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Look before you leap: Jumping ability affects distance perception

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Abstract

Previous research has demonstrated that changing perceivers' action capabilities can affect their perception of the extent over which an action is performed. In the current study, we manipulated jumping ability by having participants wear ankle weights and examined this manipulation's influence on the perception of jumpable and un-jumpable extents. When wearing ankle weights, jumpable gaps appeared longer than when not wearing ankle weights; however, for un-jumpable gaps, there was no difference in the apparent gap extent regardless of whether the participant was wearing ankle weights. This suggests that the perception of a jumpable extent is affected by one's action boundary for jumping, but only if jumping is an action that can be performed over the extent.

In order to successfully perform any action in a given environment, perceivers need to know their action boundaries, or the maximum extent over which they can successfully perform an action. To make these determinations, they must relate optical information to the body and its action capabilities. Because visual information comes to the eye in the form of visual angles and changes in these angles, angular information must be transformed into distance appropriate units in order to perceive extents. In this study, we provide evidence that optical information is scaled directly to the body by using the action boundary of the intended action as a perceptual ruler to measure the relevant extent. Specifically, we show that modifying the perceiver's ability to jump affects the perception of the jumpable extent.

Previous research has shown that action boundaries may provide the unit to which action-relevant extents are perceptually scaled, and therefore, act as a mechanism for combining visual information with information about the body (Fajen 2005; Witt et al 2005; Linkenauger et al in press). For example, when the action boundary for reaching was expanded by using a tool, distances to targets within reach with the tool but outside of reach without the tool appeared closer (Witt et al 2005). Presumably, the perception of distance changes depending on whether or not an object is within or outside of one's action boundary, hence affecting the apparent distance to the target.

We propose that action boundaries serve as perceptual rules in the following way. The extent of people's reach defines the length of their "reachability ruler." Construing this ruler as a unit distance, then a target displaced from a person by half of this extent would measure .5 reachability units. Now suppose that people employ a tool that doubles their reachability distance. Measuring the previous target with this tool-enhanced reachability ruler will cause its extent to decrease to .25 reachability units. Thus, extending reachability results in a decrease in target distances as measured by this action boundary ruler. Similarly, when the action boundary for reaching was compressed, by having participants use a difficult grasp, targets appeared farther away than when using an easier grasp (Linkenauger et al in press). The difficult grasp likely compressed the "perceptual ruler" making the same extents measure as farther on the then shorter ruler.

In the present study, we observed whether changing the action boundaries for jumping could influence the perception of the jumpable extent. We had participants wear ankle weights to reduce their jumping capabilities. We expected that participants would see distances as longer when they were wearing ankle weights because their action boundary for jumping was compressed, which should in turn affect the scaling of the jumpable extent, but only for distances within their jumpability range. If the extents were outside of their action boundary for jumping, then they cannot use that action boundary to scale the extent, and therefore, effort to jump is no longer relevant.

To test this hypothesis, twelve undergraduate students (5 female, 7 male) estimated their jumping capabilities across two platforms. The two platforms (0.76 × 1.22 × 0.15 m) were placed on a cloth facing each other to create a gap (see Figure 1). The experiment was performed indoors in an area where a hallway made a right angle turn. Participants stood on one platform that remained stationary (standing platform) facing the other platform that was moved between trials (target platform). Participants stood on the platform and indicated whether they thought they could successfully jump to the target platform. Then participants estimated the gap extent by instructing the experimenter to move a wooden dowel away from a wooden block so that the distance between the dowel and block matched the extent of the gap (see Figure 1). Participants were encouraged to make any adjustments necessary for an accurate measure of the distance, and then faced the wall in between each trial while the target platform was moved. Participants completed 2 blocks, one with and one without wearing ankle weights. Each block consisted of 20 trials of gap length estimations (40 total trials), at gap extents every 0.15 m from 0.15 m to 3.05 m. The gap length order was randomized and condition was counterbalanced. In the ankle weights condition, participants wore ankle weights on each ankle calculated as 1/20th of their self-reported body weight. Before starting each block, participants walked ~ 60m to calibrate to their current action capabilities. After the two blocks participants performed a standing jump on flat ground with and without the ankle weights to determine actual maximum jumping ability.

