A COMPUTATIONAL MODEL ON THE EMERGENCE OF CANONICAL WORD ORDER IN LANGUAGE AND TRANSFER THROUGH GENERATIONS OVER DIFFERENT COMMUNICATIONAL STRUCTURES

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ABSTRACT

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English abstract here

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ÖZ

DİLDE KANONİK KELİME DİZİLİMİNİN ORTAYA ÇIKIŞI VE FARKLI İLETİŞİM YAPILARI ÜZERİNDEN NESİLLER ARASI AKTARIMI ÜZERİNE BİR HESAPLAMALI MODEL

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Türkçe öz buraya

Anahtar Kelimeler: kanonik kelime dizilimi, kelime diziliminin ortaya çıkışı, iletişim yapıları, hesaplamalı model, tekrarlamalı model

Dedication here

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LIST OF ABBREVIATIONS

S	Subject
O	Object
V	Verb
ABSL	Al-Sayyid Bedouin Sign Language
CTSL	Central Taurus Sign Language
NSL	Nicaraguan Sign Language
L1	First Language
L2	Seconf Language

CHAPTER 1

INTRODUCTION

Most of the sentences we use today are consciously or unconsciously formed in a certain word order. Many languages are sensitive to word orders, and a canonical word order is important as it includes most of the meaning of the sentence spoken as well as different orderings of it can lead to other meanings. For example, the knowledge of who did what to whom can be a knowledge learned by ordering the words appropriately. There is a huge difference in 'man kisses woman" vs. "woman kisses man". The canonical word order of a language is defined by the order of the three main components of basic transitive sentences: subject (S), verb (V), and object (O). Subject is the one who does the action, verb is the action to be done, and the object is the one who is affected by the action. Logically, we can order these three items in 6 different ways: SOV, SVO, VSO, VOS, OVS, OSV. For example, while the dominant word order for Turkish is SOV, for English it is SVO. In addition to these, there are also languages that do not conform to a certain basic element sequence. We can call this as free word order languages. But these seven possible word orderings are not evenly distributed amongst the world languages. According to [1] 41% of languages use SOV as their cannonical word order, like Turkish, Korean, Persian. 35% of the languages use SVO as their canonical word order, like English, Chinese, French. 7% of the languages use VSO, 2% of the languages use VOS, 0.8% of the languages use OVS, again, 0.3% of the languages use OSV as their canonical word order. Also, 13.7% of the languages use free word order to communicate. In these languages there is also a dominant word order, but other orderings are also possible to convey a true meaning while communicating. So the overall distribution looks like this: (SOV, SVO) > free order > VSO > (VOS, OVS) > OSV. However, where does this canonical orders and the agreement in a certain order came from is still a matter of curiosity. To explore this, we need to go back a very long time, to our ancestors which is impossible with today's facility. Although experimental studies on the subject give various ideas, a holistic approach is not satisfactory due to the comprehensiveness of the research.

As mentioned before, it is not possible to observe the exact stages of the languages spoken in the world from their emergence to the present day. Therefore, in the researches on the subject, mostly the findings obtained from the young emerged sign languages (village sign languages like ABSL, CTSL and NSL) or the silent gestures (or pantomimes) of the speakers were used. SOV and SVO are also predominant word orders in sign languages according to [2]. This comparative study of 42 sign languages suggests that cognitive/communicative biases are involved in determining the dominant order in a language. These studies mostly done on basic sentences, complex sentences need more deep researches and experiments.

In this study we too only cover basic transitive sentences with three components (subject, object and verb). These transitive sentences also split into two kinds of sentences: reversible and irreversible

transitive sentences. In reversible sentences it is semantically logical and possible to change the places of object and subject in the sentence, i.e. "the girl pushes the boy" could be "the boy pushes the girl" depends on the situation. On the other hand, irreversible transitive sentences does not allow us to change the places of subject and object semantically, i.e. "the girl cuts the paper" cannot turn into "the paper cuts the girl".

One of the explanations from [3] is that the observed word order frequencies may be the result of genetically encoded biases towards certain orders, as part of the universal grammar hypothesis. This could be a possibility, some word orders may be easier for us from birth. [4] suggests that the prevalence of SOV order across the world's languages may arise in part because SOV order is most compatible with how we conceptually represent transitive events. Also, [5] proposes that all living languages today descend from a single common ancestor, a proto-language uses the SOV word order. Thereof, it is possible that SOV and SVO have a special cognitive place.

