The Impact of Word Order and Case Marking on Word and Structure Learning - An Artificial Language Learning Experiment

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ABSTRACT
In this artificial language learning experiment, we investigated how difficult to learn different structural cues are (word order, case marking) and whether these cues bootstrap word learning. The results show that the ease of learning depends on the learner's native language. Exposure to a word order similar to their native language improved performance, allowing participants to use their word order knowledge to bootstrap word learning. Case marking helps structure learning if word order and case marking cues are familiar. However, participants learning a language with case marking could not use this cue to bootstrap word learning.

Keywords
artificial language learning, syntactic bootstrapping, cross-linguistic transfer, word order, case marking.

INTRODUCTION

Learning a language involves learning the meaning of words and learning the language structure. How are children able to acquire both from the linguistic input without needing any explicit training? Children first start to learn the meaning of a few, frequently occuring words using *cross-situational word learning* (CSWL) (Pinker, 1989). Whenever children encounter a word, they keep track of the concepts which are in view at that moment and use this statistical record to calculate which object is the most likely to be referred to by the particular word. When hearing a new word for the first time, there are still multiple possible word-world mappings, but over multiple exposures the distribution becomes more and more skewed in favor of one mapping (Pinker, 1989).

Children map the words they have learned to a (non-linguistic) structured conceptual representation of the event they are perceiving (Fisher, 2002). This process is called *alignment*. Children can notice structural patterns in these alignments. In the beginning, they are only able to learn the structure of a few, frequently occuring items, but over time they generalize across these items and form more language-general rules (Tomasello, 2003). For instance in English, children first only know the word order of sentences containing familiar verbs (e.g. they know that the 'pusher' comes before the verb and that the 'pushee' follows it) and only later realize that all transitive sentences in English have a Subject-Verb-Object (SVO) pattern (Tomasello, 2003).

Children can use their structure knowledge to bootstrap word learning. For instance, once they know that the basic word order is SVO in English, they can infer that the first word of the sentence refers to the agent, the second word to the action and the third one to the patient of the event. The same is true for the structural cue case marking. Once children know which grammatical marker is used to mark the noun as the subject or object of the sentence, they can infer to which part of the conceptual representation the marked word refers to. This word learning mechanism is known as *syntactic bootstrapping* (Gleitman, 1990). Studies on *syntactic bootstrapping* have repeatedly shown that learners who are familiar with the structural cues of the language such as word order and case marking can effectively use them to guide word learning (Göksun & Naigles, 2008).

It is however unclear thus far to what extent *syntactic bootstrapping* is exploited in word learning by second language learners, who are still in the process of developing their knowledge of the syntactic structures underlying the language. Therefore, we wanted to investigate (1) how difficult to learn are different structural cues (word order and case marking) and (2) can the knowledge of these cues indeed bootstrap word learning? To address these questions, we conducted an artificial language learning experiment, which allows for a systematic variation of the cues in the language input and therefore makes it possible to study the cues' ease of learning and bootstrapping effects in isolation.

We also wanted to investigate whether the ease of learning of the structural cues depends on the learner's native language. *Positive transfer* between the learner's first and second language can occur when the patterns of the two languages are similar. However, when the new language differs from the native language, *negative transfer* can occur, which hinders the learning process (Ellis, 2006). To test whether this *cross-linguistic transfer* also influences the acquisition of the structural cues word order and case marking, the experiment is conducted with Dutch and

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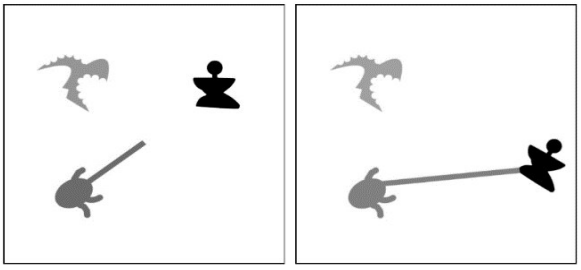
German participants. The basic word order of both Dutch and German is SVO, which means that there should be no differences in the ease of learning of word order cues. However, German participants are used to case marking in their native language, while Dutch participants are not. We therefore expected that case marking is more difficult to learn for the Dutch participants than for the German participants. We also expected participants who perform better at learning the language structure to perform better at word learning as they can use their structure knowledge to bootstrap word learning.

