BREATHING PATTERNS DURING READING SPEECH IN TURKISH

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ABSTRACT

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Breathing is a process that is actively involved in speech production and has an impact on pace of reading. The main purpose of this thesis is to study the relationship between text complexity and the breathing pattern of the readers. This study approaches this question from two distinct aspects. First, it asks whether the syntactic complexity of a text affects the breathing frequency during reading in Turkish. Secondly, it investigates whether text complexity influences the readers' decisions on where to re-breath within the sentences. In order to answer these questions, three experimental conditions were generated: reading two simple texts aloud, reading two middle-complex text aloud, reading two complex texts aloud. The results reveal significant effect of the text complexity level both on the breathing frequency and the locations chosen to re-breath by the readers. The outcomes may provide an input for designing speech generation patterns that may improve naturalness of synthetic speech.

Keywords: respiration, reading speech, text complexity, phrase boundaries

ÖZ

TÜRKÇE OKUMA SIRASINDA NEFES ALMA ÖRÜNTÜLERİ

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Yüksek Lisans, Bilişsel Bilimler Bölümü
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Solunum, konuşma üretimi sürecine etkin olarak dahil olan ve okuma hızı üzerinde etkisi olan bir süreçtir. Bu tezin temel amacı, metinlerin sözdizimsel karmaşıklığı ile okuyucuların solunum örüntüleri arasındaki ilişkiyi incelemektir. Bu çalışma, söz konusu probleme iki farklı açıdan yaklaşmaktadır. İlk olarak, sözdizimsel karmaşıklığın Türkçe okuma sırasında nefes alma sıklığı üzerindeki etkisini incelenmiştir. İkinci olarak, sözdizimsel karmaşıklığın okuyucuların cümlelerin neresinde nefes tazeleyecekleri konusundaki kararlarını etkileyip etkilemediği araştırılmıştır. Bu soruları cevaplamak için 2 basit metni sesli okuma, 2 orta karmaşık metni sesli okuma, 2 karmaşık metni sesli okuma olmak üzere üç farklı deney koşulu oluşturulmuştur. Deney sonuçları, metnin karmaşıklık düzeyinin hem nefes alma sıklığı hem de okuyucular tarafından nefes tazelemek için seçilen konumlar üzerindeki belirgin etkisini ortaya koymaktadır. Bulgular, yapay konuşmanın doğallığını artırabilecek kalıpların tasarlanması için bir veri sağlayabilir.

Anahtar Sözcükler: solunum, sesli okuma, metin karmaşıklığı, sözcük grupları

To Sisterhood…

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

PD	Parkinson Disease
AD	Alzheimer's disease
NP	Noun Phrase
VP	Verb Phrase
NBP	Non-Breath Pauses
BP	Breath Pauses
L1	Language 1
L2	Language 2
f0	Fundamental Frequency
HRI	Human Robot Interaction
NLP	Natural Language Processing
GRE	Graduate Record Examination

CHAPTER 1

INTRODUCTION

The evolution of human language has been studied by scholars from diverse disciplines for many years. Therefore, it is widely accepted that humans have acquired a range of physical abilities to produce complex speech sounds and advanced cognitive abilities over time. For example, manipulating the vocal tract to produce a wide range of different sounds, such as vowels or consonants, is an essential physical ability for humans to produce speech. In addition to production, humans have developed particular skills to understand the message conveyed through communication in several ways. Since communication is described as an interaction between two speakers, it is necessary to approach the most critical tool in human communication, which is the language, from the perspectives of both how sentences are produced and understood (Chun, 1988). Therefore, a new field of study has emerged: conversational analysis, which is an approach to the subject of social interaction, examining both verbal and non-verbal behavior in situations of everyday life.

Wiener (1972) stated that it was appropriate and cogent to analyze various movements as body or head positions, lint picking, foot kicking, scratching, gross postural shifts, and hand and arm movements such as palm up during speech for a proper investigation of communication. In addition to these non-verbal behaviors, some investigated the effect of intonation on communication. According to Chun (1988) for example, communicating through speech does not include only the information but also the intent, and successful communication requires the agents to use and rely on non-verbal cues such as intonation. Although the existence of emotion-specific intonation patterns is controversial among scholars, it has been accepted that various pitch levels during speech refers to various types of emotions. In other words, intonation patterns are one of the reliable cues to understand the emotional state of the encoder and interpret the message conveyed during communication. As for the respiratory cues, they play a vital role in the flow of the conversation by indicating the intention of turn-taking or turn-yielding (Rochet-Capellan & Fuchs, 2014). In addition, speech-breathing patterns have been found to hold implications for inter-individual personality characteristics and intra-individual change with changing emotional states (Heim, Knapp, Vachon, Globus, & Nemetz, 1968). Therefore, exhaling and inhaling during speech might have certain implications in conversational analysis.

Humans usually attain excellent control of breathing during speech. While nonhuman primates cannot modify the airflow from the lungs, subglottal air pressure, and use patterns of inhalation and exhalation to convey meaning in communication, humans can perform each during speech (Maclarnon & Hewitt, 2004). Manipulating the vocal tract, integrated with cognitive process has given the humans the ability to manipulate the meaning during speech. Therefore, the investigations on humans' breathing patterns while speaking have suggestions concerning human cognitive processes throughout this action, in similar way to oculomotor processes that go hand in hand with cognitive processes during communication and reading.

During rest, we take long and slow inhalations. On the contrary, we take short and fast inhalations when we speak. At some parts of speech, we exhale slowly, in synchrony with the speech flow. Therefore, speech breathing has its well-known asymmetrical form (Rochet-Capellan & Fuchs, 2014). However, this asymmetrical form follows a particular pattern feeding the asymmetry with symmetry. The statement that humans display regular patterns, such as breathing at the end of structural boundaries, is a widely accepted phenomenon among scholars. Therefore, irregularities in this pattern may be the indicator of a certain type of neurological or visceral disorder. Consequently, studies on breathing patterns have also diagnostical implications.

Breathing patterns have been studied in many languages, including English, German, French, Hungarian, etc. Although systematic breathing patterns have been explored in these languages, it is not known whether Turkish exhibits similar or different patterns due to shallow orthography-phonology interface it has. In order to explore more about breathing patterns during speech, this study approaches the same subject from a different perspective and focuses on breathing patterns during reading speech in Turkish. More generally, there are two main research questions this study focuses. First, it asks whether syntactic complexity of a text influences the breathing frequency during reading. In order to answer this question, texts of different complexity level were introduced to the participants and their respiration was measured with a pneumograph. The second question asks whether syntactic complexity of a text influences the breath locations during reading speech. If the alternative hypothesis is rejected in the first question, then the possibility of the second question's answer coming out negative is very high. In other words, if the text complexity does not affect the breath frequency, it might mean that the participants display respiration to meet their physiological needs. Therefore, the second question can be improved in the following way "If text complexity determines the breath frequency during reading, does it also influence the breath locations decided by the participants?"

Understanding the breathing pattern while producing speech is essential for the improvement of naturalness in speech synthesis. The two speaking tasks, reading and spontaneous speech, differ in their physical and cognitive demands. As a result, the location and the duration of the breath groups may differ across these tasks. In a study conducted to investigate the difference between the effects of reading and spontaneous speech on breathing patterns, it was found that the speakers displayed significantly more grammatically inappropriate breath locations and longer breath durations than they did while performing the reading task (Wang et al., 2010). Since the cognitive load of spontaneous speech or the external factors, such as the behaviors of the other parties, may alter the usual breathing pattern of the speakers, finding a consistent breathing pattern for this task can be more challenging than reading. In order to eliminate these determinants, this current study required the participants to perform reading tasks rather than spontaneous speech.

This thesis consists of five chapters. In the first chapter, the focus of the thesis is stated briefly, and the motivations for the research are explained. In addition, a basic outline is introduced to the readers.

The second chapter starts with explaining the physiological process of breathing and then introduces the critical studies in the literature. Since these studies have various focuses, they are introduced to the reader in 6 categories.

In the third chapter, the methodology of the experiment is explained. The participants are offered three experimental conditions in which they read texts of different levels of complexity. The 6 texts, which consisted of 2 simple, 2 middle-complex, and 2 complex texts, are presented to the participants in random order. In addition, the description of the experimental data has been made.

In the fourth chapter, the statistical results of the experiment results are stated and discussed. In summary, it has been found that text complexity significantly affects the respiration frequency during reading. The respiration rate of the participants is highest in the first condition: reading the simple text. When it comes to the second research question, it has been found that the text complexity has a shallow effect on the breathing locations of the participants.

In the last chapter, the study's key findings are summarized, interpreted, and discussed briefly. Finally, recommendations for further studies are presented.

CHAPTER 2

LITERATURE REVIEW

The fundamental rhythmic unit of our organism is constituted by the successive inhalation and exhalation cycle (Shea, 1996). While resting, the rhythm of breathing is relatively regular and symmetrical, regarding the lung volume altered by the air volume inhaled or exhaled. However, speech production, which involves specific neural networks to control the respiratory muscles, significantly affects the rhythm of breathing compared to the rhythm at rest (Aleksandrova & Breslav, 2009). Therefore, examining the breathing patterns during speech might serve various purposes, such as cognitive linguistic analysis, psychological analysis, or diagnostic analysis. As a result, different kinds of data are needed to reach those purposes. Regarding the types of data collected in those studies, it can be said that there are two main categories of research to review: The studies focusing on the respiration patterns during spontaneous speech and the others centering on the same analysis during reading speech.

2.1. Diagnostic and Therapeutic Implications of Breathing

An early study (Hoshiko, 1965) explains why analyzing respiration patterns in speech analysis is crucial by claiming that conveying information through oral communication is a kind of behavior controlled by bodily machinery, and exploring this machinery is a must to understand how this behavior is shaped. Therefore, he investigated the vital capacity at which phonations were typically initiated by a group of healthy young male and female adults. He believed that discovering a definite point in the vital capacity to initiate phonation was vital since any wide deviation from this point might have diagnostic and therapeutic implications. In order to determine this particular point, thirty normal young male and thirty normal young female adults inhaled oxygen in a closed-circuit respirometer in a standing position. They measured the vital capacity, expiratory reserve, tidal volume for breathing, and phonation volume for each subject. The mean percent of vital capacity at which phonation was typically initiated was found to be 49.7 for males and 50.3 for females. Comparing the tidal volume for breathing and the lung volume when the phonation was initiated, his data revealed that the phonation volumes were slightly more than the tidal volume for life purposes.