[6] tries to explain the current frequencies of languages with three principles: "theme-first-principle", "verb-object-bonding", and the "animate-first principle". The frequencies are proportional to the number of principles they realised. According to [7] these three principles are realised in SOV and SVO, two are realised in VSO, one in VOS and OVS and none in OSV. It is also seen that the animacy level of subject and object also affected how we structure the sentences in many studies [2][8][4][9] [10][11], which will be explained in the literature review section in detail.

1.1 Research Questions

The current studies proposes some explanations to different questions, like why some orders more preferred than others, which are mentioned before, how network communication frequency and network type helps to make a language more systematic [12][13], how different generations behave while transferring the language by iterated learning[14], and so on.

There are several questions this study seeks to answer. These questions also serve as a source for the creation and testing of the model. First, previously studies suggest that SOV is cognitively most basic word order to start a language. But what if this is not the case? If we start our with another word order bias will the word order converge to one of the most frequent orders today, SOV or SVO? Second, how does size of the community and different network structures affects the dominant word order emergence and evolution speed? We know that not all people are the same. We don't learn the same way, or live the same way. Therefore, there should be an effect of if. We want to observe where the margin of error is different and how these differences will affect the word order of the model. So, what will it change if there are many/few people who change the language? And what does it tell us about real life? Will word orders remain fixed without language changers?

1.2 Contributions of the Study

This study was carried out with the hope of filling a few gaps in the literature. Although there are experimental studies and explanations on the subject, human life and opportunities do not allow a holistic study. For this reason, computers and models can enable us to combine different existing views. This study mainly focused on a computational model that connects the current explanations to

strengthen our valid understandings and/or give another perspective, and of course expects to benefit the literature.

The model produced in this study allows us to see how different and many effects affect the today's dominant word order distributions. It tries to be a playground for many people to try, observe and understand. And the good thing is, they don't need to go back or forth a century or so. This model that has not been created in the literature before and has a deficiency. People can try different network models to communicate, different frequencies of communication, different sizes of population, different language types, different starting bias and different numbers of generations to predict. This model will give us a holistic perspective of what has been told in the literature before.

1.3 Study Limitations

First, this is a study based on inferences made upon the behavior of users of languages that have emerged in the near future. It is difficult to generalize to the whole world and to all times. This study captures the current understandings. Also, the study has built upon experimental data and the way of making sense of this data that there is no holistic information due to the limitations of experiments and setups. Hence, not all sentence types (like complex ones) could not be included we only cover reversible and irreversible transitive sentences.

1.4 Organisation of the Thesis

This master's thesis shows a model that can help us to understand how the word orders of today's languages distribute, while connecting different arguments from different studies. The organisation of the thesis is as follows: This first chapter explains the overall topic and general views about the topic, while presenting the research questions, contributions of this study to the literature and giving the limitations of the study.

Chapter 2 represents literature review on the topic. It will give more in-depth information on how the other previous studies contribute and suggests ideas to our study.

Chapter 3 will explain the overall model. There are different steps and stages in the model, all will be covered in this section.

Chapter 4 provides the different experiments setups on the model. And the results of these experiments will be given. Also, it will include explanations to understand how the model works and what the results tell us.

Chapter 5 is where the discussion will be done and represented, and the links and differences with existing studies also will be presented.

Chapter 6,the last chapter, gives the conclusion of this master's thesis and possible future work will be presented.

Last but not the least, references follows up all the chapters and Appendix A ... Appendix B ...

CHAPTER 2

BACKGROUND INFORMATION

In this chapter, related studies are given in detail. Since our study tries to make a model that connects different parameters of emergence in word orders in languages and transmission to the generations in different circumstances, we need to understand the actual human behaviour. To do that, current literature needs to be examined. There are different studies done on the topic. They will be given to see what has been changed and how we can connect them with our model. This section is divided into three sections in terms of their contribution to the model. First section tries to give the previous studies on the relationship and implications of nonverbal communication (gestures/pantomimes), newly emerged sign languages, and artificial language experiments done labs with word ordering behaviour of humans. Second section examines the studies on iterative learning and reflects the effect of language on the transfer of generations. In third section, studies on the effect of the size of the community and the network structures on the systematicity of the language will be discussed.

2.1 Gestures, Young Sign Languages and Dominant Word Orders

We can first understand how gestures help us to convey how humans learn languages. [15] supports that we all learn languages which we are exposed after we born. But if we are not able to acquire language as we supposed to be, like what if we cannot hear? Human beings need to communicate, so, they will try alternative ways like gesturing. Furthermore, what if the deaf people are the first ones in a population? They need to be the bridge between hearing ones and future generations.