METHOD

The experiment has a 3x2x2 design with word order (3 levels: SOV, VSO, random word order), case marking (2 levels: without case marking, with case marking) and native language (2 levels: Dutch, German) as between participants variables. 328 participants (150 native speakers of German, 178 native speakers of Dutch; 213 females, 105 males) participated in the experiment. The mean age was 19.2 years ranging from 15 to 34 years.

The artificial lexicon contained 12 CVCV words (e.g. 'foga' and 'wani'). In the case marking conditions, two case suffixes were added to the words to indicate the word as the grammatical subject ('-lu') or object ('-mo') of the sentence. The visual material in this experiment consisted of 8 drawn objects and 4 actions, which were combined into 24 animations, using Adobe Flash CS6. Each animation contained 3 objects (agent, patient, distractor) and one action that the agent performed towards the patient (see Figure 1 for an example). For the presentation of the animations and tests, E-Prime (Schneider, Eschman, & Zuccolotto, 2002) was used.

Figure 1: Two snapshots of an animation, in which the agent's 'arm' (bottom left) moves towards the patient (top right) and moves it around



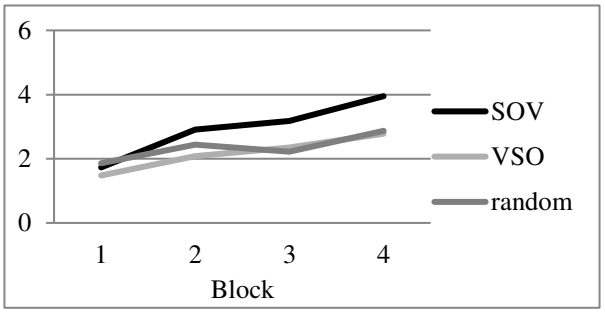
Participants were told that they were going to listen to sentences in a new language which described animations they saw on a computer screen. Each animation was accompanied by a corresponding three-word sentence with a grammatical subject (referring to the object in the agent role), a grammatical object (referring to the object in the patient role) and a verb (referring to the action). The distractor was not mentioned in the sentence. After 12 training trials, participants performed a word test (6 trials). They heard one word while watching 4 boxes on the screen, showing 2 moving objects and 2 actions, and had to mouse-click on the box matching the word. After four blocks of training session and word test, participants performed a sentence production task to measure whether they had learned the word order of the language input. Participants saw an animation and were asked to type the corresponding sentence. The words for the three objects (subject, object, and distractor) and action were given next to the referents. In the case marking conditions, the case suffixes were added. Participants thus only had to decide which of these words to use and in which order.

RESULTS

Word Test

For each participant, the number of correct answers in the word test was calculated, resulting in a score between 0 and 6 for each of the four blocks. Repeated measure ANOVAs were run with Block (4 levels) as a within-participant variable and Native Language (2 levels: Dutch, German), Case Marking (2 levels: with case marking, without case marking) and Word Order (3 levels: SOV, VSO and random) as between-participant variables. The analysis shows a main effect of Block ($F(3, 918) = 80.53$, $p<.001$, $\eta^2 = .21$). Repeated contrasts show that scores improved significantly between the first and second and the third and fourth block. There is a main effect of Word Order ($F(2, 306) = 16.53$, $p<.001$, $\eta^2 = .10$) with participants in the SOV word order condition performing better than participants learning a VSO language or a language with a random word order (SOV: $M = 2.92$, $SD = .10$; VSO: $M = 2.17$, $SD = .10$; random: $M = 2.34$, $SD = .10$) (see Figure 2). The analysis also shows a main effect of Case Marking ($F(1, 306) = 7.22$, $p=.01$, $\eta^2 = .02$). Participants exposed to a language without case marking performed significantly better than participants exposed to a language with case marking (without case marking: $M = 2.71$, $SD = .13$; with case marking: $M = 2.24$, $SD = .14$). There is no main effect of Native Language ($F<1$). The performance of Dutch and German participants on the word test thus did not differ (Dutch: $M = 2.52$, $SD = .08$; German: $M = 2.43$, $SD = .08$). There are no interaction effects involving Case Marking or Native Language.