For many years, speech breathing has been studied to diagnose specific disorders such as Parkinson's and Alzheimer's diseases or arrhythmia. In a clinical study (Solomon & Hixon, 1993), they compared subjects' breathing patterns with Parkinson's disease (PD) to healthy subjects by measuring the kinematic, spirometric, acoustic, and pressure parameters during resting tidal breathing, reading aloud, and monologue production. The data implied that the experimental group had a more accelerated respiratory rate, greater minute ventilation, and a minor relative contribution of the rib cage to lung volume change than the control group. Another study (Rusz & Cmejla, 2011) was conducted to investigate whether voice and speech disorders were present at early stages of PD and discover the specific characteristics of the PD-related vocal impairment. They also examined PD-related acoustic signatures for the major part of traditional clinically used measurement methods with respect to their automatic assessments. With all these data obtained, they aimed to design new automatic measurement methods of articulation. The study's main finding was that 78% of early untreated PD subjects displayed some form of vocal impairment. Since the disturbances of respiration and phonation caused disruptions in speech prosody and articulation, they claimed that measurement of respiratory parameters could be a successful tool for symptomatic analysis. Apart from Parkinson's disease, breathing patterns were found to be disordered in Alzheimer's disease (AD) as well. For example, it was hypothesized that AD could be more sensitively distinguished with the help of a linguistic analysis rather than with other cognitive examinations by a group of scholars (Szatloczki, Hoffmann, Vincze, Kalman, & Pakaski, 2015). Although they did not precisely measure the respiratory parameters of the subjects in this study, they found that patients spoke more slowly with longer pauses resulting in irregular breathing patterns. Besides, the subjects spent more time finding the correct word, which in turn led to speech disfluency or break messages. Regarding the results of these studies, it can be assumed that healthy people share a regular breathing pattern for speech production. Therefore, an impairment in the respiratory system or a cognitive disorder resulting in a disordered breathing pattern might be the implication of a more severe disorder. Since this assumption comes from the hypothesis that there is a consistent breathing pattern during speech among healthy people, a number of scholars in the past studied how this regular pattern worked. Similarly, this current study investigates the breathing patterns in Turkish reading speech with the aim of finding a regular pattern among healthy readers and offering that pattern as a model for speech synthesis in the future.

2.2. Psychological Significance of Respiratory Variations

Apart from diagnostic analysis, speech studies are also conducted to determine individuals' mental and emotional states. One way of conducting a speech study serving this purpose is to compare the individual's speech rate to what is accepted as typical. A recent study (Barbosa, Madureira, Fontes, & Menegon, 2020) investigated the role of breathing patterns on the emotional content appraisal in two speech styles -singing and reading. The results showed that the breath durations were longer, and the lung volumes were higher in singing rather than reading. They argued that the reason behind the differences between the breathing characteristics between two tasks result from different emotional state of the participants.

In an early study (Goldman-Eisler, 1954), speech rates were calculated for each utterance in a conversation (as the average number of syllables uttered each minute). They found that consistency was confined to long utterances containing 100 syllables or more; however, for shorter utterances, a person's rate varied over five times as wide a range as for long utterances. Additionally, short utterances were generally faster than long utterances. The fast rates of speech that were common in short utterances rarely occurred in utterances of more than 60 syllables long and never in utterances of more than 100 syllables. However, this study did not consider breathing pauses while measuring the average speech rate of the subjects. Therefore, she conducted another study (Goldman-Eisler, 1955) to break down the measure of speech rate into fundamental measures derived from respiration during speech. She claimed that measures of speech-breathing activity might be more directly relevant to the dynamic states of emotion given the importance of breathing for the speech utterance on the one hand and the emotional significance of respiratory variations on the other. In addition to the speech rate measurements of the previous study, this follow-up version included the rate of inspiration (the number of inspirations per minute) and output per breath (the number of syllables per expiration) measurements. The study was conducted with the participation of variously diagnosed individuals in a psychiatry clinic, such as adults of superior intelligence, young female neurotics, one person with schizophrenia. The subjects were asked to participate in interviews or discussions. The results of the study indicated that hyperventilation was the typical consequence of intense emotion and mental disturbance. Although these results are parallel with the results of many psychology studies investigating hyperventilation and emotional state, the data collection method of this study is questionable. Since they did not measure the respiration with the standard equipment, such as pneumography or spirometer, and instead decided the respiration locations by listening to the voice records, the results of this specific research may not be reliable. Since the cause of the hyperventilation might be the structural challenge of the utterance the subjects produced, a linguistic analysis was required to reach these conclusions. Therefore, another study, which included linguistic analysis, was published (Henderson, Goldman-Eisler, & Skarbek, 1965). In this study, they investigated the syntactic and cognitive aspects of both spontaneous and reading speech. The data revealed that the subjects inhaled exclusively at grammatical junctures during reading. Therefore, it could be concluded that the syntactic structure of the language ruled the gaps in speech is vital for breathing. However, in the readings, the proportion of the gaps in which breaths were taken was significantly higher than in spontaneous speech. The pauses were grouped according to their occurring locations:

> "(A) Gaps designated as grammatical junctures. (1) At "natural" punctuation points, e.g. the end of a sentence. (2) Immediately preceding a conjunction, whether (i) co-ordinating, e.g. and, but, neither, therefore or (ii) subordinating, e.g. if, when, while, as, because. (3) Before relative and interrogative pronouns, e.g. who, which, what, why, whose. (4) When a question is indirect or implied, e.g. " I don't know whether I will ". (5) Before all adverbial clauses of time (when), manner (how), and place (where). (6) When complete parenthetical references are made, e.g. " You can tell that the words-this is the phonetician speaking-the words are not sincere "." (pp. 239-240)

In addition to the gaps governed by the grammatical structure of English language, they examined the gaps at the non-grammatical breaks:

"(B) Gaps of non-grammatical breaks: (1) Where a breath occurs in the middle or at the end of a phrase, e.g. " In each of /B the cells of the body /B . . . " (2) Where a breath occurs between words and phrases repeated, e.g. (i) "the question of the /B the economy ". (ii) " this attitude is narrower than that /B than that of many South Africans ". (3) Where a breath occurs in the middle of a verbal compound, e.g. " We have /B taken issue with them and they are /B resolved to oppose us ". (4) Where the structure of a sentence is disrupted by a reconsideration or a false start, e.g. "I think the problem of de Gaulle is the /B what we have to remember about France is, etc."." (pp. 239-240)

Since it is the characteristic of spontaneous speech to display generative hesitation pauses, subjects did not exhibit as many hesitations pauses during reading. Although they provided a list of commonly occurring types of non-grammatical breaks, 31.1% of the gaps they detected were not included in this list. These findings indicated that, hesitation gaps scattered randomly throughout speech instead of following a systematic pattern. Given the fact that individual characteristics of the subjects may easily cause inexplicable gaps during natural speech, the present thesis focuses on reading speech rather than spontaneous speech.

2.3. The Variability of Lung Volumes and Linguistic Locations of Inspirations

In the following years, respiration patterns during speech attracted much more attention. For example, a study was conducted to investigate the variability of lung volumes and the linguistic locations of inspirations during reading speech, using respiratory inductance plethysmography (Winkworth, Davis, Ellis, & Adams, 1994). The study was conducted with the participation of six healthy young women, whose speech data indicated that speech breathing was governed by both physiological and linguistic determinants, which were also correlated with each other. According to this study, lung volumes were significantly higher at louder utterances, longer utterances, and initial breaths. Also, subjects displayed more inspirations at sentence and paragraph boundaries than other locations within sentences. In short, lung volumes were significantly variable over time during reading speech. As an additional study (Winkworth, Davis, Adams, & Ellis, 1995), they examined the variability of lung volumes and the linguistic locations of inspirations during spontaneous speech, applying the same measurement method. In this study, the subjects were asked to perform two spontaneous speech tasks: a conversation with the researcher and a monologue. The speech tasks were designed carefully to maximize the freedom of expression and minimize the emotion and cognitive load. In the conversation condition of the session, the subjects were asked to discuss familiar topics with the researcher, whose participation was designed to maximize the number of the participants' utterances by directing appropriate questions. In the monologue condition, the subjects were asked to speak entirely by themselves on the chosen topic. The results of this study were parallel to the previous one: The linguistic and physiological factors govern a systematic breathing pattern. The data analysis revealed that inspirations during speech mainly were at sentence boundaries or other grammatically appropriate locations. In addition, the data implied that the length of the utterance was another determinant on the lung volume level since longer sentences uttered on a single breath resulted in a greater volume expired, and therefore a lower termination lung volume level. The data also suggested the existence of neural planning for the respiratory system in anticipation of the demands of the utterance. However, the role of the central nervous system, which is to anticipate the length or the type of utterance in order to adjust the lung volume level, was revealed by the previous study.

Winkworth and colleagues were not the only ones comparing the respiration patterns in reading and spontaneous speech. For example, a number of scholars examined the locations of breath inspirations both in reading and natural speech (Henderson, Goldman-Eisler, & Skarbek, 1965). They found that breathing always occurred at structural boundaries in reading speech. However, the spontaneous speech data in this study suggested that only 67% of breaths occurred at those locations. Lieberman (1967) examined the breathing patterns only in reading individual sentences and found that subjects uttered 87% of all sentences in a single expiration. Grosjean and Dechamps (1985) examined the temporal variables of 30 English and French radio interviews to determine the locations and the frequency of breath-pauses in the speech stream. They reported a greater number of breath pauses at the end of sentences than within sentences in both English and French. However, due to the individual characteristics of these languages, 82% of the respiration occurred at the sentence boundaries in French, while this ratio was 76% for English. They also pointed out that breath pauses were significantly longer than non-breath pauses for both languages. In order to test the impact of punctuation on breathing patterns, Fodor, Bever and Garret (1974) examined how the speakers would shape their breathing patterns in a punctuation-free text. They asked the participants to read passages that were typed in groups of five words on file cards. Although they induced artificial boundaries by showing them incomplete sentences on a single card, the speakers rarely breathed at a card boundary that was not also a syntactic boundary. Instead, the inspirations occurred at syntactically appropriate locations. However, only the major linguistic breaks were considered in these studies and no attempt was made to investigate which type of sentence boundary was preferred when inhaling or where inspiration occurred within sentences when the clauses were extended. To provide a response for the unanswered questions left behind by those studies, Conrad, Thalacker, and Schönle (1983) conducted a study to investigate coordination of speech and respiration mechanisms applying a linguistic analysis. Claiming that speech utterance was not only interrupted for gas exchange but also for reasons unique to speech-generating system itself, they asked the following questions:

> "Which higher-order central mechanisms (apart from the need of oxygen supply) determine the need to breath anew during speech? Which factors control the timing and the amount of inspiration? Which factors determine the duration of expiration? How important are the effects of linguistic structures on the organization of the speech breathing pattern?" (p. 220)

They collected the data from 15 healthy medical students and measured the respiration with a chest pneumograph while the subjects performed the required tasks. Each subject was asked to read aloud eight different brief texts projected on a screen. Those texts consisted of 16 sentences, which contained around 100 syllables, arranged in eight lines. However, the formal structure of the texts was varied systematically. Both text-1 and text-2 were divided into four paragraphs containing equal number of sentences. They separated the sentences in text-1 by a full stop while the sentences in text-2 were separated by the conjunction ‘and’ or a ‘comma’. The remaining of the texts were offered as single paragraphs containing equal number of sentences. While all the sentences in text-3 were separated by a full stop, they used the same punctuation to separate every two sentences (these two sentences were connected by an ‘and’ or a ‘comma’.) in text-4. As for text-5, a full stop was used to separate every three sentences connected with each other by the same conjunctions as in previous texts. There were no full stops in text-6 and each sentence was followed by an ‘and’ or a ‘comma’. Text-7 was not divided into sentences at all but formed one long continuous sentence of 100 syllables. Text-8 had the same structure as text-6, but all blank spaces between words were filled by a series of x’s (i.e. xxx). They designed the reading tasks in this way in order to examine the effect of structural variation upon speech breathing pattern. The data suggested that there was a significant difference between the strength of the text positions in terms of requiring a re-breath. Besides, they found that a new inspiration was never located within a sentence but rather occurred at the beginning of a new sentence. Comparing the breath amplitudes showed that the participants chose the ‘paragraph + a full stop’ as the most preferred stimulus to re-breath, followed by ‘a full stop’, ‘and + comma’, ‘comma’, and ‘and’ respectively. Although these results shows that linguistic factors such as the structural organization of the text had a significant effect on the respiration locations and breath volume, it does not answer the question which kinds of phrase boundaries are preferred over each other.

