Perceiving Affordances for Fitting Through Apertures

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Affordances—possibilities for action—are constrained by the match between actors and their environments. For motor decisions to be adaptive, affordances must be detected accurately. Three experiments examined the correspondence between motor decisions and affordances as participants reached through apertures of varying size. A psychophysical procedure was used to estimate an affordance threshold for each participant (smallest aperture they could fit their hand through on 50% of trials), and motor decisions were assessed relative to affordance thresholds. Experiment 1 showed that participants scale motor decisions to hand size, and motor decisions and affordance thresholds are reliable over two blocked protocols. Experiment 2 examined the effects of habitual practice: Motor decisions were equally accurate when reaching with the more practiced dominant hand and less practiced nondominant hand. Experiment

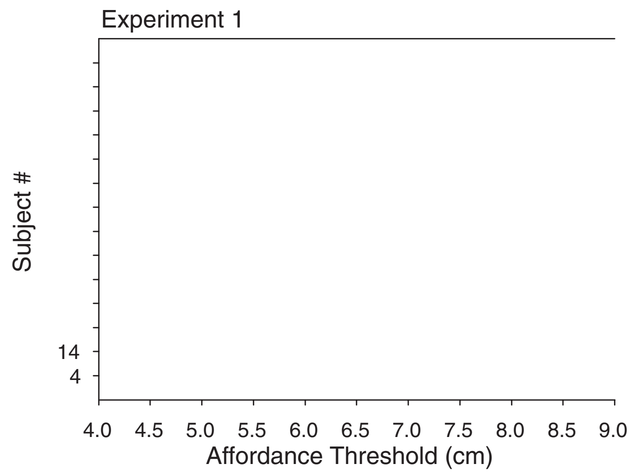
Current Studies

In a series of experiments, we examined adults' ability to gauge

Aperture apparatus. As shown in Figure 1, participants sat on a swiveling office chair in front of an adjustable aperture apparatus. The apparatus consisted of a wooden frame (111.44 cm $\times$ 84.60 cm) housing two 0.50-cm thick fiberboard panels with right triangles cut from their inner edge. The panels were offset to allow them to overlap like a camera shutter so that the total depth of the aperture was 1.00 cm. An aperture operator moved a handle on the outer edge of either panel to create a diamond-shaped opening with four equal sides. When closed, each side of the aperture was 0 cm long; when the panels were pulled completely apart, each side of the aperture was 40 cm long. The size of the aperture could be finely adjusted in 0.10-cm increments using a knob on top of the wooden frame. Calibration markings along the top and back of the apparatus indicated the length of one side of the aperture. A small camera attached to the apparatus magnified the calibration markings on a monitor so that the experimenter could correctly set the aperture size with millimeter precision. The center of the aperture remained fixed at 42.30 cm from the top and bottom edge of the frame. Sufficient clearance (75.40 cm) beneath the frame allowed participants to easily swivel their chair with their knees beneath the apparatus. Small targets (candies and snacks less than 2 cm in size) were placed in the center of the aperture on the end of a long, flat stick (91 cm $\times$ 2.54 cm).

Procedure. Participants were tested in a single session lasting 60 to 90 min. At the beginning of the session, the experimenter determined participants' dominant hand (the hand used for writing and playing sports) through a short interview. Participants removed all rings, watches, and bracelets. Next, the experimenter measured the length of participants' dominant hand, from the tip of the middle finger to the flexor *pollicis brevis* muscle (base of thumb), to determine the distance to place the target from the edge of the aperture. Pilot testing showed that this target distance required participants to fit the widest part of their hand through the aperture (from the second to fifth knuckles of all four fingers with the thumb folded in toward the palm). Then the experimenter adjusted the height of the chair so that participants' eyes were level with the center of the aperture. Pilot testing showed that this height enabled participants to see the target through the smallest apertures.

Two experimenters were required to run the reaching trials: a computer operator who ran a customized software program that suggested the aperture size for each trial and an aperture operator



turned toward the aperture and said "no" without moving their hand, as if their decisions were based solely on visual information for the aperture. Sometimes they lifted their hand and held it up in front of the aperture, as if visually comparing their hand size with the aperture size. On other trials, they inserted their fingertips into the aperture as if to gain a clearer perspective of their hand size relative to the aperture size. Least frequently, they formed their hand into a point and inserted one or two fingertips into the aperture; this gesture may have reflected a compulsion to touch the aperture rather than exploration of the aperture size. Note, less than half of the participants (denoted by the *n*s above the bars) contributed refusal data to the two largest aperture groups.

Summary. Experiment 1 validated the use of the psychophys-

Condition 1

Cm from T

pants showed no intermanual differences when estimating how far they could reach for targets in space (Fischer, 2005) or while copying complex designs on the Rey Complex Figure Test (Bush & Martin, 2004).

Method

Participants and procedure. Fourteen adults (7 women, 7 men) were recruited and compensated as in Experiment 1. Their mean age was 20.10 years (range = 19.19 to 21.46), and they reported their race as White ($n = 9$), Asian ($n = 4$), and Hispanic ($n = 1$). Only one participant was left-handed. Two additional participants were tested but their data were excluded due to experimenter error.

The experimental procedure and data coding were identical to Experiment 1. Dominant and non-dominant hand conditions were blocked and counterbalanced; 3 of the men and 3 of the women reached first with their dominant hand. Agreement between the primary and secondary coder was high for trial outcome (98.1%, $\kappa = .97$, $p < .001$), reaching strategy (97.9%, $\kappa = .96$, $p < .001$), and orientation (99.0%, $\kappa = .96$, $p < .001$).

the middle panel of Table 1, dominant hand width was 0.28 cm larger for the dominant hand compared with the non-dominant hand, $t(12) = 3.52$, $p = .004$. Scrunched hand width was correlated with affordance thresholds, $r_{\text{dominant}}(13) = .70$, $p = .008$, and $r_{\text{non-dominant}}(13) =$

prosthesis covering the pinky side of the hand. Pilot testing showed that participants could easily flex and contort their hands while wearing either prosthesis. Because the padding could be compressed to different extents depending on the pressure, we expected that affordance thresholds might not increase by exactly 1 cm for each participant. The normal hand prosthesis was identical but unpadded. We built three pairs of prostheses to accommodate small, medium, and large hands.

Procedure and data coding. As in Experiment 1, participants were encouraged to reach through the aperture apparatus using their dominant hand in two conditions: big hand and normal hand. Condition order and gender were counterbalanced (4 men and 5 women reached with the big hand first). Participants put on the appropriate prosthesis just before the start of the condition. They

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