Figure 2: Mean accuracy scores on the word test for the word order conditions



Sentence Production Task

The responses on the Sentence Production Task (5 trials) were scored as either correct or incorrect (i.e., the word order did or did not correspond to the order they had been

exposed to). This applies only to the fixed word order conditions, as no order is incorrect in the random word order condition. The distribution of the different scores shows that the scores center on the categories 0 and 5, which means that most participants either did not produce any sentence in the correct word order or were able to reproduce the correct word order across all trials.

On the basis of their sentence production score, the participants were divided into two groups: one group that acquired word order knowledge (scores above 3) and one group that was not able to (score of 3 or lower). For the Dutch participants, case marking hinders the acquisition of the word order in the SOV word order condition and does not have any effect in the VSO word order condition (see Figure 3). For the German participants, case marking facilitates word order learning in the SOV condition, but leads to more participants not being able to learn the word order in the VSO condition (see Figure 4).

Figure 3: Distribution of participants with and without word order knowledge for the Dutch participants

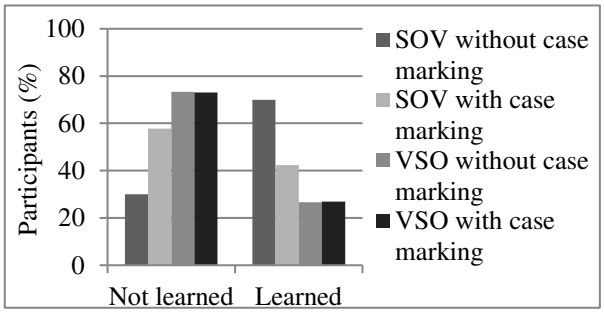
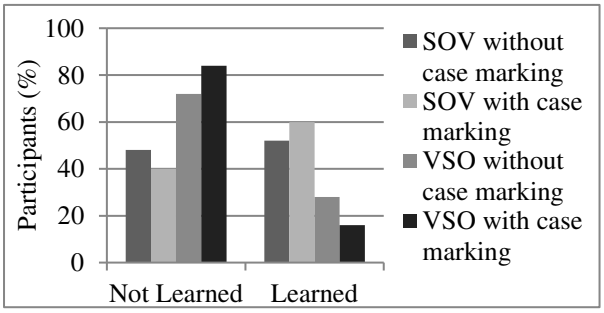


Figure 4: Distribution of participants with and without word order knowledge for the German participants



CONCLUSION

The results of this experiment show that both Dutch and German participants are able to learn the meaning of new words when exposed to the language input. They perform better when learning an SOV word order language than a VSO or random word order language. Case marking hinders the learning of word meanings in all conditions. Dutch and German participants perform equally well on the sentence production task. For the Dutch participants, case marking hinders the acquisition of the word order in the SOV word order condition, but neither helps nor hinders in the VSO word order condition. German participants are better able to learn the SOV word order when exposed to the language with case marking, but learn the VSO word order better when exposed to the language without case marking.

DISCUSSION

The purpose of this study was twofold. First, we wanted to investigate how difficult to learn the structural cues word order and case marking are and whether the ease of learning depends on the language learner's native language. Secondly, we investigated whether knowledge of these structural cues can bootstrap word learning.

The results of the experiment show that Dutch and German participants perform better at structure learning when learning a language with an SOV word order than a language with a VSO word order. This can be explained by *cross-linguistic transfer*. The basic word order SVO in Dutch and German and the SOV order used in the experiment are relatively similar, as both orders place the subject in sentence-initial position. The VSO word order, on the other hand, greatly differs from the SVO order. Here, not the subject but the verb appears in sentence-initial position. Participants learning the SOV word order, therefore, experience no or at least less *negative transfer* than participants learning the VSO word order and consequently perform better at learning this aspect of the language structure. In future experiments, it would be interesting to see whether participants whose native language has a VSO word order, performed better at learning that word order pattern.

