Acquiring recursive structures through distributional learning

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This study investigates the learning mechanism that enables the acquisition of recursive structures. Languages differ regarding the syntactic domains of recursive structures (Pérez-Leroux et al., 2018). For example, the genitive *-s* can infinitely embed in English, (1), but is largely restricted to only one level in German, (2), (Weiss 2008). Thus, while the ability for recursion is considered universally available (e.g. Hauser et al., 2002), speakers need to learn in which syntactic domains this ability can be applied.

This study tests the distributional learning proposal (Grohe et al., 2021; Li et al., 2021), which views recursion as structural substitutability: A structure like X_1*'s*-X_2 is recursive if any word that appears in one position (X_1 or X_2) can also appear in the other; therefore, children learn recursion through learning substitutability as a productive generalization: X_1*'s*-X_2 is freely recursive if there is sufficient evidence that X_1 and X_2 are fully substitutable.

We used an artificial language learning experiment to test the proposal. In each condition, 25 adults were exposed to 88 X_1-*ka*-X_2 strings, where 12 different pseudo-words were attested in X_1 position. In the Unproductive condition, only some of the words were also attested in X_2 position (6 out of 12); in the Productive condition, nearly all were (10 out of 12). To mimic natural language, some words were more frequent than others, but the total frequency of each word was the same across conditions. At test, we asked participants to rate on a scale of 1 to 5 the acceptability of one-level (X_1-*ka*-X_2) and two-level (X_1-*ka*-X_2-*ka*-X_3) attested strings (i.e. strings or combinations of two strings attested during exposure), unattested phrases (i.e. strings or combinations of two strings whose post-*ka* position (X_2 or X_3) was occupied by a word that never appeared after *ka* in the input), and ungrammatical strings with wrong word order (e.g. *ka*-X_1-X_2, *ka*-X_1-X_2-X_3-*ka*). The distributional learning proposal predicts only participants from Productive condition would learn that X_1-*ka*-X_2 may freely recurse, so they would rate unattested strings higher than participants from Unproductive condition at both one- and two-level, even though two-level strings were never attested in the input.

Results are shown in Figure 1 (one-level) and Figure 2 (two-level). We analyzed the results using ordinal regression. There was a main effect of test string Type (attested, unattested, or ungrammatical) for both one- ($\chi^2(2)=253.00$, $p<0.001$) and two-levels ($\chi^2(2)=323.82$, $p<0.001$); particularly, as predicted, unattested recursive strings were rated significantly higher than ungrammatical strings in Productive condition ($p<0.001$) but not in Unproductive condition ($p=0.47$). There was also a significant interaction between Type and Condition (Productive, Unproductive) for both one-level ($\chi^2(2)=8.67$, $p=0.01$) and two-level ($\chi^2(2)=52.74$, $p<0.001$). Comparison between conditions showed that unattested strings were rated marginally lower in Unproductive condition than in Productive condition at one-level ($p=0.08$) and significantly lower at two-level

(p<0.01). Overall, our results suggest that speakers can use distributional information at one level to learn whether a structure can be recursive. We have also preregistered an adapted child version of the experiment, and data collection is underway. (497 words)

(1) the man*'s* neighbor*'s* book
(2) *das Mann*s* Nachbar*s* Buch ('the man's neighbor's book')

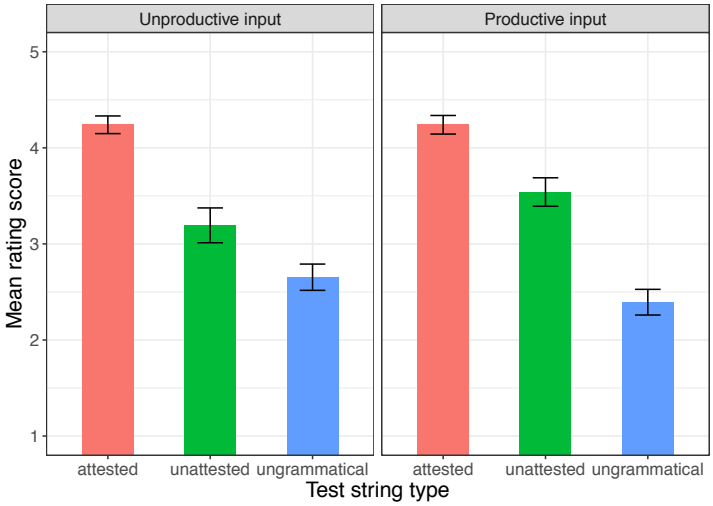

Figure 1. Mean rating scores for each type of one-level test strings. Error bars indicate standard errors of the mean.

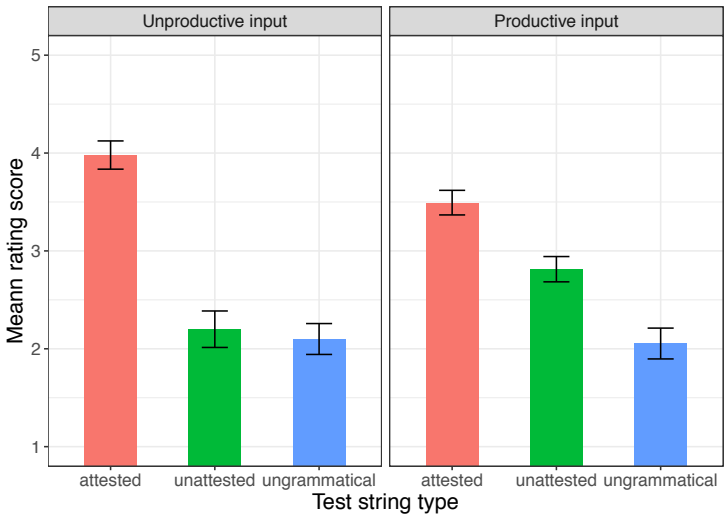

Figure 2. Mean rating scores for each type of two-level test strings. Error bars indicate standard errors of the mean.

Selected References

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