When Judgments are Insufficient: An Evaluation Metric for Syntactic Theory

**Background:** One challenge in linguistic theory is when conventional forms of data such as speaker judgments do not allow us to choose between competing theories. This can occur when two theories are both descriptively adequate (i.e. both account for all judgments), and it can give rise to substantial debate. As an initial proposal to resolve this debate, one might consider evaluating the theories based on complexity: as per Occam’s razor, we adopt the simpler theory and reject the more complex one. But is there any empirical reason a theory should be rejected simply because it is more complex than its alternative? After all, the more complex theory accounts for all the judgments available. An evaluation metric based on complexity does not adequately address the broader empirical issue – what we need is some new form of data that can help us tease apart the theories.

**Proposal:** In line with Chomsky (1986), I take a fundamental goal of theory creation to be the development of grammars that can be acquired. I propose a concrete procedure for analyzing the learnability implications of particular theories as a new evaluation metric for linguistic theory comparison. I investigate if there is robust data that a target grammar posited by a particular theory is learnable given (a) a particular learning procedure and (b) the input available to the learner. Theories that do not provide such robust data for target-grammar learnability should be rejected in favor of those that do. This metric is implemented using the probabilistic learning model in Gould (2015) to provide a proof-of-concept illustration that shows that the target grammars of some theories are much harder to learn – and are possibly not always learnable – compared to those of others. As a case study, I focus on verb movement in Mainland Scandinavian (MS). Two theories of verb movement parameters, have been proposed and debated, one more complex than the other. To shed light on this debate, I show in learning simulations that only the more complex theory leads to a target grammar that is consistently learnable.

**Case study of competing theories:** Following the symmetric analysis of V2 in den Besten (1977/1989), according to which the finite verb in matrix clauses moves to C, analyses of verb movement in MS vary as to whether there is a parameter for V-to-C movement.

**Stepwise Theory:** In the Stepwise analysis (Platzack 1986; Lightfoot 1991, 1995), there are multiple independent parameters that, when positively set, result in V raising to C. An example of two such parameters is in the matrix clause schema in (1), in which both a parameter for V-to-T movement and another for T-to-C movement must be positively set for V to end up in C:

(1) \[ \text{[CP Subject [CP V+T+C [TP V+T [VP V Object]]]]} \]

\[ \text{T-to-C} \]

\[ \text{V-to-T} \]

In embedded clauses a phonologically overt complementizer, such as om ‘if’ in Swedish, blocks V raising to C, but given the [+V-to-T] setting from (1), V must still raise to T in embedded contexts:

(2) \[ \text{... [CP om [TP Subject [TP V+T [VP V Object]]]]} \]

\[ \text{V-to-T} \]

If we assume clause-medial adverbials such as negation adjoin to TP, then we can thereby account for the variable position of the finite verb: pre-adverbial in matrix clauses, and post-adverbial in embedded clauses. This is illustrated for Swedish in (3); data from Waldmann (2011).

(3) a. Författaren skrev inte någon bok i år. Swedish

‘The author didn’t write any book this year.’

\[ \text{[CP Subject [CP V+T+C [TP Neg [TP V+T [...V...]]]]] } \]

b. Vi frågade om författaren inte skrev någon bok i år. Swedish

‘We asked if the author didn’t write any book this year.’

\[ \text{[CP om [TP Subject [TP Neg [TP V+T [...V...]]]]] } \]

It is important to note that the logic of a Stepwise theory does not actually hinge on V-to-T movement (cf. Koeneman and Zeijlstra 2014). What characterizes this approach is that there is some parameter for intermediate movement, say V-to-X, and that a positive setting of this parameter feeds V2 order by
means of some other positively set parameter(s), for example X-to-C. For expository purposes, I assume this intermediate movement is V-to-T movement.