In contrast to Conrad et al (1983), several studies focused on the phrase boundary types in terms of speakers' preferences for rebreathing. Grosjean and Collins (1979) studied the relationship between linguistic structure and breath pauses in a variable-rate reading task. The difference between patterns followed by the breath pauses and non-breath pauses at varying rates of speech was also analyzed in this study. By requiring the subjects to read at various rates, they also inquired into whether inhalation controls, or is subservient to fluent pausing. They offered a 116-word passage to the subjects to obtain five different reading rates. The breath data was collected by monitoring rib-cage contraction and expansion with a pneumograph. In order to separate breath pauses from non-breath pauses, they used oscillographic tracing of the subject’s breathing, displayed on the second channel of the oscillograph. When it comes to the linguistic analysis, they used seven syntactic boundaries: “The sentence boundary, the break between two conjoined sentences, the break between an adverbial or prepositional phrase and the preceding or following NP or VP, the NP-VP breaks, the breaks inside the NP subject or object, the breaks inside the VP, and finally the breaks within adverbial or prepositional phrases” (p. 103). For each of these categories, all breath pauses, and non-breath pauses were counted and their durations were averaged across readings and subjects. They reported that physiological need of breathing did not control pausing patterns and there were as many NBPs as BPs at slow rate. When it comes to the normal rate, one-fifth or all pauses were NBPs. Physiological need to breath took over control only at the fastest rate. On average, all types of pauses decreased when speech rate increased. The data also suggested that the durations of the breath pauses were longer than non-breath pauses. This was either due to that breathing takes more time than pausing without breathing or that breathing occurs only at major syntactic boundaries which requires the speaker to wait more before starting the following utterance. Apart from the major syntactic boundaries, respiration also occurred within sentences when the rate was quite slow. Although the authors of this study claimed they challenged the very strong claim that speakers only paused to inhale, the definition of non-breath pauses is quite controversial in the literature.

Godde, Bailly, Bosse (2021) investigated how children develop the ability to use pauses during oral reading. They compared the breathing patterns of young French-speaking students to adult readers and found that the youngest students performed more ungrammatical pauses, displayed more breath frequency, and produced deeper inhalations. When it comes to the eldest ones in the young reader group, their proficiency for pause planning was almost at the adult level. These results indicated that pause planning is a cognitive process and is acquired in stages. In order to avoid the effect of these individual differences, such as age, between the participants, this current study was conducted with only adults.

2.4. Breath Pauses, Non-breath Pauses and Silent Pauses During Speech

Sweet (1877) and (1890) was the one who first identified the pause as a unit of the language system in the phonetics literature. He approached the problem from a physiological angle by relating pauses to breathing. After him, a number of other scholars (Viëtor, 1898) related silent pauses to breathing which is a physiological necessity (Gyarmathy, 2018). Jones (1922) approached the problem from a different perspective and offered that there was a distinction between breath pauses, which served the physiological necessity, and non-breath pauses, which were meant to make the message clearer. Hegedüs (1953), published a comprehensive paper based on empirical research that discussed pauses. He claimed that there was no doubt on the connection of pauses with breathing; however, he also pointed out that the primary function of breathing during speech was not biological. Rather, he claimed that breathing was controlled by the way thoughts were conveyed. Regarding the human evolution, the physiological necessity of breathing is associated with a high-level conscious form of activity, which is human speech. He contradicted to what previous phoneticians had thought by claiming that the solely explanation for occurrence of pauses could not be biological needs (Gyarmathy, 2018).

Trouvain, Fauth and Möbius (2016) conducted a study comparing the breath and non-breath pauses in fluent and disfluent phases of German to French, L1 to L2 read speech. 20

German and 20 French native speakers read the same text in their native and non-native language. The data revealed that subjects displayed more frequent pauses and disfluencies in the text written in their non-native language. In addition, this study suggested that speakers determine the pause locations in their native languages in the same way for both languages. The general pattern of pausing in native speech is that breath pauses were used for marking higher syntactic-prosodic breaks while non-breath pauses were used for within sentence breaks. Since pauses play a significant role for fluency measurement, the results of this study can be used to assess the proficiency level of the speakers in their L2.

Gyarmathy (2018) studied the silent pauses in Hungarian spontaneous speech and hypothesized that silent pauses had specific functions and that the various types of these pauses differed from each other in terms of frequency and duration, which were determined by their syntactic positions. They differentiated the silent pauses occurring within phrases or phrase boundaries from the others functioning as editing phases. The syntactical silent pauses in the study, was subcategorized as follows: (1) phrase boundary pauses, (2) within phrase pauses, (3) end of phrase pauses, and (4) utterance onset pauses (p. 53). The subcategories of the editing phases depend on the type of disfluency surrounding the silent pause at hand. Gyarmathy explains how the categorization works as follows:

"In the present investigation, we identified the following types of editing phases: (a) repetitions, (b) restarts, (c) false starts, (d) false words, (e) anticipations, and (f) cases of pause in word. We subcategorized syntactical silent pauses having a segmentation function (S) in terms of their positions within the utterances. We distinguished utterance onset pauses (S_Uo) occurring at turn-taking when the current speaker began talking; such pauses may be preceded at most by a contentless expletive or a discourse marker. Silent pauses at phrase boundaries (S_PhrB) are ones that occur at phrase boundaries within virtual sentences (Gósy 2003b), often before or after conjunctions. We labelled pauses occurring within a grammatical unit ("clause") as within phrase pauses (S_PhrW). Finally, end of phrase pauses (S_PhrE) are silent pauses occurring after virtual sentences, where the speaker begins a new virtual sentence, often a new unit of thought." (p. 58).

Similarly, this current study categorized the breath locations according to their syntactic positions. However, the numbers of breaths taken at different syntactic position categories varied due to the differences between the levels of syntactic complexities of the texts.

2.5. Syntactic Complexity and Breathing

Main purpose of this thesis is to analyze the breathing patterns of Turkish speakers during reading speech and spot the linguistic locations and the frequency of the respiration throughout various reading tasks consisted of reading two syntactically simple, two syntactically complex and two syntactically middle-complex texts. There are similar studies investigating the effect of text complexity on the breathing pattern in the literature. Fuchs, Petrone, Krivokapić and Hoole (2013) conducted two experiments to explore the effect of utterance length and syntactic complexity of an upcoming utterance on two acoustic parameters (pause duration and the initial fundamental frequency peak) and two respiratory parameters (inhalation depth and inhalation duration). In the first experiment, they asked the participants, who were native speakers of German, to read sentences of different length and syntactic complexity. They examined the data on the basis of four phonetic parameters and found that although sentence length had a significant effect on pause duration, inhalation depth and inhalation duration, syntactic complexity did not have a major effect on those parameters. As for fundamental frequency peak (f0 peak), it was not affected by the experiment conditions. Therefore, they hypothesized that the initial f0 peak was only sensitive to length manipulations of the first constituent. To test this assumption, they conducted a second experiment in which they asked the subjects to read utterances varying in length of the first (short, medium, long) and last syntactic constituent (short and long). The data suggested that f0 peak is influenced by the length of the first constituent of the upcoming utterance. Their main conclusion from this study was that the pause duration and respiration parameters are global for planning the upcoming utterance, while the f0 peak was tailored in accordance with the upcoming constituent.

2.6. Human-Robot-Interaction Design and Breathing

The term "Robot" is drawn from an old Church Slavonic word, robota, which means arduous work and was used by the Czech playwright, novelist, and journalist named Karel Čapek for the first time in 1920 in his work R.U.R. (Rosumovi Umělí Roboti). This highly influential play begins in a factory that produces *roboti*s with artificial flesh and blood rather than machinery. These robots are also equipped with flawlessly designed artificial intelligence. At first, they work for their human masters with obedience; however, at the end of the play, a robot rebellion rises and leads to the extinction of the human race. In the following years, a more optimistic opinion of robots started to develop, and the robots were introduced as helpful servants of humans. In 1942, Russian-born American science-fiction writer Isaac Asimov proposed the relieving "Laws of Robotics" and promoted the idea of cobots (collaborative robots) in the industry. Although industrial robots designed with programming expertise became highly common in various manufacturing sectors towards the 2000s, the emergence of cobots arrived in the early 2000s. By definition, cobots differ from industrial robots that generally work in traditional safety cages and are designed for direct interaction with human workers (STEİN & Kaivo-Oja, 2020). Although these workmates have a positive influence on productivity and function to minimize human workers' physical/cognitive load, nearly all commercial cobots are designed solely as robotic operators with no support for human-robot interaction (Terzioğlu, Mutlu, & Şahin, 2020).

The number of applications for developing robots to perceive them as capable creatures or partners rather than tools is on the increase. However, there are controversies on how to meet this need of humans. Although some scholars state that designing human-like robots would be bothersome due to the uncanny valley phenomenon, some believe that equipping the robots with human-like features without upgrading their appearance would intensify the relationship between humans and robots. In an attempt to enhance cobots with HRI capabilities and improve their communication with and perceptions by human collaborators, Terzioğlu, Mutlu, and Şahin (2020) investigated the effects of social cues on collaborator perceptions of the robot. The principles they chose to focus on were Appeal, Arcs, and Secondary Action to extend the robot's ability to signal its task intent and internal states. In order to improve Appeal, they manipulated the physical appearance, posture, and gaze by creating a head-on-neck morphology. To utilize Arcing, they generated smooth trajectories for the robot arm. When it comes to the Secondary Action, they added breathing motions to the robot. By conducting two user studies, the effects of these modifications on the user experience were evaluated. Although the analysis showed no impact of the Appeal factor on any of the measures, they found that breathing had a significant positive effect on the measures such as perceived intelligence, likeability, social presence, perceived sociability, intention to use, anxiety, attitude, perceived adaptability, perceived enjoyment, anthropomorphism, and animacy. Finally, Arcing factor was found to affect measures of likeability, anthropomorphism, and animacy significantly positively. In summary, incorporating Secondary Action to cobots, even during the periods when the robot is idle, can significantly improve the perception of the cobots.

