and Table 1.), it is clear that participant's estimates for themselves decreased significantly in both age groups, but didn't decrease similarly for the actor. Only with child participants, however, were there significant differences between estimates for themselves and the actor across conditions. The lack of an effect in the adult group is similar findings of Ramenzoni et al. (2008a). The non-effect in the adult group, though, might be due to the eye-height similarity between the adult participants and actor. The children, on average, had a greater eye-height difference to the actor than the adult group.

If perceivers used eye-height information to tune affordance judgments of jumping for the actor, then estimate accuracy should scale with eye-height (Ramenzoni et al., 2008b). Specifically, perceivers with the closest similarity in eye-height to the actor should exhibit the greatest accuracy, assuming they have similar jumping abilities. The regression analyses of eye-height difference across conditions support this proposal. The R^2 values demonstrate that a high, and similar, amount of variance is captured by the model across all conditions and age groups. Furthermore, the standardized coefficients are significant and similar across all conditions (Table 2.). Examination of Figure 3 reveals increased accuracy for participants closest in eye-height to the actor. The mean estimation errors (Table 1.) also show that adults were more accurate than children. Interestingly, the scaling relationship shows that as the participant's eye-height decreased away from the actor, there was an increasing tendency to overestimate the actor; as participant eye-height increased away, there was a tendency to underestimate. Together, these findings suggest a potential two part process to perceiving action capabilities for others. Observers can estimate boundaries for another person's abilities by simulating a potential action. Detection of optical information — such as eye-height difference can fine tune these estimates.

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