

RESISTANCE TO VARIABILITY FROM THE ENVIRONMENT IN LANGUAGE LEARNING: CROSS-SITUATIONAL LEARNING OF WORDS FROM MULTIPLE CUES

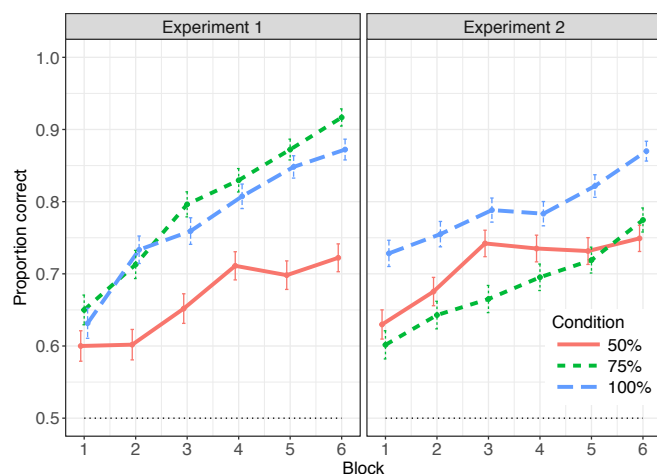
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Studies of language acquisition have moved from considering the internal structure of language toward embedding language learning in rich, multimodal environments, involving consideration of both verbal and non-verbal communication, as well as interactions with objects and events that occur around the learner. This changed perspective extends our understanding of the sources of information potentially available to constrain acquisition, including distributions between words, prosody, and gesture accompanying speech. However, multiple environmental cues are also replete with noise and variability in their occurrence (Clerkin et al., 2017) which increases the computational cost of processing them, but also provides opportunities for learning. Dynamic systems theory predicts that noise in a computational system can facilitate learning, and the source of this advantageous noise can result from the environmental input to the system by increasing salience of individual cues, and reducing reliance on a single cue during learning (Monaghan, 2017). In two experiments, we tested the prediction that multiple cues are processed by the learner, and that variability in cues may even elicit an advantage for learning.

In Experiment 1, adults learned referents for 10 words on a cross-situational word learning task. In each trial, two spoken words and two objects were presented, and the task was to determine which object the speech referred to. Over multiple trials, one of the words and objects always co-occurred. No feedback was given. For the distributional cue, the referring word was preceded by a marker word. For the prosodic cue, the referring word was increased in amplitude. For the gestural cue, the target object was indicated by a finger point. Between subjects, we manipulated the variability of individual cues, whether they occurred in 100%, 75%, or 50% of trials. After training, participants' ability to identify the referent from the word with no cues present was tested. Results indicated that participants were sensitive to individual distributional, prosodic and gestural cues. Learning for 75% variability was quicker and 50% variability was slower than 100%, $p = .034$, $p < .001$, respectively (see Figure), indicating that variability in cue presence reduced reliance on particular cues and best supported learning.

In natural language learning, cues may vary in their presence (leading) or absence but they may also be (accidentally) misleading (e.g., pointing to an object whilst talking about another). In Experiment 2, we manipulated whether cues were present, absent, or misleading. The 100% condition was as in Experiment 1. In the 75% condition, in $\frac{3}{4}$ of trials the cue was present and leading, and for the remaining $\frac{1}{4}$ of trials the cue was misleading. In the 50% condition, in $\frac{1}{2}$ the trials, the cue was leading, in $\frac{1}{6}$ of trials, the cue was misleading, and in the remaining $\frac{1}{3}$ of trials the cue was absent. This time, misleading cues did not significantly affect pace of learning (100%:75%, $p = .448$, 100%:50%, $p = .079$). Overall accuracy was lower for 75% than 100%, $p = .009$, but not when variability was even higher (100%:50%, $p = .183$).

Variability in environmental cues can enhance word learning, and learning is robust to noise in the environment not only for the presence or absence of cues, but even when those cues are accidentally misleading to the learner.



References: Clerkin, E.M., Hart, E., Rehg, J.M., Yu, C., & Smith L.B. (2017). *Phil Trans Royal Soc London B*, 372. Monaghan, P. (2017). *Topics Cog Sci*, 9, 21-34.