In another study, personality design in a non-anthropomorphic voice-assisted home robot was explored (Whittaker, Rogers, Petrovskaya, & Zhuang, 2021). They assigned three distinct robot personas: Butler, Buddy, and Sidekick, intended to differ in proactivity and emotional impact. The distinctions between personas were indicated to users by combining humanoid (speech, intonation) and indirect cues (colors and movement). The different personas also had different breathing and reactive cadences. The results showed that the participants were mainly able to identify underlying personality types attributed through cue combinations. Although the study explained the decision process on creating the personalities and stated that they used Big Five personality theory and conducted a Wizard of Oz study, they did not provide any information on how they designed the breathing patterns of different personalities. Besides, the specific effect of breathing was not mentioned in the study.

In addition to studies exploring the effect of the robot's breathing, others investigate the turn-taking patterns while talking to a robot. For example, Skantze, Hjalmarsson, and Oertel (2014) manipulated turn-taking cues such as completeness and filled pauses in the robot's speech as well as gaze behavior. The study showed that the users benefit from both robot's gaze and verbal behavior while taking turns. However, these studies do not include the respiratory cues for turn-taking investigations. Besides investigation, several studies have looked into generating appropriate behaviors, such as altering prosody, gaze, and gestures to promote turn-taking. Although they manipulated particular elements in speech, they did not equip the robots with respiration. Even if the effect of respiration was not analyzed in these studies, the related literature is of importance since enhancing the HRI designs by including the respiration effect is one of the aims of this current thesis study.

There were also attempts to model human-like talking robots by designing the physical machinery of the respiratory system. For example, a group of scholars (Nishikawa, Asama, Hayashi, Takanobu, & Takanishi, 2001) conducted a mechanical design study to clarify the human vocal mechanism from an engineering perspective by simulating the vocal movement with a robot. The model experimented only on Japanese vowels, and the results showed that f1 and f2 frequencies of all vowels were similar to the human averages. However, the sound was not natural. Besides, this study is lacking the realization of consonant sounds.

Although the literature offers a number of studies on breathing patterns during reading speech with a linguistic analysis, this is not a well-established domain of research in speech generation and relevant fields of research recently. In particular, the studies focusing on respiration generation are quite limited. Moreover, due to the differences among the linguistic structure of various languages, the findings of the previous studies may not apply to Turkish language. Text complexity works in a more subtle way in Turkish compared to English, which most studies examined. Therefore, this present study aims to investigate the effect of text complexity on breathing pattern during reading speech in Turkish. In addition, it offers a breathing pattern while reading Turkish for future work such as implementing the respiration pattern in robot speech.

CHAPTER 3

3. METHODOLOGY

This study investigates the effect of linguistic structure on breathing patterns during reading speech in Turkish. There are two main questions in terms of the relationship between the linguistic structure and respiratory parameters:

1. Does sentence complexity influence the frequency of re-breathing during reading in Turkish?
2. If sentence complexity has an effect on the breathing patterns, which types of phrase boundaries in Turkish are preferred by the speakers to precede re-breathing?

To answer these questions, texts of various syntactic complexity levels (see appendix A) was offered to the participants to read aloud in a random order. The stimuli consisted of six texts (298-310 characters): two simple texts, two complex texts, two middle-complex texts. The complexity of the texts was determined according to the ratio of the sum of subordinate and coordinate sentences to the whole text as suggested by Beaman (1984).

Each text was offered to the participants as different sessions. Therefore, the experiment consisted of six sessions and three conditions: Reading two simple texts aloud, Reading two middle-complex texts aloud, Reading two complex texts aloud.

3.1. Material and Procedure

Before starting the experiment, a consent form (see appendix B) was introduced to the participants. Each participant took part in all the sessions in the experiment; however, the data collected from three participants was not used in the analysis due to technical problems occurred during the experiment. A trial session was applied to each participant to check their tidal volume, respiratory rate, and speech rate. Tidal volume refers to the amount of air that humans inhale or exhale with each respiratory cycle. It measures approximately between 400 mL – 500 mL in healthy adults. When it comes to the respiratory rate, it refers to the number of breaths taken per minute. Speech rate (number of syllables uttered per minute) of the participants was also measured to recognize the individual differences. These measurements showed that none of the participants were in the non-normal population.

3.1.1 Condition 1: Reading the Simple Texts Aloud

Although the texts appeared on the screen in a random order, the participants always started the experiment with a simple text. Since reading the simple texts does not overwhelm the participants in deciding where to re-breath, it has been estimated that beginning with a simple text is more convenient for the participants to warm up for the tasks.

The first experimental condition, which was reading aloud the simple texts, aimed to identify the basic breathing patterns of the speakers when there were no structural complexities to affect the central nervous system on deciding where to re-breath. The first simple text, a short story from a children's book, consisted of 299 characters with 49 simple sentences, 15 complex sentences. The second text had 310 characters with 44 simple sentences and 12 complex sentences. In both texts, the sentences' length and structure were manipulated to prevent the physiological need of breathing before the sentences came to an end. In order to determine the physiological limits of the participants, a trial session was applied before the experiment started. A short piece from the first simple text is as follows:

“Yeryüzü yeşil olur. Papatyalar açar hep. Kelebekler renkli olur. Çiçeklere uçar hep. Bir varmış ama iki yokmuş. Üç varmış ama dört çok çokmuş. Develer ile cüceler masallarda kalmış. Ejderhalar uzaklara doğru koşarmış. Ejderhasız masala başlanır mı? İşte bizim masal da tam burada başlamış. Çocuklar masalcının kapısını taşlamış. Masalcı da masalı anlatmaya başlamış. Evvel zaman içinde bir papatya varmış. Yeşil çimlerin üzerinde, bir tarlanın içinde açmış. Orada ne aradığını bilmiyormuş. Etrafta pek komşusu da yokmuş. Kendisinden biraz uzakta birkaç papatya daha varmış. Ama sesi çok cılızmış. Diğer papatyalara ulaşamıyormuş. Birgün sabahtan akşama kadar bağırmış. Ama kimse papatyayı duymamış. Ne kadar şanssız bir papatyayım diye düşünmeye başlamış. Tam o sırada bir ses duymuş. Etrafına bakınmış. Sağına soluna dönmüş. Kimseyi görememiş. Birdenbire burnunun ucunda bir çift göz ile karşılaşmış. Önce korkmuş. Sonra bu iki gözün bir kelebeğe ait olduğunu anlamış. Kelebek demiş ki “ben seninle tanışmaya geldim. Tanışmışlar, kaynaşmışlar ve arkadaş olmuşlar. …” (Karacan, 2017)

3.1.2 Condition 2: Reading the Middle-Complex Texts Aloud

The second experimental condition aimed to investigate the variance in the breathing patterns when the participants read more complex and longer sentences compared to the first condition. However, the length of the sentences in these two texts was not beyond the limits of the participants' physiological needs. The first middle-complex text consisted of one paragraph, 299 characters, and 54 sentences (30 simple sentences, 24 complex sentences). The second one included one paragraph, 298 characters, 44 sentences (26 simple sentences, 18 complex sentences). Both texts were from the books of well-known Turkish authors. A short piece from the first simple-to-complex text is as follows:

“İşsizlik kötü şey vesselam. Bunu da yalnız aç kaldığım zamanlar düşünüyorum. Can sıkıntısından bunaldığım sıralarda da düşünsem ya. Olmuyor. Bu bahçeye de hep böyle zamanlarımda gelirim. Neden acaba? Etraftakilerin de çoğu işsiz. Bu bahçe sadece kaderleri bu yolda ortak olanları mı çekiyor dersiniz? Olabilir. Vakit öğleyi geçiyor. Açlıktan bahsettim ama pek de aç değilim. Bununla beraber, neden bilmem, etraftakilerden utanıyorum. Herkesin yemeğe gittiği bir saatte benim, parasız pulsuz buralarda dolaşmam bir suçmuş gibi geliyor bana. Boş sıralardan birine oturdum. Cigaram var. O da olmasa felaket. Bilmem ne dağındaki petrol arama kampında bir iş teklif etmişlerdi. Gitseydim kötü mü olurdu sanki. Enayilik işte, parayla pulla değil ki! Bir odam olurdu. Ev kirası da düşünmezdim. Yemek parası düşünmezdim. Sabahları acı kahvemi içebilir, öğle akşam yemeklerini kampın tabldotundan yiyebilirdim. Tabldotu düşünür düşünmez karnım guruldadı. Acıkmışım. Şu yemek denilen şey de tuhaf bir şey. İnsanlar neler icat etmişler! …” (Kanık, 2012)

3.1.3 Condition 3: Reading the Complex Texts Aloud

The third experimental condition, which required participants to read highly complex texts aloud, aimed to identify the participants' breathing patterns when they came across sentences beyond their physiological needs or shorter than those. The first complex text consisted of one paragraph, 307 characters, and 22 sentences (five simple sentences, 17 complex sentences). The second one consisted of one paragraph, 308 characters, 35 sentences (10 simple sentences, 25 complex sentences). Both texts were from the books of well-known Turkish authors. A short piece from the first complex text is as follows:

“Bu yerlerde, eski mahallelerdeki gibi çeşit çeşit başlıklı, sarıklı, tuhaf görünüşlü, esrarlı yıkıntı mezar taşlarıyla dolu mezarlıklar yoktu. Tıpkı büyük fabrikalar, askeri kışlalar, hastaneler gibi yüksek beton duvarlarla çevrili, servisiz, ağaçsız yeni ve modern mezarlıklar bütün bu mahallelerin dışındaydı. Tahsildar Mevlut’u sabahları sokaklarda sinsice takip eden köpekler, mezarlıksız bu mahallelerde geceleri Atatürk heykelinin karşısındaki çamurlu parkta uyuyorlardı. Köpekler en çok, Mevlut’un iyi niyetlerle gittiği, şehrin yeni gecekondu mahallelerinde saldırganlaştılar. Sayaçları yeni bağlanmış, defterleri yeni dosyalanmış sokaklarda Mevlut mutsuz saatler geçirdi. Şehrin merkezinden, çevreyollarının altından geçen otobüslerle iki saatte gidilen bu yerlerin çoğunun adını bile yeni duyuyordu. Otobüsten inince Mevlut şehirlerarası yüksek elektrik tellerinden göz göre göre çekilen kaçak hatları, ya da otobüs durağının karşısındaki dönercinin çektiği acemi kaçakları “iyi niyetlerle” görmezlikten geliyordu. Bu mahallelerin bir ağabeyleri, bir reisleri olduğunu, gözlendiğini hissediyordu. Kararlı, düzgün, ilkeli haliyle Mevlut onlara, “Ben yalnızca resmi sayaçlarla meşgulüm.” demek istiyordu. “Benden korkacak bir şeyiniz yok.” …” (Pamuk, 2014)

3.2 Measuring Breathing During the Experiment

The breathing parameters were measured with impedance pneumography. The *Shimmer3 ECG Unit* measures the impedance across the chest, using adhesive ECG electrodes[1]. During the inhalation/exhalation phases, this impedance increases/decreases, respectively. The impedance change is correlated to the volume of air that is inhaled. Although the device offers five electrodes (See Figure 1), only three ECG electrodes was used in this experiment for the measurement since two of them were not required for respiration measurement: The reference electrode was placed on the top of Right Leg, Left-Mid Axillary electrode was placed on the top of the mid-axillary line, on the left side of the body, and lastly Right-Mid Axillary electrode was placed at the same location on the right-hand side of the body.

