INCREMENTAL PROCESSING OF MORPHOSYNTAX FOR COUNTERFACTUAL REASONING: AN EYE-TRACKING STUDY WITH TURKISH-SPEAKING CHILDREN AND ADULTS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

SEMİH CAN AKTEPE

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF ARTS
IN
THE DEPARTMENT OF ENGLISH LANGUAGE TEACHING

SEPTEMBER 2022

Approval of the thesis:

INCREMENTAL PROCESSING OF MORPHOSYNTAX FOR COUNTERFACTUAL REASONING: AN EYE-TRACKING STUDY WITH TURKISH-SPEAKING CHILDREN AND ADULTS

submitted by **SEMİH CAN AKTEPE** in partial fulfillment of the requirements for the degree of **Master of Arts in English Language Teaching, the Graduate School of Social Sciences of Middle East Technical University** by,

Prof. Dr. Sadettin KİRAZCI
Dean
Graduate School of Social Sciences _____

Prof. Dr. Nurten BİRLİK
Head of Department
Department of Foreign Language Education _____

Assoc. Prof. Dr. Duygu ÖZGE
Supervisor
Department of Foreign Language Education _____

Examining Committee Members:

Assoc. Prof. Dr. Tilbe GÖKSUN (Head of the Examining Committee)
Koç University
Department of Psychology _____

Assoc. Prof. Dr. Duygu ÖZGE (Supervisor)
Middle East Technical University
Department of Foreign Language Education _____

Prof. Dr. Çiğdem SAĞIN ŞİMŞEK
Middle East Technical University
Department of Foreign Language Education _____

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: Semih Can AKTEPE

Signature:

ABSTRACT

INCREMENTAL PROCESSING OF MORPHOSYNTAX FOR COUNTERFACTUAL REASONING: AN EYE-TRACKING STUDY WITH TURKISH-SPEAKING CHILDREN AND ADULTS

AKTEPE, Semih Can

M.A., The Department of English Language Teaching

Supervisor: Assoc. Prof. Dr. Duygu ÖZGE

September 2022, 71 pages

This study aimed to investigate whether children as young as age four can incrementally use morphosyntactic cues for counterfactual reasoning at adult-like level. Therefore, in this study, we answered (i) when children can reason adult-like using counterfactuals and (ii) whether they can incrementally integrate the morphosyntax of counterfactuals in a language that encodes both the conditional and counterfactual meaning in concatenated verbal suffixes, Turkish. We conducted an eye-tracking experiment using visual world paradigm to answer these questions. Our results showed that children attended the target referent after they heard the verb conjugation of the antecedent in the conditional sentences. This result suggests that children as young as age four can interpret counterfactual conditionals incrementally using counterfactual morphosyntax as adults do. To our knowledge, this is the first piece of evidence showing that the morphosyntax marked on verbs quickly leads to complex inferences such as generating hypothetical alternative worlds for counterfactual reasoning not only in adults but also in very young children.

Keywords: counterfactuals, language development, incremental processing, reasoning, eye-tracking

ÖZ

KARŞI OLGUSAL USLAMLAMADA ARTIMLI BİÇİM-SÖZDİZİM İŞLEMESİ: TÜRKÇE KONUŞAN ÇOCUKLAR VE YETİŞKİNLER İLE BİR GÖZ İZLEME ÇALIŞMASI

AKTEPE, Semih Can
Yüksek Lisans, İngiliz Dili Öğretimi Bölümü
Tez Yöneticisi: Doç. Dr. Duygu ÖZGE

Eylül 2022, 71 sayfa

Bu çalışmada, dört yaş kadar küçük çocukların karşı olgusal uslamlamada biçim-sözdizimsel ipuçlarını yetişkin düzeyinde artımlı olarak kullanıp kullanamayacağının incelenmesi amaçlanmıştır. Bu yüzden biz bu çalışmada (i) çocuklar ne zaman karşı olgusal ifadeleri kullanarak yetişkinler gibi akıl yürütebiliyor ve (ii) ardışık fiil ekleriyle hem koşullu hem de karşı olgusal anlamı kodlayan bir dilde, Türkçe, karşı olgusal ifadelerin biçim-sözdizimini artımlı olarak bütünleştirebiliyorlar mı sorularını yanıtladık. Bu soruları yanıtlamak için görsel dünya paradigması kullanan bir göz izleme deneyi gerçekleştirdik. Sonuçlarımız, çocukların koşullu cümlelerinin öncülündeki fiil çekimlerini duyduktan sonra hedef göstergeye dikkatlerini verdiklerini sergilemektedir. Bu sonuç, dört yaşındaki çocukların, yetişkinler gibi, karşı olgusal biçim-sözdizimi kullanarak artımlı bir şekilde karşı olgusal ifadeleri anlayabildiklerini göstermektedir. Bildiğimiz kadarıyla bu, fiillerin biçim-sözdiziminin yalnızca yetişkinlerde değil, aynı zamanda dört yaş kadar küçük çocuklarda da karşı olgusal akıl yürütme için varsayımsal alternatif dünyalar oluşturmak gibi karmaşık çıkarımlara anlık olarak yol açtığını gösteren ilk kanıttır.

Anahtar Kelimeler: karşı olgusal ifadeler, dil gelişimi, artımlı işleme, uslamlama, göz izleme

To the ones who succeed without being obsequious

ACKNOWLEDGMENTS

I thank my supervisor, Assoc. Prof. Dr. Duygu Özge, for her guidance and providing me with a laboratory environment to conduct my studies.

Also, I would like to thank the jury members, Prof. Dr. Çiğdem Sağın Şimşek and Assoc. Prof. Dr. Tilbe Göksun, for their constructive feedback.

Then, I present my gratitude to the members of METU language and Cognitive Development Laboratory, especially Özge Günay and Sena Gül for helping me with the data collection, Meryem Ezgi Bayramoğlu for voice recordings in the experiment and Mehmet İlteriş Bozkurt for having a lot of conversation with me regarding the things that we think are a joke in academia (and many other fields).

Finally, huge thanks to my parents, Arzu and Davut Aktepe, for their endless and unconditional support. Sorry that I sometimes harshly criticize your (traditional) parenting; you might have found my actions disrespectful. Also, I have never been a kid that you desired me to be (probably, I will not be ever anyway). Despite all these, you still trust your son and ask for the best for him. Thanks again.

This research was supported by Scientific and Technological Research Council of Turkey (TÜBİTAK) 1001 grant (218K184).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

VWP	Visual World Paradigm
GLMM	Generalized Linear Mixed Model
GAMM	Generalized Additive Mixed Model
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
CN	Counterfactual Negative
CP	Counterfactual Positive
IN	Indicative Negative
IP	Indicative Positive

CHAPTER 1

INTRODUCTION

Children can reason through logical words such as *and* (Morris, 2008) and *not* (Feiman et al., 2017) from two and a half years of age, *or* from three years of age (Mody & Carey, 2016) and can differentiate the semantic and pragmatic use of these logical connectives by the age of four (Jasbi & Frank, 2017). They can also incrementally process the morphosyntactic cues such as case markers (Özge et al., 2019) and passivation (Huang et al., 2013) for thematic role assignment and predicting the upcoming context. What about more complex structures requiring inferencing via both morphosyntax and conditional logical connective: counterfactual conditionals? Along with their complex linguistic structure, counterfactual conditionals also necessitate a complex reasoning ability in which people need to represent both the hypothetical alternative and real-world situations as well as their possible outcomes (Byrne, 2007; Roese, 1997).

Different languages encode the linguistic structure of the counterfactual conditionals differently. Counterfactual conditionals in Turkish are encoded with the linear combination of a conditional marker *-sA* and a (fake) past tense marker that gives the counterfactual meaning *-DI*. Therefore, it is not certain whether young children can acquire such a complex structure given its semantic interpretation and morphosyntactic parsing early in their language development. Because of these complexities involved in counterfactual reasoning and morphosyntax, their acquisition might be later, and their processing might be harder compared to those of the logical connectives such as *and, or,* and *not*. Also, in some accounts, children are not expected to be fully developed in their domain-general logical abilities such as preemption, abstraction, and analogy making until the age of five or six (Tomasello, 2003). Hence, developing counterfactual thinking ability may last even longer than developing these abilities. Similarly, using morphosyntactic cues predictively for thematic role assignment may be earlier than doing so for counterfactual reasoning as case marking of morphosyntactic cues in thematic role assignment reflects the agents, themes, and recipients of the events which are already accessible from the percep-

tual system. However, case marking of morphosyntax in counterfactuals might be reflecting possible alternative realities about the events. Therefore, counterfactual conditionals require developing a more advanced conceptual system and a parser to process their morphosyntax, which may lead to later development in children.

Previous studies investigating the acquisition of counterfactuals yielded mixed findings about when children could interpret counterfactual conditionals at an adult-like level. While some studies report that children as young as age four could reason counterfactually (German & Nichols, 2003; Harris et al., 1996; Nyhout & Ganea, 2019b), others reveal that it is not until age 6-7 (sometimes not until 14) for children to interpret counterfactual situations in an adult-like fashion (McCormack et al., 2018; Rafetseder et al., 2010; Rafetseder et al., 2013). The difference among these studies may be methodological as they all relied on different offline measures incurring heavy processing demands where children need to both comprehend some stories including counterfactual situations and keep in mind the inferences of these situations. Therefore, it is possible that children process these structures on the fly, but they fail to retrieve their initial interpretation until the end of the utterance. Furthermore, we are still not certain whether adults can even incrementally interpret the morphosyntax of counterfactuals in different languages such as English and Spanish (Ferguson et al., 2010; Orenes et al., 2019).

To our knowledge, no other study has investigated the real-time processing of counterfactuals in children and focused on the acquisition of such a structure in a language that encodes both the conditional and counterfactual meaning in concatenated verbal suffixes. Therefore, we aim to fill this gap by investigating the online processing of counterfactual conditionals in Turkish.

In the remaining of this chapter, we give information about the syntax and semantics of counterfactual conditionals, which is the structure under investigation, then cover the previous literature regarding the processing of this structure by adults and its development in children for reasoning. Finally, we present the research questions attempted to answer in this thesis.

1.1 Counterfactual Conditionals in Syntax-Semantics Interface

There are different kinds of conditional sentences. These sentences vary by their morphosyntactic structures, and these structures differentiate the semantics of these different kinds of conditional sentences. For example, conditional sentences of the type, *if John drives the car, he will be on time for the job*, are called indicative conditionals. Such sentences have different interpretations according to

different views. One is that either John does not drive the car, or he is on time for the job. The other is that John is on time for the job because he drives the car. Another is that they are non-truth functional, so we cannot know the truth of their antecedent and consequent, rather they are assertible or acceptable by the interlocutors of the speech (Edgington, 2020; Jackson, 1991; Stalnaker, 1976).

Indicative conditionals lead to the imagination that John drives the car, and he is on time for the job. On the other hand, conditional sentences of the type, *if John had driven the car, he would have been on time for the job*, are called counterfactual conditionals. Unlike indicative conditionals, counterfactuals refer to the conceptual or imaginative alternatives that refer to the states and actions that might have happened but did not happen in reality (Roese & Epstude, 2017; Starr, 2021). These alternatives indicate a possible world counter to the fact or different from the factual world (Byrne, 2007; Epstude & Roese, 2008; Evans & Over, 2004; Roese, 1997). Counterfactual conditionals, unless it is stated in the context explicitly[1], imply that their antecedent is negated (Anderson, 1951). Therefore, the sentence, *if John had driven the car, he would have been on time for the job*, denotes that John did not drive the car and he is late for the job.

The linguistic configuration of the counterfactual sentences varies for different languages. Sentences can be made to infer counterfactual meaning by subjunctive mood such as German *(Konjunktiv II)* as in 1 (Durrell, 2013). Therefore, the presupposition implying the falsity of the antecedent is often associated with subjunctive mood (Karawani, 2014; Stalnaker, 1976; Von Fintel, 2012).

(1) Wenn mich jener Anruf nicht mehr **erreicht hätte, wären** wir einander nie
If me that call not more reached had, would have we each other never
begegnet.
met.
If that call had not reached me, we would never have met.

However, although some sentences may look like counterfactuals due to the use of subjunctive mood, they do not denote counterfactual meaning. Thus, the verbal inflection in the subjunctive form does not guarantee the counterfactuality of the sentence. For example, French subjunctives do not infer counterfactual meaning, so the subjunctive sentence in 2a *(Subjonktif)* does not convey the counterfactual meaning in 2b *(Conditionnel Passé)* (Iatridou, 2000, 2014).

[1] The counterfactual conditional sentence *if John had taken arsenic, he would have shown just exactly those symptoms which he does in fact show* does not denote that John did not take the arsenic, and he does not show the symptoms.

(2) a. Je doute que Pierre **soit venu.**
I doubt that Pierre had come.
I doubt that Pierre had come.

b. Si Pierre **était/*soit venu,** je l'**aurais vu.**
If Pierre had come, I him would seen.
If Pierre had come, I would have seen him.

Consequently, for a sentence to denote a counterfactual meaning, its verb must be *x-marked*. X-marking refers to the fact that a verb is ornamented with a certain morphological structure to denote a counterfactual meaning (von Fintel & Iatridou, 2020). For example, in English, the verb of the antecedent must have a past tense inflection, and that of the consequent must be in (perfect) modal form, and also this sentence must allow conditional inversion as in 3a (Iatridou, 2000). Otherwise, without the inversion, the antecedent of the counterfactual sentence is the same as the indicative sentence in 3b.

(3) a. Were Oswald not to kill Kennedy, someone else would.
If Oswald did not kill Kennedy, someone else would.

b. If Oswald did not kill Kennedy, someone else did.
*Were Oswald not to kill Kennedy, someone else did.

On the other hand, in Turkish, the linear morpheme order disambiguates counterfactual conditionals from the indicative ones. In indicative conditionals, first the temporal verbal inflection *(-DI, -r, -AcAk)* is concatenated to the root of the verb, then the conditional marker *-sA* is added to the verbal inflection as in 4a. In Turkish, there is no explicit conditional connective, *if ("eğer" in Turkish)* needed because the conditional marker *-sA* functions as *if* (Kornfilt, 1997). On the other hand, in counterfactual conditionals, the conditional marker is concatenated to the root of the verb first, and only past verbal inflection is added to the conditional marker as in 4b.

(4) a. Oswald Kennedy'yi öldür-me-di(y)-se başkası öldür-dü.
Oswald-Nom Kennedy-Acc kill-Neg-Past-Cond someone else kill-Past
If Oswald did not kill Kennedy, someone else did.

b. Oswald Kennedy'yi öldür-me-se(y)-di başkası öldür-ecek-ti.
Oswald-Nom Kennedy-Acc kill-Neg-Cond-Past someone else kill-Fut-Past
If Oswald did not kill Kennedy, someone else would.

Yarbay Duman et al. (2015) state that counterfactual and indicative conditionals are of the equivalent morphosyntactic structures except for the fact that the aforementioned morpheme order differentiates them. However, although the morpheme *-DI* seems to be phonologically equivalent in both structures, their morphosyntactic-semantic functions are different from each other. While the one in indicative conditionals points to the past tense conjugation of the verb as the other temporal morphemes like *-r* (Aorist) and *-AcAk* (Future), the one in counterfactual conditionals is an x-marking (fake past) morpheme (not a temporal morpheme). Therefore, such a linear combination of morphemes given in 5a is not possible in Turkish counterfactual conditionals, unlike the indicative ones in 5b. In other words, Turkish marks counterfactual conditionals with a *fake* past tense morpheme, not with the regular past tense morpheme (Iatridou, 2014). According to Can Bakırlı (2010), the verbal structures in the antecedent and consequent of the counterfactual conditionals in Turkish create a causal reasoning chain where the situation in the consequent triggers the situation in the antecedent. This causal chain infers the fact that the consequent did not happen. Therefore, when we regard sentence in 4b, we can say that someone else's not killing Kennedy triggered Oswald to kill Kennedy, and anyone else but Oswald did not kill Kennedy. As a result, sentence 4b implies the fact that Oswald killed Kennedy and no one else killed Kennedy. On the other hand, the verbal inflections in the antecedent and consequent of the sentence 4a do not make any judgment about their falsity. Thus, the truth of the consequent of someone else's not having killed Kennedy is determined by the truth of the antecedent of Oswald's having killed Kennedy (Can Bakırlı, 2010).

(5) a. *öldür-me-se(y)-ecek
kill-Neg-Cond-Fut
*If he would not kill, ...

b. öldür-me-(y)ecek-se
kill-Neg-Fut-Cond
If he will not kill, ...

1.2 Studies on the Processing of Counterfactual Conditionals in Adults

We can outline the studies investigating the adults' processing of counterfactuals in terms of inferring to the falsity of the antecedent of counterfactual conditional sentences, dual meaning representation caused by this and making these inferences using morphosyntactic parsing.

1.2.1 Inferring to the falsity of the antecedent in counterfactual conditionals

In section 1.1, we said that counterfactual conditionals have the presupposition that their antecedent is negated. For instance, the counterfactual conditional sentence, *if John had driven the car, he would have been on time for the job*, points to the fact that John did not drive the car; possibly John's not driving the car is the cause of his being late for the job. Such counterfactual sentences also denote the false suppositional state in which John drove the car, and he was on time for the job.

Fillenbaum (1974) states that participants falsely recognized the negated antecedents of the counterfactual conditional sentences, *he did not catch the plain* as already uttered after the counterfactual sentence, *if he had caught the plane, he would have arrived on time*, in a memory task where they decide whether the sentences have already been uttered or they are uttered newly. This early study suggests that people presuppose the antecedents of the counterfactual conditional as their denied propositions. Therefore, counterfactuals might be more costly to process as they require access to these alternative hypothetical possibilities and their presuppositions.

1.2.2 Dual meaning representation in counterfactual conditionals

Related to imagination and planning skills, the representation of these two contradicting meanings in counterfactual sentences makes them cognitively complex (Fauconnier, 1994; Johnson-Laird & Byrne, 2002). The dual meaning representation triggered during counterfactual language comprehension is considered as the typical feature of counterfactual sentences (Kulakova & Nieuwland, 2016a). Therefore, the processing of counterfactuals is discussed from the view of dual meaning representation and the suppositions expressed by them.

Some studies proved the fact that counterfactuals trigger two different mental models in mind. For instance, Byrne and Egan (2004) stated that contrary to indicative conditionals such as *if I were a movie star, I moved to Hollywood*, counterfactual conditionals such as *if I had been a movie star, I would have moved to Hollywood*, create a dual representation of an event that I am not a movie star and falsified proposition that I am a movie star. They also added that indicative conditionals such as *if I am a movie star, I will move to Hollywood*, imply a single representation that constructs the suppositional state *I am a movie star and I will move to Hollywood* unlike counterfactuals on which people make negated inferences. In another study, Santamaría et al. (2005) presented that the counterfactual conditional sentences such as *if it had rained, we would have gone to picnic* prime negative *not-p and not-q*

conjunctions that it did not rain and we did not go to picnic, and these conjunctions are read faster when they are read after counterfactual conditionals than when they are read after indicative conditionals.

In a self-paced reading study, the participants read a narrative sentence, *while keeping the ticket in her hand, Mary switched on the radio and heard the winning lottery number*. This sentence was either followed by a factual sentence, *as she won the lottery first prize, the first thing she did was to buy a luxurious Mercedes car*, or a counterfactual sentence, *if she had won the lottery first prize, the first thing she would have done was to buy a luxurious Mercedes car*, de Vega et al. (2007) measured the reading times of the participants in the new coming sentences, *Mary got into the Mercedes car and she felt like a queen*. The results showed that the participants read the new coming sentence faster after factuals than counterfactuals. Also, they read the sentence, *Mary tore the ticket to pieces and started to clean the kitchen*, faster after counterfactuals than factuals. The reading time results of the study demonstrated that only on reading the post-critical sentence, *and started to clean the kitchen*, the factual meaning of the counterfactual sentence that Mary won the lottery vanishes, unlike the factual sentences. Therefore, although people temporarily keep the new information in their mind after counterfactual sentences in the initial phases of the sentences, they fix their attention to the older sentences, suggesting that both meanings of the counterfactual scenarios are represented in counterfactual conditionals. Unlike offline studies, this study asserts that the processing of counterfactuals is more costly in comparison to their factual counterparts in terms of updating the processor based on the incoming information.

The use of brain imaging techniques provided further evidence for the dual representation of the counterfactual language processing and their processing load (De Brigard et al., 2013; Ferguson & Cane, 2015; Kulakova & Nieuwland, 2016b; Urrutia et al., 2012). For instance, Urrutia et al. (2012) reported that stronger activation in the left superior frontal gyrus, the area for executive functioning in the brain, was observed in counterfactual conditional sentences, *if Pedro had decided to paint the room, he would have moved the sofa*, than in factual causal sentences, *since Pedro decided to paint the room, he is moving the sofa*, suggesting that people create a different neural network for different types of input. They posited that as two representations are active simultaneously during the comprehension of the counterfactual sentence, inhibiting these representations is cognitively effortful. Hence, the activation in this area during counterfactual language comprehension might be pointing to the generation of alternative possibilities and inhibiting these possibilities to trigger the real-world situation during counterfactual thinking.

