LANGUAGE ABILITY IN SCHIZOPHRENIA PATIENTS AND GENETIC HIGH-RISK INDIVIDUALS: NEUROPSYCHOLOGICAL AND COMPUTATIONAL INVESTIGATION

A Ph.D. Dissertation

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The Graduate School of Economics and Social Sciences
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I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy in Psychology.

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ABSTRACT

LANGUAGE ABILITY IN SCHIZOPHRENIA PATIENTS AND GENETIC HIGH-RISK INDIVIDUALS: NEUROPSYCHOLOGICAL AND COMPUTATIONAL INVESTIGATION

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May 2024

The study aimed to define language-related phenotypes in schizophrenia and analyze language in schizophrenia patients (SZ) and their unaffected siblings (SIB) as a possible endophenotype. For experiment 1, language was evaluated with the Thought and Language Disorder Scale (TALD), Thought and Language Index (TLI), phonemic and semantic verbal fluency, Boston Naming Test, and Scale for Scoring the Inclusion and the Quality of the Parts of the Story. Language skills of SIB were higher than those of SZ, but lower than those of healthy controls (HC). The best predictor of SZ and SIB was TLI score in the main regression model compared to HC. For experiment 2, I utilized Natural Language Processing (NLP) to explore whether there are altered linguistic features in Turkish-speaking SZ and whether these possible features as phenotypes are language-dependent or -independent. Analyses was conducted in two parts. Firstly, mean sentence length (MSL), total completed words (TCW), moving average type-token ratio (MATTR), and first-

person singular pronoun usage (FPSP) were calculated. Secondly, I used parts-of-speech tagging (POS) and Word2Vec. I found that SZ had lower MSL and MATTR but higher use of FPSP. Results were correlated with the TALD. POS demonstrated that SZ used fewer coordinating conjunctions. Word2Vec detected that SZ had higher semantic similarity than HC and K-Means could differentiate between SZ and HC into two distinct groups with high accuracy, 86.84%. My findings suggest that semantics as subparts of language could be a possible endophenotype in schizophrenia. Thus, their assessment may improve the early diagnosis of the illness. Also, it showed that altered linguistic features in SZ are mostly language-independent.

Keywords: Schizophrenia, Language Disorder, Endophenotype, Sibling, Natural Language Processing, Machine Learning

ÖZET

ŞİZOFRENİ HASTALARINDA VE GENETİK OLARAK YÜKSEK RİSK ALTINDAKİ BİREYLERDE DİL BECERİSİ: NÖROPSİKOLOJİK VE HESAPLAMALI ARAŞTIRMA

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Çalışma, şizofrenide dile bağlı fenotipleri tanımlamayı ve şizofreni hastalarında (ŞZ) ve kardeşlerinde (KRD) dili olası bir endofenotip olarak analiz etmeyi amaçladı. Deney 1 için dil, Düşünce ve Dil Bozukluğu Ölçeği (DDBÖ), Düşünce ve Dil Ölçeği (DDÖ), fonemik ve anlamsal sözel akıcılık, Boston Adlandırma Testi ve Hikaye Elementleri Değerlendirme Ölçeği ile değerlendirildi. KRD'nin dil becerileri ŞZ'den daha yüksek, ancak sağlıklı kontrolden (SK) daha düşüktü. ŞZ ve KRD'nin en iyi yordayıcısı, SK'ya kıyasla ana regresyon modelinde TLI skoruydu. Deney 2 için, Türkçe konuşan ŞZ'de değişen dilsel özellikler olup olmadığını ve fenotipler olarak bu olası özelliklerin dile bağlı veya bağımsız olup olmadığını araştırdım. Bunun için Doğal Dil İşleme'yi (DDİ) kullandım. Analizler iki bölümde gerçekleştirildi. Öncelikle ortalama cümle uzunluğu (OCU), toplam kelime (TK), hareketli ortalama tür-belirteç oranı (HOTBO) ve birinci tekil şahıs zamiri kullanımı (BTŞZ) hesaplandı. İkinci olarak, konuşma parçası etiketleme (KPE) ve Word2Vec'i

