Adult learners use both entrenchment and preemption to infer grammatical constraints

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***Abstract*—Learners acquire grammatical constraints (e.g., the knowledge that *giggle*'s use in *The joke giggled me* is ungrammatical) in part through statistical learning. The *entrenchment* and *preemption* hypotheses claim that correlated statistics are relevant. This makes it difficult to find unambiguous evidence in favor of one or the other. The present work circumvents this issue by orthogonalizing effects of entrenchment and preemption in a learning task with a novel verb. We find evidence that both entrenchment and preemption have significant independent effects in adult learners.**

***Index Terms*—Entrenchment and preemption, grammatical constraints, statistical learning, language acquisition.**

I. Introduction

How is it that children come to know that some word uses are ungrammatical—e.g., that *mouse* cannot be used in the noun plus *-s* pattern of plural formation (**mouses*), that *a-* adjectives cannot be used before the nouns they modify (**The asleep/afloat/afraid duck...*, cf. *The duck that's asleep/afloat/afraid...*), or that not all verbs can be used in the transitive construction (**The joke giggled me*) [1, 2]? Across nearly three decades, researchers have made a number of claims concerning how *grammatical constraints* of this sort might be acquired. Some have argued that innate language-specific biases play a role [3]; others have proposed that constraints are learned from the input via cues from semantics [2, 4], and adult recasts [5]. In the present work, we add to a growing body of research on *statistical constraint learning* by attempting to identify the exact statistics that learners consider.

The general idea behind statistical approaches is that learners are able to infer constraints specifying how a word *cannot* be used by considering how it *is* used in their input. This process has been studied with respect to a number of phenomena. Here we focus on how it is that learners infer that intransitive-only verbs like *giggle* cannot be used transitively.

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The *entrenchment* hypothesis maintains that *giggle*'s frequency across *all* attested uses is relevant: each time *giggle* is witnessed intransitively this incrementally strengthens the inference that it cannot appear transitively [6]. In contrast, the *preemption* hypothesis emphasizes that the incremental strengthening process is magnified in the presence of periphrastic causative uses of *giggle* (e.g., *The joke made me giggle*). This is because the usual way that we talk about causation in English is with the transitive. Consequently, when *giggle* is used causatively in the periphrastic causative rather than the transitive, this constitutes especially informative input suggesting that a transitive constraint should be inferred [7].

A fundamental problem for distinguishing between entrenchment and preemption is that the statistics that drive constraint learning in each—the overall frequency of a verb for entrenchment, and its frequency in the periphrastic causative for preemption—are highly correlated in natural language materials, in part because the latter quantity is a subset of the former. This means that studies that have found effects of overall frequency on constraint learning cannot rule out preemption [4, 8, 9], and that attempts to statistically partial out effects of entrenchment and preemption run the risk of finding spurious null results for one because all of the variance has already been accounted for by the other [10].

The present experiment circumvents this problem by orthogonalizing the effects of entrenchment and preemption using a novel verb. This strategy has been used in at least two prior studies to argue for an independent effect of preemption [11, 12], but the designs that were employed did not allow for any conclusions to be drawn about whether entrenchment might be playing an independent role. Additionally, it is possible that the production measures that were used do not actually reflect constraint learning [4].

The present experiment addresses these issues by (i) implementing a control condition that allows one to measure independent entrenchment effects, and (ii) collecting—in addition to production data—grammaticality judgments, which are claimed to more directly reflect constraint acquisition.

II. Methods and Results

A. Participants

Thirty-six UCSD undergraduates were randomly assigned in equal numbers to three groups: *control*, *intransitive only*, and *mixed*. All participants were native speakers of English.

B. Materials, Procedure, and Predictions

The experiment consisted of three blocks. In the *exposure* block participants viewed six movies depicting causative bouncing events (e.g., a squirrel bouncing an apple on a trampoline). In the intransitive only group the experimenter described each movie seven times using a novel verb in simple intransitive constructions only (e.g., *Look! The apple is yadding!*). In the mixed group the verb was modeled using a mixture of four simple intransitives and three periphrastic causatives per movie (e.g., *The apple is yadding* and *The squirrel really made the apple yad!*). In addition, for each movie the experimenter gave participants the opportunity to use the verb themselves by asking three questions (e.g., *What did the squirrel do?*, *What happened with the apple?*, and *What happened?*). Participants in the control group received no models and were instructed to respond to questions using the English verb *bounce*.

In the *production* block all participants viewed an additional three movies and were prompted to describe the movies three times apiece using the same verb that they had used in the exposure block.

In the *ratings* block participants rated one transitive and one periphrastic causative use of their respective verbs on a five-point grammaticality scale.

Because *bounce* can alternate between transitive and intransitive uses, the control group provides a baseline measure of how likely *transitive consistent* descriptions are for bounce events in production—i.e., transitives and passives. All such responses in the intransitive only and mixed groups are overgeneralization errors akin to **The joke giggle me*, or **I was giggled (by the joke)*. It is thus possible to measure constraint learning by looking in the production block data for decreases in the likelihood of transitive consistent responses relative to control. Entrenchment predicts that the intransitive only group should show such a decrease, even in the absence of periphrastic causative input. Preemption predicts that the mixed group should show a decrease above and beyond the intransitive only group, reflecting improved constraint learning in the presence of periphrastic causative input.

The dependent measure in the ratings task is the difference between participants' grammaticality ratings on periphrastic causative and transitive sentences. Differences that are statistically larger than zero represent a dispreference for transitive relative to periphrastic causative uses. Entrenchment predicts that there should be a significant dispreference in both the intransitive only and mixed groups; preemption predicts a stronger dispreference in the mixed than the intransitive only group.

C. Results

The data are summarized in Table 1. Logit mixed models [13, 14] of the production data found a lower likelihood of transitive consistent responses in the intransitive only relative to the control group (B = -2.47, z = -2.17, p = 0.030), and in the mixed relative to the intransitive only group (B = -2.74, z = -2.69, p = 0.0072). T-tests of the ratings data showed a statistically significant dispreference towards transitive uses in the mixed, p = 0.013, but not in the intransitive only group.

TABLE I
SUMMARY OF RESULTS

Measure	Group		
	Control	Intransitive Only	Mixed
P(Transitive Consistent)	0.84 (0.08)	0.63 (0.09)	0.28 (0.10)
Periphrastic Causative Rating - Transitive Rating	0.17 (0.27)	-0.27 (0.14)	1.33 (0.45)

Quantities in parentheses represent the standard error of the mean.

III. CONCLUSIONS

The stronger constraint learning demonstrated by the mixed relative to the intransitive only group in both the production and ratings tasks suggests an independent preemption effect, since entrenchment (the overall frequency of *yad*) was held constant across groups. In addition, although constraint learning was null in the intransitive only group on the ratings task, significant learning in the intransitive only group relative to control in the production data is consistent with an independent entrenchment effect. The present work thus represents the first demonstration of independent entrenchment and preemption effects in the same experiment. Further research is needed to determine the developmental time course of these effects in child learners.

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