In another study, different from the other ones, Kulakova et al. (2013) compared the processing of

the indicative conditional scenarios, *the motor is switched off today; if the motor was switched on yesterday, did it burn fuel?*, with that of the counterfactual conditional scenarios, *the motor is switched off today; if the motor had been switched on today, would it have burned fuel?* This study revealed that more activity was observed in the right occipital cortex, which is the visual processing center in the brain, during the processing of counterfactual conditional sentences than indicative conditional sentences. In addition, more increased reaction times for follow-up responses in counterfactuals than indicatives showed that counterfactual conditionals create more processing load in the brain.

1.2.3 Morphosyntactic parsing for semantic interpretation of counterfactual conditionals

Kulakova and Nieuwland (2016a) remark that the point in counterfactual language processing should not be whether counterfactuals imply two meaning representations but rather how these representations are related to the incremental sentence construction. In this context, the role of linguistic input that might lead to the counterfactual meaning in speech, such as verbal inflections and conditional markers, is to be investigated. Not directly, but a few eye-tracking studies using visual world paradigm provide us with some ideas about the incremental processing of counterfactual conditionals.

Ferguson et al. (2010) pointed out that English-speaking participants shifted their gaze to the related referent (critical word) using the prior context right after the verb of the consequent and before the critical word in both counterfactual and indicative conditionals *(If cats were vegetarians/are hungry, they could feed their cats with a bowl of carrot/fish)*. However, even before the critical time points in the consequent, there is an increase in the look to the related referent for the counterfactual world in the study. Therefore, we cannot decide whether it is the linguistic cues in the antecedent or in the consequent that gave rise to the related referent looks. In addition, as the verbal configuration is the same for both counterfactual and indicative conditionals in the experiment, we cannot determine whether the linguistic cues incur more looks to the related referent. On the other hand, only the lexico-semantic units such as contextual words (vegetarian) and critical nouns (carrot, fish) in the utterances might have led to the correct looks. Thus, we cannot abstract out the clear effect of morphosyntactic units for counterfactual reasoning in this study.

In another study with Spanish-speaking participants, Orenes et al. (2019) presented that the fixations were made to a single referent in the indicative conditional structures, whereas the referents for both the reality and its negated alternative were almost equally fixated in the counterfactual probes after the verb conjugation. Nevertheless, this study has some possible confounds because of its experimental

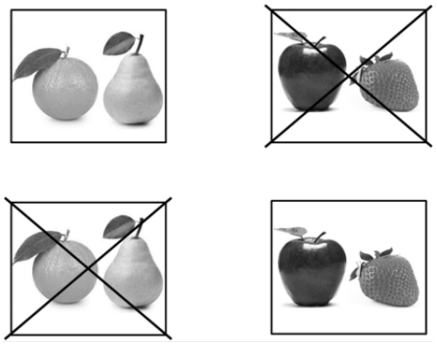

Figure 1.1: A visual scene used in Orenes et al. (2019)

design. The first is that in their experimental sentences, *(e.g., if there had been[counterfactual verb] oranges[noun], then there would have been pears)*, the noun after the verb was explicitly uttered, and this might be masking the effect of verb conjugation on the shifts in gaze. Thus, we cannot ascertain whether the counterfactual inflection of the verb in the antecedent or the noun coming right after the verb diverges the gaze of the participants. The second is that some of the referents were crossed out to represent the real-world situation for the counterfactual sentences, yet non-alternative world referents better represent the real-world situation for the counterfactual (Figure 1.1). In this study, two equally fixated referents are the alternative world referent and its crossed-out version. However, the non-alternative world referent must have been fixated. Therefore, it is not clear whether the looks would have converged on a single referent as in the indicative conditional sentences if there had been no crossed-out referents. Therefore, it is unclear to what extent the verbal markers in the counterfactual conditionals induced the generation of alternative possibilities in this study. On the other hand, the replication of this study conducted with English-speaking participants revealed that the participants' gaze converged on a single referent both in indicative and counterfactual conditional sentences. However, that referent was the same for both types of conditional sentences, such that the participants only looked at the referents similar to the ones at the top left side of Figure 1.1. In their second experiment, Evcen and Wittenberg (2022) asked the participants follow-up questions regarding what should be expected from the situation implied by the conditional sentences. The results indicated that most of the participants kept their gaze on the same referent as in the previous experiment, although some of them fixated on the referents similar to the ones at the top right side of Figure 1.1. These results show that there is no clear finding regarding how conditional morphosyntactic structures are processed for counterfactual reasoning in adults.

In addition to these online studies, in an offline study, Yarbay Duman et al. (2016) presented the pa-

tients with Broca's aphasia whose native language is Turkish, a series of connective, indicative conditional, and counterfactual conditional sentences. The connective sentences were of the type, *he ironed the shirt and hung it in the closet*, the indicative conditional sentences were of the type, *if he has ironed the shirt, he will hang it in the closet*, and the counterfactual conditional sentences were of the type, *if he had ironed the shirt, he would have hung it in the closet*. Uttering these sentences, (Yarbay Duman et al., 2016) asked the participants to match them with the correct representation among four pictures (*the shirt is not ironed and not hung in the closet*, *the shirt is ironed and hung in the closet*, *a dress is ironed and hung in the closet* and *a dress is not ironed and not hung in the closet*). As patients with Broca's aphasia are characterized by having difficulty in integrating functional words and inflectional morphology into their speech (Goodglass et al., 1972; Kean, 1977), and Turkish is a highly inflectional agglutinating language (Taylan, 1984), Turkish-speaking patients of Broca's aphasia were expected to perform poorly matching the correct picture in conditional sentences. Therefore, Yarbay Duman et al. (2016) demonstrated that patients with Broca's aphasia were better at picking the correct picture in connective sentences than in indicative and counterfactual conditional sentences. Furthermore, the control group (individuals without Broca's aphasia) had ceiling performance in all sentence types. These results suggest that in order to extract the semantic inferences made by the morphosyntax of the conditional sentences and distinguish them from each other, a proper morphosyntactic parser is required.

Finally, Yarbay Duman et al. (2016) also mention that Turkish counterfactuals are morphosyntactically less complex than their English counterparts because, unlike English, there are no if-embedding, modal auxiliaries, and past participles in Turkish. We cannot compare the complexity of these structures because Turkish counterfactuals might also be more complex than their English counterparts since, as we discussed in section 1.1, they have a more compact structure in which tense morphemes and conditional marker are packed within a more condensed morphemic structure of the verbs. Therefore, they may require a more advanced parser to process their morphology to interpret the semantic presuppositions of these structures. After all, although this study reveals the importance of morphosyntactic processing in generating the semantic interpretations of counterfactual conditionals, it does not disclose when the morphosyntactic units give rise to these interpretations during language comprehension.

1.3 Studies on the Development of Counterfactual Reasoning in Children

In section 1.2.1, looking at the counterfactual conditional, *if John had driven the car, he would have been on time for the job*, we said that John's not driving the car is probably the cause of his being late for the job. Therefore, we can conclude that counterfactual sentences suggest a causal relationship between the situations implied by their antecedent and consequent. On the other hand, many studies assert that making such causal reasoning using counterfactuals requires a series of executive functioning abilities. In this section, we first present how counterfactuals imply a causal relation, and when children can understand the causal implicatures of counterfactuals, then how the assertedly required cognitive abilities relate to this kind of causal reasoning in children.

1.3.1 Counterfactuals in building causal relations

Causality refers to the fact that one action, event, or process (cause) leads to the emergence of another (effect). The causal associations between causes and effects are the abstractions that allow people to understand how things in the world proceed (Mackie, 1980). The ability to construct such causal associations is called causal reasoning. Young children can make causal inferences about the events if they have real-world knowledge (Bullock, 1985; Shultz, 1982). Therefore, experience is necessary to build a concept of causality (Carey, 2009). However, some argue that there are basic blocks for causality driven by intuitions, so human causality is innate (Goodman et al., 2011; Griffiths & Tenenbaum, 2009; Steyvers et al., 2003). Therefore, children might be able to make causal inferences from a very early age, but their ability to reason might be constrained by the contextual knowledge and linguistic demands to express their reasoning, which limits their innate knowledge to put into practice (Bullock et al., 1982).

Fundamentally, the claims about the idea of causality about the actions, events, and processes are made by the existence of their effects given the existence of their causes. On the other hand, according to the counterfactual theory of causation, the causal claims are made by the counterfactual conditions of the form if A had not occurred, B would not have occurred (Menzies & Beebee, 2020). In other words, the non-existence of the cause will lead to the non-existence of all its effects. D. Lewis (1973/2013) states that the cause of an effect must make a difference from the case where it does exist, so we must be able to claim that if the cause had been absent, all its effects would have been absent as well. Therefore, counterfactuals play a crucial role in human reasoning. Sobel (2004) states that even very

young children could make predictions about possible situations using counterfactuals, even though, as mentioned earlier, counterfactual conditionals necessitate the representation of multiple alternative scenarios in mind and have a linguistically complex structure. However, different researchers handle the ability to reason counterfactually differently depending on how they view this ability.

Counterfactual reasoning can be seen in children's imaginations, beliefs about other people's actions, and pretence. Therefore, imagination, theory of mind, pretend play in children, and counterfactual reasoning point to the same segment of cognition (Byrne, 2016; Ferguson et al., 2010; Weisberg & Gopnik, 2013). Counterfactual reasoning is important for children to plan their actions according to the false premises through pretending about non-real situations (e.g., supposing a banana as if it was a telephone). Therefore, pretend play in the early phases of their development is crucial to generate alternatives for future events. However, psychologists do not compromise on whether imagination and pretend play contribute to the counterfactual reasoning ability of children. Pretend play and counterfactual reasoning ability are asserted to have some common features in terms of the separation from reality, referring to alternative reality based on unreal events and considering these alternatives as future possibilities, suggesting that pretence is adequate for planning, causal models, and counterfactual processes (Buchsbaum et al., 2012; Weisberg & Gopnik, 2013). In the definition they adopt, counterfactuals cover the pretence, imagination of the real world, and future planning. However, unlike the scientists regarding this definition, Beck (2016) argues that reasoning with counterfactuals includes generating thoughts about alternative and real-world situations. Therefore, we also view counterfactual reasoning as the ability to make inferences about the real-world situation given the alternative situations triggered by counterfactuals.

Generating alternative situations in mind and inferring the real-world situation among these situations included in counterfactual reasoning are often related to such cognitive abilities as theory of mind, false belief, inhibitory control, and working memory capacity. In the following sections, we will discuss the effects of these abilities when children engage in tasks where they need to reason counterfactually.

1.3.2 Counterfactuals require inhibiting alternative possibilities

Given the nature of the task employed in different studies and the requirements for counterfactual reasoning, previous studies conducted on such languages as English, German, Greek, and Turkish have not addressed children's processing patterns of counterfactuals, and they yielded mixed findings about when children could interpret counterfactual conditionals in an adult-like fashion. For instance,

in an earlier study, Harris et al. (1996) tested if counterfactual thinking allows children to make causal inferences. In their experiments, 3- to 4-year-old children were told a story where an event, *a girl named Carol walk in with muddy boots*, causes another event, *making kitchen floor dirty*. Then, the children were asked a question about the story, *what if Carol did not walk in with muddy boots, would the floor be dirty?* The results showed that children as young as three years of age could answer such questions, and 4-year-old children were even more accurate in their responses. To make such a causal inference that the floor is dirty, children should have the ability to inhibit the fact that the floor is clean, as explicitly stated by the counterfactual sentence. Therefore, the earlier signs of inhibiting some of the possibilities seem to be observed by the age of three.

Another study shows that children can also inhibit the multiple alternatives to reason about a possibility when the events have two causes. Rafetseder et al. (2010) told children stories such as a mother placed a candy on either the top shelf or the bottom shelf. If it was placed on the top one, the boy could pick it up, and if on the bottom one, the little girl could pick it up, and they brought to their room. Children could answer such counterfactual questions as *what would happen if the candy was on the top shelf and the little girl came?* or so. However, after telling the story in which the mother placed the candy on the top shelf, and the boy picked it up then brought to his room, they asked children *what if the girl had come instead of the boy?* 6-year-old children had difficulty in answering such questions unlike the adults because in this case there was more than one alternative possibility. Rafetseder et al. (2013) further investigated this and demonstrated that 14-year-old children showed adult-like performance answering such questions. Thus, in this case, although previous research pointed out that inhibiting the possibilities is seen at three years of age, as the task requires inhibiting more than one possibility, young children have difficulty inhibiting the alternative possibilities.

Similarly, in an experiment where either an event A or an event B (or both) causes an event C to happen, McCormack et al. (2018) asked children from four years of age to nine years of age counterfactual questions such as *if A had not happened, would C have happened?* and *if A had been prevented, would C have happened?* Their results showed that 6-to-7-year-old children could answer such questions, and 8-to-9-year children did so at ceiling level. The difference between the experimental paradigm of Rafetseder et al. (2013) and McCormack et al. (2018) was that while Rafetseder and colleagues' experiment required children to make reasoning from the narratives about the behavior of the agents, McCormack and collegues' experiment used a physical system where the different combination of the pegs' placement caused the toy pigs to fall down or not. Nyhout and Ganea (2019b) further showed that children as young as age four could reason counterfactually with a blicket detector paradigm

where the physical objects caused the blicket detector machine to go off after asked counterfactual conditional questions such as *if she had not put the object on the box, would the light still have switched on?* Therefore, it is concluded that children are better at making counterfactual inferences about the physical events and objects compared to the stories including agents with different choices (Nyhout & Ganea, 2019a).

1.3.3 Keeping multiple representations generated by counterfactuals in mind requires working memory

As people should hold multiple alternatives in mind during counterfactual language processing, working memory capacity could affect their ability to reason counterfactually. German and Nichols (2003) stated that counterfactual reasoning in children emerges at the age of four, and maintaining causal relations between the antecedent and the consequent of the counterfactual sentence depends on the temporal proximity between the antecedent and the consequent. For example, in a sequence of events A, B, C, and D, 3-year-old children could answer questions where the event in the antecedent and the consequent were closer in the sequence, such as *what if C had not happened, would D have happened?* (short causal chains). However, they failed to answer questions where the event in the antecedent and the consequent were more distant from each other in the sequence, such as *what if A had not happened, would D have happened?* (long causal chains). The result showed that 4-year-old children could answer these questions while 3-year-olders could not. Thus, we can say that as the memory load increases, retrieving the information about the earlier events becomes harder during speech.

In addition, Beck et al. (2006) reported that in an experiment where an object follows either the blue way or the red way, if it continues to follow the red way, it separates into two ways as spotty and stripy based on the cards chosen, the participants were asked future hypothetical question about the path the object follows, *what if next time it goes the other way, where will it be?* As the second event (spotty-stripy selection) happens later than the first event (red-blue selection), the participants are expected to respond by saying spotty or stripy, and most of them did so. However, some participants inferred the red or blue selection, which can be indirect evidence for German and Nichols' (2003) claim that longer causal chains require more processing power, yet because Beck et al. (2006) did not specify these participants, it is not possible to make a proper discussion. The issue raised in causal chains is that the possible lack of transitivity between the events, which does not contribute to the counterfactual causation of an outcome. The causal chains in these studies maintain the connections

between the events so that these events are consecutively the cause of each other due to transitivity. On the other hand, suppose such a story in which an enemy puts a bomb outside the door of Lucy, and Brian sees the bomb and then pinches out the fuse, so Lucy survives. In this story, Brian's pinching out the fuse is the cause of Lucy's survival, yet the enemy's planting the bomb is not the cause of Lucy's survival. Hence, the counterfactual conditional sentence, *if someone had not placed the bomb, Lucy would not have survived*, suggesting the cause of Lucy's survival is someone's placing a bomb at her door, is not an appropriate sentence regarding the transitivity in causal chains. Therefore, children might be considering the possibility that some of the events are not the cause of the final situation in counterfactual conditionals, or they simply find some of the possible causes as irrelevant, thus failing to respond correctly in such experimental tasks.

1.3.4 Counterfactual reasoning requires addressing to other minds

Besides the executive functioning skills, as people must consider the alternative situations and reality when thinking counterfactually, counterfactual thinking ability might address to theory of mind and false belief skills where one's and others' views are considered (Drayton et al., 2011; Guajardo & Turley-Ames, 2004; Riggs et al., 1998). Guajardo and Turley-Ames (2004) tested the 3-to-5-year-old children's ability to generate alternative situations about the counterfactual scenarios after telling them stories like the ones in Harris et al. (1996) and checked whether this ability correlates with the children's performance in a series of theory of mind tasks. The results showed that there was a significant correlation between counterfactual thinking and theory of mind ability. However, whether theory of mind or counterfactual thinking is the prerequisite for the other is not clear.

Yet, the studies conducted with the children with autism present a more precise image regarding the effect of theory of mind on counterfactual reasoning. Children with autism spectrum disorder often have certain conditions such as having difficulty in social interactions, understanding emotions, and pretending the objects as if they were something else (Frith, 2003). Therefore, as counterfactual reasoning is asserted to be related to theory of mind abilities, children with autism are expected to have poorer counterfactual reasoning abilities as well. Nonetheless, the research shows that children with autism can make counterfactual inferences as accurately as the typically developing children (Begeer et al., 2014; Grant et al., 2004; Scott et al., 1999). For example, in an experiment where children were told a story, *John and Mary are in the kitchen. They have some chocolate. They put the chocolate in the fridge. Then John leaves the house to go and visit a friend. Mary wonders to herself, "what*

will I do today? I know, I'll bake a cake." She goes to the fridge and gets the chocolate. She makes the cake with some of the chocolate and puts the rest of it away in the cupboard. Then, she eats the cake. John has finished visiting his friend now. He's hungry and wants to eat some chocolate., and asked a counterfactual question, *if Mary had not baked a cake, where would the chocolate be?*, and a false-belief question, *where does John think the chocolate is?*, Peterson and Bowler (2000) showed that children with autism could correctly respond to counterfactual questions as typically developing children. However, there was a significant difference between their response accuracy in false belief questions, such that typically developing children were better than the ones with autism.

In another study, children listened to a story, *In the bedroom, John hears his sister Anne say she wants to find her ball to play with it. Then, John goes to kitchen. But while he is away, Anne's mother tells Anne to tidy her bedroom. When John passes Anne's bedroom again, he sees her picking up toys from her bedroom floor.* Then, they were asked a counterfactual question, *if Anne's mother hadn't asked Anne to tidy her room, what would have been the reason she was picking up toys?*, and a false belief question, *what will John believe is the reason that Anne is picking up toys?* Rasga et al. (2017) indicated that 6- and 8-year-old autistic children's performances answering false belief and counterfactual conditional questions were poorer compared to their typically developing peers, but this different faded at the age of ten. On the other hand, children with autism in all age groups had better performance answering the counterfactual questions than false belief questions. These results imply that theory of mind abilities may not be a predictor of counterfactual reasoning ability.

In both typically developing and autistic children studies, when the age of the children is controlled, the effect of theory of mind skills on counterfactual reasoning vanishes. Given the effect of age in previous research, age seems to be a better predictor than theory of mind and executive functioning skills. This may be because such abilities as working memory capacity, inhibitory control, theory of mind, and language develop as the age of the children also increase. As the development in counterfactual reasoning can be both explained by age and these cognitive abilities, which also develop by age, detecting the true effect of each is a challenge. Thus, analyzing the effect of executive functioning abilities along with age may lead to a collinearity problem in which a strong correlation between two measures makes the interpretation of their true effects difficult (Mason & Perreault Jr, 1991).

1.3.5 Comprehensive studies on the relationship between counterfactual reasoning and executive functioning

The studies covered so far showed that making causal inferences using counterfactuals might be related to age, language, working memory, inhibitory control, and theory of mind abilities. Two pieces of work studied these factors comprehensively. Drayton et al. (2011) assessed children's receptive language skills (using the TACL3 (Carrow-Woolfolk, 1985)), false belief ability (using unexpected change, deception, active deception, unexpected contents task (Bartsch & Wellman, 1989; C. Lewis & Osborne, 1990; Wimmer & Perner, 1983)), working memory capacity (using backward digit span, counting and labelling, finger tipping and labelling (Davis & Pratt, 1995; Gordon & Olson, 1998)), inhibitory control (using grass/snow, bear/dragon and card sort task (Carlson & Moses, 2001; Frye et al., 1995; Kochanska et al., 1996)) and counterfactual reasoning ability (using the experimental paradigms in Guajardo and Turley-Ames (2004) and Riggs et al. (1998)). Their regression model indicated that age, language, working memory, and counterfactual ability could account for the false belief ability of the children. This study pointed out that counterfactual thinking is related to false belief even when controlled for age and language.

Beck et al. (2009) also tested children's verbal ability measure (using the British Picture Vocabulary Scale Second Edition (Dunn et al., 1997)), inhibitory control measures (using bear/dragon and black/white Stroop tasks (Gerstadt et al., 1994; Kochanska et al., 1996; Simpson & Riggs, 2005)), working memory measures (using counting and labelling, and noisy books tasks (Gordon & Olson, 1998; Hughes, 1998)) and counterfactual reasoning measures (using syllogism task in Dias and Harris (1988, 1990), causal chains in German and Nichols (2003) and location change task in Riggs et al. (1998)). The results showed that there was a significant positive correlation between counterfactual reasoning tasks and inhibitory control tasks and working memory tasks, and language scores. However, interestingly, only in the long causal chain counterfactual reasoning task, which is cognitively more demanding, and the working memory and inhibitory control tasks, there was a negative correlation. Beck and colleagues' regression model also demonstrated that inhibitory control and language but not working memory were the predictors of counterfactual thinking ability. Different from Drayton et al. (2011), their model did not include age as a predictor because it showed heteroscedasticity, and they added that they did not expect any effect of age since age did not correlate with most of their measures.