kullandık. ŞZ'nin OCU ve HOTBO'sunun daha düşük, ancak BTŞZ kullanımının daha yüksek olduğunu buldum. Sonuçların TALD ile korelasyonu vardı. KPE, ŞZ'nin daha az koordine edici bağlaç kullandığını gösterdi. Word2Vec, ŞZ'nin SK'dan daha yüksek semantik benzerliğe sahip olduğunu ve K-Means'in ŞZ ve SK'yı %86,84 gibi yüksek bir doğrulukla iki ayrı gruba ayırabildiğini tespit etti. Bulgularımız dilin alt bölümlerinden biri olarak anlambilimin şizofrenide olası bir endofenotip olabileceğini düşündürmektedir. Dolayısıyla bunların değerlendirilmesi hastalığın erken teşhisini kolaylaştırabilir. Ayrıca çalışma, ŞZ'deki değişen dilsel özelliklerin çoğunlukla dilden bağımsız olduğunu gösterdi.

Anahtar Kelimeler: Şizofreni, Dil Bozukluğu, Endofenotip, Kardeş, Doğal Dil İşleme, Makina Öğrenimi

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INTRODUCTION

1.1 Schizophrenia

1.1.1 Description and History

Schizophrenia is among the most severe, generally chronic, brain diseases, causing substantial impairments in emotion, thought, speech, and behavior and mainly emerging in the late adolescence period (Kaplan & Sadock, 2005). The term schizophrenia is derived from the combination of Greek words *schizein* (split) and *phren* (mind) (Kaplan & Sadock, 2005). What schizophrenia refers to is the splitting of the different psychic functions. Bleuler thought that in each patient there is splitting of the psychological functions and he emphasized dissociation of mental functions, to be a core feature of schizophrenia (Hoff, 2012).

There have been people with schizophrenia through the centuries. Some scholars believe that schizophrenia could be taken as an ancient disorder (Jeste et al., 1985). However, some others proposed that the illness did not begin to occur until the seventeenth or eighteenth century (Jeste et al., 1985). Some such theorists say that it

increased with industrialization and the urbanization age when many people started to live next to one another in urban environments. Others assume that "schizophrenia-like" illness has existed for centuries, but our understanding of this illness as "schizophrenia" is a product of our age. The usage of the word "schizophrenia-like" is that the history of schizophrenia could depend on the history of madness. The history of madness can be found in old religious texts such as the Bible and early medical texts like the Egyptian *Ebers Papyrus* (Marcsisin & Gannon, 2017). In Greek and Roman literature, madness description often refers to spiritual disturbances, which consist of, but are not limited to, demonic existence (Marcsisin & Gannon, 2017).

Firstly, Philippe Pinel, who is the founder of modern psychiatry, categorized mental illnesses into five categories depending on his empirical observations. He discussed many of these illnesses in one general category: "disappearance or breakdown of thinking ability." In 1764-1844, Haslam in England mentioned: "an insanity in young people." Thus, some English psychiatrists described schizophrenia as a Pinel-Haslam illness. Australian psychiatrist Benedict Augustin Morel (1809-1873) approaches the symptoms of schizophrenia as "juvenile dementia". In 1828-1899, Karl Kahlbaum defined "catatonia," characterized by solid posture and mutism. Ewald Hecker (1843-1909) used the term "hebephrenia" to describe regressive behaviors and disorganized thoughts. In the 1840s, Wilhelm Griesinger wrote the types of dementia and chronic mania, which look like to overlap with modern schizophrenia diagnosis (Işık, 2007; Marcsisin & Gannon, 2017; MacNally, 2016).

In the late nineteenth century, German psychiatrist Emil Kraepelin, who is considered the father of biological psychiatry, characterized schizophrenia while describing its symptoms and damage to the brain. Because he believed that people who have this illness suffer from continuous mental deterioration, which starts in their early adolescence and early adulthood, he called schizophrenia "dementia praecox" (dementia of young) (Kraepelin, 1921). He proposed that juvenile dementia, catatonia, hebephrenia, and paranoid dementia could be a sub-category of *dementia praecox*.