Language learners are initially attracted to a language's canonical order (for L1 [16]; for L2 [17], [18], [19], [20]), because they are one of the sources to understand who (subject) did something to whom (object). Throughout the years, to comprehend the appeal of word ordering, there has been a increase in interest in sign languages while understanding language emergence in general. Emerging sign languages allow us to discover language emergence in real time, which goes well beyond the possibilities of spoken language research. Equally valuable, gestures of spoken people also help us to understand the cognitive effects in communication.

Most of the works consist of picture/video setups and experiments. Like [21], they carried out 4 experiments, 2 with English (a subject-initial language)speaking children and 2 with Fijian (a subject-final language speaking children. Children tried to learn a miniature artificial language based on names for 2 horses and 2 carts either ordering them in horse-cart or cart-horse. Then, they examined the influence of animacy with toy graders and toy boulders.

They showed that grader+boulder sentences is more easily to learn than the reverse. So it is said that agency of an item makes a representation easy to acquire and they distinct agent/patient property then the animate/inanimate property. Also, the results were the same in both English speaking group and Fijian speaking group. Hence, there is no effect of first acquired language's word order, this may be a cognitive bias for putting agents (subjects) before patients (objects).

[4] conveyed a cross-linguistic study. They wanted to see whether the language we speak is influential on how we communicate non-verbally. They asked English, Turkish, Spanish and Chinese participants, where all their native languages have different dominant word orders. Participants carried out two non-verbal tasks: (1) describing an event without speech (using gestures only) and (2) reconstructing an event using pictures. Their results show that, speaker's word order for their native languages had no effect on their non-verbal communication. They also found out that all of the speakers of four languages adopted the same ordering behaviour, agent-patient-act (or SOV). This is also the mostly used word order in many languages, newly developing gestural languages, and experimental artificial languages, too. The results show that humans impose a natural order on occurrences when we describe and rebuild them non-verbally and when we create new language.

[22] made two gesture-production experiments and one gesture comprehension experiment on native and normally hearing Italian and Turkish participants, where the languages have different word order preferences (Italian - SVO, Turkish - SOV). In the first experiment, they tested whether participants used their gestures by following their native language's structural regularities. In the second experiment, they used a stimuli to get improvised gestures. They wanted to see if there is an evidence for phrase structure in their improvised gestures. In the third experiment, they investigated whether the preferences found in gesture production also appear in gesture comprehension. And finally, they study the preferences of phrase structure by assessing participants' order preferences for prosodically flat sequences of words in their native language. Results show that, in the direct connection between the sensory-motor and the conceptual systems, SOV is the preferred order; the SVO order is favoured by the computational system of grammar.

SOV is the most used word order in the world languages. But where did SVO come from and why? [23] treated the subject differently and wanted to test whether SVO emerged for a reason, i.e. maybe it is not well suited for describing reversible events (i.e. a girl kissing a boy). If we use SOV in reversible event, that sentence will be "a girl a boy kissing", but this will only be understood if we know SOV is the word order we use. If someone using OSV as their canonical word order, that sentence will be understood as it was the boy who is kissing the girl. Another reason is maybe the pressures of efficiency (it is logical to mention agents before patients as a principle, which will definitely rule out many other alternative word orders). They tested speakers of both English (SVO) and Turkish (SOV), by asking them to use pantomime to describe some reversible and irreversible events. Additionally, they gave some participants the task of teaching the experimenter the form of the gestures while being consistent about them. These restrictions caused SVO to appear in Turkish and English-speaking individuals (SOV). Their results show that being efficient, putting subjects before objects in the sentences, and avoiding SOV order for reversible events are the three requirements that SVO permits language users to achieve, and this is said to be at least part of the reason why SVO arises in the world's languages.

[9] also uses gesture production to see what causes preferences of SOV than SVO, or vice verse. To do that, they focused on the role of the verb in the sentences. They also mention extensional (i.e. throw) and intensional (i.e. think) verbs. Their results for events with extentional events show that SOV is mostly preferred order, which is consistent with the previous works ([4], [22], [24]). But, with

event with intentional verbs lead to the SVO order instead. They conclude that meaning of the verb is critical while ordering words in emerging language systems. This results also support the language evolutionary point, where it implies that semantic underlies the early formation of syntactic rules of the language.

[25]

[10]

[26]

[27]

2.2 Iterated Learning and Bayesian Models

There are different proposals on how learning occur as a model. One and the one that we considered is the iterated learning model where language is treated as a cultural knowledge [28]. Iterated learning is a way of transmitting one information from an individual to the other. An individual's learning is provided by the other individual's output of its learning. At each utterance, each learner sees data, forms a hypothesis, then, produces the data to the next learner (see Figure 1). The aim of this process is simply investigating the cultural evolution of linguistic structure.