The common point between Drayton et al. (2011) and Beck et al. (2009) is that they both emphasized

the effect of language on counterfactual thinking. Yarbay Duman et al. (2015) compared the performances of the typically developing children with the ones who had specific language impairment[2]. In a picture matching task, they told children a counterfactual conditional, *if he had ironed the shirt, he would have hung it in the closet*, and showed four pictures: a shirt is not ironed and not hung in the closet (target), a shirt is ironed and hung in the closet, a dress is not ironed and not hung in the closet, and a dress is ironed and hung in the closet. Their results indicated that typically developing children were significantly better at picking the correct picture than children with specific language impairment. This implies that language skills play an important role in counterfactual thinking. However, the problem with their experimental design is that there is more than one matching picture with the sentence, even though the authors determined only one. The alternative scenario implied by the counterfactual conditional might be that the person ironed something else instead of the shirt or nothing at all and hung that in the closet. Therefore, the pictures where the dress (instead of the shirt) is ironed and hung in the closet, and the dress is not ironed and not hung in the closet also correctly match the counterfactual conditional. Despite this confounding factor in the experimental design, one positive thing about this study is that they also compared the performances of the children not only in counterfactual conditional but also in indicative conditionals, *if he has ironed the shirt, he will hang it in the closet*, and connective sentences, *he ironed the shirt and hung it in the closet*. This is a design pattern that we often see in adult studies but not in children studies. Their result in this aspect showed that children in both groups were better at understanding the indicative and connective sentences than counterfactual conditionals. Thus, based on this study, we can posit that counterfactuals are language-wise more demanding compared to indicative conditional and connective sentences, yet the confounding factor in the study must be noted. This study also reported a positive correlation between age and task performance in typically developing children, but as the sample size (N=13) is too small, and the range is too wide (5:6-9:1), the results are not generalizable.

1.3.6 Counterfactual reasoning given the outcome of the events

Besides all these, one interesting point related to the provocation of the counterfactual thoughts is the outcome of the situation for the agent in the counterfactual scenario. German (1999) showed that after listening to the stories ending with negative outcome such as *Sally ate chocolate instead of sandwich and ended up hungry*, 5-year-old children could answer questions such as *what would Sally have done instead so she was hungry?* However, their performance was not as high as the performance

[2] Specific language impairment is a disorder where people have a certain deficiency in expressive and receptive languages skills although they have no hearing loss or neurological impairment (Leonard, 2014).

they showed in stories with positive outcome such as *Sally ate sandwich instead of chocolate and ended up full*. These results imply that counterfactual thinking was triggered more by the situations related to prevention from negative events rather than situations with positive outcome. This result might be related to the fact that counterfactual thinking is often attributed to regret, such that people make claims about their wrong decisions (Epstude & Roese, 2008). From this emotional aspect, some developmental studies pointed out that children have adult-like performance in understanding regret in counterfactual scenarios (Beck & Crilly, 2009; Guttentag & Ferrell, 2004; Nakamichi, 2019; Payir & Guttentag, 2019). Nevertheless, the valence of the outcome outside of regret in counterfactual thinking was not investigated by anyone else but German (1999). Therefore, German's hypothesis must be re-tested.

1.4 Motivation for the Present Study

Given the results of the studies covered so far, the literature is far from conclusive as to when children can think counterfactually, when they can interpret counterfactual conditionals, and how their executive functioning abilities and other factors affect their counterfactual reasoning abilities. The discrepancy between the difficulty of the tasks employed in the previous studies seems to be the cause of the variation. Therefore, especially the tasks where the participants make causal inferences using the counterfactual situations about the behavior of the human agents pose a greater challenge for the young children than the task using physical object paradigms. We speculate that children actually comprehend counterfactuals in these tasks, but they have difficulty expressing their inferences. After all, since the development of language augments as age increases, it is expected that young children cannot fully express their ideas. Thus, their physiological reactions, such as gaze movements, might be the indication of their early counterfactual language processing at an adult-like level. Nevertheless, when we look at adult studies, when the real-world and alternative world representations are triggered during counterfactual language comprehension and what linguistic units (morphosyntax or pragmatic context) trigger the generation of these representations are the questions still to be answered. Fortunately, Turkish, a language that expresses conditional and counterfactual meaning with a combinatorial sequence of morphemes, allows us to test the effect of morphosyntax on generating inferences caused by counterfactual conditionals. Nonetheless, while we were conducting this study, there were only two studies having investigated the comprehension of counterfactual conditionals in Turkish (see Yarbay Duman et al., 2016; Yarbay Duman et al., 2015). However, neither of them focused on the online processing of counterfactual morphosyntax.

1.4.1 Research Questions

Because of the rationales advocated in section 1.4, the present study aims to answer,

(i) whether children as young as four years of age can comprehend counterfactual conditionals at an adult-like level,

(ii) whether adults can incrementally use morphosyntax for counterfactual reasoning during speech,

(iii) whether children as young as four years of age can also incrementally interpret the morphosyntactic cues to reason counterfactually,

(iv) whether the negative outcomes of the counterfactual conditionals trigger the arousal of counterfactual thoughts more,

(v) whether the executive functioning abilities of the children predict their ability to reason counterfactually (if they do, which of them predict how).

1.4.2 Structure of the Thesis

In this chapter, we introduced counterfactual conditionals, which is the structure under investigation in this study. Then, we gave information about its syntax and semantics and covered the previous literature regarding the processing of this structure by adults and its development in children for causal reasoning. Finally, we rationalized the motivation and need for this study and presented the aim and research questions.

In chapter 2, we introduce the experimental paradigms and statistical methods employed to answer the research questions and our assumptions. In chapter 3, we present the results of our statistical analyses. In chapter 4, we discuss our findings in the light of the previous studies. Finally, in chapter 5, we share our concluding remarks and directions for future studies.

CHAPTER 2

EXPERIMENT

In this experiment, we employ visual world paradigm (VWP) (Cooper, 1974) to investigate online processing and ask an end-sentence comprehension question testing the offline interpretation of counterfactuals. In doing that, we also controlled the effect of the children's executive functioning abilities such as short-term memory, working memory, and inhibitory control on their response accuracy to examine the individual differences.

The principal hypothesis behind the visual world eye-tracking paradigm is that the probability of attending a visual stimulus, excluding noise, is $p(1/N)$ where N is the total number of stimuli in the scene when there is no auditory stimulus accompanying the visuals. Once the auditory stimulus respecting the visual scene is heard, the gaze shifts towards the related visual stimulus (Altmann & Kamide, 1999; Langton et al., 2000). These eye movements indicate attention to the information extracted from the utterance.

2.1 Participants

Twenty-three children (M_{age} = 4:10; Range = 4:05-5:11; 11 Females) and eighteen adults (M_{age} = 25,27; Range = 20-35; 11 Females) participated in the experiment (N = 41). The participants had normal or corrected-to-normal vision and were without any hearing problems. The adults reported that they had no neurological and behavioral problems. The parents of the children also reported that their children were of typical language development and had no neurological and behavioral problems. All participants were native speakers of Turkish and naïve to the purposes of the study. Child participants were recruited from preschools in Ankara or by announcements on social media. Participation in the experiment was voluntary for the adults, and children participated in the experiment on the condition that their parents gave written consent before the experiment. Additionally, children were asked for

Figure 2.1: A visual scene used in the experiment

their oral consent before the experiment started. At the end of the experiment, children were given a treat, and their parents were given a gift card from a bookstore for compensation. We excluded six children and three adult participants from the data due to some technical problems with the eye-tracking such as calibration issues.

2.2 Stimuli and Design

In this experiment, participants were first presented with a visual scene as in Figure 2.1. The referent pictures used in the visual scenes were taken from copyright-free online sources. These referents were introduced with a context sentence as in 6a and 6b[1] followed with the experimental items.

(6) a. **Context sentence (past tense)**

Garaj-da araba ve bisiklet var-dı.
Garage-Loc car-Nom and bicycle-Nom exist-Past

There were a car and a bicycle in the garage.

b. **Context sentence (aorist tense)**

Garaj-da araba ve bisiklet var-∅.
Garage-Loc car-Nom and bicycle-Nom exist-Aor

There are a car and a bicycle in the garage.

The experimental items were in two conditions with two levels. The first condition was whether the conditional sentence was in a counterfactual or indicative conditional form, and the second condition was whether the outcome of the event was positive or negative for the agent in the sentence. Therefore,

[1] Sentence 6a was used to set the scene for the counterfactual conditionals, sentence 6b was for the indicative conditionals.

this 2×2 design led to the total of four types of conditional sentences given in 7a-7d. Given these experimental items, the two referents in the visual scene corresponded to the real-world situation and the alternative world situation. The real-world situation referred to the target referent in which the agent in the experimental trials was engaged. On the other hand, the alternative world situation referred to the competitor referent in which the agent was engaged. The position of the referents in the visual scene (i.e., target or competitor) was counterbalanced so that there was no bias for the location of the target or competitor referent. There were sixteen experimental items in the experiment (four items per condition and no filler items were used). The experimental items were presented in two blocks, and their order was randomized. We also constructed four lists such that one participant could only hear one version of each experimental item. In other words, if the participant given a certain list heard a sentence in one condition, s/he did not hear its form in other conditions with the same stimuli. Before seeing the actual experimental items, the participants saw three training items with some basic questions as a warm-up (see Appendix A for the full list of items).

(7) a. **Counterfactual conditional sentence with negative outcome**

Can araba-(y)ı sür-se-(y)di, işe zamanında yetiş-ecek-ti.
Can-Nom car-Acc drive-Cond-Past job-Dat timely catch-Fut-Past

If John had driven the car, he would have been on time for the job.

Target: Bicycle

b. **Counterfactual conditional sentence with positive outcome**

Can bisiklet-i sür-se-(y)di, işe geç kal-acak-tı.
Can-Nom bicycle-Acc ride-Cond-Past job-Dat late become-Fut-Past

If John had ridden the bicycle, he would have been late for the job.

Target: Car

c. **Indicative conditional sentence with negative outcome**

Can bisiklet-i sür-er-se, işe geç kal-acak.
Can-Nom bicycle-Acc ride-Aor-Cond job late become-Fut

If John rides the bicycle, he will be late for the job.

Target: Car

d. **Indicative conditional sentence with positive outcome**

Can araba-(y)ı sür-er-se, işe zamanında yetiş-ecek.
Can-Nom car-Acc drive-Aor-Cond job timely catch-Fut

If John drives the car, he will be on time for the job.

Target: Car

At the end of each trial, the participants were asked a comprehension question asking what the agent did or will do given the sentence they heard. This question was formed in the past form after the counterfactual conditional sentences as in 8a, and it was formed in the future form after the indicative conditional sentences as in 8b. Adult participants used a button box to select the correct referent. The children did not use the button box in order to simplify the task for them. They either said the name of the referent out loud or pointed to the referent. The experimenter registered the child participants' responses using the button box. After each response, the participants received encouraging feedback such as *"You're good!"* and *"You play well!"* etc. There was no feedback implying whether the question was answered correctly or incorrectly.

(8) a. **Comprehension questions after counterfactual conditional sentences**

Sen-ce Can hangisi-(n)i sür-dü?
You-Abl Can-Nom which-Acc drive/ride-Past

Which one do you think John drove/rode?

b. **Comprehension questions after indicative conditional sentences**

Sen-ce Can hangisi-(n)i sür-ecek)?
You-Abl Can-Nom which-Acc drive/ride-Fut

Which one do you think John will drive/ride?

A female adult who was a native speaker of Turkish recorded the auditory stimuli. The speaker was instructed to voice the sentences at a normal pace in a child-directed manner. The files were recorded using *Audacity*, a free and open-source digital audio editor and recording application software, at a sampling frequency of 44100 Hz. The recordings were on a mono channel to avoid unequal sound levels between right and left ears. The critical onset and offset times of the experimental items were determined using Audacity. In the same software, we also manipulated these critical times so that none of the values were significantly discrete from the others and the lengths of the experimental items were closer to each other as much as possible by adding or removing some pauses. In addition, any noise in the recording was cleaned, and they were normalized so that each had the same volume level. The visual scenes were shown 500ms prior to the onset of the context sentences. Besides, there were 1000ms silent periods between each experimental phase (i.e., context sentence, experimental sentence, and comprehension question). The participants heard the auditory stimuli via either a headset or external speakers based on their choice. Prior to the experiment, the volume of the sound system equipment was adjusted to a level that the participants could hear the auditory stimuli comfortably.

2.3 Procedure

The experimental session took place in a silent room at a preschool or METU Language and Cognitive Development Laboratory. Participants were seated in front of a laptop computer with a 15.6-inch 1920 by 1080 resolution screen running at a 144 Hz refresh rate. They saw the visual stimuli on this screen. The experiment was created using SR Research Experiment Builder software. The participants' eye movements were sampled using SR Research Eyelink Portable Duo head-free eye-tracking system running at 1000 Hz. The recording was binocular, but the dominant eye of the participants was used for the analysis. Before the experiment, the participants received the following instruction from the experimenter: *In this experiment, you will hear a story and see pictures related to that story. After the story, you will hear a comprehension question about the story, and you will answer that question. Please look at the screen and listen to the stories carefully*. Then, five-point calibration and validation were performed, and this procedure was repeated whenever the calibration was off, or the participants moved from the chair and had excessive head movement. After the calibration and validation, this instruction was repeated with an animation where a character spoke in a more child-directed manner before the experiment began. Before each trial, a fixation cross in the form of a star having a dot in the middle appeared at the center of the screen as a drift correction procedure to check the calibration. The whole session lasted approximately fifteen minutes.

2.4 Cognitive Tasks

We also measured the cognitive skills of the participants, such as short-term memory capacity, working-memory capacity, and inhibition skills, using a series of executive function tests. These tests included forward digit-span task for short-term memory capacity, backward digit-span task for working-memory capacity (Wechsler, 1949; Wechsler & Kodama, 1949) and happy-sad face task for inhibition skills (Lagattuta et al., 2011). The participants participated in these tasks after the eye-tracking experiment. The order of the memory tasks and the inhibition task were counterbalanced across the participants.

In the forward digit-span tasks, the experimenter told the participants a series of integers from 1 to 9, differing in length, and asked them to repeat that series in the order she recited after her. The trials started from the series of the length 3, and if the participants correctly recited at least one out of two series with the same length, n, the experimenter gave them a series of the length, $n + 1$. If the

participants failed to recite two series of the same length consecutively, the experimenter finished the task. For each correct recitation, the experimenter gave one point to the participants. In the backward digit-span task, the procedure was the same, but the participants had to recite the series in reverse order. Also, the trials started from the series of length 2 in this task.

For the inhibition task, we used a Stroop test where the experimenter showed the participants happy or sad faces and asked them to say *"sad"* if the face seen is happy, and *"happy"* if the face seen is sad. The participants saw twenty faces, and the gender of the person whose face they saw was counterbalanced across them as female and male. For each correct answer, the participants got one point. The experimental stimuli were shown on a computer screen in random order.

2.5 Predictions

If the participants can incrementally process the morphosyntax of indicative and counterfactual conditionals, we expect that the participants move their gaze to the target referent after they hear the verb conjugation of the antecedent. Also, if children use such morphosyntactic cues as adults do, we predict a similar fixation pattern among adults and children. German (1999) stated that the performances of the children answering counterfactual situations with negative outcome were better than those with positive outcome. Similarly, we predicted that the increase in the target looks happens earlier in the counterfactual sentences with negative outcome than the ones with positive outcome. Besides, there might be overall more looks to the target in the negative outcome sentences than in positive outcome sentences. On the other hand, with respect to the responses to the end-sentence comprehension questions, we predict more correct answers for the counterfactuals with negative outcome than the ones with positive outcome if German's claim is right. In addition, since indicative conditionals do not require alternative representations, unlike the counterfactuals (De Brigard et al., 2013; Kulakova & Nieuwland, 2016a), we expect more accurate answers for indicative conditionals compared to counterfactual conditionals. In counterfactual conditionals, the real-world and the alternative world situations are represented at the same time according to the dual representation theories (Byrne, 2007; Byrne & Egan, 2004; Kulakova et al., 2013). Therefore, we expect fixations to be distributed equally between the target and competitor referents in our experiment. However, the fixations of the participants should converge on a single referent in indicative conditionals as they do not require generating multiple possibilities. Such gaze patterns were observed in Orenes et al. (2019), so we also anticipate a similar pattern. As to the cognitive task scores and the performances in the comprehension questions, we

expect that children with higher working memory capacity and inhibitory control ability will perform better as the previous research showed that working memory capacity and inhibitory control skills necessary for generating alternative situations, representing them simultaneously and inhibiting them to reason about the real-world situation (Beck & Riggs, 2014; Beck et al., 2009; Drayton et al., 2011).

CHAPTER 3

RESULTS

From the experiment, we collected two types of data. The first is the participants' responses to the comprehension questions at the end of the trials, and the second is the participants' gaze patterns recorded during the experiment. We first report the analysis of the response data and then the analysis of the eye-tracking data.

3.1 Analysis of Response Data

The participants' responses to the end-sentence comprehension questions were coded as 1 if they answered the question correctly and 0 otherwise. Therefore, our data was distributed binomially. We analyzed this binomial data by fitting a series of generalized linear mixed models (GLMM) using *lme4* package (version 1.1.27.1) in *R* statistical programming language environment (Bates et al., 2015; Bates et al., 2011). Prior to the analysis, the data points with no response were removed from the data. We started our analysis with the most complex model and reduced the model complexity by checking the model convergence. The models that did not converge were discarded. Thus, we eliminated the random slope models and the model with three-way interaction (age$\times$ type of conditional $\times$ outcome). The final models included the main effects of the experimental manipulations (group, type of conditional, and outcome), the interaction between type of conditional and outcome, and random intercepts for subjects and items (Equation 3.1). The model comparisons were made using Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) (Akaike, 1974; Schwarz, 1978). We also used *multcomp* package (version 1.4.18) to compare the levels of factors (Hothorn et al., 2016).

$$Model = glmer(accuracy \sim age + conditional * outcome + (1|Subject) + (1|Item)) \quad (3.1)$$

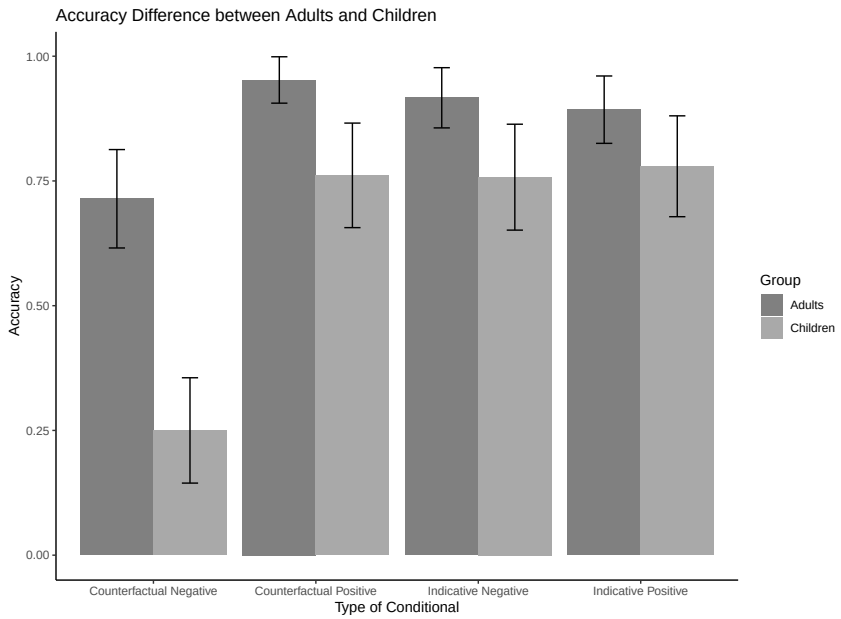

Figure 3.1: The difference in accuracy between adult and child participants.

3.1.1 Accuracy as a function of age, conditional and outcome

Figure 3.1 demonstrates that the participants' proportion of correct answers for each type of conditional and outcome. The accuracy of the participants' responses was analyzed with a generalized linear mixed model where the age group (adults and children) and type of conditional (counterfactual and indicative), and outcome (negative and positive) were the independent variables. The model including the three-way interaction term between age group, type of conditional, and outcome did not converge, so we reduced the nAGQ parameter of the model to 0 (default 1). This model was compared with the model with two-way interaction between type of conditional and outcome. The comparison revealed that the three-way interaction term did not significantly improve the model fit. Moreover, the model with only a two-way interaction term had lower AIC and BIC values (Table 3.1). Therefore, we presented the results of the model with two-way interaction.

Table 3.1: Comparison between two-way and three-way interaction models

Model	npar	AIC	BIC	logLik	dev	Chisq	Df	p-value
Two-way	7	517.29	548.13	-251.64	503.29			
Three-way	10	517.61	561.67	-248.81	497.61	6.675	3	0.1285

The results of the model (Table 3.2) show that the adults were significantly better than the children ($Estimate = 0.8727, SE = 0.3574, z = 2.442, p < 0.05$). These results suggest that children

did not perform as well as adults in their comprehension of conditionals. Nevertheless, although the children had lower performance compared to the adults, their performance in all conditions, except for the CN condition, was over 75%, indicating that they had good enough comprehension of the conditionals. On the other hand, even the adults had 100% accuracy in none of the conditions; even they had accuracy below 75% in the CN condition. These mark that such linguistic structures are demanding to process even for adults.