Eugen Bleuler, Kraepelin's contemporary, disagreed with Kraepelin's point of view, and he thought that patients' conditions could improve and that schizophrenia does not result in dementia every time (Bleuler, 1911). According to him, the main reason for this illness is the functional disorders in emotions, thought, and memory, which makes out "loosening of association" (Anıl Yağcıoğlu & Ayhan, 2018). He is the first to call the illness "schizophrenia" and described the famous "the four A's," which defined the illness's primary signs: lack of *affect*, disorganized *associations*, *ambivalence* in feelings and behaviors, and *autism*. The secondary signs defined by Bleuler were delusion, hallucination, catatonia, and motor disorders. Bleuler emphasized that the primary (fundamental) signs are the core ones that must be present in all people who receive the schizophrenia diagnosis; however, the secondary (accessory) signs are the ones that could be seen with the core signs together in schizophrenia and could come across in other mental illnesses (Işık, 2007).

In his book General Psychopathology (1913), Karl Jaspers suggested that the obscurity of a person with schizophrenia is the distinctive and leading feature of schizophrenia. Jaspers also laid the foundations of the Diagnostics and Statistical Manual of Mental Disorders (DSM) by defending the specific symptoms that must be dealt with first. Jaspers indicated that the organization of psychopathological structuring consists of layers from deep to the top, and the most organic symptoms are in the deep, which is the core of primary diagnosis. The organic ones are followed by schizophrenia, affective and neurotic symptoms, and on the top, personality disorders are seen (Kaplan & Sadock, 2005).

German psychiatrist Kurt Schneider contributed to the differential diagnosis of schizophrenia from other psychotic disorders in the 1930s. He called "Schneiderian first-rank symptoms," also known as "ABCD symptoms": *auditory hallucinations*, *broadcasting of thought, controlled thought,* and *delusional perception*. Schneider believed that certain symptoms are characteristics of schizophrenia. So, they are critical for differential diagnosis. "Second-rank symptoms" can be ordered other perception disorders, sudden delusional thoughts, confusion and depressive and euphoric mood dysregulation (Işık, 2007).

In the diagnostic systems, schizophrenia was included under the headline of "psychotic diseases" of the International Statistical Classification of Diseases, Injuries, and Causes of Death, published by the World Health Organization (WHO) in 1948. Then, by American Psychiatric Association (APA), schizophrenia was classified under "schizophrenic reactions" in DSM-I in 1952; "schizophrenic disorders" in DSM-II (1968); "schizophrenia" in DSM-III (1980); "schizophrenia

and other psychotic disorders in DSM-IV (1994) and in DSM-V (2013) "schizophrenia spectrum and other psychotic disorders." Likewise, WHO published International Classification of the Diseases-10 (ICD-10) in 1992 and included schizophrenia under the headline of "schizophrenia, schizotypal and delusional disorders." On the other hand, in ICD-11, published in 2022 schizophrenia is included under the headline of "schizophrenia or other primary psychotic disorders" like DSM-V (2013).

1.1.2 Diagnosis of Schizophrenia

In DSM-V (2013), "schizophrenia spectrum and psychotic disorders" is the classification name of all psychotic disorders. Schizophrenia is the most important one in this class because of its prevalence, functional outputs, and response to treatment (Rosenstock, 2017). The diagnosis of schizophrenia depends on the clarification of positive and negative symptoms, which last at least a month and cause severe functional decline over at least six months of overall illness (APA, 2015). This diagnostic approach is not without problems; for one, it fails to consider cognitive deficits unique to schizophrenia, but it facilitates treatment decisions, especially for positive symptoms.

Table 1
The diagnostic criteria for schizophrenia

Positive Symptoms	Delusions Hallucinations Disorganized thought Disorganized behavior
Negative Symptoms.	Flat affect, motivation
Functioning	Social/occupational decline
Duration	1 month for core symptoms Six months' total duration
Rule-outs	Other psychosis/autism Other medical/substance

At least two positive/negative symptoms are required.
Cognitive symptoms are not included diagnostically.
Can specify first or multiple episodes, acute episode or in full or partial remission, with or without catatonia.

Note. From "Diagnosis and Assessment of Schizophrenia and Related Psychoses," by the J. B. Rosenstock in M. J. Marcsisin, J. B. Rosenstock, & J. M. Gannon (Eds.), *Schizophrenia and Related Disorders*, (p.72), 2017. Oxford University Press. Copyright 2017 by Oxford University Press.

Just two out of the five core positive and negative symptoms are required to make the diagnosis, and at least one must be a positive symptom, which means that one person with schizophrenia may not have experienced hallucinations and delusions. So, there could be different combinations of symptoms in the profile of patients with the same diagnosis. At that point, it could be proposed that each person with schizophrenia is a bit different from the other (Rosenstock, 2017).

