Statistical learning and morphosyntax acquisition

Heidi R. Getz[1,2,3] and Elissa L. Newport[1,3]

[1]Interdisciplinary Concentration in Cognitive Science, Georgetown University; [2]Department of Linguistics, Georgetown University;
[3]Learning and Development Lab, Center for Brain Plasticity and Recovery, Georgetown University Medical Center

Learning and Development Lab
Georgetown University

Scan for PDF:

BACKGROUND

- Human languages require abstract and highly detailed grammatical representations. (**Figure 1**)

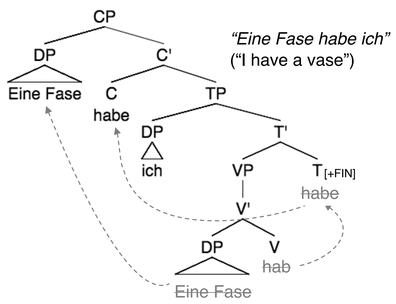

Figure 1. In German, while embedded clauses have SOV word order, main clauses allow either subjects or non-subjects first ("topicalization") and always have verbs second. This is called V2 word order. Linguists account for children's knowledge of V2 by positing innate knowledge of underlying trees (in this case, with SOV word order) and principles for how words move in these trees (in this case, nouns moving up and into Spec, CP, and verbs moving into T and then C).

- Similar patterns occur in many different languages (topicalization, verb movement, and verbal morphology that produce V2 patterns on the surface).
- Many linguists believe that these representations are innate and that toddlers' abstract grammatical representations are adultlike.[1]
- However, a distributional or statistical learning approach can explain the acquisition of many grammatical phenomena.[2,3]

- *Our question: Could complex word-order contingencies such as the V2 word order pattern be acquired via statistical learning?*

APPROACH

- Using a miniature language, we ask:
  1. Can the *patterns* of functional projections be learned without representing them as "CP", etc.?
  2. Do learners preferentially acquire the particular patterns that frequently co-occur in natural languages?

DESIGN

- In our miniature language, "topicalization" (non-subjects in 1st position) is contingent on verb position. (**Figure 2**)

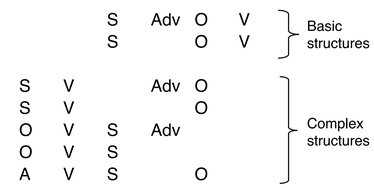

Figure 2. Complex sentences are derived from the basic structure (S-Adv-O-V) by fronting a non-verb and placing the verb 2nd. These constraints allow sentences with initial Subjects having either V2 or Vfinal, while sentences with initial Objects or Adverbs require V2.

- In 4 conditions, we manipulated the **inflectional morphology** on verbs and asked how learning is affected.
  - In the **V2+CC** condition, V2 was marked with prosodically reduced morphology, as in natural V2 languages.
  - In other conditions, V2 had non-reduced morphology (**V2+OC**); there was no morphology (**V2-ø**); or morphology occurred only on Vfinal (**Vfinal+CC**). All of these are uncommon in natural V2 languages.
- Undergraduates (n=32) listened to and repeated sentences and watched accompanying videos for 30 minutes.

RESULTS

V2+CC, Vfinal-ø V2 marked with high-frequency, phonologically reduced ("closed-class") affix
V2+OC, Vfinal-ø V2 precedes a form that is prosodically like an "open-class" content word
V2-ø, Vfinal-ø Both verbs are unmarked
V2-ø, Vfinal+CC Vfinal marked with "closed-class" affix

Knowledge was measured on a 2AFC test. Figures represent the proportion of times participants chose the grammatical sentence (darker colors) or a foil containing an error (lighter colors). The figure header (grey strip) lists the type of error. Chance is 50%.