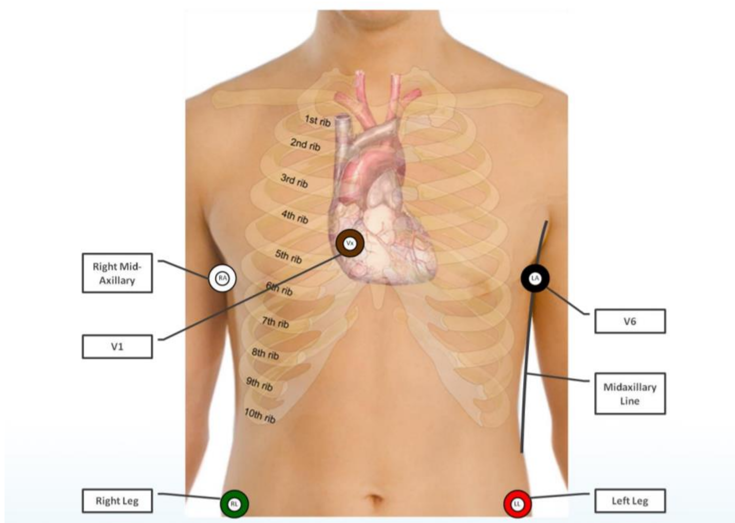

Figure 1 Recommended Electrode Placement During the Experiment[2]

The output is a waveform of the respiratory signal. As the speakers inhale, the lung volume increases; when they exhale, the volume of the lungs decreases. This fluctuation can be clearly seen in the respiratory signal as in Figure 2. The subject displayed this breathing pattern was asked to perform the following actions: breathing normally for almost 80 seconds, followed

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[1] http://www.shimmersensing.com (Shimmer Research)

[2] From the "ECG Respiration User Guide" Shimmer Research, 2018, p.6.

by three pronounced inhalations and exhalations, followed by another 30 seconds of normal breathing, followed by three pronounced inhalations and exhalations.

As a result, the tidal volume of the three pronounced inhalations and exhalations are larger than normal breathing as seen in the figure. Similarly, participants display a larger tidal volume when they decide to breath during reading aloud.

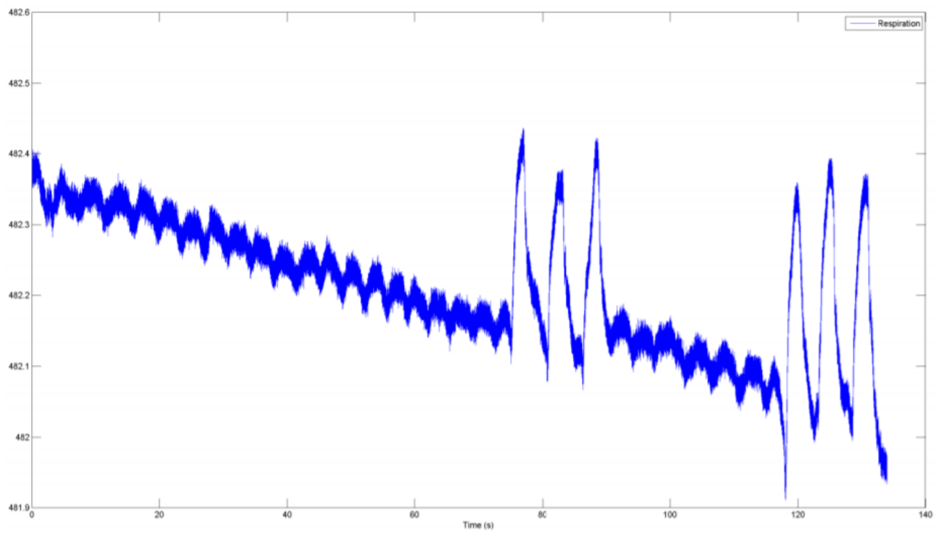

Figure 2 Respiratory Signal[3]

3.3 Participants

Twenty-three subjects (11 females) with the mean age 27,3 took part in the study; however, three of the 23 data set was eliminated during the analysis due to low data quality. All subjects have a bachelor's degree and have graduated from a high school of which medium of instruction was their native language, Turkish. Two subjects notified the researcher about the chronic asthma disease they suffered from. Besides this, one subject stated that he recovered from stuttering. However, since they displayed perfectly regular performances in the trial session, those disorders were ignored during the analysis.

[3] From the "ECG Respiration User Guide" Shimmer Research, 2018, p.12.

3.4 Technical Specifications of the Collected Data

The left column in the Table 1 includes the list of the data taken from the experiment. The right column includes the description of the data and some further information on how the data was collected.

Table 1 All the data that were collected during the three phases of the experiment

1. Tidal Volume	It is the amount of air that human inhale or exhale within each respiratory cycle and is measured with impedance pneumography.
2. Time	It is directly kept by the sensing device and is used to identify the locations of the re-breathing throughout the texts.
3. Voice Record	The software specifically designed to read the data from this device does not have sound record function. In order to synchronize the respiration data with the voice record, a MATLAB code has been generated. This data has been used for linguistic analysis.
4. Respiratory Rate	It is the number of breaths taken per minute. This data was collected at the beginning of the experiment, during the trial session to see if the participant displays any kind of abnormalities.
5. Speech Rate	It is the number of syllables uttered per minute. This data was also collected during the trial session. Speech rate and respiratory rate were examined together to detect the participants that may take part in non-normal population.

3.5. Analysis

The data was collected from all experimental conditions. Each participant was required to read six texts. For each text, respiration and voice record data were obtained simultaneously and as separate output files. Therefore, 120 respiration and 120 voice record data were analyzed in this study.

3.5.1 Respiration Analysis

When analyzing the respiration data, the tidal volume was used. The significant increase points of the lung volume were considered as the breath-taking locations during reading. Although the initial lung volume was always the highest for all participants, significant increases could also be observed throughout the act of reading. As can be seen in Figure 3, the participant started reading with a lung volume of 479.3 mVolts and ended reading with a lung volume of 478.8 mVolts. The decline between the breath-location points refers to the act of reading.

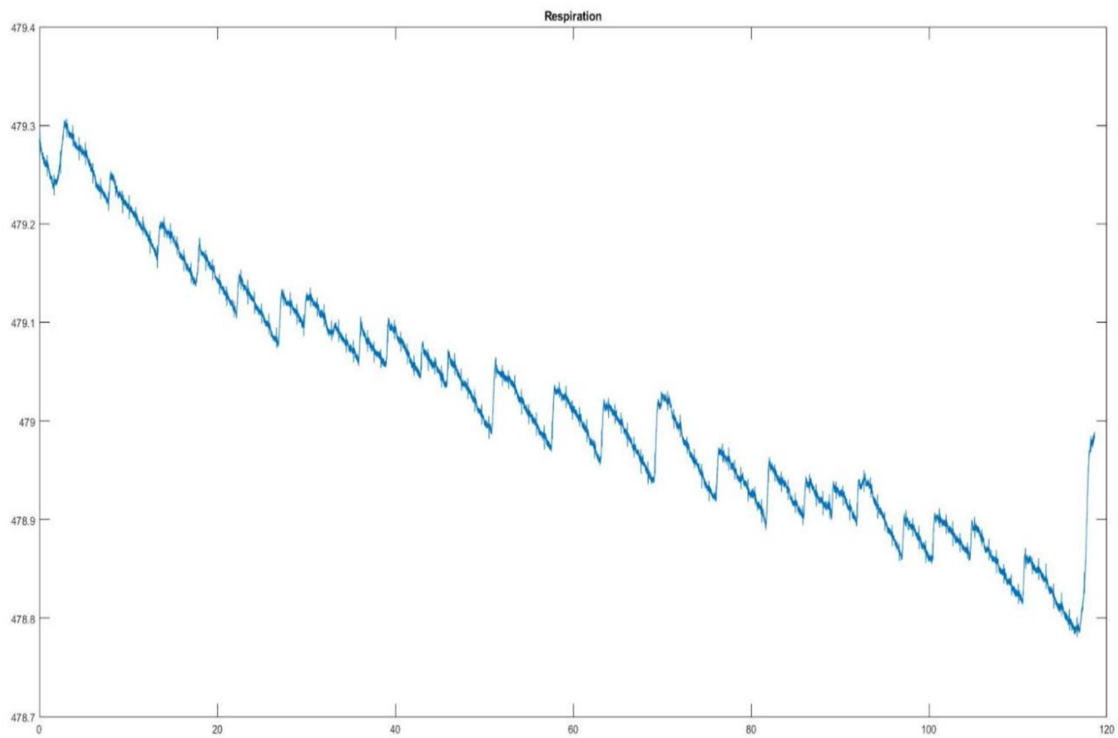

Figure 3 Respiratory Signal of Participant 2 During Reading

The x-axis of Figure 3 represents time and is synchronized with the voice record data. After detecting the corresponding time for the increases of the lung volume, the breath locations were marked on the voice record data enabling the linguistic analysis.

3.5.2 Linguistic Analysis

This study included six different texts of 3 diverse categories for the participants to read aloud. The divisions of the texts were determined regarding their syntactic complexity rates. In order to avoid generating erroneous hypothesis, more than one text was used in each case. Thus, there were two simple texts, two complex texts, and two others with an intermediate level of complexity.

The breath locations of each participant for each text were identified using the respiratory signal. Then, those locations preferred by the participants were classified according to their syntactic functions, as can be seen in Table 2. However, the classes in the table did not constitute all the boundaries preferred for re-breathing, and only the most preferred ones were included in the analysis.

Table 2 The syntactic categories of the breath-taking locations

Breath Locations	**Description**
Full sentence	Breaths taken after a full sentence
Independent sentence	Breaths taken after an independent sentence which is followed by another independent sentence
Dependent sentence	Breaths taken after a dependent sentence which is followed by a main clause.
Subject	Breaths taken after any phrase that are in the subject position Breaths taken after the subjects followed by an adverb, a noun (i.e., object)
Series of words	Breaths taken before commas conjoining words or word groups

3.5.3. Statistical analysis

The numbers of breaths taken reading each text was calculated and recognized in two excel sheets with the description of the independent variables. Since the same entities participated in all conditions, a one-way analysis of variance (ANOVA) with repeated measures and a multivariate analysis (MANOVA) were conducted to detect the differences between each condition.