Table 3.2: Summary of the generalized linear mixed model

	Estimate	Std. Error	z-value	p-value	sig.
(Intercept)	0.8727	0.3574	2.442	0.0146	*
Children	-1.8801	0.4425	-4.249	<0.001	***
Indicative	2.2618	0.3936	5.746	<0.001	***
Positive	2.4759	0.4035	6.136	<0.001	***
Indicative:Positive	-2.5194	0.5762	-4.373	<0.001	***
*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*					

The results also indicate that the performances of all participants were higher in the indicative conditional sentences than in the counterfactual conditional sentences with negative outcome ($Estimate = 2.2618, SE = 0.3936, z = 5.746, p < 0.001$). In addition, the model summary points that the participants had more correct answer in the conditional sentences ending with a positive outcome than a negative outcome ($Estimate = 2.4759, SE = 0.4035, z = 6.136, p < 0.001$). Therefore, we can conclude that the participants found the comprehension questions after the counterfactual conditional with negative outcome harder. Finally, the model shows that there is a significant interaction between type of conditional and outcome ($Estimate = -2.5194, SE = 0.5762, z = -4.373, p < 0.001$). Figure 3.2 points out that the participants' accuracy increases if the outcome is negative in the indicative conditionals, yet if the outcome of the event is positive, then the accuracy of the participants slightly increases in the counterfactual conditionals.

We also ran pairwise comparisons to investigate if there was any significant difference between the four conditionals that emerged from the two-way interaction. The results of the pairwise comparisons showed that counterfactual sentences with negative outcome significantly differed from the other three conditional sentence types, and these three conditional sentence types did not significantly differ from each other (Table 3.3).

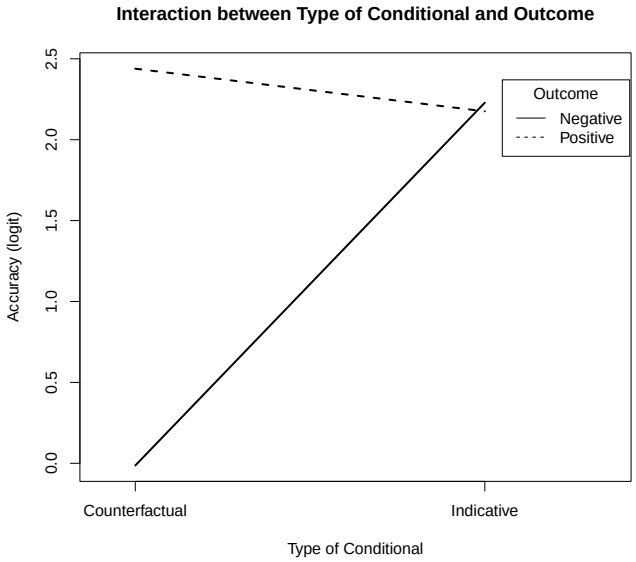

Figure 3.2: Visualisation of the interaction between type of conditional and outcome

Table 3.3: Pairwise comparisons between the conditional sentence types

	Estimate	Std. Error	z-value	p-value	sig.
CP - CN	2.47595	0.40349	6.136	<0.001	***
IN - CN	2.26179	0.39365	5.746	<0.001	***
IP - CN	2.21828	0.38767	5.722	<0.001	***
IN - CP	-0.21415	0.42065	-0.509	0.957	
IP - CP	-0.25767	0.41727	-0.618	0.926	
IP - IN	-0.04351	0.40907	-0.106	1.000	
*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*					

3.1.2 Accuracy as a function of cognitive tasks

We fitted a second generalized linear mixed model where the predictors were the standardized short-term and working memory and inhibition task scores for the response accuracy of the participants. The standardization was made using the formula, *(Raw Task Score – mean(Task Score))/sd(Task Score)*. This procedure scales all the predictor variable values to standard normal distribution. Similar to the first model, subject and item were added to the model as the random effects. As the previous model showed that the adult participants were significantly better at giving correct responses to the comprehension questions, only the child data was analyzed in this model to avoid the collinearity problem, touched upon at the end of section 1.3.4.

We first analyzed the interaction model, where we checked if any cognitive task score intervened with

Table 3.4: Summary of cognitive tasks model with no interaction

	Estimate	Std. Error	z-value	p-value	sig.
(Intercept)	2.0649	0.9007	2.293	0.0219	*
Short Term Memory	1.1900	0.9023	1.319	0.1872	
Working Memory	0.5389	1.0354	0.521	0.6027	
Inhibition	-0.8686	0.4385	-1.981	0.0476	*
*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*					

the other. The model summary showed that there was no significant interaction between any cognitive task score and no significant effect of any predictor variable. Therefore, we re-ran the model with no interaction to reduce the model complexity. The model without interaction had slightly lower AIC and BIC scores than the interaction model. The model summary (Table 3.4) indicated that there was a marginally significant effect of inhibition task score ($Estimate = -0.8686, SE = 0.4385, z = -1.981, p < 0.05$). This result implies that as the inhibition scores of the participants decreased, there was a higher chance that the participants give correct responses. The implications are discussed in chapter 4. The effects of the short-term and working memory capacity did not turn out to be significant.

3.2 Analysis of Eye-Tracking Data

In analyzing eye-tracking data, we first processed the raw data as outlined in section 3.2.1. Then, we analyzed the processed data using generalized additive mixed modeling, the use which was rationalized in section 3.2.2.

3.2.1 Data Processing

The eye-tracking data sample reports were created using SR Research Viewer software. We used fixation counts on the areas of interest (referents) for the analysis because the number of fixations on a referent shows the attention paid to that referent (Cooper, 1974). No switch type of analysis was performed, so saccades and regressions were not used for the analysis. The raw files were merged as a single file using the statistical programming language, *R* (version 4.1.2) (R Core Team, 2021). Then, the training items were removed from the data. Data preparation, relabelling of interest areas, creating time-series were performed using *VWPre* package (version 1.2.4) (Porretta et al., 2017). Then, the time points were subdivided into 100ms bins. Binning the data was necessary to reduce the noise. As our dependent variable, we used a score we call target preference, which was acquired through

the difference between the empirical logit score of the target referent and the empirical logit score of the competitor referent at a given time point (for a similar application see Cooper-Cunningham et al., 2020). This variable indicated whether and to what extent there were more looks towards the target referent on a Gaussian continuous scale where the mean of the dependent variable ($\mu_{targetpreference}$) is 0 if the target and competitor looks' empirical logit scores are equal to each other, and its standard deviation ($\sigma_{targetpreference}$) varies with a certain degree.

In the CN, CP, and IN conditions, at around 675ms, the participants heard the noun referring to the competitor referent in the antecedent, whereas, in the IP condition, they heard the noun referring to the target referent. Therefore, in the CN, CP, and IN conditions, we expected less target preference (below 50%) in these conditions, while the target preference was expected to increase in the IP condition for this period. However, after the participants heard the verb conjugation in the antecedent ($\sim$2200ms) and the consequent ($\sim$3900ms) before the comprehension question, we anticipated an increase in the target preference in all conditions (not below 50%).

The raw plot in Figure 3.3 shows the participants' target preference as a function of time. After the offset of the verb conjugation in the antecedent, the target preference in all conditions is at the 50% band (not below 50% anymore). Additionally, the plot demonstrates no significant difference between adults and children. To statistically evaluate these results, we fitted a series of Generalized Additive Mixed Models (GAMM).

3.2.2 Generalized Additive Mixed Modeling

Generalized Additive Mixed Model is a flexible generalized linear regression method to capture non-linear covariate effects with the linear predictor that has the sum of a smooth function of those covariates (Hastie & Tibshirani, 1987, 1990; Wood, 2006). GAMMs are suitable for time series analysis since the change in the time series can be modeled not only linearly but also non-linearly by smooth terms. In addition, the autocorrelation in the time series where the observation at a time point, t, is correlated with the previous time points, $t - n$ with a certain lag can be controlled in GAMM (Baayen et al., 2018). In many previous studies, the effect of time was analyzed using GLMM by splitting the time course data into critical time windows. However, this procedure causes a problem called *researcher degrees of freedom* where the researcher's selection of a data analysis procedure among the other possibilities may lead to false positive results (Simmons et al., 2011). On the other hand, the effect of the whole time series without the split time windows can be analyzed using GAMM. Furthermore,

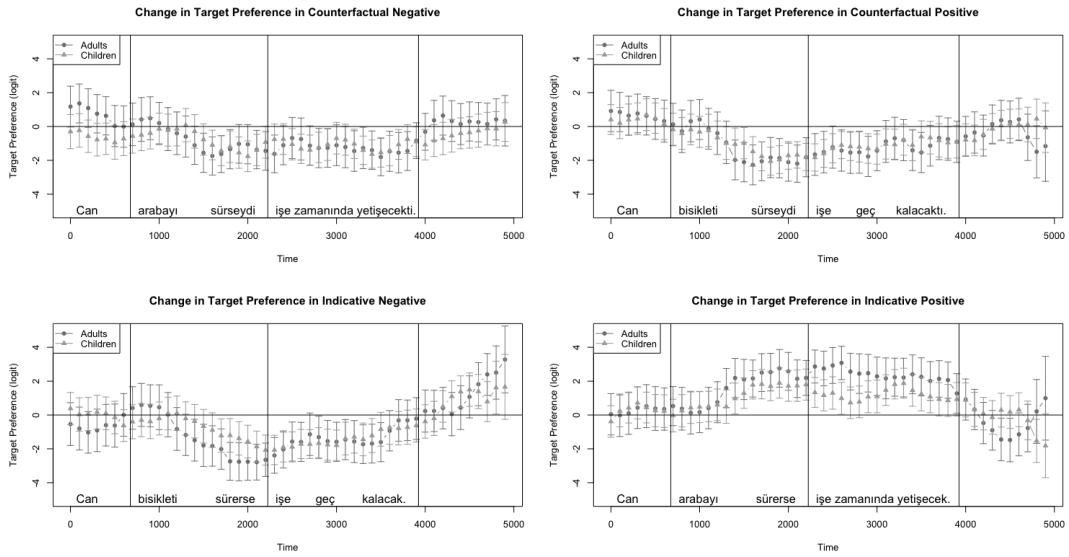

Figure 3.3: Raw plot of the eye-tracking data showing the target preference for each age group and the conditional sentence type. The first black line indicates the critical word onset, the second one represents the offset of the verb conjugation in the antecedent and the third one marks the end of the sentence. Error bars indicate 95% confidence intervals.

the (non-linear) interaction between continuous variables (time) and the other variables (categorical or continuous) can be analyzed using GAMM (Wieling, 2018; Winter & Wieling, 2016). GAMMs also allow for the random effects of the non-linear terms (Baayen et al., 2017). Thus, GAMM was suitable for our data analysis as we aimed to investigate the change in gaze positions of the participants as a function of time and examine the random effects of participant and item.

For the GAMM analysis, we selected the period starting from the offset of the verb conjugation until the onset of the comprehension question. This period lasts approximately 2700ms. Our dependent variable was target preference (detailed in section 3.2.1), and the independent variables were age group, type of conditional, and outcome. These terms as a function of time were also introduced to the model as the smooth terms. To better interpret the smooth terms of the categorical interactions between type of conditional and outcome, we introduced the type of conditional in four factors (CN, CP, IN, and IP). Because there may be a significant change as a function of time in one type of conditional and outcome (say CP) but may not be any change in the other (say IN), this was necessary. Otherwise, separate smooth terms for the type of conditional and outcome do not reveal that information. Furthermore, the random effect of subject and item by the type of conditional sentence as a function of time was introduced to the model as the smooth terms. The statistical analysis was made using *mgcv* package (version 1.8.38) (Wood, 2012), and the visualization of the statistical results was made using *itsadug*

Table 3.5: Summary of the generalized additive mixed model for age group and type of conditional

A. Parametric coefficients	Estimate	Std. Error	t-value	p-value	sig.
(Intercept)	-0.7855	0.2505	-3.1357	0.0017	**
groupChildren	-0.0699	0.2081	-0.3359	0.7369	
condtypeCP	-0.0177	0.3169	-0.0559	0.9554	
condtypeIN	0.1624	0.2953	0.5499	0.5824	
condtypeIP	1.8984	0.3320	5.7186	< 0.0001	***
B. Smooth terms	edf	Ref.df	F-value	p-value	sig.
s(Time):condtypeCN	1.2109	1.3046	2.8795	0.0585	.
s(Time):condtypeCP	1.0001	1.0002	1.9989	0.1574	
s(Time):condtypeIN	0.0025	0.0036	0.0038	0.9971	
s(Time):condtypeIP	1.0009	1.0012	13.7327	0.0002	***
s(Time):groupAdults	1.0001	1.0002	14.1709	0.0002	***
s(Time):groupChildren	1.7300	2.0097	8.4048	0.0002	***
s(Time,Subject):condtypeCN	126.9190	341.0000	0.6588	< 0.0001	***
s(Time,Subject):condtypeCP	113.8793	341.0000	0.5433	< 0.0001	***
s(Time,Subject):condtypeIN	145.3579	341.0000	0.8171	< 0.0001	***
s(Time,Subject):condtypeIP	148.3552	341.0000	0.8344	< 0.0001	***
s(Time,Item):condtypeCN	8.3095	44.0000	0.2521	0.0786	.
s(Time,Item):condtypeCP	13.2706	35.0000	0.6098	0.0113	*
s(Time,Item):condtypeIN	6.9014	35.0000	0.2809	0.0559	.
s(Time,Item):condtypeIP	20.1580	35.0000	1.6846	< 0.0001	***
*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*					

package (version 2.4) (van Rij et al., 2015) in *R* statistical programming language environment (R Core Team, 2021).

We first ran the model that has both the effect of age group and the type of conditional (deviance explained = 23.9%). The model summary did not show any significant effect of age according to the parametric coefficients of the model, which suggests that there is no difference between adults and children in terms of overall looks to the target (Table 3.5). On the other hand, the smooth terms of the model pointed to a significant change in the target preference as a function of time for both adults and children. To observe the trend of the change, visual inspection was necessary. The visualization of the smooth terms of the conditional sentence types indicates an increase in the target looks not only for adults but also for children in CN, CP, and IN conditions. Besides, there was significantly more target preference in the IP condition than in the other conditions according to the parametric coefficients of the model and significant change as a function of time according to the smooth terms, although we observed a decrease in the target looks in that condition, suggesting that the participants attended the target after the offset of the verb conjugation until the end of the sentence in all conditions but the IP condition (Figure 3.4). As the target referent and the referent uttered in the critical word are the same

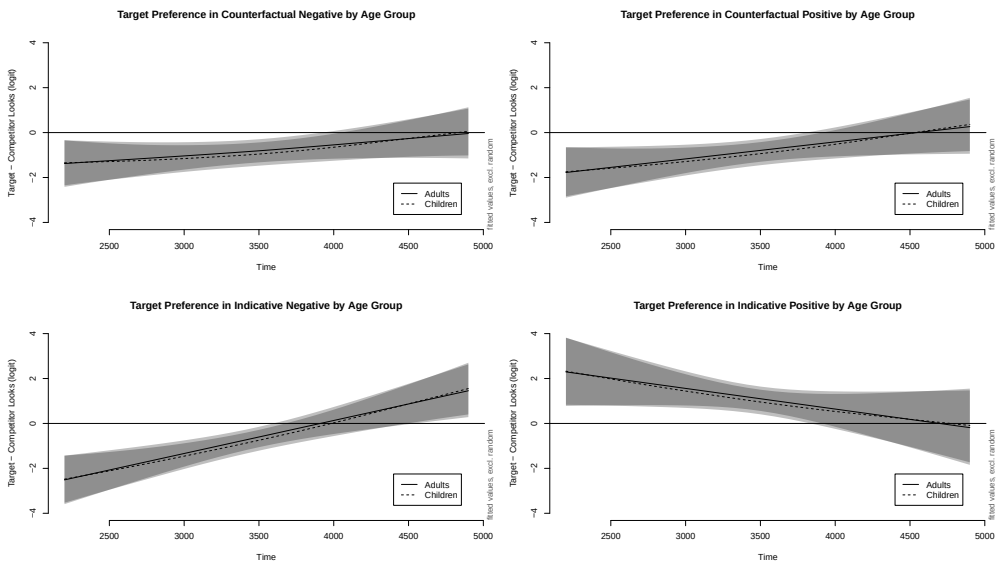

Figure 3.4: Smooth plots for the summed effects of the age group and the conditional sentence type. The shaded bands represent 95% confidence intervals.

in the IP condition, the participants already had more target looks even before the verb conjugation in the antecedent and started to look at the competitor referent towards the end of the utterance.

As the age groups did not differ from each other, we subset the data into two (adults and children) and fitted a separate GAMM to investigate the effect of the conditional sentence type for each age group individually. This procedure reduces the model complexity and allows us to compare the differences between the conditional sentence types in terms of the change in target preference for a given age group (Cooper-Cunningham et al., 2020).

3.2.2.1 Adults' Processing of Conditional Morphosyntax

The summary of the GAMM for the adult participants (deviance explained = 25.8%) presented that the participants had significantly more target looks in the IP condition than in the other conditions, and there was no significant difference among the other three conditions according to the parametric coefficients. According to the smooth terms of the model, there was a significant change in the target preference in the IN and IP conditions (Table 3.6). A visual inspection is necessary to learn the trend of change in the conditions. The smooth terms of the model as visualized in Figure 3.5 demonstrated that adults' target looks increased as a function of time in all conditions except for the IP condition.

Table 3.6: Summary of the generalized additive mixed model for the adults

A. Parametric coefficients	Estimate	Std. Error	t-value	p-value	sig.
(Intercept)	-0.7370	0.2911	-2.5318	0.0114	*
condtypeCP	-0.1916	0.4444	-0.4312	0.6663	
condtypeIN	0.0728	0.4287	0.1699	0.8651	
condtypeIP	2.1272	0.5257	4.0467	0.0001	***
B. Smooth terms	edf	Ref.df	F-value	p-value	sig.
s(Time):condtypeCN	1.0003	1.0004	2.2448	0.1340	
s(Time):condtypeCP	1.0000	1.0001	0.6590	0.4169	
s(Time):condtypeIN	1.0002	1.0003	9.3960	0.0022	**
s(Time):condtypeIP	4.8244	5.8210	3.0919	0.0056	**
s(Time,Subject):condtypeCN	54.5429	143.0000	0.7122	< 0.0001	***
s(Time,Subject):condtypeCP	61.6102	143.0000	0.8391	< 0.0001	***
s(Time,Subject):condtypeIN	65.0208	143.0000	0.9433	< 0.0001	***
s(Time,Subject):condtypeIP	45.9063	143.0000	0.6044	< 0.0001	***
s(Time,Item):condtypeCN	0.4130	35.0000	0.0120	0.3783	
s(Time,Item):condtypeCP	11.4194	35.0000	0.5189	0.0149	*
s(Time,Item):condtypeIN	2.5815	35.0000	0.0830	0.2452	
s(Time,Item):condtypeIP	6.0590	35.0000	0.2402	0.0843	.
*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*					

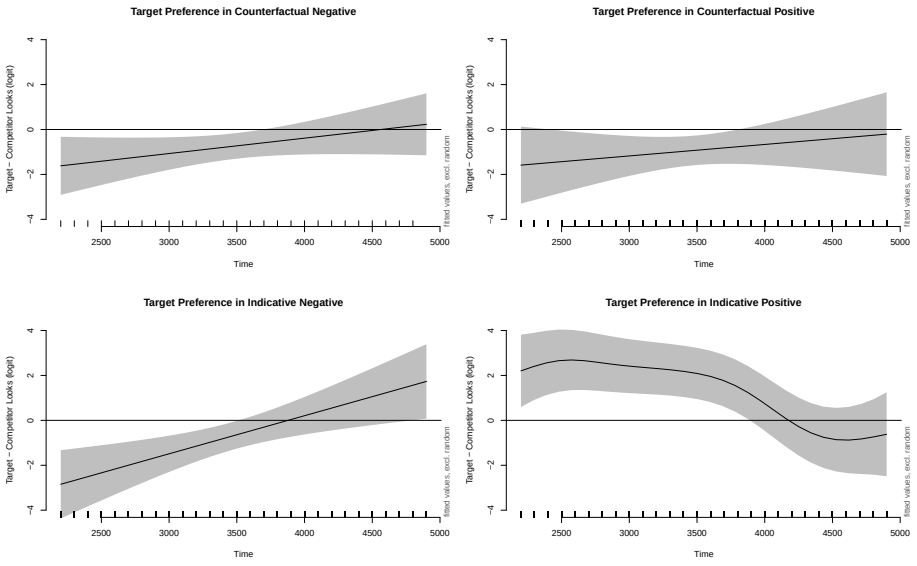

Figure 3.5: Smooth plots for the summed effect of the conditional sentence type for the adults. The shaded bands represent 95% confidence intervals.