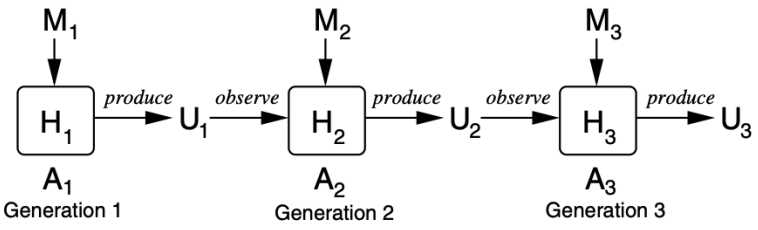

Figure 1: iterated learning model

This model is also related with Bayesian inference. At each learning process each learner update their beliefs based on rational procedure.

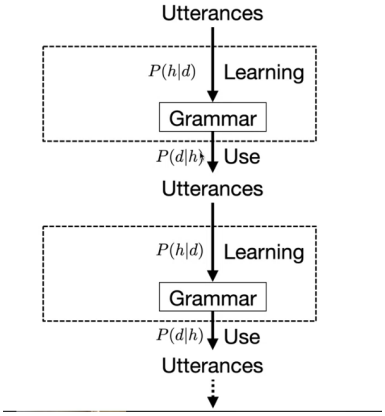

Figure 2: modelling iterated learning based on hypothesis

[29]

[30] Griffiths and Kalish (2007) [31] Xu and Tenenbaum (2007) [32] Kirby et al. (2008) [14] Kirby, Griffiths, Smith (2014) [33] Kirby, Tamariz, Cornish, and Smith (2015), [34] Goodman Frank, 2016

The models themselves, building on work by, e.g., Griffiths and Kalish (2007); Kirby et al. (2008); Kirby, Tamariz, Cornish, and Smith (2015), will consist of two main components: a model of an individual language learning agent; and a model of the population of these agents. Each agent will use Bayesian learning techniques to infer a hypothesis about how to form signs when interacting with another agent. In a Bayesian model, this hypothesis is selected on the basis of two things: the experience of the agent (i.e. the signing behavior that the agent has observed in its lifetime), and the agent's prior expectations about language (e.g. how regular or variable it is expected to be both within and across signers, what word orders are preferred for which meanings, etc.). In addition to learning, agents also interact in a population. During interaction, agents attempt to make inferences about the other agent's knowledge to construct a signal that is likely to result in communicative success (Goodman Frank, 2016). We simulate population dynamics by orchestrating when agents are added and removed, who learns from whom, and who interacts with whom. In this way, we can not only check that the simulation model behavior matches the behavior of our participants in the three experiments in Strand 2, but also interpolate between these extremes and extrapolate to the more naturalistic setting we see in Strand 1.

2.3 Network Structures

Another issue that this study deals with is the structures of communities. Of course, today there are communities that communicate in different sizes and in different ways. Previous study reveals that the size and social structure of the community may play an important influence in the evolution of language ([35]; [36]; [12]). It was theorized that emerging sign languages that emerge in tiny groups (i.e. village sign languages) had less conventionalized structure. Languages forming in larger groups and/or communities with less common heritage (deaf community sign languages, for example) tend to be more uniform ([37]).

[38] investigates the word order variability to test the hypothesis. They search how word order becomes a standard in new communication systems that differ in their social structure and community size by using real data. The results shown that there is significantly more variance in word order preferences in CTSL (used in a small community in Turkey) as opposed to those in ABSL (used in a bigger community in Israel, both within and across signers: CTSL signers show less convergence as a community, and are less consistent in their own productions. These results support the hypothesis that the size of a language community has an effect on conventionalizing in early stages of language emergence: the language of bigger communities is more uniform in structure that that of smaller communities.

CHAPTER 3

THE MODEL

In this chapter, the details of the user experiment are presented.

3.1 Research Method and Experiment Design

CHAPTER 4

EXPERIMENT SETUPS AND THEIR RESULTS

4.1 Method

CHAPTER 5

DISCUSSION

5.1 Method

CHAPTER 6

CONCLUSION AND FUTURE WORK

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APPENDIX A

TABLES FOR RELATED WORK CHAPTER

A.1 Summary of the Studies

APPENDIX B

EXTRA MATERIAL

APPENDIX C

INSTRUMENTS AND ETHICAL CLEARANCE