There were two goals of this study. The first goal was to see the effect of the text complexity level on the breathing frequency the participants displayed. The second goal was to understand the effect of text complexity on the participants' decisions for breath location. Basically, it was about the distribution of respiration in three different conditions: simple text, middle-complex text, complex text. In addition to these conditions, an additional condition, in which the participants read the same texts without punctuation marks, was introduced to 4 participants. However, the data collected from this condition was not analyzed statistically. Apart from this data collected manually, the excel sheets were processed with JASP2 (JASP 2019, Version 0.10.2) by ANOVA and MANOVA, respectively.

The ANOVA analysis was conducted with three factors, namely, the numbers of breaths taken at simple text condition, middle-complex text condition, complex text condition. Since the participants read two texts in each condition, the numbers of breaths taken reading each text were summed, and the total numbers were included in the analysis. Before the ANOVA conducted with the first excel sheet, a one sample t-test was conducted to test the assumption of normality of the data.

The MANOVA analysis was conducted with five dependent variables, which were the phrase boundary types, and 1 independent variable which was the text type. The data processed with MANOVA was also processed with separate univariate ANOVA to see effects of text type on the breathing scores. Moreover, descriptive statistics was obtained from the same date to see the differences between the numbers of preferred phrase boundaries.

The results of these analysis are reported in Chapter 4.

CHAPTER 4

RESULTS

In the third chapter, the research questions of the present study and the methodology were presented. This chapter reports the results of the data analyses. The first research question was:

1. Does sentence complexity influence the frequency of re-breathing during reading in Turkish?

The second question was:

2. If sentence complexity has an effect on the breathing patterns, which types of phrase boundaries in Turkish are preferred by the speakers to precede re-breathing?

Question 1: Does sentence complexity influence the frequency of re-breathing during reading in Turkish?

Since the same entities participated in all conditions, a one-way analysis of variance (ANOVA) with repeated measures was conducted to determine and compare the means of the total number of breaths taken reading each category of the texts. Before that, the assumption of normality was tested. Table 3 shows that the data was normally distributed for each measurement.

Table 3 Test of Normality (Shapiro-Wilk)

	W	**p**
numbers of breath taken simple	0.98	0.98
numbers of breath taken middle-complex	0.97	0.79
numbers of breath taken complex	0.95	0.45

Table 4 shows that, on average, the number of breaths taken while reading the simple texts were more than the amount consumed during complex text. These results reject the null hypothesis that sentence complexity does not influence the frequency of re-breathing during reading in Turkish. The data explicitly illustrates that the number of breaths decreased as the text complexity increased.

Table 4 Descriptive Statistics of the Breaths Taken in Three Conditions

RM Factor 1	Mean	SD	N
complex	75.1	15.7	20
middle	78.3	14.9	20
simple	84.9	14.4	20

Table 5 shows that the data violated the assumption of sphericity according to Mauchly's Test of Sphericity, $\chi 2(2) = 6.846$, $p < 0.05$. In other words, variances of differences between all related conditions were not equal for this data. However, departure from sphericity was not severe according to Table 6, which shows that The Huynh–Feldt estimate of the departure from sphericity was $\varepsilon = 0.812$. In summary, the amount of breaths taken during reading was significantly affected by the complexity level of the texts, $F(2, 30.85) = 6.47$, $p = 0.007$, $\eta^2 = 0.25$.

Table 5 Mauchly's Test of Sphericity for the Breaths Taken in Three Conditions

	Mauchly's W	Approx. X^2	dfSphericity	p-value	Greenhouse-Geisser ε	Huynh-Feldt ε	Lower Bound ε
Text_Type	0.68	6.84	2	0.03	0.76	0.81	0.50

Table 6 Sphericity Correction for the Breaths Taken in Three Conditions
Within Subjects Effects

Cases	Sphericity Correction	Sum-of-Squares	df	Mean Square	F	p	η^2	ω^2
Text_Type	Greenhouse-Geisser	997	1.51	656	6.47	0.008	0.25	0.058
	Huynh-Feldt	997	1.62	614	6.47	0.007	0.25	0.058
Residuals	Greenhouse-Geisser	2926	28.9	101				
	Huynh-Feldt	2926	30.9	94.8				

In order to understand the differences between the effects of each text type, tests of within-subjects contrast were conducted. Table 7 shows that the number of breaths taken reading simple texts were significantly more than the breaths taken during middle-complex texts, $p<0.05$ and complex texts, $p<0.05$, but that the effects of middle-complex texts and complex texts on breathing frequency were roughly the same, $p=0.265$.

Table 7 Comparison of the Effects of Three Conditions on Breathing Patterns

Post Hoc Comparisons - RM Factor 1

		Mean Difference	**SE**	**t**	**P_{holm}**
simple	middle	6.55	1.95	3.35	0.01
	complex	9.80	3.36	2.91	0.01
middle	complex	3.25	2.82	1.14	0.26

Note. P-value adjusted for comparing a family of 3

In a study (Lieberman, 1967), the breathing patterns reading individual sentences were examined, and it was observed that subjects uttered 87% of all sentences in a single expiration. The participants' decisions on breath locations in this current study were similar to Lieberman's because the frequency of re-breathing was the most distinguished in the simple texts among all the others. The simple texts used in this study certainly had more full sentences than the others. While the simple texts have 115 full sentences in total, the middle-complex texts have 98, and the complex texts have 56 full sentences. Although the middle-complex texts and the complex texts included more phrase boundary types to re-breath, breathing after full sentences was the prevalent breath location leading the simple texts to have the highest breath rate.

Question 2: Does sentence complexity have an effect on the types of phrase boundary, and which types of phrase boundary in Turkish are preferred by the speakers to precede re-breathing?

In order to detect the differences between the scores for the phrase boundary types, a multivariate analysis of variance (MANOVA) was conducted. Using Pillai's Trace on Table 8 there was a significant effect of text type on the preferences about which phrase boundary to stop and re-breath, $V = 1.2$, $F(2,108) = 16.183$, $p < 0.05$.

Table 8 The Effect of Text Type on the Breath Location Preferences

Cases	df	Approx.F	Pillai Trace	Num df	Den df	p
(Intercept)	1	203	0.95	4	53	< .001
text type	2	16.1	1.19	8	108	< .001
Residuals	57					

Similarly, separate univariate ANOVAs on the outcome variables revealed significant effects of text type on the breathing scores for the boundaries of full sentence, $F(2,57) = 22.172$, $p < 0.05$, independent clause, $F(2,57) = 63.79$, $p < 0.05$, dependent clause, $F(2,57) = 13.29$, $p < 0.05$, subject, $F(2,57) = 69.42$, $p < 0.05$, and series of words $F(2,57) = 60.29$, $p < 0.05$ according to Table 9.

Table 9 Separate Univariate ANOVAs on the Phrase Boundary Types

ANOVA: full sentence

Cases	Sum of Squares	df	Mean Square	F	p
(Intercept)	244609	1	244609	1049	< .001
text type	10334	2	5167	22.2	< .001
Residuals	13283	57	233		

ANOVA: independent clause

Cases	Sum of Squares	df	Mean Square	F	p
(Intercept)	2077	1	2077	251.8	< .001
text type	1052	2	526	63.7	< .001
Residuals	470	57	8.24		

ANOVA: dependent clause

Cases	Sum of Squares	df	Mean Square	F	p
(Intercept)	81.6	1	81.6	48.6	< .001
text type	44.6	2	22.3	13.2	< .001
Residuals	95.7	57	1.67		

ANOVA: series of words

Cases	Sum of Squares	df	Mean Square	F	p
(Intercept)	1581	1	1581	154	< .001
text type	1233	2	616	60.2	< .001
Residuals	583	57	10.2		

ANOVA: subject

Cases	Sum of Squares	df	Mean Square	F	p
(Intercept)	220	1	220	201	< .001
text type	152	2	76	69.4	< .001
Residuals	62.4	57	1.09		

4.1 Simple Text Condition

In the simple text condition, the participants were asked to read two texts. One of these texts consisted of 299 characters, 49 simple sentences, 15 complex sentences, and the other text had 310 characters with 44 simple sentences, 12 complex sentences. The total numbers of phrase boundaries of interest in those texts are shown in Table 10 below.

Table 10 Total Numbers of Phrase Boundaries of Interest in Two Simple Texts

Breath Locations	Description	The number of boundaries in the text
Full sentence	Breaths taken after a full sentence	59+56= 115
Independent sentence	Breaths taken after an independent sentence which is followed by another independent sentence	12+8=20
Dependent sentence	Breaths taken after a dependent sentence which is followed by a main clause.	6+7=13
Subject	Breaths taken after any phrase that are in the subject position Breaths taken after the subjects followed by an adverb, a noun (i.e object)	More than 115
Series of words	Breaths taken before commas conjoining words or word groups	1+0=1

Table 11 shows the descriptive statistics of the preferred phrase boundary types during the simple text condition. The mean number of breaths taken at the end of a full sentence is significantly more than the other phrase boundary types. Although the simple texts included independent and dependent clauses, subjects, and series of words, the mean number of the breaths taken at those locations was significantly less than the actual number of these phrase boundary types. In other words, the participants mostly ignored these phrase boundaries while reading and decided to take a breath at the end of the full sentences.

Table 11 Descriptive Statistics for Simple Texts

	full sentence	**independent clause**	**dependent clause**	**subject**	**series of words**
Valid	20	20	20	20	20
Missing	0	0	0	0	0
Mean	81.7	1.50	0.05	1.05	0.40
Std. Deviation	13.4	1.05	0.22	1.09	0.82
Minimum	53	0.00	0.00	0.00	0.00
Maximum	112	4.00	1.00	4.00	3.00
Sum	1635	30.0	1.00	21.0	8.00

4.2. Middle Complex Text Condition

In the middle-complex text condition, the participants were asked to read two texts. One of these texts consisted of 299 characters, 30 simple sentences, 24 complex sentences, and the other text had 298 characters with 26 simple sentences, 18 complex sentences. The total numbers of phrase boundaries of interest in those texts are shown in Table 12 below.

Table 12 Total Numbers of Phrase Boundaries of Interest in Two Middle-Complex Texts

Breath Locations	Description	The number of boundaries in the text
Full sentence	Breaths taken after a full sentence	55+43=98
Independent sentence	Breaths taken after an independent sentence which is followed by another independent sentence	24+10=34
Dependent sentence	Breaths taken after a dependent sentence which is followed by a main clause.	16+14=30
Subject	Breaths taken after any phrase that are in the subject position Breaths taken after the subjects followed by an adverb, a noun (i.e object)	More than 98
Series of words	Breaths taken before commas conjoining words or word groups	0+7=7

Table 13 shows the descriptive statistics of the preferred phrase boundary types during the middle complex text condition. The mean number of the breaths taken at the end of a full sentence was significantly more than the other phrase boundary types in this condition as well. Similar to the simple text condition, the second most preferred phrase boundary type was independent clause. When it comes to the third most preferred phrase boundary type, the participants' preferences changed to series of words from dependent clause. This implies that the participants regarded more phrase boundary types while reading than they did in the simple text condition.

