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Exploration in Information Space during Affordance Perception

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Acting and perceiving in the world requires active exploration to detect informational variables that specify properties of the environment and potential behaviors. The study of exploration therefore necessitates quantifying both the useful informational variables that specify relevant properties and the accompanying exploratory patterns. An information space is a manifold where each point represents an informational variable of potential relevance for perceiving a given property like the length of a rod (Jacobs & Michaels, 2007). The information space identifies informational variables that are more or less relevant for a particular property, and the most useful informational variable is defined as the optimal locus in the information space. The information space analysis is a useful way for understanding the informational basis of perceptual reports. Previous work has demonstrated that fractal fluctuations of wielding behavior predict perceptual judgements in a dynamic touch task (Stephen, Arzamarski, & Michaels, 2010). This finding suggests that fractal fluctuations in exploratory movements facilitate the pick up of information.

We hypothesized that fractal fluctuations in movement are indicative of the flexible structure of exploration in the service of picking up information for a perceptual goal. In the current study, we used a dynamic touch affordance perception task to test the hypothesis that the fractality of exploration relates to the informational variables perceivers use for a particular task. If fractality of exploratory behavior relates to specificity of information picked up for perception, increased fractality should correspond to the use of informational variables in close proximity to the optimal locus in the information space.

Method

University of Cincinnati undergraduate students (*N* = 11) were given course credit for participating in this study. Participants were instructed to sit in a chair with an elongated right armrest. An occlusion screen was hung from the ceiling, and participants were asked to put their right arm through it up to their shoulder. A report apparatus (2 m × 35 cm) was positioned lengthwise in front of participants at about waist height. The report apparatus had an arrow attached to a string that participants could move towards or away from them by spinning a wheel from which the string hung.

Participants were handed a series of 10 wooden dowel rods in their right hand in randomized order.. Participants were instructed to wield each rod for 15 s to gauge the maximum forward distance they could reach with it. Participants were asked to keep their elbow planted on the armrest and their forearm parallel to their body while wielding. Participants were asked to avoid hitting the occlusion screen and moving their hand up or down the rod but otherwise had free range of motion about the elbow and wrist. A Polhemus Fastrak® motion capture unit was used to track rod movements during wielding. A sensor was attached to the bottom of the rod and recorded movements at 60 Hz.

After the 15 s of wielding, participants gave reports of the maximum distance they could reach forward with the rod without leaning forward or lifting off of the chair. Participants gave reports by adjusting the arrow on the report apparatus until it was at the point where they could just touch it with the tip of the rod. Participants were never given any information about the actual length of rods, nor did they ever see the rod during the study.

Detrended Fluctuation Analysis (DFA) was used to estimate the fractal exponents (α) of the Euclidean distance fluctuations of wielding behavior.

Results and Discussion

Mean α-DFA exponent for wielding was .69 (*SD*=.09). Mean distance from optimal locus was .11 (*SD*=.08). There was a reliable association between α-DFA exponents and distance from the optimal locus, ($r[10]=-.58$, $p<.05$), suggesting that more fractal exploratory behavior was associated with occupying areas of information space closer to the optimal locus.

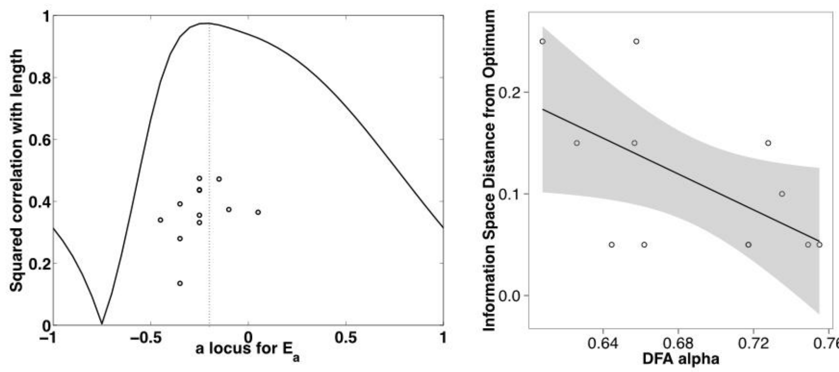

Figure 1. (Left) The information space for the affordance perception task. The x-axis represents the information space. The y-axis is the squared correlation coefficient between stimulus length and each E. The solid line represents the usefulness of each locus in the space. The small circles represent the loci occupied by each of the individual participants. The vertical dotted line represents the optimal locus. (Right) Scatter plot of the relationship between α-DFA exponents (x-axis) and the absolute difference between the optimal locus and each participant's locus (y-axis). Solid line represents the estimated regression line and grey ribbon represents 95% CIs.

Increased fractality of exploratory wielding behavior corresponded to a shorter distance from the optimal locus in the information space. These results suggest that the flexibility of the haptic system relates to the utilization of more useful information variables. Future work should consider alternative experimental designs to test for a causal relationship between patterns of exploratory behaviors and movements through information space toward more useful information variables.

References

Jacobs, D. M., & Michaels, C. F. (2007). Direct learning. *Ecological Psychology*, *19*(4), 321-349.

Michaels, C. F., Arzamarski, R., Isenhower, R. W., & Jacobs, D. M. (2008). Direct learning in dynamic touch. *Journal of Experimental Psychology: Human Perception and Performance, 34,* 944-957.

Stephen, D. G., Arzamarski, R., & Michaels, C. F. (2010). The role of fractality in perceptual learning: Exploration in dynamic touch. *Journal of Experimental Psychology: Human Perception and Performance*, *36*(5), 1161.