Table 3.7: Summary of the generalized additive mixed model for the children

A. Parametric coefficients	Estimate	Std. Error	t-value	p-value	sig.
(Intercept)	-0.8732	0.2860	-3.0529	0.0023	**
condtypeCP	0.1233	0.3976	0.3102	0.7564	
condtypeIN	0.2127	0.4344	0.4897	0.6243	
condtypeIP	1.7593	0.4259	4.1309	< 0.0001	***
B. Smooth terms	edf	Ref.df	F-value	p-value	sig.
s(Time):condtypeCN	1.0003	1.0004	0.8672	0.3519	
s(Time):condtypeCP	1.0006	1.0010	10.9281	0.0009	***
s(Time):condtypeIN	1.0002	1.0003	7.0275	0.0080	**
s(Time):condtypeIP	1.0000	1.0000	1.4221	0.2331	
s(Time,Subject):condtypeCN	72.6502	197.0000	0.6592	< 0.0001	***
s(Time,Subject):condtypeCP	46.9836	197.0000	0.3434	0.0004	***
s(Time,Subject):condtypeIN	79.3574	197.0000	0.7272	< 0.0001	***
s(Time,Subject):condtypeIP	97.3761	197.0000	1.0085	< 0.0001	***
s(Time,Item):condtypeCN	12.4916	44.0000	0.4779	0.0079	**
s(Time,Item):condtypeCP	0.8309	35.0000	0.0328	0.2460	
s(Time,Item):condtypeIN	13.4207	35.0000	0.6799	0.0036	**
s(Time,Item):condtypeIP	21.7281	35.0000	1.9688	< 0.0001	***
*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*					

3.2.2.2 Children's Processing of Conditional Morphosyntax

The summary of the GAMM for the children (deviance explained = 23.7%) showed that as the adults did, the children had overall more target preference in the IP condition than the other conditions according to the parametric coefficients of the model (Table 3.7). There was also a significant effect of time in the IN condition, which is similar to the adults' results according to the smooth terms of the model. However, unlike the adults, there was a significant change in the CP condition as a function of time in the children, yet the significant change in the IP condition in the adults could not be observed in the children.

The smooth terms as visualized in Figure 3.6 pointed that the children had an increasing trend in the CP and IN conditions (also in CN, albeit not significant) in terms of their target preference. These results suggest that the children attended the target in these conditions after the offset of the verb conjugation in the antecedent.

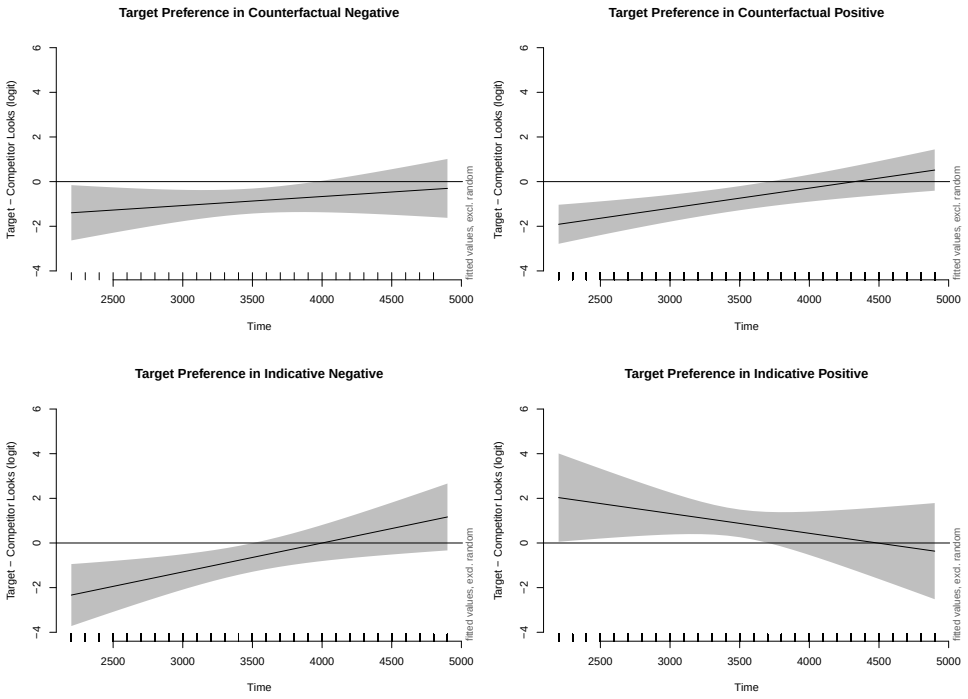

Figure 3.6: Smooth plots for the summed effects of the conditional sentence type for the children. The shaded bands represent 95% confidence intervals.

CHAPTER 4

DISCUSSION

This study investigated whether children as young as age four could reason at adult-like level when they hear counterfactual conditionals and whether they use the morphosyntactic cues for counterfactual reasoning in a language that encodes both the indicative and counterfactual conditional meaning with concatenated verbal suffixes, Turkish.

4.1 Do counterfactual conditionals pose a greater challenge than indicative conditionals?

We showed that children could respond to the comprehension questions with high accuracy after they heard counterfactual conditionals. However, their performance was even better in indicative conditionals. This result is also valid for the adults as their performance was better in indicative conditionals than in counterfactual ones. This result suggests that counterfactual conditionals pose a greater challenge than indicative ones. This might be because counterfactual conditionals require access to the representation of the real and alternative worlds (Byrne, 2007; Epstude & Roese, 2008; Roese, 1997; Roese & Epstude, 2017). Furthermore, counterfactual conditionals presuppose the falsity of their antecedents. As the presuppositions are not computed by default, and they necessitate further processing to activate the other implicatures of the speech, they are more costly (Degen & Tanenhaus, 2015, 2016). Therefore, when reasoning counterfactually, people may need to suppress the alternative world explicitly uttered in counterfactual conditionals to surface the real-world representation. Since indicative conditionals activate only one representation, selecting the target referent in these conditionals is probably less challenging than in counterfactual conditionals. Therefore, our results are in line with the previous experimental research pointing that indicative conditions are processed more easily compared to counterfactual conditionals due to their not requiring generating alternative possibilities and inhibiting these possibilities, thus incurring less activation in the left superior frontal gyrus in contrast to counterfactuals (De Brigard et al., 2013; Kulakova & Nieuwland, 2016a).

4.2 Do young children have an adult-like performance?

We also demonstrated that children had adult-like performance responding to the comprehension questions after indicative conditionals but not after counterfactual conditionals although their accuracy was over 75% in CP, IN, and IP conditions. The better performance of the adults is probably because adults have much more exposure to the linguistic input and more familiarity with the conditional structures. In addition, adults have better executive functioning abilities which they can entertain multiple alternatives, shift between them and inhibit less likely ones. Another reason may be that children have poorer working memory capacities, and they could process the up-to-date linguistic input immediately yet fail to remember the earlier input as the new input comes, thus leading to less accurate answers in the comprehension question phase. From one view, these results are in line with Harris et al. (1996) and German and Nichols (2003) stating that 4-year-old children could reason counterfactually. From another view, they are not, as we cannot observe a ceiling performance in children in any of the conditionals, which is in line with Rafetseder et al. (2013) asserting that adult-like ceiling performance in counterfactual reasoning can only be seen after 14 years of age. Nevertheless, in our study, even adults did not have a $\sim$100% accuracy in any of the conditionals. Moreover, their performance was as low as 75% in CN condition. Therefore, some counterfactual conditionals are even harder for the adults, and it is reasonable that children had difficulty in answering comprehension questions after such complex structures.

As German (1999) stated that children had better performance in counterfactuals with negative outcome than the ones with positive outcome, we expected our participants to have a better performance in CN condition than CP condition. However, our results conflict with German (1999), such that the participants were better at CP condition than CN condition. This finding is intriguing, such that people engage in counterfactual thinking more when they have experiences with their wrong decisions (Epstude & Roese, 2008). From this view, our finding seems incompatible with these assertions. Therefore, both the findings of German (1999) and ours are still open to question and must be re-evaluated with a more robust experimental design.

4.3 Do executive functioning abilities affect counterfactual reasoning ability?

Johnson-Laird et al. (1992) state that working memory capacity may limit the representation of the alternative possibilities in mind. Furthermore, suppressing the alternative representations to make an in-

ference about the real-world situation is an essential skill for counterfactual reasoning (Beck & Riggs, 2014). Therefore, enhancement in the counterfactual reasoning abilities can be explained with the development of working memory and inhibitory control (Byrne, 2007; Robinson & Beck, 2014). Nevertheless, Beck et al. (2009) demonstrated that there was no relation between counterfactual thinking and working memory capacity. Our findings are in line with these results, such that working memory measure was not a significant predictor of the response accuracy of children. However, Beck et al. (2009) also stated that there was a negative correlation between the inhibitory skills and one counterfactual thinking task, which is the long causal chains in German and Nichols (2003). Interestingly, their finding points to the claim that the lower the inhibitory control abilities of children, the better their performances in long causal chains, which is cognitively a more demanding task. Even more intriguing finding is that there was a negative effect of inhibition score on the accuracy of the responses according to our analysis. Therefore, we speculate that children might stick to one representation instead of switching between the alternative representations to select their responses. Another reason might be that children pick a clue allowing them to reason about the real-world representation, such as counterfactual conditional morphosyntax or contextual information, and they incrementally cancel out the inferences about the previous alternative representations instead of evaluating the alternatives to choose which one to inhibit. On the other hand, our results might have originated from the small sample size. Obviously, to make more robust generalizations, a larger sample of participants is needed.

4.4 Do children and adults incrementally use morphosyntactic cues for counterfactual reasoning?

As to the participants' gaze patterns, our results show that not only adults but also children as young as four years of age can predict the real-world situation and assign meaning to indicative and counterfactual conditionals by incrementally integrating their morphosyntactic structures. These results are compatible with the previous studies demonstrating that children can extract information and predict the upcoming context incrementally using the morphosyntactic cues in many different languages such as Turkish (Özge et al., 2019), Chinese (Huang et al., 2013), Dutch (Brouwer et al., 2017) and German (Özge et al., 2022).

Our findings provide further evidence for Ferguson et al. (2010) and Orenes et al. (2019) revealing that people could use contextual information to predict the related referent in the indicative and counterfactual conditionals. Unlike English and Spanish, which mark conditional meaning via the explicit

connective, *if/si*, Turkish marks conditional meaning via compound morphemes (Kornfilt, 1997). The order of these morphemes separates the indicative conditional meaning from the counterfactual conditional meaning (Göksel & Kerslake, 2004). Consequently, we could demonstrate the use of morphosyntax to engage in complex logical reasoning. However, this effect becomes larger towards the end of the utterance. In Turkish, the verb conjugation in the consequent is also marked differently for indicative and counterfactual conditionals, and we even observe a further increase in the target looks after the end of the sentence where the participants fully heard the verb conjugation in the consequent. Therefore, it may be the case that our participants might have combined the verbal counterfactual morphosyntax in the antecedent with the one in the consequent to comprehend the counterfactual conditionals fully. Nevertheless, this might also be a late effect of only the morphosyntactic structure in the antecedent. Normally, it takes around 200-400ms to program a fixation (Fischer, 1992; Matin et al., 1993), yet late effects could also surface after around 1000ms (Huettig & Altmann, 2011). We think this type of late effect is actually expected for our experimental design because, in the counterfactual conditional probes, the presented noun in the antecedent refers to the alternative world referent, which corresponds to the competitor picture. Therefore, as the noun is processed before the verbal inflection, the gaze shift to the referent referring to the real-world situation begins from a lower probability, and it requires a shift from the competitor referent and inhibiting this stronger alternative.

The same effect is also observed for the indicative conditionals with negative outcome because of the same reason. The only condition where we do not observe this pattern is the indicative conditionals with positive outcome since the noun in the antecedent already refers to the real-world situation, so this condition does not require a shift in the fixations. That's why, after the verb conjugation in the antecedent, the probability of fixations quickly goes over 50% in that condition. Besides, many studies mention the dual representation model proposing that both the real and alternative worlds are represented in mind at the same time when the counterfactuals are processed (De Brigard et al., 2013; Ferguson & Cane, 2015; Kulakova & Nieuwland, 2016b; Urrutia et al., 2012). This further strengthens our hypothesis that this is indeed an effect of incremental morphosyntactic integration. To be sure about this interpretation and to dissociate the effect of the antecedent and the consequent, we plan to conduct a future study.

Finally, German (1999) asserted that children's responses to the comprehension questions about counterfactual stories are better when the events have a negative outcome for the agent in the story. Therefore, for our eye-tracking analysis, we expected more target looks for the counterfactuals with negative outcome than those with positive outcome. In our study, the participants from neither of the age groups

showed any sign of such an effect. Hence, the results are not in line with German's conclusions. However, there is an effect of outcome of the event for the indicative conditionals such that there are more looks towards the target in the positive outcome sentences than in the negative outcome sentences. However, this effect is most probably not because either condition generates more thoughts for the real-world situations but because the experimental probes differentiate from each other for the indicative conditionals with positive and negative outcome. In our experimental design, as the indicative conditionals with positive outcome do not require a shift in the fixations in contrast to the ones with negative outcomes, this situation might have led to more fixation for the target referent in indicative conditionals with positive outcome.

CHAPTER 5

CONCLUSION

Children can make inferences about the real-world by using logical connectives such as *and, or* and *not*, and they can differentiate the semantic and pragmatic functions of these logical structures in speech from a very early age. On the other hand, young children can also incrementally integrate the morphosyntax of their language to make predictions about the forthcoming context (Snedeker & Huang, 2009). With this regard, we questioned how about the development and processing of counterfactual conditionals, which require a sophisticated reasoning ability such that people need to generate alternative possibilities along with inferring the real-world situation, which are triggered by some complex combinatorial sequence of morphosyntactic structure. Given these complexities in hand, not only constructing a reasoning mechanism might be delayed in the course of children's language development but building a processing mechanism for adults might be challenging as well.

Research examining the acquisition of counterfactuals rendered discrepant results in terms of when children could make inferences using these structures in an adult-like fashion. Depending on the complexity of the task employed in different research studies, the answer varies from as very early ages as three (Harris et al., 1996) to adolescent ages like fourteen (Rafetseder et al., 2013). We suspect that children can understand such structures immediately when they hear them, but when it comes to explicitly uttering their inferences about the situations, their performances might drop due to the cognitive load already involved in them. On the other hand, our knowledge about such incremental processing of counterfactual conditionals is limited even in adults.

By the time of conducting this study, no other study surveyed the online processing of morphosyntax for counterfactual reasoning. In this study, we investigated children's as well as adults' use of morphosyntactic cues to reason about counterfactual conditional sentences by conducting a visual world eye-tracking paradigm experiment. Our results demonstrated that not only adults but also children

shifted their gaze to the referent that represents the real-world situation after they heard the verb conjugation in the antecedent. To our knowledge, this is the first piece of evidence showing that the morphosyntax marked on verbs quickly leads to complex inferences such as generating hypothetical alternative worlds for counterfactual reasoning not only in adults but also in children as young as four years of age.

This finding is of importance since it suggests that children can use morphosyntactic cues incrementally to create alternative situations regarding the counterfactual situations and to make hypothetical inferences about these situations as well as their outcomes. Our findings further display that young children can respond to the comprehension questions after both indicative and counterfactual conditionals with a high percentage of accuracy, even though their performances are not as high as those of adults. However, given the fact that some of the conditionals, such as counterfactuals with negative outcome are even harder for adults, we can say that young children can make adult-like inferences when they hear counterfactual and indicative conditionals. On the other hand, whether the outcome of the events in the conditionals sentences is negative or positive does not affect the distribution of the participants' fixations, but as to the response accuracy of the participants, they had more accurate responses in the conditionals with positive outcome.

5.1 Limitations and Further Studies

Because of the COVID-19 pandemic, we were not able to reach participants during the data collection phase of the study. Therefore, our study must be replicated with a larger sample size. Although this study provides an important piece of evidence that not only adults but also children as young as four years of age could integrate the morphosyntactic structure of indicative and counterfactual conditionals, we still could not disclose whether people use the morphosyntax of the verb in the antecedent per se for such a parsing, or they integrate the contextual information provided in the consequent and its verb conjugation to reason counterfactually. Therefore, the next study will attempt to factor out the possible effects of these linguistic cues to better examine the direct effect of verbal inflection in the antecedent with more participants.

REFERENCES

Akaike, H. (1974). A new look at the statistical model identification. *IEEE transactions on automatic control*, *19*(6), 716–723.

Altmann, G. T., & Kamide, Y. (1999). Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition*, *73*(3), 247–264.

Anderson, A. R. (1951). A note on subjunctive and counterfactual conditionals. *Analysis*, *12*(2), 35–38.

Baayen, H., van Rij, J., De Cat, C., & Wood, S. (2018). Autocorrelated errors in experimental data in the language sciences: Some solutions offered by generalized additive mixed models. *Mixed-effects regression models in linguistics* (pp. 49–69). Springer.

Baayen, H., Vasishth, S., Kliegl, R., & Bates, D. (2017). The cave of shadows: Addressing the human factor with generalized additive mixed models. *Journal of Memory and Language*, *94*, 206–234.

Bartsch, K., & Wellman, H. (1989). Young children's attribution of action to beliefs and desires. *Child development*, 946–964.

Bates, D., Kliegl, R., Vasishth, S., & Baayen, H. (2015). Parsimonious mixed models. *arXiv preprint arXiv:1506.04967*.

Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R. H. B., Singmann, H., Dai, B., Scheipl, F., & Grothendieck, G. (2011). Package 'lme4'. *Linear mixed-effects models using S4 classes. R package version*, *1*(6).

Beck, S. R. (2016). Why what is counterfactual really matters: A response to Weisberg and Gopnik (2013).

Beck, S. R., & Crilly, M. (2009). Is understanding regret dependent on developments in counterfactual thinking? *British Journal of Developmental Psychology*, *27*(2), 505–510.

Beck, S. R., & Riggs, K. J. (2014). The development of counterfactual reasoning. In H. Markovits (Ed.), *The developmental psychology of reasoning and decision-making* (pp. 165–181). Psychology Press.

Beck, S. R., Riggs, K. J., & Gorniak, S. L. (2009). Relating developments in children's counterfactual thinking and executive functions. *Thinking & reasoning*, *15*(4), 337–354.

Beck, S. R., Robinson, E. J., Carroll, D. J., & Apperly, I. A. (2006). Children's thinking about counterfactuals and future hypotheticals as possibilities. *Child development*, *77*(2), 413–426.

Begeer, S., De Rosnay, M., Lunenburg, P., Stegge, H., & Terwogt, M. M. (2014). Understanding of emotions based on counterfactual reasoning in children with autism spectrum disorders. *Autism*, *18*(3), 301–310.

Brouwer, S., Özkan, D., & Küntay, A. C. (2017). Semantic prediction in monolingual and bilingual children. *Cross-linguistic influence in bilingualism* (pp. 49–74). John Benjamins.

Buchsbaum, D., Bridgers, S., Skolnick Weisberg, D., & Gopnik, A. (2012). The power of possibility: Causal learning, counterfactual reasoning, and pretend play. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1599), 2202–2212.

Bullock, M. (1985). Causal reasoning and developmental change over the preschool years. *Human Development*, *28*(4), 169–191.

Bullock, M., Gelman, R., & Baillargeon, R. (1982). The development of causal reasoning. *The developmental psychology of time*, 209–254.

Byrne, R. M. (2007). *The rational imagination: How people create alternatives to reality*. MIT press.

Byrne, R. M. (2016). Counterfactual thought. *Annual review of psychology*, *67*(1), 135–157.

Byrne, R. M., & Egan, S. M. (2004). Counterfactual and prefactual conditionals. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale*, *58*(2), 113.

Can Bakırlı, Ö. (2010). *Türkçede koşullu yapılar* (Doctoral dissertation). DEÜ Sosyal Bilimleri Enstitüsü.

Carey, S. (2009). *The origin of concepts*. Oxford University Press.

Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child development*, *72*(4), 1032–1053.

Carrow-Woolfolk, E. (1985). *Test for auditory comprehension of language*. DLM Teaching Resources Allen, TX.

Cooper, R. M. (1974). The control of eye fixation by the meaning of spoken language: A new methodology for the real-time investigation of speech perception, memory, and language processing. *Cognitive psychology*.

Cooper-Cunningham, R., Charest, M., Porretta, V., & Järvikivi, J. (2020). When couches have eyes: The effect of visual context on children's reference processing. *Frontiers in Communication*, 99.

Davis, H. L., & Pratt, C. (1995). The development of children's theory of mind: The working memory explanation. *Australian Journal of Psychology*, *47*(1), 25–31.

De Brigard, F., Addis, D. R., Ford, J. H., Schacter, D. L., & Giovanello, K. S. (2013). Remembering what could have happened: Neural correlates of episodic counterfactual thinking. *Neuropsychologia*, *51*(12), 2401–2414.

Degen, J., & Tanenhaus, M. K. (2015). Processing scalar implicature: A constraint-based approach. *Cognitive science*, *39*(4), 667–710.

Degen, J., & Tanenhaus, M. K. (2016). Availability of alternatives and the processing of scalar implicatures: A visual world eye-tracking study. *Cognitive science*, *40*(1), 172–201.

de Vega, M., Urrutia, M., & Riffo, B. (2007). Canceling updating in the comprehension of counterfactuals embedded in narratives. *Memory & Cognition*, *35*(6), 1410–1421.

Dias, M. d. G., & Harris, P. L. (1988). The effect of make-believe play on deductive reasoning. *British journal of developmental psychology*, *6*(3), 207–221.