Two additional participants were excluded for not following directions (peeking between trials and ignoring instructions during distance estimations). Participants estimated that they could jump across longer gaps when not wearing ankle (M= 1.61, SE = .10) than when wearing ankle weights (M=1.36, SE=.12), $t(1,11) = 3.35$, $p = .003$, $\eta_p^2=.51$, one-tailed. Because different extents were within and outside of jumpability for each participant in each condition, we were able to compare across different extents by transforming into distance estimations ratios by dividing the estimated gap distance by the actual gap distance. As predicted, a univariate analysis of variance (ANOVA) with jumpability (within or outside of jumpability) and condition (with or without ankle weights) with participant as a random factor showed a significant interaction between condition and jumpability, $F(1, 11.15) = 10.66$, $p = .007$, $\eta_p^2=.49$ (see Figure 2). As a result, separate analyses were performed on distance ratios that were within and outside of jumping ability using a univariate ANOVA with actual distance (0.15 – 3.05 m) and condition as fixed factors and participant as a random factor. For distances within jumping ability, the distance ratio were greater when the participant was wearing the ankle weights (M = 1.37, SE = .01) than when not (M = 1.28, SE = .01), $F(1, 22.22) = 4.75$, $p =.04$, $\eta_p^2=.18$. There was also a main effect of distance with greater distances being underestimated more, $F(14, 121.72) = 10.52$, $p <.001$, $\eta_p^2=.39$. The same analysis was performed on distances ratios that were outside of jumping ability. Conversely, ankle weights did not affect distance ratio, $p = .95$; however, distance ratios did decrease as a function of actual distance, $F(14, 128.25) = 2.66$, $p = .002$, $\eta_p^2=.23$. These data show that wearing ankle weights affected the apparent gap extent, but only when the extent was within the participants jumping capabilities.

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The experiment demonstrated that decreasing action capabilities makes distances appear longer but only over extents upon which the action can be performed. Outside of someone's jumping ability range, there is no reason or benefit for scaling distances according to jumping's action boundary; beyond this boundary, all extents are un-jumpable. Compared to unencumbered jumping, ankle weights reduce the range over which someone can jump, and consequently, distances within this range are scaled to a shorter action boundary (i.e. shorter ruler) This shorter perceptual ruler will, and in turn, cause targets, viewed within this compressed range, to be perceived as being further away relative to when no weights are worn. In conclusion, the perception of distances is action-specific. Viewing extents as a “jumper” causes extents within one's jumping range to be scaled to this action boundary.

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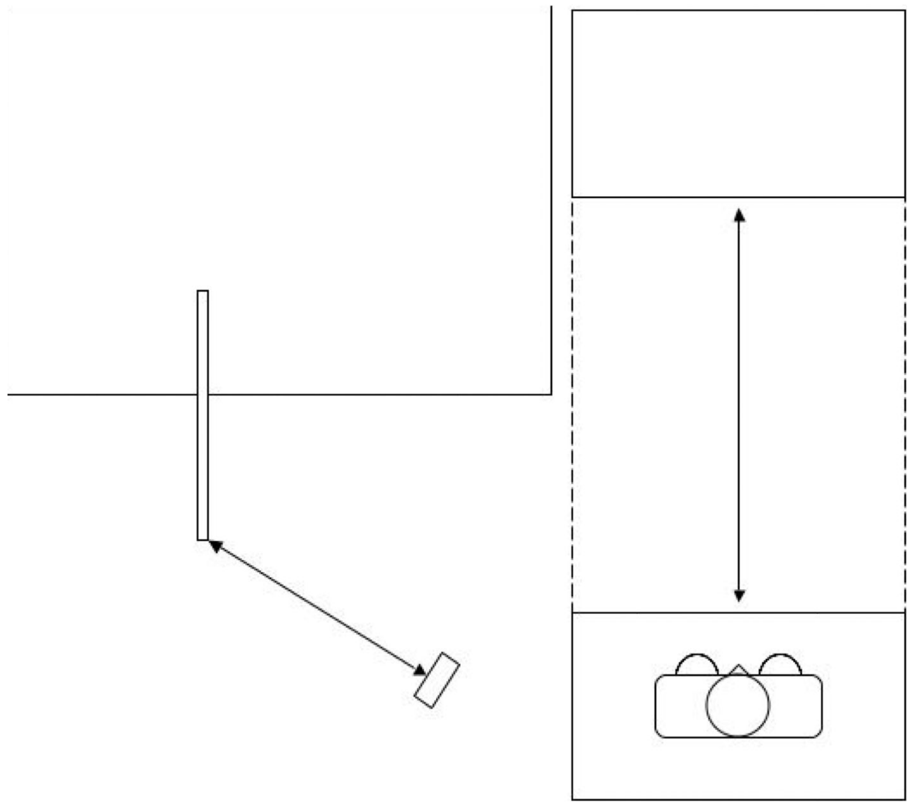