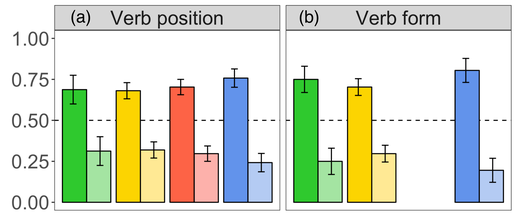

Figure 3: Verb distribution. (a) Subjects preferred V2 and Vfinal sentences to *V1 or *V3. (b) Subjects preferred correctly inflected V2 and Vfinal sentences over incorrectly inflected alternatives.

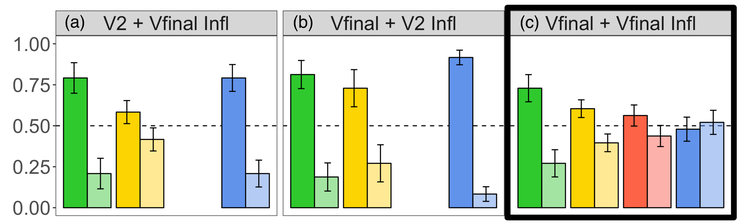

Figure 4: Word order. (a,b) With an Adverb or Object 1st, all groups preferred V2 sentences with V2 inflection over incorrectly inflected sentences. (c) When the verb's inflection was correct, accuracy was highest in the condition most like natural languages (V2+CC).

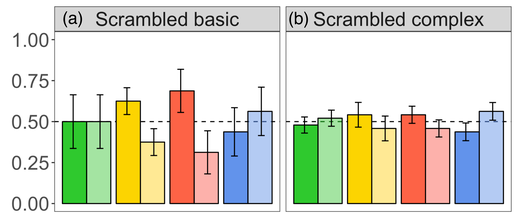

Figure 5: Global structure. (a,b) Despite knowledge of V2, subjects in the V2+CC condition did not choose correct basic or complex structures over structures where "unmoved" words occurred in the wrong order.

	V2+CC	V2+OC	V2-ø	Vfinal+CC
Verb distribution				
Position	.69 (.25)	.68 (.14)	.70 (.13)	.76 (.16)
Form	.75 (.23)	.70 (.14)	n/a	.80 (.21)
Word order				
Verb correct	.73 (.23)	.60 (.15)	.56 (.18)	.48 (.21)
Verb incorrect	.80 (.24)	.66 (.18)	n/a	.85 (.15)
Global structure				
Basic	.50 (.46)	.63 (.23)	.69 (.37)	.44 (.42)
Complex	.48 (.14)	.54 (.21)	.54 (.14)	.44 (.15)

Table 1. Choice of the correct structure across four conditions (mean (sd)).

SUMMARY & DISCUSSION

- **Patterns are learnable**: Learners can acquire contingencies among linguistic patterns without representing them as part of a larger global structure.
- **Learning mirrors typological patterns**: A word-order contingency is best learned when it clusters with a prosodically reduced morphological pattern.
- Counterintuitively, clustered patterns may be easier to learn than overall basic word order.

These results show that it is possible to learn V2 patterns without having full linguistic representations. Likewise, then, toddlers' knowledge of linguistic contingencies may also reflect strong pattern-learning abilities, and not full abstract grammatical representations.

REFERENCES

1. Poeppel, D., & Wexler, K. (1993). The Full Competence Hypothesis of Clause Structure in Early German. *Language, 69*(1), 1–33. **2. Reeder, P. A., Newport, E. L., & Aslin, R. N. (2013).** From shared contexts to syntactic categories: The role of distributional information in learning linguistic form-classes. *Cognitive Psychology, 66*(1), 30–54. **3. Thompson, S. P., & Newport, E. L. (2007).** Statistical Learning of Syntax: The Role of Transitional Probability. *Language Learning and Development: The Official Journal of the Society for Language Development, 3*(1), 1–42.

Many thanks to Kathleen Coughlin, Alannah Connolly, and Jaclyn Horowitz for assistance with data collection.

Contact: Heidi Getz, hrg2@georgetown.edu

This research was supported by Georgetown University, the Feldstein Veron Fund for Cognitive Science, and NIH grant HD037082.