Table 13 Descriptive Statistics for Middle-Complex Texts

	full sentence	**independent clause**	**dependent clause**	**subject**	**series of words**
Valid	20	20	20	20	20
Missing	0	0	0	0	0
Mean	71.1	5.40	1.40	0.75	4.55
Std. Deviation	29.1	3.34	0.82	1.25	3.36
Minimum	45.0	2.00	0.00	0.00	0.00
Maximum	187	14.0	3.00	4.00	12.0
Sum	1423	108	28.0	15.0	91.0

4.3 Complex Text Condition

In the complex text condition, the participants were asked to read two texts. One of these texts consisted of 308 characters, five simple sentences and 17 complex sentences, and the other text had 308 characters 10 simple sentences 25 complex sentences. The total numbers of phrase boundaries of interest in those texts are shown in Table 14 below.

Table 14 Total Numbers of Phrase Boundaries of Interest in Two Complex Texts

Breath Locations	Description	The number of boundaries in the text
Full sentence	Breaths taken after a full sentence	22+34=56
Independent sentence	Breaths taken after an independent sentence which is followed by another independent sentence	12+38=50
Dependent sentence	Breaths taken after a dependent sentence which is followed by a main clause.	17+11=28
Subject	Breaths taken after any phrase that are in the subject position Breaths taken after the subjects followed by an adverb, a noun (i.e object)	56+ (more than full sentences)
Series of words	Breaths taken before commas conjoining words or word groups	1+5=6

Table 15 shows the descriptive statistics of the preferred phrase boundary types during the complex text condition. As in the other conditions, the mean number of the breaths taken at the end of a full sentence was significantly more than the other phrase boundary types in this condition. However, participants did not ignore the other phrase boundary types as much as they did in the previous conditions and shaped their breathing patterns accordingly.

Table 15 Descriptive Statistics for Complex Texts

	full sentence	independent clause	dependent clause	subject	series of words
Valid	20	20	20	20	20
Missing	0	0	0	0	0
Mean	46.4	11.4	2.15	4.15	11.2
Std. Deviation	7.62	4.04	2.05	1.04	4.59
Minimum	22.0	4.00	0.00	1.00	2.00
Maximum	55.0	17.0	7.00	6.00	20.0
Sum	928	229.0	43.0	83.0	225

4.4. No-Punctuation Condition: Qualitative Observations

Due to the determinants for the syntactic complexity, the number of different phrase boundary types in the middle-complex and complex texts was more than the ones in simple texts. As a result, the participants came across more punctuation marks in the second and the third condition than they did reading the simple texts. M. B. Parkes (1993) states that the primary function of punctuation is to resolve the ambiguities resulting from the structure in a text and signal distinctions of semantic significance. According to him, without punctuation, conveying the information in a text would be impossible or critically challenging. Regarding the importance of the punctuation marks and the widely accepted statement that written forms -including the punctuation marks- are the secondary symbols of oral speech (Sapir, 1921), punctuations marks were not omitted from the texts in this study. Since these marks helped the readers comprehend the semantic structure of the texts and separate the phrases, they might be playing a role in determining the breathing patterns of the readers. In order to eliminate this question, a fourth condition was introduced to 4 of the participants after the data from the conditions mentioned earlier was collected. However, the data was manually collected at this condition, and statistical analysis was not conducted.

This qualitative data showed that the participants did not reflect the same breathing patterns while reading a punctuation-free text as they did in the aforementioned conditions. However, when they were offered the texts more than once, they started to figure out the boundaries without punctuation marks. While reading the same texts for the fifth time, the breathing patterns of the four participants developed similar to the patterns they displayed in the previous conditions. Although the data collected with this additional condition was not indistinguishable from the actual data, it suggested that the readers tended to separate the phrases and shape their breathing patterns accordingly without external manipulation such as punctuation marks.

CHAPTER 5

CONCLUSION AND DISCUSSION

Communication occurs in several ways when an agent has information to transfer to another. One of these ways is oral communication, which requires human vocalization. Human vocalization is an encoding procedure that deals with the physical planning for message transmission. However, encoding information into sounds is not limited to physical activity but involves particular cognitive abilities such as intonation and breath planning. Similar to intonation, breath planning has been subject to a number of linguistic analyses.

This study investigates how text complexity level influences the breathing patterns of readers while reading aloud in Turkish. Whether the text complexity level influences the frequency of breathing was the first research question. In order to elucidate this question, texts of different complexity levels were offered to the same entities to read aloud. The results revealed that participants tend to inhale more during the simple text condition. Similar to a relevant study (Winkworth, Davis, Ellis, & Adams, 1994), the lung volumes of the participants significantly increased for the inspirations at sentence boundaries when compared to the inspirations at other phrase boundaries within sentences. Since the simple texts included the highest number of full sentences, the respiration rate was also highest in the simple text condition.

Whether the text complexity level influenced the participants' decisions on which location to breathe was the second research question in this study. The measurement for this question was held under the same conditions as the first question. The data revealed that the effect of text complexity level on the dependent variable was significant. While the full sentence boundaries were the most preferred and the independent clause boundaries were the second most preferred breath locations for all conditions, the tendencies for other types of phrase boundaries showed variance. For example, the number of inhalations following the subjects (as a syntactic phrase) in the simple text condition was more than the inspirations performed after the phrases series of words and dependent clauses. On the contrary, the number of breaths inhaled after series of words was higher than the other types of phrase boundaries in both middle-complex text conditions and complex text conditions.

Turkish is a language that allows free constituent order with predominantly head-final syntactic constructions even though the constituent order generally conforms to the SOV order in written texts (Eryiğit, Nivre, & Oflazer, 2008). Besides, it has rich agglutinative morphology, allowing the words to reconstruct meaning through very productive derivation and inflection. Hence, processing the morphological structure of individual units might be a valuable step for sentence parsing while reading. As a result, it is rational to say that the readers may integrate the linguistic information at the end of phrases, where they capture all the inflection and derivation. However, the participants, as expected, did not display respiration at the end of every phrases. Instead, they preferred major phrase boundary locations to re-breath. Since comprehending the message that a sentence conveys requires higher cognitive demands than comprehending smaller phrase units, the coding procedure may focus more intensely on the critical semantic units, which are the actor, action, and the object (Aaronson & Scarborough, 1976). As a result, the most popular respiration location in all texts was full sentence boundaries for all participants. In addition to arguing these two main questions, this study has also aimed to propose a breathing pattern deduced from reading speech in Turkish to be implemented in robot speech in the future. Since one way of enhancing the HRI designs is to improve the verbal communication between humans and robots, it is crucial to propose a cognitively inspired natural language processing system for robots. In order to accomplish this, the way humans process language should be investigated thoroughly. Brick and Scheutz (2007) describes the three characteristics of the human language process as follows: (1) humans process language incrementally, when possible, (2) humans automatically make use of perceivable context in the production and resolution of referential expressions, and (3) humans react both verbally and non-verbally to language as they process it (p. 1). Therefore, the NLP studies focus on providing artificial agents with similar characteristics. However, the cognition of human language is highly complex and full of details to be reproduced. As a result, enhancing the HRI designs proceeds with humble but quintessential steps. Implementing respiration patterns of human speakers in artificial agents is one of these essential steps. As stated previously, breathing during speech meets the speakers' both physiological and cognitive demands. Since exploring the cognitive implications of respiration and generating the robot speech accordingly can offer a more satisfying experience for the human agents and improve the naturalness of the robots along with serving as a non-verbal communication tool, it is vital to implement human-like respiratory patterns to robots.

5.1. Key Findings

The data collected for both questions revealed a significant relationship between the text complexity levels and the breathing patterns during reading speech. However, the difference between the effects of simple texts and the other four texts was higher than the difference between the effects of middle-complex and complex texts. In other words, participants behaved significantly different reading the simple texts than reading the other texts.

The highest number of respirations was observed in the simple text condition. Correlatively, breathing after a full sentence was the top choice of the participants. As expected, the number of breaths taken during the middle-complex text condition was more limited than the simple text condition and more than the complex text condition. Similarly, their tendency level to breathe at other locations than the full sentence was in-between. When it comes to the complex text condition, the participants performed the least breath number compared to other conditions and showed more variance deciding where to breath.

Although the results of this study reject the null hypothesis and offer proof for the effect of text complexity level on the breathing patterns during reading speech, the expected outcomes of the study were that as the complexity level increased, the frequency of the breaths would also increase. However, the data revealed the exact opposite of the expectations. While it was anticipated that the participants would display respiration following most of the commas, subjects, or independent and dependent clauses, it was observed that the participants behaved economically in terms of breathing. Obviously, the participants did not shape their breathing patterns according to their physiological needs since they could read both three words and fifteen words sentences in single respiration. Moreover, they performed inhalations at the end of the three words sentences. This suggests that act of respiration did not follow a random pattern.

5.2. Limitations of the Study

In all conditions, the breathing patterns were definitely affected by the syntactic structure of the sentences according to the respiration data. However, in the punctuation-free condition, where the participants had difficulty figuring out the syntactic structures, the lung movements of the participants were not measured. Therefore, the results inferred from the manual analysis of the voice records may not be accurate. Even if it is, the data was collected from four of the participants, which cannot be the representation of a higher population. As a result, this study has limitations in making deductions about the punctuation effect on the breathing patterns. In order to test the effect of the punctuation, a different group of participants could be offered the same texts without punctuation. In this way, a more reliable comparison analysis could be conducted.

The phrase boundaries in each condition were categorized after the analysis of the respiration data. In other words, the breathing patterns of the 20 participants manipulated the categorization of the syntactic components during the analysis. Although the categories full sentence, independent clause, dependent clause, and subject were expected to be preferred breath locations before the analysis, the series of words category was created after analyzing the respiration data. Although each element in this category was regarded as different categories at first, they were included in a single cluster during the statistical analysis. This cluster contains adjectives, nouns, and adverbs conjoined with commas. The data revealed that the breaths taken at these boundaries were generally where the conjoining commas were. Since a semantic analysis was not conducted to determine the significance of different elements in this category, further analysis is needed to see which element in this category has a more significant effect on the participants' breathing patterns and explain the underlying reason for this preference.

When it comes to the ratio of the phrase boundary types to each other in each category of the texts, it is seen that the texts do not contain the same rate of phrase boundaries which is a determinant for the complexity level. One solution to this problem could be introducing longer sentences with more phrases in the simple text condition, considering that the character number does not affect the breathing patterns. However, including more independent or dependent clauses would affect the complexity level of the texts. Therefore, increasing the number of texts in each condition or introducing longer texts to the participants could be more efficient. In this way, the ratio of the phrase boundaries could be optimized.