Dias, M. d. G., & Harris, P. L. (1990). The influence of the imagination on reasoning by young children. *British Journal of Developmental Psychology*, *8*(4), 305–318.

Drayton, S., Turley-Ames, K. J., & Guajardo, N. R. (2011). Counterfactual thinking and false belief: The role of executive function. *Journal of Experimental Child Psychology*, *108*(3), 532–548.

Dunn, L. M., Dunn, L. M., Whetton, C., & Burley, J. (1997). British picture vocabulary scale 2nd edition (bpvs-ii). *Windsor, Berks: NFER-Nelson*.

Durrell, M. (2013). *Hammer's german grammar and usage*. Routledge.

Edgington, D. (2020). Indicative Conditionals. In E. N. Zalta (Ed.), *The Stanford encyclopedia of philosophy* (Fall 2020). Metaphysics Research Lab, Stanford University.

Epstude, K., & Roese, N. J. (2008). The functional theory of counterfactual thinking. *Personality and social psychology review*, *12*(2), 168–192.

Evans, J. S. B., & Over, D. E. (2004). *If: Supposition, pragmatics, and dual processes*. Oxford University Press, USA.

Evcen, E., & Wittenberg, E. (2022). Making the question under discussion explicit shifts counterfactual interpretation. *Proceedings of the Annual Meeting of the Cognitive Science Society*, *44*(44).

Fauconnier, G. (1994). *Mental spaces: Aspects of meaning construction in natural language*. Cambridge University Press.

Feiman, R., Mody, S., Sanborn, S., & Carey, S. (2017). What do you mean, no? toddlers' comprehension of logical "no" and "not". *Language Learning and Development*, *13*(4), 430–450.

Ferguson, H. J., & Cane, J. E. (2015). Examining the cognitive costs of counterfactual language comprehension: Evidence from erps. *Brain research*, *1622*, 252–269.

Ferguson, H. J., Scheepers, C., & Sanford, A. J. (2010). Expectations in counterfactual and theory of mind reasoning. *Language and Cognitive Processes*, *25*(3), 297–346.

Fillenbaum, S. (1974). Information amplified: Memory for counterfactual conditionals. *Journal of Experimental Psychology*, *102*(1), 44.

Fischer, B. (1992). Saccadic reaction time: Implications for reading, dyslexia, and visual cognition. *Eye movements and visual cognition* (pp. 31–45). Springer.

Frith, U. (2003). *Autism: Explaining the enigma*. Blackwell Publishing.

Frye, D., Zelazo, P. D., & Palfai, T. (1995). Theory of mind and rule-based reasoning. *Cognitive development*, *10*(4), 483–527.

German, T. P. (1999). Children's causal reasoning: Counterfactual thinking occurs for 'negative'outcomes only. *Developmental Science*, *2*(4), 442–457.

German, T. P., & Nichols, S. (2003). Children's counterfactual inferences about long and short causal chains. *Developmental Science*, *6*(5), 514–523.

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 312–7 years old on a stroop-like day-night test. *Cognition*, *53*(2), 129–153.

Göksel, A., & Kerslake, C. (2004). *Turkish: A comprehensive grammar*. Routledge.

Goodglass, H., Gleason, J. B., Bernholtz, N. A., & Hyde, M. R. (1972). Some linguistic structures in the speech of a broca's aphasic. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior*.

Goodman, N. D., Ullman, T. D., & Tenenbaum, J. B. (2011). Learning a theory of causality. *Psychological review*, *118*(1), 110.

Gordon, A. C., & Olson, D. R. (1998). The relation between acquisition of a theory of mind and the capacity to hold in mind. *Journal of experimental child psychology*, *68*(1), 70–83.

Grant, C. M., Riggs, K. J., & Boucher, J. (2004). Counterfactual and mental state reasoning in children with autism. *Journal of autism and developmental disorders*, *34*(2), 177–188.

Griffiths, T. L., & Tenenbaum, J. B. (2009). Theory-based causal induction. *Psychological review*, *116*(4), 661.

Guajardo, N. R., & Turley-Ames, K. J. (2004). Preschoolers' generation of different types of counterfactual statements and theory of mind understanding. *Cognitive development*, *19*(1), 53–80.

Guttentag, R., & Ferrell, J. (2004). Reality compared with its alternatives: Age differences in judgments of regret and relief. *Developmental psychology*, *40*(5), 764.

Harris, P. L., German, T. P., & Mills, P. (1996). Children's use of counterfactual thinking in causal reasoning. *Cognition*, *61*(3), 233–259.

Hastie, T., & Tibshirani, R. (1987). Generalized additive models: Some applications. *Journal of the American Statistical Association*, *82*(398), 371–386.

Hastie, T., & Tibshirani, R. (1990). Exploring the nature of covariate effects in the proportional hazards model. *Biometrics*, 1005–1016.

Hothorn, T., Bretz, F., Westfall, P., Heiberger, R. M., Schuetzenmeister, A., Scheibe, S., & Hothorn, M. T. (2016). Package 'multcomp'. *Simultaneous inference in general parametric models. Project for Statistical Computing, Vienna, Austria*.

Huang, Y. T., Zheng, X., Meng, X., & Snedeker, J. (2013). Children's assignment of grammatical roles in the online processing of mandarin passive sentences. *Journal of memory and language*, *69*(4), 589–606.

Huettig, F., & Altmann, G. T. (2011). Looking at anything that is green when hearing "frog": How object surface colour and stored object colour knowledge influence language-mediated overt attention. *The Quarterly Journal of Experimental Psychology*, *64*(1), 122–145.

Hughes, C. (1998). Executive function in preschoolers: Links with theory of mind and verbal ability. *British journal of developmental psychology*, *16*(2), 233–253.

Iatridou, S. (2000). The grammatical ingredients of counterfactuality. *Linguistic inquiry*, *31*(2), 231–270.

Iatridou, S. (2014). Grammar matters. In L. Walters & J. Hawthorne (Eds.), *Conditionals, probability, and paradox: Themes from the philosophy of dorothy edgington*. Oxford University Press.

Jackson, F. (1991). Conditionals.

Jasbi, M., & Frank, M. C. (2017). The semantics and pragmatics of logical connectives: Adults' and children's interpretations of and and or in a guessing game. *CogSci*.

Johnson-Laird, P. N., Byrne, R. M., & Schaeken, W. (1992). Propositional reasoning by model. *Psychological review*, *99*(3), 418.

Johnson-Laird, P. N., & Byrne, R. M. (2002). Conditionals: A theory of meaning, pragmatics, and inference. *Psychological review*, *109*(4), 646.

Karawani, H. (2014). *The real, the fake, and the fake fake: In counterfactual conditionals, crosslinguistically*. Netherlands Graduate School of Linguistics.

Kean, M. L. (1977). The linguistic interpretation of aphasic syndromes: Agrammatism in broca's aphasia, an example. *Cognition*, *5*(1), 9–46.

Kochanska, G., Murray, K., Jacques, T. Y., Koenig, A. L., & Vandegeest, K. A. (1996). Inhibitory control in young children and its role in emerging internalization. *Child development*, *67*(2), 490–507.

Kornfilt, J. (1997). *Turkish*. Routledge.

Kulakova, E., & Nieuwland, M. S. (2016a). Understanding counterfactuality: A review of experimental evidence for the dual meaning of counterfactuals. language and linguistics compass, 10 (2), 49–65.

Kulakova, E., Aichhorn, M., Schurz, M., Kronbichler, M., & Perner, J. (2013). Processing counterfactual and hypothetical conditionals: An fmri investigation. *NeuroImage*, *72*, 265–271.

Kulakova, E., & Nieuwland, M. S. (2016b). Pragmatic skills predict online counterfactual comprehension: Evidence from the n400. *Cognitive, Affective, & Behavioral Neuroscience*, *16*(5), 814–824.

Lagattuta, K. H., Sayfan, L., & Monsour, M. (2011). A new measure for assessing executive function across a wide age range: Children and adults find happy-sad more difficult than day-night. *Developmental Science*, *14*(3), 481–489.

Langton, S. R., Watt, R. J., & Bruce, V. (2000). Do the eyes have it? cues to the direction of social attention. *Trends in cognitive sciences*, *4*(2), 50–59.

Leonard, L. B. (2014). *Children with specific language impairment*. MIT press.

Lewis, C., & Osborne, A. (1990). Three-year-olds' problems with false belief: Conceptual deficit or linguistic artifact? *Child development*, *61*(5), 1514–1519.

Lewis, D. (1973/2013). *Counterfactuals*. John Wiley & Sons.

Mackie, J. L. (1980). *The cement of the universe: A study of causation*. Clarendon Press.

Mason, C. H., & Perreault Jr, W. D. (1991). Collinearity, power, and interpretation of multiple regression analysis. *Journal of marketing research*, *28*(3), 268–280.

Matin, E., Shao, K. C., & Boff, K. R. (1993). Saccadic overhead: Information-processing time with and without saccades. *Perception & psychophysics*, *53*(4), 372–380.

McCormack, T., Ho, M., Gribben, C., O'Connor, E., & Hoerl, C. (2018). The development of counterfactual reasoning about doubly-determined events. *Cognitive Development*, *45*, 1–9.

Menzies, P., & Beebee, H. (2020). Counterfactual Theories of Causation. In E. N. Zalta (Ed.), *The Stanford encyclopedia of philosophy* (Winter 2020). Metaphysics Research Lab, Stanford University.

Mody, S., & Carey, S. (2016). The emergence of reasoning by the disjunctive syllogism in early childhood. *Cognition*, *154*, 40–48.

Morris, B. J. (2008). Logically speaking: Evidence for item-based acquisition of the connectives and & or. *Journal of Cognition and Development*, *9*(1), 67–88.

Nakamichi, K. (2019). Young children's counterfactual thinking: Triggered by the negative emotions of others. *Journal of experimental child psychology*, *187*, 104659.

Nyhout, A., & Ganea, P. A. (2019a). The development of the counterfactual imagination. *Child Development Perspectives*, *13*(4), 254–259.

Nyhout, A., & Ganea, P. A. (2019b). Mature counterfactual reasoning in 4-and 5-year-olds. *Cognition*, *183*, 57–66.

Orenes, I., García-Madruga, J. A., Gómez-Veiga, I., Espino, O., & Byrne, R. M. (2019). The comprehension of counterfactual conditionals: Evidence from eye-tracking in the visual world paradigm. *Frontiers in psychology*, 1172.

Özge, D., Kornfilt, J., Maquate, K., Küntay, A. C., & Snedeker, J. (2022). German-speaking children use sentence-initial case marking for predictive language processing at age four. *Cognition*, *221*, 104988.

Özge, D., Küntay, A. C., & Snedeker, J. (2019). Why wait for the verb? turkish speaking children use case markers for incremental language comprehension. *Cognition*, *183*, 152–180.

Payir, A., & Guttentag, R. (2019). Counterfactual thinking and age differences in judgments of regret and blame. *Journal of Experimental Child Psychology*, *183*, 261–275.

Peterson, D. M., & Bowler, D. M. (2000). Counterfactual reasoning and false belief understanding in children with autism. *Autism*, *4*(4), 391–405.

Porretta, V., Kyröläinen, A. J., van Rij, J., & Järvikivi, J. (2017). Visual world paradigm data: From preprocessing to nonlinear time-course analysis. *International conference on intelligent decision technologies*, 268–277.

R Core Team. (2021). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. Vienna, Austria. https://www.R-project.org/

Rafetseder, E., Cristi-Vargas, R., & Perner, J. (2010). Counterfactual reasoning: Developing a sense of "nearest possible world". *Child development*, *81*(1), 376–389.

Rafetseder, E., Schwitalla, M., & Perner, J. (2013). Counterfactual reasoning: From childhood to adulthood. *Journal of experimental child psychology*, *114*(3), 389–404.

Rasga, C., Quelhas, A. C., & Byrne, R. M. (2017). How children with autism reason about other's intentions: False-belief and counterfactual inferences. *Journal of Autism and Developmental Disorders*, *47*(6), 1806–1817.

Riggs, K. J., Peterson, D. M., Robinson, E. J., & Mitchell, P. (1998). Are errors in false belief tasks symptomatic of a broader difficulty with counterfactuality? *Cognitive Development*, *13*(1), 73–90.

Robinson, E. J., & Beck, S. (2014). What is difficult about counterfactual reasoning? *Children's reasoning and the mind* (pp. 115–134). Psychology Press.

Roese, N. J. (1997). Counterfactual thinking. *Psychological bulletin*, *121*(1), 133.

Roese, N. J., & Epstude, K. (2017). The functional theory of counterfactual thinking: New evidence, new challenges, new insights. *Advances in experimental social psychology* (pp. 1–79). Elsevier.

Santamaría, C., Espino, O., & Byrne, R. M. (2005). Counterfactual and semifactual conditionals prime alternative possibilities. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *31*(5), 1149.

Schwarz, G. (1978). Estimating the dimension of a model. *The annals of statistics*, 461–464.

Scott, F. J., Baron-Cohen, S., & Leslie, A. (1999). 'if pigs could fly': A test of counterfactual reasoning and pretence in children with autism. *British Journal of Developmental Psychology*, *17*(3), 349–362.

Shultz, T. R. (1982). Rules of causal attribution. *Monographs of the society for research in child development*, 1–51.

Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological science*, *22*(11), 1359–1366.

Simpson, A., & Riggs, K. J. (2005). Inhibitory and working memory demands of the day–night task in children. *British Journal of Developmental Psychology*, *23*(3), 471–486.

Snedeker, J., & Huang, Y. T. (2009). Sentence processing. *The Cambridge handbook of child language*, 321–337.

Sobel, D. M. (2004). Exploring the coherence of young children's explanatory abilities: Evidence from generating counterfactuals. *British Journal of Developmental Psychology*, *22*(1), 37–58.

Stalnaker, R. C. (1976). Indicative conditionals. *Ifs* (pp. 193–210). Springer.

Starr, W. (2021). Counterfactuals. In E. N. Zalta (Ed.), *The Stanford encyclopedia of philosophy* (Summer 2021). Metaphysics Research Lab, Stanford University.

Steyvers, M., Tenenbaum, J. B., Wagenmakers, E.-J., & Blum, B. (2003). Inferring causal networks from observations and interventions. *Cognitive science*, *27*(3), 453–489.

Taylan, E. E. (1984). *The function of word order in Turkish grammar* (Vol. 106). University of California Press.

Tomasello, M. (2003). *Constructing a language: A usage-based theory of language acquisition*. Harvard University Press.

Urrutia, M., Gennari, S. P., & de Vega, M. (2012). Counterfactuals in action: An fmri study of counterfactual sentences describing physical effort. *Neuropsychologia*, *50*(14), 3663–3672.

van Rij, J., Wieling, M., Baayen, H., & van Rijn, D. (2015). Itsadug: Interpreting time series and autocorrelated data using gamms.

Von Fintel, K. (2012). Subjunctive conditionals.

von Fintel, K., & Iatridou, S. (2020). Prolegomena to a theory of x-marking. *Ms. under review for Linguistics and Philosophy*.

Wechsler, D. (1949). Wechsler intelligence scale for children; manual.

Wechsler, D., & Kodama, H. (1949). *Wechsler intelligence scale for children* (Vol. 1). Psychological corporation New York.

Weisberg, D. S., & Gopnik, A. (2013). Pretense, counterfactuals, and bayesian causal models: Why what is not real really matters. *Cognitive science*, *37*(7), 1368–1381.

Wieling, M. (2018). Analyzing dynamic phonetic data using generalized additive mixed modeling: A tutorial focusing on articulatory differences between l1 and l2 speakers of english. *Journal of Phonetics*, *70*, 86–116.

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition*, *13*(1), 103–128.

Winter, B., & Wieling, M. (2016). How to analyze linguistic change using mixed models, growth curve analysis and generalized additive modeling. *Journal of Language Evolution*, *1*(1), 7–18.

Wood, S. (2006). *Generalized additive models: An introduction with r*. chapman; hall/CRC.

Wood, S. (2012). Mgcv: Mixed gam computation vehicle with gcv/aic/reml smoothness estimation.

Yarbay Duman, T., Altınok, N., & Maviş, İ. (2016). Grammar and cognition: Deficits comprehending counterfactuals in turkish individuals with broca's aphasia. *Aphasiology*, *30*(7), 841–861.

Yarbay Duman, T., Blom, E., & Topbaş, S. (2015). At the intersection of cognition and grammar: Deficits comprehending counterfactuals in turkish children with specific language impairment. *Journal of Speech, Language, and Hearing Research*, *58*(2), 410–421.

APPENDICES

A. EXPERIMENTAL SENTENCES

Item	Experimental Sentence
1	CN: Ahmet tostu yeseydi karnı tok olacaktı.
	CP: Ahmet çikolatayı yeseydi karnı aç kalacaktı.
	IN: Ahmet çikolatayı yerse karnı aç kalacak.
	IP: Ahmet tostu yerse karnı tok olacak.
2	CN: Pelin çizmeyi giyseydi ayakları temiz olacaktı.
	CP: Pelin terliği giyseydi ayakları çamur olacaktı.
	IN: Pelin terliği giyerse ayakları çamur olacak.
	IP: Pelin çizmeyi giyerse ayakları temiz kalacak.
3	CN: Umut arabayı sürseydi işe zamanında yetişecekti.
	CP: Umut bisikleti sürseydi işe geç kalacaktı.
	IN: Umut bisikleti sürerse işe geç kalacak.
	IP: Umut arabayı sürerse işe zamanında yetişecek.
4	CN: Leyla kazağı giyseydi dışarıda sıcak kalacaktı.
	CP: Leyla tişörtü giyseydi dışarıda çok üşüyecekti.
	IN: Leyla tişörtü giyerse dışarıda çok üşüyecek.
	IP: Leyla kazağı giyerse dışarıda sıcak kalacak.
5	CN: Cengiz koltuğa otursaydı sırtı rahat edecekti.
	CP: Cengiz sandalyeye otursaydı sırtı çok ağrıyacaktı.
	IN: Cengiz sandalyeye otururssa sırtı çok ağrıyacak.
	IP: Cengiz koltuğa otururssa sırtı rahat edecek.

Item	Experimental Sentence
6	CN: Ela şemsiyeyi alsaydı dışarıda kuru kalacaktı.
	CP: Ela atkıyı alsaydı dışarıda çok ıslanacaktı.
	IN: Ela atkıyı alırsa dışarıda çok ıslanacak.
	IP: Ela şemsiyeyi alırsa dışarıda kuru kalacak.
7	CN: Ömer domatesi kullansaydı yemeği tatlı olacaktı.
	CP: Ömer biberi kullansaydı yemeği acı olacaktı.
	IN: Ömer acı biberi kullanırsa yemeği acı olacak.
	IP: Ömer domatesi kullanırsa yemeği tatlı olacak.
8	CN: Zeynep gözlüğü taksaydı etrafı net görecekti.
	CP: Zeynep uyku bandını taksaydı etrafı karanlık görecekti.
	IN: Zeynep uyku bandını takarsa etrafı karanlık görecek.
	IP: Zeynep gözlüğü takarsa etrafı net görecek.
9	CN: Ege kolayı içseydi dili tatlı hissedecekti.
	CP: Ege çayı içseydi dili çok yanacaktı.
	IN: Ege çayı içerse dili çok yanacak.
	IP: Ege kolayı içerse dili tatlı hissedecek.
10	CN: Salih atlı karıncaya binseydi lunaparkta çok eğlenecekti.
	CP: Salih korku trenine binseydi lunaparkta çok korkacaktı.
	IN: Salih korku trenine binerse lunaparkta çok korkacak.
	IP: Salih atlı karıncaya binerse lunaparkta çok eğlenecek.
11	CN: Erdem haritayı alsaydı yolunu kolayca bulacaktı.
	CP: Erdem defteri alsaydı yolunu hemen kaybedecekti.
	IN: Erdem defteri alırsa yolunu hemen kaybedecek.
	IP: Erdem haritayı alırsa yolunu kolayca bulacak.
12	CN: Elif can yeleğini kapsaydı denizde yüzeyde kalacaktı.
	CP: Elif telsizi kapsaydı denizde dibe batacaktı.
	IN: Elif telsizi kaparsa denizde dibe batacak.
	IP: Elif can yeleğini kaparsa denizde yüzeyde kalacak.

Item	Experimental Sentence
13	CN: Furkan yağmurluğu giyseydi kıyafetleri kuru kalacaktı.
	CP: Furkan yeleği giyseydi kıyafetleri sırılsıklam olacaktı.
	IN: Furkan yeleği giyerse kıyafetleri sırılsıklam olacak.
	IP: Furkan yağmurluğu giyerse kıyafetleri kuru kalacak.
14	CN: Özlem çizgi filmi izleseydi çok eğlenecekti.
	CP: Özlem belgesel izleseydi canı çok sıkılacaktı.
	IN: Özlem belgeseli izlerse canı çok sıkılacak.
	IP: Özlem çizgi filmi izlerse çok eğlenecek.
15	CN: Mehmet mandalinayı yeseydi dişleri sapsağlam olacaktı.
	CP: Mehmet şekeri yeseydi dişleri hemencecik çürüyecekti.
	IN: Mehmet şekeri yerse dişleri hemencecik çürüyecek.
	IP: Mehmet mandalinayı yerse dişleri sapasağlam olacak.
16	CN: Burak asansörü kullansaydı dinlenmiş hissedecekti.
	CP: Burak merdivenleri kullansaydı yorgun hissedecekti.
	IN: Burak merdivenleri kullanırsa yorgun hissedecek.
	IP: Burak asansörü kullanırsa dinlenmiş hissedecek.
T1	Masanın üstünde kaşık ve boya kalemi vardı.
	Ezgi resim defterine resim yaptı.
	Sence Ezgi hangisini kullandı?
T2	Masada top ve raket var.
	İlte futbol oynamak istiyor.
	Sence İlte hangisini alacak?
T3	Dolapta siyah tişört ve mavi gömlek var.
	Arda mavi rengi çok seviyor.
	Sence Arda hangisini giyecek?

B. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

DUMLUPINAR BULVARI 06800
ÇANKAYA ANKARA/TURKEY
T: +90 312 210 22 91
F: +90 312 210 79 59
ueam@metu.edu.tr
www.ueam.metu.edu.tr

Sayı: 28620816 /2486

12 EYLÜL 2018

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Dr.Öğretim Üyesi Duygu ÖZGE ve Dr.Öğretim Üyesi Umut ÖZGE

"Türkçe'de koşullu ifadelerin işlenmesi, gelişimi ve anlambilimsel modellenmesi" başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2018-EGT-102** protokol numarası ile **01.03.2018 - 31.03.2022** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Ş. Halil TURAN
Başkan V

Prof. Dr. Ayhan SOL
Üye

Prof. Dr. Ayhan Gürbüz DEMİR
Üye

Doç. Dr. Yaşar KONDAKÇI
Üye

Doç. Dr. Zana ÇITAK
Üye

Doç. Dr. Emre SELÇUK
Üye

Dr. Öğr. Üyesi Pınar KAYGAN
Üye

C. TURKISH SUMMARY / TÜRKÇE ÖZET

KARŞI OLGUSAL USLAMLAMADA ARTIMLI BİÇİM-SÖZDİZİM İŞLEMESİ: TÜRKÇE KONUŞAN ÇOCUKLAR VE YETİŞKİNLER İLE BİR GÖZ İZLEME ÇALIŞMASI

1 Giriş

Çocuklar, iki buçuk yaşında itibaren *ve* (Morris, 2008) ve *değil* (Feiman et al., 2017), üç yaşından itibaren *veya* (Mody & Carey, 2016) gibi mantıksal yapıları kullanarak akıl yürütebilir ve dört yaşından itibaren bu mantıksal yapıların anlamsal ve pragmatik kullanımlarını birbirinden ayırt edebilirler (Jasbi & Frank, 2017). Çocuklar ayrıca artımlı olarak hâl-durum (Özge et al., 2019) ve edilgen fiil ekleri (Huang et al., 2013) gibi biçim-sözdizimsel ipuçlarını konusal rol ataması ve gelecek bağlamı tahmin etmede kullabilirler. Peki ya çocuklar hem biçim-sözdizimle hem de mantıksal şartlı bağlaçla çıkarım yapmayı gerektiren karmaşık bir yapı olan karşı olgusal ifadeleri kullanarak nasıl akıl yürütebilirler? Karmaşık dilsel yapısının yanı sıra karşı olgusal koşullu ifadeler insanların hem varsayımsal alternatif ve gerçek dünya durumlarını hem de bunların sonuçlarını temsil etmelerini gerektiren sofistike bir akıl yürütme yetisi istilzam etmektedir.

Farklı diller karşı olgusal koşullu ifadelerin dilsel yapısını farklı şekilde kodlamaktadır. Türkçedeki karşı olgusal koşullu ifadeler koşullu belirtici, *-sA*'nın ve karşı olgusal anlamı veren (sahte) geçmiş zaman belirticisi, *-DI*'nın çizgisel kombinasyonuyla kodlanmaktadır. Bu nedenle küçük çocukların erken dil gelişimindeki biçim-sözdizimsel çözümleme becerisi göz önüne alındığında böylesine karmaşık bir yapıyı edinip edinemeyecekleri kesin görünmemektedir. Karşı olgusal uslamlama ve biçim-sözdizimde yer alan bu karmaşıklıklardan dolayı *ve, veya* ve *değil* gibi diğer mantıksal yapılara kıyasla bu yapının edinimi daha geç görülebilir ve işlenmesi de daha zorlu olabilir. Ayrıca bazı görüşlere göre çocukların beş ya da altı yaşına kadar soyutlama ve karşılaştırma yapma gibi genel mantıksal yetileri tam anlamıyla gelişmemiş olması da beklenebilir (Tomasello, 2003). Bu sebeple karşı olgusal uslamlama yetisinin gelişmesi bu yetilerin gelişmesinden daha uzun sürebilir. Benzer şekilde konusal rol ataması için biçim-sözdizimsel ipuçlarını tahmin edici bir şekilde kullanmak bunları karşı olgusal

uslamlama için yapmaktan daha erken görülebilir çünkü konusal rol atamasında biçim-sözdizimsel ipuçlarındaki hâl-durum ekleri hâlihazırda algısal sistemden erişilebilir olan olayların kişilerini, konularını ve alıcılarını yansıtmaktadır. Ancak karşı olgusal ifadelerin biçim-sözdizimindeki ekler olaylar hakkındaki muhtemel alternatif gerçeklikleri yansıtıyor olabilir. Bu nedenle de karşı olgusal koşullu ifadelerin biçim-sözdimini işlemek için daha ileri bir kavramsal sistem ve ayrıştırıcı icap ediyor olabilir ki bu da çocuklarda bu yetinin gelişiminin daha geç gerçekleşmesine yol açıyor olabilir.

Karşı olgusal ifadelerin edinimini araştıran çalışmalar çocukların bu yapıları kaç yaşından itibaren anladıkları konusunda çeşitli sonuçlara sahiptir. Bazı çalışmalar dört yaş kadar küçük çocukların karşı olgusal ifadeleri anladığını savunurken (German & Nichols, 2003; Harris et al., 1996; Nyhout & Ganea, 2019b), bazı çalışmalar bunun yetişkin seviyesinde bir hâl almasının yedi yaşa (hatta on dört yaşa bkz. Rafetseder et al., 2013) kadar sürebileceğini ileri sürmektedir (McCormack et al., 2018). Çalışmalar arasında bu denli bir fark olmasının sebebi çocukların hem karşı olgusal ifadeler içeren hikayeleri anlamasını hem de bu hikayelerdeki durumlar hakkındaki çıkarımlarını akılda tutmasını gerektiren bilişsel olarak yüklü deneysel görevler içermeleri olabilir. Bu nedenle de çocukların bu yapıları duydukları esnada anlıyor olmaları ancak konuşma sonunda önceki yorumlarını hatırlamada başarısız oluyor olmaları muhtemeldir. Dahası henüz yetişkinlerin bile İngilizce ve İspanyolca gibi dillerde karşı olgusal biçim-sözdizimi artımlı olarak anlayıp anlayamadıkları hakkında emin değiliz. (Ferguson et al., 2010; Orenes et al., 2019).

Bildiğimiz kadarıyla bu zamana kadar hiçbir çalışma çocukların karşı olgusal ifadeleri gerçek zamanlı olarak işlenmesini incelemedi ve karşı olgusal koşullu ifadeleri birleşik fiil ekleriyle kodlayan bir dilde bu tarz yapıların edinimine odaklanmadı. Bu yüzden biz Türkçedeki karşı olgusal koşullu ifadelerin çevrim içi işlenmesini inceleyerek literatürdeki bu boşluğu doldurmayı hedefliyoruz.

1.1 Çalışmanın Gerekliliği

Literatürde bu zamana kadar yapılan çalışmaların sonuçları göz önüne alındığında bu çalışmaların çocukların ne zamandan itibaren karşı olgusal uslamlama yapabildiği ve yürütücü işlevlerin bu yetiyi nasıl etkilediği konusunda nihai bir sonuca varamamış olduğu görülmektedir. Bu çalışmalarda kullanılan deneylerin zorlukları arasındaki farklılıklar bu varyasyonun temel sebebi olarak görülebilir. Bu nedenle özellikle katılımcıların karşı olgusal ifadeleri kullanarak olayların içindeki kişilerin davranışları hakkında nedensel çıkarımlar yaptığı görevler fiziksel obje paradigmaları kullanan görevlere göre çocukları daha fazla zorlamaktadır. Biz çocukların aslında bu görevlerdeki karşı olgusal yapıları anladığını ancak çıkarımlarını ifade etmede zorlandığını tahmin etmekteyiz. Sonuçta dildeki gelişim

yaş ilerledikçe iyileştiği için çocukların düşüncelerini bütünüyle ifade edememeleri bu seviyede gayet beklenebilirdir. Bu yüzden çocukların göz hareketleri gibi fizyolojik tepkileri yetişkin seviyesindeki karşı olgusal dil işlemenin erken göstergelerinden biri olabilir. Lâkin yetişkinlerle yapılan çalışmalara bakıldığında alternatif ve gerçek dünya temsilleri karşı olgusal dil anlamada ne zaman tetiklenir ve hangi dilsel yapılar (biçim-sözdizim ya da pragmatik bağlam) bu temsilleri tetikler gibi soruların da henüz yanıtlanamamış olduğunu görmekteyiz. Neyse ki Türkçenin karşı olgusal ve şartlı anlamı kombinatoryal biçimbirim dizileriyle ifade etmesi biçim-sözdizimin karşı olgusal ifadelerden mütevellit çıkarımların üretilmesi üzerine etkisini sınamamızı sağlamaktadır. Ama ne yazık ki bu çalışmayı yürüttüğümüz esnada yalnızca iki çalışma Türkçede karşı olgusal ifadelerin anlanmasını incelemiştir (Yarbay Duman et al., 2016; Yarbay Duman et al., 2015). Ancak her ikisi de karşı olgusal biçim-sözdizimin çevrim içi işlenmesine odaklanmamıştır. Bu sebeple de böylesine bir çalışmayı yürütmek elzemdir.

1.2 Araştırma Soruları

Yukarıda izah ettiğimiz nedenlerden dolayı bu çalışmada,

(i) dört yaş kadar küçük çocuklar karşı olgusal koşullu ifadeleri yetişkin seviyesinde anlayabilir mi,

(ii) yetişkinler konuşma esnasında karşı olgusal uslamlama için biçim-sözdizimi artımlı olarak kullanabilir mi,

(iii) dört yaş kadar küçük çocuklar da karşı olgusal akıl yürütürken biçim-sözdizimsel ipuçlarını anlayabilir mi,

(iv) karşı olgusal koşullu ifadelerdeki olayların olumsuz sonuçları karşı olgusal düşüncelerin ortaya çıkışını daha fazla tetikler mi,

(v) çocukların yürütücü işlevleri karşı olgusal uslamlama yetisini öngörebilir mi (eğer görürse hangileri nasıl öngörür),

sorularını yanıtlamayı amaçlamaktadır.

2 Deney

Bu deneyde çevrim içi işlemeyi araştırmak için görsel dünya göz izleme paradigması (Cooper, 1974) kullandık ve karşı olgusal ifadelerin nasıl yorumlandığını test eden anlama soruları sorduk. Bunları yaparken ayrıca bireysel farklılıkları incelemek adına çocukların kısa süreli bellek kapasitesi, çalışma belleği kapasitesi ve baskılama yetisi gibi yürütücü işlevlerinin etkisini de kontrol ettik.

Görsel dünya paradigmasının arkasındaki prensip insanların sahnedeki belli sayıda (N) görsel uyaran-dan birine bakma olasılığının bu uyaranlara eşlik eden herhangi bir sesli uyaran yokken $p(1/N)$ olması ancak bu görsel uyaranlarla alakalı bir sesli uyaran duyulduğunda bakışların bu olasılıktan daha yüksek bir olasılıkla sesli uyaranla alakalı bulunduğu düşünülen görsel uyarana çevrilmesidir (Altmann & Kamide, 1999; Langton et al., 2000). Bakışlardaki bu değişim sesli uyarandan çıkarılan bilgiye verilen dikkatin göstergesidir.

2.1 Katılımcılar

Anadili Türkçe olan yirmi üç çocuk (M_{yas} = 4:10; Aralık = 4:05-5:11; 12 Erkek) ve on sekiz yetişkin (M_{yas} = 25,27; Aralık = 20-35; 7 Erkek) çalışmaya katılmıştır (N = 41).

2.2 Uyaranlar ve Tasarım

Bu deneyde katılımcılar iki göstergenin bulunduğu bir görsel sahne gördüler. Bu göstergeler 9a'daki ya da 9b'deki bağlam cümleleriyle tanıtıldılar. Bu cümleleri deneysel cümleler takip etmiştir.

(9) a. **Bağlam cümlesi (geçmiş zaman)**
Garajda araba ve bisiklet vardı.

b. **Bağlam cümlesi (geniş zaman)**
Garajda araba ve bisiklet var.

Deneysel cümleler iki seviyeli iki koşulda yer aldılar. İlk koşul cümlenin karşı olgusal koşullu ifade mi yoksa bildirim koşullu ifadesi mi olduğuydu. İkinci koşul ise cümledeki olayın olumsuz mu yoksa olumlu mu sonuçlandığıydı. Bu nedenle 2×2 tasarım toplamda dört tipte koşullu cümle oluşturmuştur (10a-10d). Görsel sahnedeki iki gösterge gerçek dünya ve alternatif dünya durumlarına karşılık gelmekteydi. Gerçek dünya durumu hedef göstergeye, alternatif dünya durumu ise rakip göstergeye karşılık gelmekteydi. Deneyde her tipten dört cümle olmak üzere toplamda on altı deneysel cümle yer aldı (Dolgu *(filler)* cümleleri kullanılmamıştır). Deneysel cümlelerden önce katılımcılar deneye alışmak adına üç tane deneme cümlesi görmüştür.

(10) a. **Olumsuz sonuçlu karşı olgusal koşullu ifade**
Can arabayı sürseydi işe zamanında yetişecekti.
Hedef: Bisiklet

b. **Olumlu sonuçlu karşı olgusal koşullu ifade**

Can bisikleti sürseydi işe geç kalacaktı.

Hedef: Araba

c. **Olumsuz sonuçlu bildirim koşullu ifadesi**

Can bisikleti sürerse işe geç kalacak.

Hedef: Araba

d. **Olumlu sonuçlu bildirim koşullu ifadesi**

Can arabayı sürerse işe zamanında yetişecek.

Hedef: Araba

Her deneysel cümleden sonra katılımcılara cümledeki kişinin ne yaptığının ya da yapacağının sorulduğu bir anlama sorusu yöneltildi. Bu sorular karşı olgusal koşullu ifadelerden sonra geçmiş zaman (11a), bildirim koşullu ifadelerinden sonra gelecek zaman formundaydı (11b). Yetişkin katılımcılar yanıt vermek için bir buton kutusu kullandılar. Çocuk katılımcılar ise görevi onlar adına zorlaştırmamak adına buton kutusundaki tuşlara basmak yerine yalnızca cevabı söylediler ya da parmaklarıyla işaret ettiler. Deney yürütücüsü bu cevapları buton kutusunu kullanarak kaydetti. Her cevaptan sonra katılımcılar *"Böyle devam et!"* ve *"Çok iyi gidiyor!"* gibi teşvik edici geri bildirimler aldılar. Bu geri bildirim ifadeleri cevabın doğru ya da yanlış olduğunu ima etmemekteydi.

(11) a. **Karşı olgusal koşullu ifadelerden sonraki anlama sorusu**

Sence Can hangisini sürdü?

b. **Bildirim koşullu ifadelerinden sonraki anlama sorusu**

Sence Can hangisini sürecek?

2.3 Prosedür

Deney oturumu bir anaokulunda ya da ODTÜ Dil ve Bilişsel Gelişim Laboratuvarı'nda sessiz bir odada gerçekleşmiştir. Katılımcılar 144 Hz tazeleme hızında çalışan 1920'ye 1080 çözünürlükte bir dizüstü bilgisayar ekranının karşısına oturtulmuştur. Deneysel uyaranlar bu ekranda gösterilmiştir. Deney SR Research Experiment Builder yazılımı ile derlenmiştir. Katılımcıların göz hareketleri 1000 Hz örnekleme hızında çalışan SR Research Portable Duo baş serbest *(head-free)* göz izleme sistemiyle kaydedilmiştir. Kayıt her iki göz için de alınmış ancak analiz için baskın göz kullanılmıştır. Deney öncesinde beş noktalı kalibrasyon ve validasyon gerçekleştirilmiştir ve bu prosedür kalibrasyon her

bozulduğunda ya da katılımcı başını aşırı derecede oynattığında tekrarlanmıştır. Oturum yaklaşık on beş dakika sürmüştür.

2.4 Bilişsel Testler

Bu çalışmada ayrıca bir dizi yürütücü işlev testiyle kısa süreli bellek kapasitesi, çalışma belleği kapasitesi ve baskılama yetisi gibi bilişsel yetileri de ölçümledik. Bu testler, kısa süreli bellek kapasitesi için ileri sayı dizisi testini, çalışma belleği kapasitesi için ters sayı dizisi testini (Wechsler, 1949; Wechsler & Kodama, 1949) ve baskılama yetisi için de mutlu-üzgün surat testini (Lagattuta et al., 2011) içermekteydi. Katılımcılar bu testlere göz izleme deneyinden sonra katıldılar ve bu testlerin sırası katılımcılar arasında eşit şekilde dengelendi.

2.5 Öngörüler

Eğer katılımcılar bildirim ve karşı olgusal koşullu ifadelerin biçim-sözdizimini artımlı olarak işleyebiliyorsa öncüldeki fiil çekimini duyduktan sonra bakışlarını hedef göstergeye çevirmeleri beklemekteyiz. Ayrıca eğer çocuklar biçim-sözdizimsel ipuçlarını yetişkinler gibi kullanıyorsa yetişkinler ve çocuklar arasında benzer bir bakış deseni öngörmekteyiz. German (1999) çocukların olumsuz sonuçlu karşı olgusal ifadeler içeren soruları cevaplamadaki performansının olumlu sonuçlu olanlardakinden daha iyi olduğu söylemektedir. Benzer şekilde biz de hedef göstergeye olan bakışlardaki artışın olumsuz sonuçlu karşı olgusal ifadelerde olumlu sonuçlu olanlardan daha fazla olmasını beklemekteyiz. Diğer yandan eğer German'ın iddiası doğru ise anlama sorularına da olumsuz sonuçlu karşı olgusal ifadelerden sonra daha fazla doğru cevap verilmesini öngörmekteyiz. Bunların dışında bildirim koşullu ifadeleri karşı olgusal koşullu ifadelerin aksine alternatif temsillerin üretimini gerektirmediği için bildirim koşullu ifadelerinde karşı olgusal ifadelerden daha fazla doğru cevap verilmesini beklemekteyiz (De Brigard et al., 2013; Kulakova & Nieuwland, 2016a). Karşı olgusal koşullu ifadelerde gerçek ve alternatif dünyalar eş zamanlı olarak temsil edilmektedir (Byrne, 2007; Byrne & Egan, 2004; Kulakova et al., 2013). Bu yüzden bu koşulda fiksasyonların hedef ve rakip göstergeler arasında eşit dağılmasını öngörmekteyiz. Ancak bildirim koşullu ifadelerinde fiksasyonların tek bir göstergede birleşmesini beklemekteyiz çünkü bu ifadeler birden fazla temsilin üretilmesini gerektirmemektedir. Bu çalışmada bildirim ve karşı olgusal koşullu ifadeler hakkında öngördüğümüz bakış desenleri Orenes ve diğerlerinde (2019) de görülmektedir. Bilişsel test skorlarına ve anlama sorularına verilen cevaplara geldiğimizde ise çalışma belleği kapasitesi ve baskılama yetisi daha iyi olan çocukların anlama sorularına daha fazla doğru cevap vereceklerini beklemekteyiz çünkü önceki çalışmalar alternatif durumlar üretme, bunları eş zamanlı temsil etme ve gerçek durum hakkında akıl yürütme için çalışma belleği

kapasitesinin ve baskılama yetisinin gerektiğini öne sürmüşlerdir (Beck & Riggs, 2014; Beck et al., 2009; Drayton et al., 2011).

3 Tartışma

Bu çalışmada dört yaş kadar küçük çocukların karşı olgusal koşullu ifadeleri duyduklarında yetişkin düzeyinde akıl yürütüp yürütemediği ve ardışık fiil ekleri ile hem bildirim hem de karşı olgusal koşullu ifadelerin anlamını kodlayan bir dilde, Türkçe, karşı olgusal akıl yürütmede biçim-sözdizimsel ipuçlarını kullanıp kullanamadığı araştırılmıştır.