Figure 1.
The layout of the apparatus used in Experiment 1.

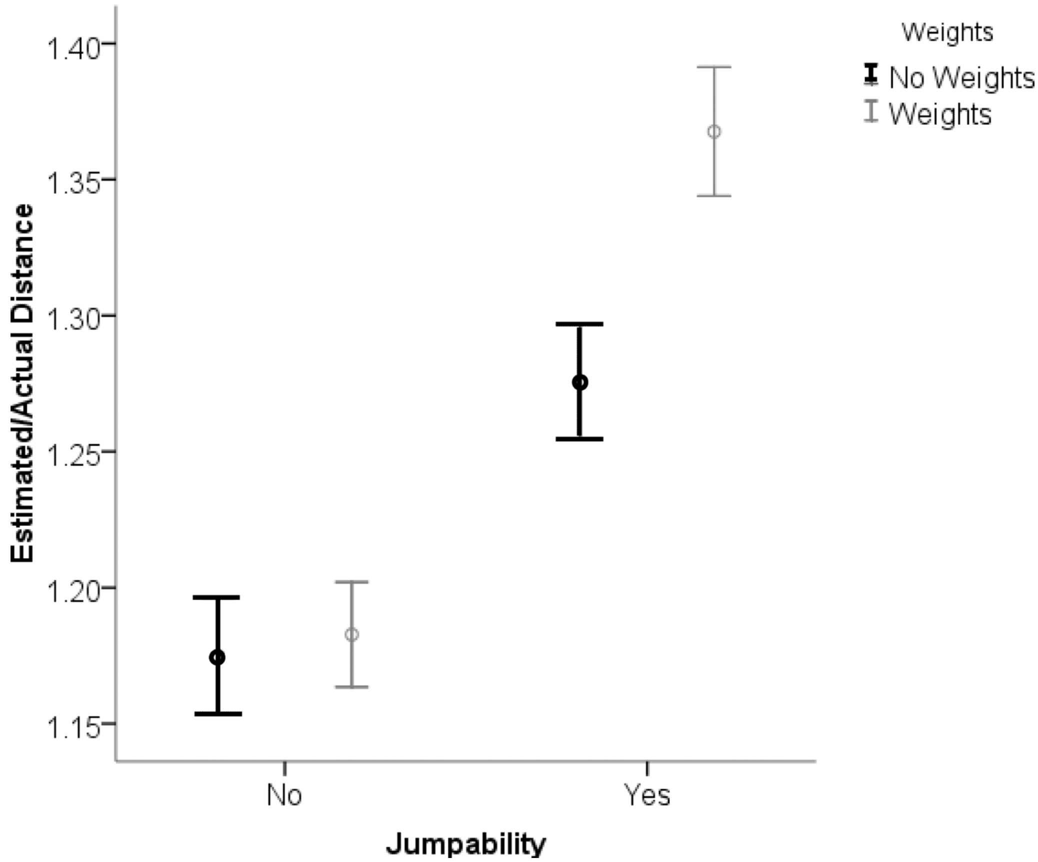

Figure 2.
Jumpability as a function of the ratio of estimated over actual distance. Error bars represent 1 standard error above and below the mean.