The analysis for each condition revealed that the most prevalent breath location for all participants was full sentence boundaries. These results were obtained from the descriptive analysis conducted with the numbers of breaths taken at those locations. However, the duration of the respirations was not included in the analysis procedure. Therefore, to support the comparison analysis results or to bring a new perspective to the study, the duration of the breaths taken at these locations could be compared.

Lastly, this study does not account for the individual differences among readers in terms of their cognitive abilities. However, some explanations are offered about how individual cognitive differences among speakers might affect the speech planning process in the psycholinguistic literature. For example, it has been argued that readers with a low working memory span tend to chunk a text into smaller prosodic phrases (Swets, Desmet, Hambrick, & Ferreira, 2007). Moreover, there are studies examining the effect of cognitive load on the reading process. According to Ferreira and Swets (2002) and Wagner et al. (2010), speakers decrease the scope of planning when the cognitive load increases. These findings suggest that the speech planning process might be flexible among readers.

5.3. Future Work

The effect of punctuation marks on the breathing patterns during reading speech is ambiguous in this study since the qualitative data collected from no-punctuation condition was not analyzed statistically. Therefore, further study can be conducted with additional stimuli, new participants and new data analyzed statistically to explore the effect of punctuation.

The qualitative analysis of no-punctuation condition brings another question: How would the breathing patterns of the readers be affected if they knew the texts before? In other words, knowing the syntactic structure and the message conveyed in the texts might influence the breathing pattern during reading. Since the speakers usually pre-plan and know what they are going to say before starting to speak, their breathing patterns during spontaneous speech might be closer to the breathing patterns they display while reading a text that they already recognize. In order to find a more accurate breathing pattern for spontaneous speech, this investigation can be conducted in a further study.

The complexity level of the texts is one of the most crucial measure in this study. Although the complexity level of the texts was determined applying the widely accepted methods in the literature with careful examination, an independent measure, such as computers, to decide on text complexity might give the most accurate results. In addition to this suggestion for the future work, further modifications regarding text complexity level can be applied. For example, the texts can be manipulated to include the same rate of phrase boundary types and introduced to a new experimental group. The new texts may include longer sentences or be longer than the original texts. This adjustment can explain, for example, whether the participants neglect dependent clauses in the simple texts when they look for a breathing location, or they wait until the end of a sentence because they do not come across a dependent clause within the sentence more than a couple of times. Since the phrase boundary types are the determinant element for the text complexity level, it might be challenging to adjust the texts to include the same number of phrase boundary types without damaging the complexity level, particularly in some languages. In order to solve this problem or conduct a related study in the future, the texts can include sentences of equal length with different syntactic structures in terms of complexity. In this way, the effect of sentence length could be eliminated while analyzing the effect of structure on the breathing patterns.

Similar to the independent measure suggested for text complexity level, an independent rater for lung volume level can be used in the future studies. Although the output obtained from the pneumography shows the respiration cycle clearly, an independent rater would cancel out the error margin.

The duration of the respiration displayed in specific locations can also be analyzed and used as another dependent variable in the analysis procedure. In this way, the effect of character count on the lung volume level can be examined.

Explorations of the breathing patterns during reading speech in a particular language can also be used to detect the L1 effect on the language learning process. Since the learners may tend to display similar breathing patterns as their first language while reading in the second language, comprehending the text might be a challenge for them. With the findings of a related study, new language teaching approaches may defeat this challenge.

It is claimed that the processing mechanism that works for humans' comprehension of sentences is entirely inborn and applies to different languages in different ways (Fodor J. D., 1998). Therefore, specific strategies, which are altered according to the complexity, syntactic and lexical ambiguity of the linguistic input, for sentence parsing have been developed by the speakers. Since breathing patterns during reading are affected by the human parsing mechanism, it is important to analyze these strategies. Displaying respiration at unexpected and ungrammatical locations could be one of these strategies if they do not result from physiological needs. Although the participants displayed respiration in ungrammatical and unpopular locations in this study, the number of these breaths were too few to examine. Besides, most of them resulted from physiological needs such as gulping and yawning. Therefore, as a future work, these irregularities, of which reasons are unknown, can be examined with a larger data set to learn more about the human parsing process.

Just as the process behind comprehension of sentences applies differently to different languages, it may also apply differently to distinct groups of humans in terms of their practical habits. The literature offers several studies investigating these practices affecting the comprehension level of humans. For example, it was discovered that daily exercise promoted neurological activity and cognitive improvements, which resulted in greater comprehension skills (Tomporowski, 2003). Similar to regular physical exercise, regular mindfulness exercise was also thought to affect reading comprehension and studied by several scholars. For example, Mrazek et al. (2013) investigated the effects of a 2-week mindfulness-training course on GRE reading-comprehension test scores and found that the training reduced mind wandering and improved cognitive performance on that specific task. Since breath exercises are one of the most common practices in mindfulness trainings, there might be an interrelation between reading and breathing. In other words, there might be a possibility that the effect of text complexity on the breathing patterns of the readers can be eliminated by prior breathing exercises. If the participants were trained meditators and had greater comprehension skills, their breathing patterns during reading texts of different complexity levels might not vary. In order to answer the question “If breathing patterns are affected by the comprehension process of the readers, and meditation enhances comprehension skills, do people with meditation training display the same breathing pattern while reading the texts of various complexity levels, and display different patterns of respiration than people with no meditation training?” In summary, the effects of breath-controlled meditation training on the breathing patterns during reading can be investigated in the future. One of the earliest goals of this study was to find a consistent breathing pattern across the participants and build a computational model to detect the breath locations in a text. Although this thesis did not include building the model, it can be one of the future works for this study.

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APPENDICES

1. Example of Simple Text in English

The earth is green. Daisies always bloom. Butterflies are colorful. They alway fly to the flowers. Once upon a time, when the camels and dwarves were in fairy tales and dragons would run far away... Can we start the tale without dragons? This is where our fairy tale began. The children stoned the storyteller's door. The storyteller began to tell the story. Once upon a time there was a daisy. It bloomed in a field on green grass. It didn't know what it was doing there. There weren't many neighbors around. There were a few more daisies a little distance from it. But its voice was very weak. It couldn't reach other daisies. One day, it shouted from morning to evening. But no one heard its voice. It started to think what an unlucky daisy it was. Just then, it heard a voice. It looked around. It turned left and right. It did not see anyone. All of a sudden, it saw a pair of eyes at the tip of its nose. It was scared at first. Then it realized that these two eyes belonged to a butterfly. The butterfly said, “I came to meet you". They met and became friends. …

2. Example of Middle-Complex Text in English

“Unemployment is a bad thing. I think about it only when I'm hungry. I wish I could think about it when I'm overwhelmed with boredom. No, I don't. I always come to this garden at times like these. I wonder why. Most of the people around are unemployed. Do you think this garden attracts only those whose destinies are common on this path? May be. It's past noon. I talked about hunger, but I'm not very hungry. However, I don't know why, I am ashamed of myself. It feels like an offense to wander around here, impecuniously, at an hour when everyone is out to lunch. I sat in one of the empty benches. I have a cigarette. Otherwise, it would be a disaster. They had offered a job at oil exploration camp on some mountain. Would it be bad if I went? Well, I did not pay for being sucker! I would have a room. I wouldn't even think about the rent. I wouldn't think about money for food. I could drink my fresh coffee in the morning and have lunch and dinner from the camp table. My stomach rumbled as soon as

I thought of the tableau. I felt hungry. That thing called food is a strange thing. What an invention! …”

3. Example of Complex Text in English

“There weren't cemeteries in these places, as in the old quarters, with all kinds of headdresses, turbans, strange-looking, mysterious rubble tombstones. Just like large factories, military barracks, hospitals, new and modern cemeteries surrounded by high concrete walls, without services, without trees, were outside all these neighborhoods. Dogs stalking Tahsildar Mevlut on the streets in the morning were sleeping in the muddy park opposite the Atatürk statue at night in these neighborhoods without graveyards. The dogs became most aggressive in the city's new slums, where Mevlut went with good intentions. Mevlut spent many unhappy hours in the streets, of which counters had just been wired and recorded. Before, he had not heard the names of most of these places, which can be reached in two hours by buses passing under the ring roads from the center of the city. When he got off the bus, Mevlut ignored the illegal connections - "with good intentions"- drawn from high intercity electric wires, or the connections drawn blatantly by the doner shop opposite the bus stop. He felt that these neighborhoods had an elder brother, a leader, and that he was being watched. With his determined, neat, principled manner, Mevlut wanted to tell them "I'm only busy with official counters.", “You have nothing to fear from me.” …”

Bilgilendirilmiş Onay Katılım Formu (Informed Consent Form)

Bu çalışma, ODTÜ Enformatik Enstitüsü Bilişsel Bilimler Programı bünyesinde yürütülmekte olan 113K723 No.'lu TÜBİTAK projesi ve IRIS Marie Curie IAPP 610986 projesi kapsamında düzenlenmektedir. Çalışma yürütücüsü Yrd. Doç. Dr. Cengiz Acartürk ve çalışmanın gerçekleştirildiği dönem itibariyle doktora öğrencisi Ayşegül Özkan ve bursiyer, yüksek lisans öğrencisi Tuğçe Nur Bozkurt'tur.

Çalışma, Türkçe okuma vb. görsel alışkanlıkların incelenmesi amacı ile gerçekleştirilmektedir. Çalışma boyunca gösterilecek materyal genel olarak kişisel rahatsızlık verecek içeriğe sahip değildir. Sizden beklenen, cihaz ekranında gösterilen yönergeleri takip etmektir. Ancak, katılım sırasında gösterilen materyalden ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz çalışmayı yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda çalışmayı yürüten kişiye, çalışmayı tamamlamadığınızı söylemek yeterli olacaktır.

Çalışmaya katılım bilgilendirilmiş onay (informed consent) esasına dayanmaktadır. Çalışma boyunca, sizden istenecek kimlik bilgileri verilerle eşleştirilmemektedir. Cevaplarınız tamamıyla gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir; elde edilecek bilgiler bilimsel yayınlarda kullanılacaktır. Çalışma sonunda, varsa çalışmayla ilgili sorularınız cevaplanacaktır. Çalışma tamamlandığında katılım ücretiniz çalışma yöneticisi tarafından ödenecektir.

Katılımınız için şimdiden teşekkür ederiz.

(Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

Bu çalışmaya bilgilendirilmiş olarak katılıyorum ve istediğim zaman yarıda kesip çıkabileceğimi biliyorum. Verdiğim bilgilerin bilimsel amaçlı yayınlarda kullanılmasını kabul ediyorum.

İsim Soyad	Tarih	İmza
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Ethical Approval Form

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Sayın Cengiz ACARTÜRK

Danışmanlığını Yaptığınız Gamze EŞDUR'un ***"Doğal Konuşma ve Okuma Eylemleri Sırasında Gösterilen Nefes Alışveriş Örüntülerinin Karşılaştırılması ve Saptanan Örüntülerin Yapay Konuşma Modellerine Dahil Edilmesi"*** başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **387-ODTU-2020** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

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