For case marking, we expected the German participants, who are used to case marking in their native language, to perform better and the Dutch participants to perform worse. The results show that case marking indeed hindered structure learning for the Dutch participants. However, for the German participants, it also hindered structure learning in the VSO condition and only helped them in the SOV condition. This shows that case marking can only help pattern detection when both the word order and the case marking system are relatively familiar to the language learner. Sentences in which both word order and case marking cues are available and support each other are the most prototypical sentences in German (Dittmar et al., 2008). We therefore argue that German participants did not transfer the case marking cue in isolation -because the German participants learning the VSO word order with case marking should have benefitted in this case too-, but rather transfered the cue combination of word order and case marking to the learning process of the new language. Consequently, they find it easier to learn the structure when both case marking and word order are relatively familiar (SOV with case marking condition), but do not expect case marking to be present when the word order greatly differs from German and perform worse on structure learning (VSO with case marking condition).

The results of the experiment show that the acquisition of the language structural is not a gradual process, but rather shows an 'all-or-nothing'-pattern: participants either did not learn the language structure at all or learned it completely (score of 0 or 5 on the sentence

production task). This finding is inconsistent with earlier studies investigating structure learning in first language acquisition, which have repeatedly shown that structure learning proceeds gradually because children do not have any a priori knowledge about the linguistic categories. After experiencing thousands of example sentences and generalizing across them, they are able to deduce the categories from the language input (Tomasello, 2003). This does not apply to second language learners, who can transfer and use knowledge from their native language when learning a new one (as long as the same linguistic categories apply to both languages). This can explain why the participants in our experiment were so quick to generalize the word order pattern across all sentences of the new language.

We expected participants who were able to acquire the language structure to use this knowledge to bootstrap word learning and consequently to perform better on word learning as well. However, the results show that better scores on the sentence production task do not necessarily lead to a better performance on the word tests. German participants in the SOV word order condition and Dutch participants in the VSO word order condition performed equally well or even better at structure learning than participants learning the same word order language without case marking, but still performed worse on the word tests. This shows that the case marking cue can hinder word learning. Despite the same or an even higher amount of structure knowledge, participants learning a language with case marking performed worse at word learning than participants learning the same word order without case marking.

To understand this finding, it is necessary to look at the implementation of the case marking system in this experiment. The nouns are morphologically marked for their case: '-lu' marks the noun as the agent of the sentence, '-mo' as the patient. Participants thus have to understand that each noun can take both endings, e.g. 'fogalu' and 'fogamo', but that this does not change the object the noun is referring to. As long as participants have not understood this system, they perceive the two forms of each noun to be referring to two distinctive objects. This will limit them in their abilities to perform *cross-situational word* learning and they will perform worse at word learning.

In sum, the results of this experiment show that participants are better able to learn the language structure of a language with a familiar word order and case marking system. The learning process of the structure does not proceed gradually, but learners are either able to deduce the complete language structure or are not able to do so at all. In the case marking languages, there are multiple forms of each noun, which limits the participants' ability to perform *cross-situational word learning*. Therefore, case marking hinders word learning.

Future research should investigate whether this language model, which is based on artificial language learning, can also be applied to 'natural second language learning'. Artificial language learning allows for a systematic variation of the language input and therefore makes it possible to study the effect of different structural cues in isolation. However, these experiments lack the complexity of natural languages and therefore, the ecological validity is reduced (Pelucchi et al., 2009). Therefore, Pelucchi and colleagues argue that artificial language learning experiments should primarily be used for the inital investigation of the language learning process. Knowing what language learners are able to acquire from the input of an artificial language and knowing what effect different structural cues have in isolation can help formulating specific hypotheses about the mechanisms in natural language learning.

ROLE OF THE STUDENT

The experimental data of the Dutch participants learning a language without case marking were collected by Eva van den Bemd in 2014. In 2015, Marie Barking collected the data of the Dutch participants learning a language with case marking. For her bachelor thesis in 2016, Marie Barking collected the data of the German participants learning a language with and without case marking. Marie Barking was an undergraduate student working under the supervision of prof. dr. A. M. Backus and dr. M. B. J. Mos when the research in this report was performed.

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