Focused Learning in a Linguistic Environment

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ACT-R is a general theory of cognition (Anderson, 1993) which is capable of learning the relative usefulness of alternative rules. Are ACT-R's learning mechanisms suitable for modeling language acquisition? Evidence from a concept formation task analogous to a linguistic role assignment task would suggest so.

In this paper, a model developed within the ACT-R architecture is applied to a concept formation task created to be an analog of a linguistic role assignment task. The model makes general predictions consistent with linguistic findings and novel predictions supported by subject data.

When trying to understanding a sentence, people assign nouns to linguistic roles such as actor, patient, and recipient. In order to do this assignment, cues of the language such as word order, noun animacy, and case inflection are used. These cues may or may not be present in every sentence, and one cue may conflict with another cue as to the correct role assignment. These conflicts are resolved by the cue dominance hierarchy of the language. Researchers have found that the order in which these cues are initially acquired by children is predicted by a statistic called overall validity and later is predicted by another statistic called conflict validity. The validity of a cue is its availability (probability of presence in a sentence) times its reliability (probability of correctly indicating role assignment). Overall validity is computed for a cue using all sentences in the language, while conflict validity is computed from all sentences in which the role assignment of that cue conflicts with the assignment of another cue.

This order of cue use — cues with high overall validity being used before cues with high conflict validity — has also been observed in a concept formation task created by McDonald and MacWhinney (1991) to be an analog of the role assignment task. In their task, subjects were presented with two geometric figures and asked to determine which figure was "dominant". Linguistic cues such as word order, animacy, and case inflection, were mapped to graphical cues. The stimuli were created such that three graphical cues (in one condition, size, shading, and shape) had three levels of overall validity (high, medium, and low, respectively), and three levels of conflict validity (low, high and medium, respectively). Early in training, the cue with the highest overall validity (size) was used the most, and later the cue with the highest conflict validity (shading) was used the most.

McDonald and MacWhinney also showed that their Competition Model could explain these general results. Under its learning mechanism, cues voted for figure dominance with their strength. If an error was made, all cues correctly predicting dominance had their strength increased.

In this paper, a model using the learning mechanism of the ACT-R architecture (Anderson, 1993) was also shown to explain the general results. ACT-R determined figure dominance according to its assessment of the most reliable cue. Unlike the Competition Model, ACT-R only updated the reliability of the one cue used to determine dominance.

Both models made the same general prediction that the cue with the highest overall validity (size) would be used most in early learning and that the cue with the highest conflict validity (shading) would be used most in later learning. However, the two models made different predictions about the relative ordering of the other two cues in later learning. The Competition Model predicted the ordering of cue use would be the same as the conflict validity ordering (i.e. shape would be used more than size). The ACT-R model predicted that since cues with high and medium overall validity (size and shading) were used more in early learning, they would block learning of the reliability of the cue with low overall validity and medium conflict validity (shape). Therefore, the cue with low conflict validity (size) could be used more than the cue with medium conflict validity (shape). Subject response data support this prediction. These results suggest that ACT-R may be useful in making novel predictions in language domains.

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References

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