3.1 Karşı olgusal koşullu ifadeler bildirim koşullu ifadelerinden daha mı zor?

Biz bu çalışmada çocukların karşı olgusal koşullu ifadeleri duyduktan sonra gelen anlama sorularına yüksek doğrulukla cevap verebildiği gösterdik. Ancak çocukların performanslarının bildirim koşullu ifadelerinden sonra gelen anlama sorularını cevaplamada daha da iyi olduğunu göz ardı edemeyiz. Bu durum ayrıca yetişkinler için de geçerlidir ki onların da performansları bildirim koşullu ifadelerinde karşı olgusallarda olanlardan daha iyidir. Bu sonuçlar karşı olgusal koşullu ifadelerin bildirim koşullu ifadelerin daha fazla güçlük oluşturduğuna işaret etmektedir. Bu durumun sebebi karşı olgusal koşullu ifadelerin bildirim koşullu ifadelerinin aksine gerçek ve alternatif dünya temsillerine erişim gerektirmesi olabilir (Byrne, 2007; Epstude & Roese, 2008; Roese, 1997; Roese & Epstude, 2017). Bunun dışında karşı olgusal koşullu ifadeler öncüllerinin yanlışlığını önvarsaymaktadır. Önvarsayımlar da varsayılan olarak hesaplanmadığı ve konuşmadaki diğer sezdirileri etkinleştirmeyi gerektirdiği için daha zor işlenmektedir (Degen & Tanenhaus, 2015, 2016). Bu nedenle karşı olgusal akıl yürütürken insanların gerçek dünya temsilini ortaya çıkarması için alternatif dünyaları baskılaması gerekmektedir. Bu nedenle bildirim koşullu ifadeleri yalnızca tek bir temsili etkinleştirdiği için bu koşuldaki hedef göstergeyi seçmek muhtemelen karşı olgusal ifadelerden daha kolaydır denilebilir. Zaten bizim sonuçlarımız da karşı olgusal koşullu ifadelerin işlenmesinin bildirim koşullu ifadelerinden daha zor olduğunu öne süren çalışmaların sonuçlarıyla parallellik göstermektedir (De Brigard et al., 2013; Kulakova & Nieuwland, 2016b).

3.2 Çocuklar yetişkin seviyesinde bir performansa sahip mi?

Biz bu çalışamada ayrıca çocukların bildirim koşullu ifadelerinden sonra gelen anlama sorularına cevap vermede yetişkinler gibi performans sergilediğini gösterdik. Öte yandan CP, IN ve IP koşullarında yüzde yetmiş beşin üzerinde doğruluğa sahip olmalarına rağmen karşı olgusal koşullu ifadelerden sonra gelen anlama sorularında çocukların yetişkinler kadar performans gösteremediği de gözlem-

ledik. Yetişkinlerin daha iyi performans sergilemesinin muhtemel sebebi dilsel ifadelere daha fazla maruz kalmış olmaları ve koşullu ifadelere daha fazla aşinalığının olmasıdır. Buna ek olarak yetişkinler daha gelişmiş yürütücü işlevlere sahiptir ki bu da onların birden çok temsili akıllarında tutmalarını ve daha az muhtemel olanları baskılamasını sağlamaktadır. Diğer bir neden ise çocukların daha düşük çalışma belleği kapasitesine sahip olması olabilir. Bundan dolayı da çocuklar yeni gelen dilsel girdiyi hemen işliyor ancak daha sonrasında bu girdiyi geri çağırırken zorlanıyor olabilir. Bu da anlama sorularına daha düşük doğrulukla cevap vermelerine yol açıyor olabilir. Bizim sonuçlarımızın bir bakıma Harris ve diğerlerinin (1996) ve German ve Nichols'ın (2003) sonuçları ile aynı doğrultuda olduğu söylenebilir çünkü onlar da dört yaş kadar küçük çocukların karşı olgusal ifadeler içeren sorulara bu seviyede doğrulukla cevap verdiklerini göstermiştir. Başka bir görüşe göre ise çocukların yetişkin seviyesinde performansa sahip olmadığını söylenebilir çünkü bu çalışmada tepe noktasında performans sergilememeişlerdir. Bu çıkarım da karşı olgusal ifadelerde yetişkin seviyesi tepe performansın on dört yaş kadar geç görülebileceğini savunan Rafetseder ve diğerlerinin (2013) çıkarımı ile uyumluluk göstermektedir. Yine de bizim çalışmamızda hiçbir koşulda yetişkinlerin bile yüzde yüz performans gösteremedikleri görülmüştür. Dahası CN koşulunda yetişkinlerin performansları yüzde yetmiş beş kadar düşüktür. Bu yüzden bazı koşullu ifadelerin yetişkinler için bile zor olduğunu ve çocukların da bu tarz karmaşık yapılardan sonra gelen anlama soruları cevaplamada zorlanmalarının makul olduğunu söyleyebiliriz.

German (1999) çocukların olumsuz sonuçlu karşı olgusal ifadelerdeki performansının olumlu sonuçlu olanlardakinden daha iyi olduğunu belirttiği için biz de katılımcılarımızın olumsuz sonuçlu karşı olgusal ifadelerden sonraki anlama sorularını cevaplamada olumlu sonuçlulardan sonrakilerden daha iyi performans sergileyecekelerini beklemiştik. Fakat bizim sonuçlarımız German'ınkilerle (1999) çeliştiği gözlenmiştir çünkü bizim katılımcılarımız olumlu sonuçlu karşı olgusal koşullu ifadelerde olumsuz sonuçlu olanlardan daha iyi performans göstermiştir. Bu bulgu insanların yanlış tercihlerinden kaynaklanan tecrübeleri olduğunda genelde karşı olgusal düşüncelere daha fazla girdikleri düşünülünce ilginç durmaktadır (Epstude & Roese, 2008). Bu açıdan da bizim bulgumuz bu tarz bir iddia ile uyuşmamaktadır. Bu uyuşmazlıktan dolayı hem German'ın (1999) bulguları hem de bizim bulgularımız sorgulanmaya açık hâldedir ve daha sağlam deneysel tasarımlarla yeniden değerlendirilmelidir.

3.3 Yürütücü işlevler karşı olgusal uslamlama yetisini etkiliyor mu?

Johnson-Laird ve diğerleri (1992) çalışma belleği kapasitesinin karşı olgusal uslamlamada alternatif

olasılıkların temsilini kısıtlayabileceğini söylemektedir. Bunun dışında gerçek dünya durumu hakkında çıkarım yapmak için alternatif temsilleri baskılamak da karşı olgusal uslamlama için esastır (Beck & Riggs, 2014). Bu yüzden karşı olgusal uslamlama yetisindeki gelişim çalışma belleğindeki ve baskılama yetisindeki gelişim ile açıklanabilir (Byrne, 2007; Robinson & Beck, 2014). Lâkin Beck ve diğerleri (2009) karşı olgusal düşünme ve çalışma belleği kapasitesi arasında bir ilişki olmadığını göstermiştir. Bizim bulgularımız da bu doğrultuda çalışma belleğinin cevap doğruluğunu tahmin etmede önemli bir gösterge olmadığını göstermektedir. Ayrıca Beck ve diğerleri (2009) baskılama yetileri ve karşı olgusal düşünme arasında negatif korelasyon olduğunu belirtmiştir. İlginç şekilde onların bulguları daha düşük baskılama yetisine sahip çocukların bilişsel olarak daha zor deneysel görevleri yapmada daha iyi olduğuna işaret etmektedir. Daha da ilginç olan ise bizim analizimize göre de baskılama yetisinin cevap doğruluğu üzerinde negatif bir etkiye sahip olmasıdır. Bu durumda çıkardığımız sonuca göre biz çocukların alternatif temsiller arasında gidip gelmek yerine tek bir temsile bağlanıp cevaplarını buna göre seçtiğini düşünmekteyiz. Bu durum için diğer bir sebep ise çocukların karşı olgusal biçim-sözdizim ya da bağlamsal bilgi gibi gerçek dünya hakkında akıl yürütmelerini sağlayan bir ipucu yakalıyor olmaları ve baskılayacakları temsili seçmek yerine artımlı olarak önceki alternatif temsilleri sıfırlıyor olmaları olabilir. Öte yandan bizim sonuçlarımız basitçe ufak örneklem boyutundan da kaynaklanıyor olabilir. Açıkçası daha sağlam genellemeler yapmak için daha büyük bir örneklem boyutuna sahip bir replikasyon çalışması gerekmektedir.

3.4 Çocuklar ve yetişkinler karşı olgusal uslamlamada biçim-sözdizimsel ipuçlarını artımlı olarak kullanıyor mu?

Katılımcıların bakış desenlerine geldiğimizde sonuçlarımız yalnızca yetişkinlerin değil aynı zamanda dört yaş kadar küçük çocukların da biçim-sözdizimsel yapıları artımlı olarak bütünleştirerek gerçek dünya durumunu tahmin ettiğini ve bildirim ve karşı olgusal koşullu ifadelere anlam atadığını göstermektedir. Bu sonuç çocukların Türkçe (Özge et al., 2019), Çince (Huang et al., 2013), Hollandaca (Brouwer et al., 2017) ve Almanca (Özge et al., 2022) gibi çoğu dildeki biçim-sözdizimsel ipuçlarını artımlı şekilde kullanarak bilgiyi ayıkladığını ve gelecek bağlamı tahmin ettiğini söyleyen çalışmaların sonuçlarıyla uyumluluk göstermektedir.

Bulgularımız, insanların bağlamsal bilgiyi bildirim ve karşı olgusal koşullu ifadelerde alakalı göstergeyi tahmin etmede kullandığını gösteren Ferguson ve diğerlerinin (2010) ve Orenes ve diğerlerinin (2019) üzerine kanıtlar sunmaktadır. Koşullu ifadeyi *if/si* gibi açık bir bağlaçla işaretleyen İngilizce ve İspanyolca gibi dillerin aksine Türkçe koşullu ifadeyi birleşik biçimbirimlerle sağlamaktadır. Bildirim

ve karşı olgusal koşullu ifadelerin anlamlarını ayırt eden ise bu biçimbirimlerin sırasıdır (Göksel & Kerslake, 2004). Bu durumdan istifade biz karmaşık mantıksal uslamlamada biçim-sözdizimin kullanıldığını göstermiş bulunmaktayız. Bunun dışında Türkçede sonuçtaki fiil çekimi de bildirim ve karşı olgusal koşullu ifadeler için farklı şekilde işaretlenmektedir. Bu yüzden gösterdiğimiz bu etki koşullu ifadelerin sonuna doğru daha belirgin olmaktadır ki katılımcıların sonuçtaki fiil çekimin tamamen duyduğu cümle sonundan sonra hedef göstergeye bakışlarında daha fazla bir artış gözlemlenmiştir. Bu nedenle katılımcılarımız karşı olgusal koşullu ifadeleri bütünüyle anlamak için öncüldeki fiil çekimiyle sonuçtakini birleştirmiş olabilir. Lâkin bu durumun sebebi öncülün biçim-sözdizimsel yapısının etkisini geç göstermesi de olabilir. Normalde bir fiksasyonu programlamak 200-400ms sürmektedir (Fischer, 1992; Matin et al., 1993) ama 1000ms civarı geç etkiler de görülebilmektedir (Huettig & Altmann, 2011). Aslında deneysel tasarımımız açısından bu tarz bir geç etkinin görülmesi beklemekteydik çünkü karşı olgusal koşullu ifadelerde öncülde katılımcılara açıkça sunulan isim rakip göstergeye karşılık gelen alternatif dünyayı temsil etmektedir. Bu yüzden de isim fiil çekiminden önce işlendiği için gerçek dünya durumuna karşılık gelen göstergeye olan bakıştaki geçiş daha düşük bir ihtimalle başlamaktadır ki bu da rakip göstergeden hedef göstergeye geçişi ve güçlü alternatifi baskılamayı gerektirmektedir. Yani hedef göstergeye bakışın geç görülmesi bu nedenlerden dolayı makuldür denilebilir.

Benzer bir etki aynı sebeplerden dolayı olumsuz sonuçlu bildirim koşullu ifadelerde de görülmektedir. Bu etkiyi gözlemlemediğimiz tek koşul olumlu sonuçlu bildirim koşullu ifadelerdir çünkü bu koşulda öncülde ifade edilen isim zaten gerçek dünya durumuna karşılık gelmektedir ve fiksasyonlarda herhangi bir geçiş gerektirmemektedir. Bu nedenle de bu koşulda öncüldeki fiil çekiminden sonra fiksasyonların olasılıkları yüzde ellinin üstüne hızla çıkmaktadır. Bunun yanı sıra çoğu çalışma karşı olgusal ifadeler işlenirken altenatif ve gerçek dünya durumlarının zihinde eş zamanlı temsil edildiğini öneren çift temsil modelinden bahsetmektedir (De Brigard et al., 2013; Ferguson & Cane, 2015; Kulakova & Nieuwland, 2016b; Urrutia et al., 2012). Bu da bunun gerçekte artımlı biçim-sözdizimsel bütünleştirmenin bir etkisi olduğu hipotezini daha da güçlendirmektedir. Bu çıkarımdan emin olmak ve öncül ile sonuçtaki yapıların etkilerini ayrı tutmak adına gelecekte bir çalışma daha yapmayı planlamaktayız.

Son olarak German (1999) çocukların karşı olgusal durumlar hakkındaki anlama sorularındaki cevaplarının olaylar içindeki kişi için olumsuz sonuçlandığında daha doğru olduğunu iddia etmektedir. Bu sebeple göz izleme analizimiz için olumsuz sonuçlu karşı olgusal ifadelerde olumlu sonuçlananlardan daha fazla hedef gösterge bakışı beklemekteydik. Bizim çalışmamızda her iki gruptan da katılımcılar böyle bir etki göstermemişlerdir. Bu yüzden sonuçlarımız German'ın vardığı sonuçlarla par-

alellik göstermemektedir. Ancak bildirim koşullu ifadelerinde olayın sonucunun etkisi görülmektedir. Bu koşulda olumlu sonuçlu bildirim koşullu ifadelerinden olumsuz sonuçlulara göre daha fazla hedef bakış gözlemlenmiştir. Lâkin bu etki muhtemelen bir koşulun diğerine göre gerçek dünya hakkında daha fazla düşünce ürettilmesine yol açtığından dolayı değil deneysel yapılar olumlu ve olumsuz sonuçlu bildirim koşullu ifadelerini birbirinden ayırdığı içindir. Deneysel tasarımımızda olumlu sonuçlu bildirim koşullu ifadeleri olumsuz sonuçlu olanların aksine fiksasyonlar arasında bir geçiş gerektirmediği için bu durum olumlu sonuçlu bildirim koşullu ifadelerinde hedef gösterge üzerinde daha fazla fiksasyona yol açmış olabilir.

4 Sonuç

Çocuklar, *ve, veya,* ve *değil* gibi mantıksal bağlaçları kullanarak gerçek dünya hakkında çıkarımlarda bulunabilirler ve çok erken yaşlardan itibaren konuşmadaki bu mantıksal yapıların anlamsal ve pragmatik işlevlerini ayırt edebilirler. Öte yandan, erken yaştaki çocuklar, gelecek bağlam hakkında tahminlerde bulunmak için dillerinin biçim-sözdizimini artımlı olarak bütünleştirebilirler (Snedeker & Huang, 2009). Bu bağlamda biz, insanların birtakım karışık kombinatoryal biçim-sözdizimsel yapılar tarafından tetiklenen gerçek dünya hakkında sonuç çıkarırken alternatif olasılıklar ürettiği karmaşık bir akıl yürütme yetisi olan karşı olgusal koşullu ifadelerin gelişimini ve işlenmesini sorgulamaktayız. Bu karmaşıklıklar göz önüne alındığında sadece çocukların dil gelişiminde bir akıl yürütme mekanizması oluşturması gecikiyor değil aynı zamanda yetişkinlerin de bir işleme mekanizması oluşturması zorlaşıyor olabilir.

Karşı olgusal ifadelerin edinimini inceleyen araştırmalar, çocukların bu yapıları kullanarak ne zaman yetişkinler gibi çıkarımlar yapabilecekleri konusunda farklı sonuçlar vermektedir. Bu sorunun cevabı farklı çalışmalardaki deneylerin karmaşıklığına bağlı olarak üç yaş gibi çok erken yaşlardan (Harris et al., 1996) on dört gibi ergenlik yaşlarına kadar değişmektedir (Rafetseder et al., 2013). Biz ise çocukların bu tür yapıları duyduklarında hemen anlayabileceklerinden ancak bu durumlar hakkındaki çıkarımlarını açıkça ifade ederken bu sürece dahil olan bilişsel yükten dolayı performanslarının düşebileceğinden şüphelenmekteyiz. Öte yandan karşı olgusal ifadelerin artımlı işlenmesi hakkında bilgimiz yetişkinlerde bile kısıtlı hâldedir.

Bu çalışma yürütüldüğünde daha önce hiçbir çalışma karşı olgusal uslamlamada biçim-sözdizimsel yapıların çevrim içi olarak işlenmesini araştırmamıştır. Bu çalışmada biz çocukların ve yetişkinlerin karşı olgusal cümleler hakkında akıl yürütürken biçim-sözdizimsel ipuçlarını kullanımını görsel dünya paradigması içeren bir göz izleme deneyiyle araştırdık. Sonuçlarımız yalnızca yetişkinlerin

değil aynı zamanda çocukların da öncüldeki fiil çekimini duyduktan sonra bakışlarını gerçek dünyayı temsil eden hedef göstergeye çevirdiklerini göstermektedir. Bildiğimiz kadarıyla bu, fiillere işaretlenen biçim-sözdizimin yalnızca yetişkinlerde değil aynı zamanda dört yaşındaki çocuklarda da karşı olgusal akıl yürütme için varsayımsal alternatif dünyalar oluşturmak gibi karmaşık çıkarımlara yol açtığını gösteren ilk kanıttır.

Bu bulgu çocukların karşı olgusal durumlara ilişkin alternatif durumlar yaratmak ve bu durumlarla sonuçları hakkında varsayımsal çıkarımlar yapmak için biçim-sözdizimsel ipuçlarını artımlı olarak kullanabileceğini öne sürmesi açısından önemlidir. Ayrıca bulgularımız küçük çocukların, performansları yetişkinlerinki kadar yüksek olmasa da hem bildirim hem de karşı olgusal koşullu ifadelerden sonra anlama sorularına yüksek doğruluk yüzdesiyle yanıt verebildiğini göstermektedir. Ancak olumsuz sonuçlu karşı olgusal koşullu ifadelerin yetişkinler için bile zor olduğunu göz önüne aldığımızda çocukların da bildirim ve karşı olgusal koşullu ifadeleri duyduklarında yetişkinler gibi çıkarımlar yapabildiğini söyleyebiliriz. Son olarak koşullu ifadelerin sonuçlarının olumlu ya da olumsuz olması katılımcıların fiksasyonlarının dağılımını etkilememektedir ama iş cevap doğruluğuna geldiğinde katılımcılar olumlu sonuçlu koşullu ifadelerden sonraki anlama sorularına daha fazla doğru cevap vermektedirler.

4.1 Kısıtlar ve Gelecek Çalışmalar

COVID-19 pandemisi nedeniyle çalışmanın veri toplama aşamasında çok fazla katılımcıya ulaşamadık. Bu nedenle bu çalışma daha büyük bir örneklem ile replike edilmelidir. Ayrıca bu çalışmada yetişkinlerin ve çocukların bildirim ve karşı olgusal koşullu ifadelerin biçim-sözdizimsel yapısını bütünleştirebildiğine dair önemli bir kanıt sunulmasına rağmen insanların karşı olgusal akıl yürütmek için yalnızca öncülün biçim-sözdizimini mi kullandığını yoksa sonuçtaki bağlamsal bilgi ve fiil çekimini de mi bütünleştirdiğini hâlâ açıklayabilmiş değiliz. Bu yüzden gelecek çalışma, daha fazla katılımcı ile, doğrudan öncüldeki fiil çekiminin hedef göstergeye olan bakışlar üzerindeki etkisini daha iyi araştırmak için bu dilsel ipuçlarının etkisini dışarıda bırakmaya çalışacaktır.

D. THESIS PERMISSION FORM / TEZ İZİN FORMU

(Please fill out this form on computer. Double click on the boxes to fill them)

ENSTİTÜ / INSTITUTE

Fen Bilimleri Enstitüsü / Graduate School of Natural and Applied Sciences ☐

Sosyal Bilimler Enstitüsü / Graduate School of Social Sciences ☒

Uygulamalı Matematik Enstitüsü / Graduate School of Applied Mathematics ☐

Enformatik Enstitüsü / Graduate School of Informatics ☐

Deniz Bilimleri Enstitüsü / Graduate School of Marine Sciences ☐

YAZARIN / AUTHOR

Soyadı / Surname : Aktepe
Adı / Name : Semih Can
Bölümü / Department : İngiliz Dili Öğretimi / English Language Teaching

TEZİN ADI / TITLE OF THE THESIS (**İngilizce** / English): Incremental Processing of Morphosyntax for Counterfactual Reasoning: An Eye-tracking Study with Turkish-speaking Children and Adults

TEZİN TÜRÜ / DEGREE**:** **Yüksek Lisans** / Master ☒ **Doktora** / PhD ☐

1. **Tezin tamamı dünya çapında erişime açılacaktır. /** Release the entire work immediately for access worldwide. ☒
2. **Tez iki yıl süreyle erişime kapalı olacaktır.** / Secure the entire work for patent and/or proprietary purposes for a period of **two years. *** ☐
3. **Tez altı ay süreyle erişime kapalı olacaktır.** / Secure the entire work for period of **six months**. ***** ☐

***** *Enstitü Yönetim Kurulu kararının basılı kopyası tezle birlikte kütüphaneye teslim edilecektir. / A copy of the decision of the Institute Administrative Committee will be delivered to the library together with the printed thesis.*

Yazarın imzası / Signature ..... **Tarih** / Date .....
(Kütüphaneye teslim ettiğiniz tarih. Elle doldurulacaktır.)
(Library submission date. Please fill out by hand.)

Tezin son sayfasıdır. / This is the last page of the thesis/dissertation.