**Swooping Theory:** In the Swooping analysis (Holmberg and Platzack 1995; Vikner 1995), there is an additional parameter of V-to-C, and it is possible for the verb to raise to C in matrix clauses simply by positively setting this parameter, with V raising cyclically through T:

\[
\begin{array}{c@{\quad}c@{\quad}c@{\quad}c}
\text{CP Subject} & \text{CP V+T+C} & \text{TP V+T} & \text{VP V Object} \\
\hline
\text{V-to-C} & & \end{array}
\]

In embedded clauses, an overt complementizer blocks the application of V-to-C movement. V may still raise to T if there is [+V-to-T], as in (2), or V may remain in-situ if there is [−V-to-T]. Under either scenario, assuming adverbials adjoin to TP accounts for (3). Crucially, then, there are multiple target grammars with Swooping, as a [+V-to-C] setting can mask the effects of values for [±T-to-C, ±V-to-T].

**Theory comparison:** As discussed, both theories can account for data such as (3); thus both are descriptively adequate. Swooping (5b) is more complex in that the learner’s hypothesis space contains a superset of the parameters found in Stepwise (5a); I assume learners under both theories have parameters for V-to-T and T-to-C, as motivated in Pollock (1989).

\[(5)\]  
\quad a. **Stepwise:** \{±T-to-C, ±V-to-T\}  
\quad b. **Swooping:** \{±V-to-C, ±T-to-C, ±V-to-T\}

We now have the challenge of evaluating these theories. Learnability-based data provides evidence MS is harder to learn under a Stepwise hypothesis space.

**How the model learns:** To apply the learnability-based evaluation metric, proof-of-concept simulations were run using the probabilistic learning model in Gould (2015) (cf. similar models in Yang 2002 and Pearl 2007). The model sets parameters by learning from both parametrically unambiguous input sentences, as well as from ambiguous ones. Input is sampled from a schematic corpus (e.g. SVO, OVS, etc.). Each parameter value has a probabilistic weight; in the initial state these are all assumed to be equal. Further, the parameters in (5) are augmented by additional ones for head-complement order. Given a token of input, the learner will try to construct a grammar that is compatible with that input by sampling a set of parameter values. If the grammar sampled is input-compatible, then the parameter values that have been sampled are reinforced (i.e. the weights are increased). By gradually reinforcing certain parameter values more frequently than others, the learner is thus conditioned by the input to learn a set of parameter values (i.e. a grammar) that maximizes the likelihood of being input-compatible.

**Learning simulations:** Two sets of simulations were run, one with Stepwise hypotheses (5a), and one with Swooping ones (5b). Detailed results will be presented that show the model (a) consistently learns a target [+V-to-C] grammar under Swooping; and (b) cannot consistently learn a target [+T-to-C] grammar under Stepwise, sometimes learning non-target [−T-to-C] instead. Why is this? First, nearly all input is ambiguous as to whether finite V raises to T or C (this assumes subjects need not raise to SpecTP; cf. Engdahl et al. 2004). Only input such as (6) (with both pre- and post-adverbial finite V) unambiguously requires V to be in C.

\[(6)\]  
\quad \text{[CP V+T+C [TP Neg [TP V+T [VP...V...CP if [TP Neg [TP V+T [...V...] ] ] ] ] ]]}

Second, this input is very rare (less than 0.1% of the corpus), and careful analysis reveals that for the remaining input under Stepwise (5a), the number of grammars compatible with each input type is split evenly between [+T-to-C] and [−T-to-C]. It is essentially a toss-up, and the model can learn non-target [−T-to-C]. Despite the ambiguity, careful analysis shows that for over 17% of all the input under Swooping (5b), the proportion of input-compatible grammars that are [+V-to-C] outnumber the input-compatible [−V-to-C] grammars 2 to 1. This is because there are more ways to get V in C with [+V-to-C], as noted in regard to (4), which can be contrasted with the sole [−V-to-C] type of grammar with V in C as in (1). Consequently, the model is pushed toward learning a target grammar with V in C. Learnability-based data thus provides evidence for adopting the more complex Swooping analysis for verb movement in Mainland Scandinavian. More generally, the consideration of learnability is paramount for the development of psychologically plausible linguistic theory, and this new method has the potential to shed light on a range of debates in syntactic theory.
References: