# Artificial language learning experiments for testing the learnability of possible and impossible syntactic structures and previous exposure bias

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## 1 Introduction: naturalness, exposure and micro-syntactic gaps

The grammatical variation that we see across languages is intimately connected to language contact situations engendered by larger events in the world, such as waves of immigration and the development of trade networks. However despite ever new contact between languages, research over the past half century in syntax and typology has shown that some syntactic patterns consistently occur less frequently or are completely absent. These gaps in the distribution of grammatical variants are often argued to be evidence in favour of the naturalness of and cognitive bias towards certain grammatical features.

Much of the research into variable distributions of grammatical features however has been carried out within the field of comparative syntax by applying elicitation methods from dialectology and typology to fine-grained questions such as word order in the nominal or verbal domain. Despite the ability of these methods to tap into the variability of fine-grained syntactic features, these methods bring with them disadvantages such as the ad-hoc nature of elicitation methods with individual informants, and the potential arbitrary connection of historical developments with synchronic language variation. In practice what these methodological issues mean is that any generalisation from a gap to a cognitive bias using the comparative syntax method is highly fragile, and can be quickly cast into doubt by someone eliciting a single instance of such a construction from a speaker of a hitherto understudied variety.

Whilst the occurrence or not of a particular structure in a given variety is an empirical question, the broader question that the distribution of syntactic features gives rise to is theoretical. Specifically:

(1) Do empirically-attested patterns in the distribution of syntactic features, for instance syntactic universals, typological gaps, and differing frequencies in typological distributions of syntactic features, map onto cognitive concepts such as naturalness?

It is this theoretical question that we plan to test experimentally by means of artificial grammar learning (AGL, also referred to as artificial language learning) (Reber 1967). AGL experiments are, if carefully designed, robust to these kinds of ambiguities and confounds. Artificial grammars or languages are highly reduced miniature languages designed for experimental settings. They can test a phenomenon of interest in isolation while keeping potential confounding factors (frequencies, transitional probabilities, lexical factors) controlled. In the classical paradigm, participants are (visually or auditorily) exposed to "sentences" from an artificial grammar for a fixed amount of time. After this "familiarisation phase" they enter a "test phase", in which they are tested about their knowledge of this artificial grammar.

The artificial language learning paradigm is classically used to test hypotheses about the learnability of grammatical systems, the necessary learning mechanisms and cognitive factors involved in language learning and language acquisition. Prior research has, for example, investigated whether language learning requires explicit instruction and feedback, and it was found that artificial languages can also be learned implicitly, without feedback (Reber 1967, 1980; Gomez 1997; Seger et al. 2000). Other research focused on the mechanisms involved in language acquisition in infants, such as rule learning (e.g. Marcus et al. 1999) and statistical learning (e.g. Saffran et al. 1996), the influence of variability on rule learning (Gomez & Gerken, 2002; 1999), the learnability of natural and unnatural rules (e.g. Phonology: Seidl & Buckley 2005, Moreton 2009), and the role of attention in language learning (Toro et al. 2008). Many studies have, moreover, explored how L1 knowledge is tranferred to the artificial language learning task (e.g. Phonology: LaCross, 2015, Vroomen et al 1998; morphology: Dimitriadis, Boll-Avetisyan & Fritzsche, in prep). Essentially, this prior research shows that the cognitive mechanisms involved in artificial language learning highly overlap with those involved in first and second language acquisition.

In the present study, we use a similar approach for studying the learnability of universally attested syntactic features versus the relative unlearnability of rarely attested syntactic features. Specifically, we create artificial language analogues of one such robustly attested case of syntactic variation, viz. word order in West Germanic OV languages, and test whether the observed variability correlates with differences in ease of acquisition of two artificial grammars.

The present study is by no means the first study to use AGLs to investigate syntactic structures. The artificial language learning paradigm has previously been used for instance to study the role of broad syntactic universals, such as the role of constituent structure and movement in syntax acquisition (Takahashi & Lidz, 2007), and more specifically in the learnability of certain types of micro-typological gaps for instance in the nominal domain (Martin et al. to appear).

However the present study differs from previous research in testing not only the divide between naturalness and unnaturalness, but also whether previous exposure affects the speed of training, i.e. whether an attested variant of a syntactic feature is easier to acquire for a speaker who speaks a closely related language with a different variant than for a speaker of a language where the phenomenon is absent. We base this hypothesis on theoretical work by Barbiers (2005, 2019) who suggests that different West Germanic OV languages can generate word orders beyond those that are attested in the specific variety of a speaker, but that these word orders remain unattested for sociolinguistic reasons.

## 2 Variability in the word order of West Germanic OV languages

Word order in verb clusters in West Germanic OV languages is a variable but highly constrained grammatical phenomenon. West Germanic OV languages are characterised by (i) verb-final ordering in unmarked clauses (visible in embedded clauses; masked by movement of the verb to V2 position in main clauses); and (ii) fairly free word order. These features give rise to a situation where verbal elements such as modals, auxiliaries, and the participles or infinitives of lexical verbs cluster together in clause-final position in embedded clauses. Furthermore, the verbal elements can occur in different orders, sometimes within the same construction and variety, without any change in meaning.

The puzzle associated with verb clusters is (i) why, across constructions and varieties, certain word orders occur more often than others; (ii) why certain word orders are much less frequent viz. almost absent in any construction or variety; and (iii) why varieties show the orders that they do.

In a verb cluster with three verbal elements, the order of embedding, i.e. the order of scope, can be annotated with a 1 (for the element that takes the highest scope), with a 2 (for the element embedded below 1), and with a 3 (for the element embedded below 1 and 2, i.e. the lexical verb). An example with English verbs drawn from Wurmbrand (2005: 238) is:

(2) Order of embedding/scope

a. Modal-Modal-V: John must (1) can (2) sing. (3)
finite (1) infinitive (2) infinitive (3)
'John must be able to sing.'

From a purely combinatorial point of view, these elements (1, 2 and 3) can be combined in one of 6 logically possible orders: 123, 132, 213, 231, 312, 321.

However, when we look across constructions and varieties, we see that there is a clear divide between four word orders that appear consistently and often, viz. 123, 132, 312 and 321, and two word orders that occur considerably less frequently, viz. 213 and 231. Wurmbrand (2005: table 75.2, p.240) for instance provides an overview of orders across constructions with modal verbs, auxiliaries, and lexical verbs, and across varieties (Afrikaans, Dutch, Frisian, Standard German, varieties of German spoken in Germany and Austria, varieties of German spoken in Switzerland, and West Flemish). Across these constructions and varieties, 231 occurs only twice (in IPP constructions in Afrikaans and West Flemish), and 213 is completely absent.

Whether or not 213 is indeed a true micro-typological gap has been contested: Schmidt (2005) for instance gives examples from Swiss German varieties (although arguably these are not unmarked orders and

are associated with a focus reading); and Salzmann (2019) makes further arguments in favour of a 213 order in Swiss German varieties.

The point that this ongoing and current discussion underscores is that (i) there are systematic differences in the frequency with which different word orders are attested; and that (ii) comparative syntactic data is insufficient, by itself, to make the link between typological frequencies and naturalness.

Therefore the following two questions remain open, current and ripe for study:

(3) a. Is the difference in frequency between on the one hand 213 and 231, and on the other hand the other logically possible orders 123, 132, 312, 321, simply a historical artefact either (i) of the sociology of research and the subsequent focus of empirical work; or (ii) of some historical accident of the development of the West Germanic OV languages? Or are the gaps related to the nature of the cognitive representation of language?

b. Does prior exposure to certain orders of verb clusters affect their learnability (i.e. is there a language contact aspect to the variation we see in verb clusters, as proposed for instance in Barbiers (2005)), and the resulting ease with which variants from one variety can be learned by speakers of a different variety?

# 3 Present study: artificial grammars and naturalness in verb cluster orders

### 3.0.1 Hypothesis

We hypothesise that:

(4) a. More natural orders, viz. 123, 132, 312, 321, will be easier to learn than less natural orders, viz. 213 and possibly 231

b. Experience with verb clusters in an L1 will facilitate the acquisition of novel orders of verb clusters, hence:

(i) For speakers of verb cluster languages such as German it will be easier to learn novel verb clusters than for speakers of languages without verb clusters such as English

(ii) Language experience should, however, only affect the learning of possible verb orders (but not that of impossible/unattested verb orders, which should prove difficult to learn by speakers of any language)

### 3.0.2 Approach

(5) a. To test the question of naturalness, we employ two different artificial languages, one where the resulting order is actually attested (123), versus one where the resulting order is arguably unattested (213)

b. To test the role of previous language experience, we test native speakers of (i) a language in which clustering is available (German); versus (ii) a language in which it is not available (English). Whilst the attested 123 order is attested across West Germanic OV languages (e.g. in Dutch), it is crucially not attested in Standard German, the variety spoken by participants in the German-speaking group.

The resulting design is a 2x2 factorial design (4 conditions):

(6) a. VAR1: LANG (English vs German)

b. VAR2: ORDER (123 vs 213)

In practice, this means that we have four groups: (i) English speakers presented with natural artificial languages; (ii) English speakers presented with unnatural artificial language; (iii) German speakers presented with natural artificial language; and (iv) German speakers presented with natural artificial language.

#### 3.0.3 Predictions

(7) Participants, who learn AGLs of natural orders (123), will learn the languages more easily than participants who learn the less natural orders (213)

a. In terms of cross-linguistic differences, we predict:
   (i) That speakers of German will learn the natural language more easily than speakers of English in learning the 123 order.
   (ii) That there will be no (or less of a) difference between speakers of German and English in their ease of learning the unnatural language.

### 3.1 Methods

#### 3.1.1 Participants

Participants are native speakers of English and Standard German.

#### 3.1.2 General procedure

Participants are randomly assigned to one of the artificial grammars. They are familiarised with this artificial language for 20 minutes. In the subsequent test phase, they are presented with a series of items in a forced choice judgement task. Half of these items contain the target structure they have learnt, and half include a structure that they have not learnt. Both sets of participants, regardless of artificial language learnt, are presented with the same test phase. The difference lies in which orders will be considered new, and which are considered familiar.

#### 3.1.3 Training phase (material)

The study uses two types of artificial languages that differ only with regards to the order of the verbs. In all other aspects, the stimuli remain the same.

In putting together these stimuli, we use non-words, presented auditorily using synthesised speech and presented at a predetermined pace, and control for following features: (i) the difference between lexical and functional elements, by using phonologically simple items with open mono-syllabic structure for the functional elements (e.g. *va*, *li*) and phonologically complex items with consonant clusters and bi-syllabic structure for the lexical elements; and (ii) the transitional probabilities between syllables (so that neither type of word order is predictable from statistical properties of the distribution of that order in the artificial language training material). A further distinction is made between the lexical elements that have varying counterbalanced lexicalisations, and the functional elements that are fixed (1= always *va*, 2 = always *li*).

The structures in the training phase will either be orders of embedding/scope relations (8) or actual embedded clauses (9). In this way, we (i) abstract away from including other types of movement phenomena associated with OV languages such as movement of the verb in main clauses to clause-second position (V2); and (ii) ensure that *va* is consistently associated with position 1, and *li* is consistently associated with position 2.

(8) List of structures in the training phase: scope-taking orders

a. DP + 3
b. DP + 1 3
c. DP + 2 3
d. DP + 1 2 3

(9) List of structures in the training phase: orders with verb clusters in embedded clauses

a. (main clause) + Compl + 3 1
b. (main clause) + Compl + 2 1
c. (main clause) + Compl + TARGET (possible 1 2 3, or impossible 2 1 3)

### 3.1.4 Test phase

To test whether participants learn the grammars and generalise over its syntax, items in the test phase consist in novel verb clusters, namely orders that participants have not been exposed to in the familiarisation phase but that should logically follow from the grammar they have learnt (we plan to use 4-verb clusters).

## 4 Conclusion

In conclusion, our project tests the connection between previous language learning experience, cognitive naturalness and typological gaps in the area of micro-syntactic variation in word order using artificial languages.

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