1.1.3 Incidence and Prevalence

The distribution of an illness is defined by the estimates of incidence and prevalence. Epidemiologists use this information to manage and reduce the illness. According to

WHO, the annual incidence rate of schizophrenia is between the ranges of 0.1-0.4 per 1,000 population (Jablensky et al., 1992), and it is known that it affects 20 million people worldwide (WHO, 2020). The lifetime prevalence of schizophrenia is between 0.3 and 0.7% (McGrath et al., 2008). The rate in males is higher than in females. However, recent studies did not find gender differences (Li et al., 2022).

The different results in incidence studies may be due to the differences in case-definition and case-finding methodologies. The use of different diagnostic criteria may occur different estimations on this issue. Variations in prevalence rates generally result from discrepancies in recovery, migration, rates, and mortality rates in people with schizophrenia (McGrath et al., 2008). The average age of the occurrence of the illness is between 20 and 29 years for males and higher ages such as 20 and 39 years for females but could be seen at earlier ages as well (McGrath et al., 2008; Sommer et al; 2020; Li et al, 2020). The rates of schizophrenia are also higher in some countries and groups (Nimgaonkar et al., 2000). The rates are higher in northern Finland, Sweden, and Ireland than in other geographical regions. However, lower rates were observed in Amish and Hutterites in North America (1.2 per 1.000; Nimgaonkar et al., 2000).

1.1.4 Prognosis

Schizophrenia shows a very different prognosis and outcome for each patient. The clinical course can be smoothened via rehabilitation or therapeautic intervention (Öztürk & Uluşahin, 2018).

People with schizophrenia who use medicine regularly can still experience a second period of psychotic attack in the first year of the illness, with a rate of approximately 35-40% (Wiersma et al., 1998). As long as the number of relapses increases, the possibility of the illness becoming permanent also increases (Wiersma et al., 1998). However, it is almost impossible to say something about the prognosis beforehand. The outcome of schizophrenia diagnosis is heterogenous. However, when compared with mood and schizoaffective disorders, its course is much more negative (Lang et al., 2013). Even so, it can be observed that some patients who show severe symptoms are managed to adapt to social life. Follow-up studies show that at least one out of four schizophrenic patients totally recovered, and half of them have fewer symptoms and healthy social functions (Harrison et al., 2001). A recent study showed that 24.2 % patients with schizophrenia revovered. Better outcome including recovery occured in 35.5 % of patient, on the other hand poor outcome occured in 40.3 % of patient (Molstrom et al, 2022).

Table 2
Predictors of positive and negative prognosis in schizophrenia

Positive Predictors	**Negative Predictors**
Being female	Being male
Rapid onset	Insidious onset
Late-onset	Early-onset
Presence of mood disorder in the family history	Presence of schizophrenia in the family history
Healthy social functions before the illness	Schizoid or schizotypal personality before the illness
Being married	Being single
Living in a rural area	Living in an urban area
High IQ	Low IQ
Domination of hallucination and delusion	Domination of negative symptoms
Low number of attacks	Being in-patient many and long times.
Early and regular intervention	Taking irregular intervention
No comorbid illnesses	Having comorbid illnesses
Healthy communication environment in the family	Unhealthy communication environment in the family

Note. From "Şizofreni," by M. O. Öztürk & N. A. Uluşahin in *Ruh Sağlığı ve Bozuklukları*, (p.214), 2018. Nobel Tıp Press. Copyright 2018 by Nobel Tıp.

Lastly, the rate of death in people with schizophrenia is 2-4 times higher than the average rate in society (Jablensky, 2007). The most important reason is committing suicide (Jablensky, 2007). In western countries, it is known that 10% of schizophrenic patients die because of committing suicide. This rate is twenty times higher than the average rate of society. The death rate is higher in males than in females (Jablensky, 2007). The other factors that impact the length of life of schizophrenic patients negatively are limited physical activity, obesity, smoking, and unhealthy nutrition (Öztürk & Uluşahin, 2018). Cancers linked with smoking are

known as one of the main reasons for death in people with schizophrenia (Buchanan & Carpenter, 2005; Kirkpatrick & Tek, 2005).

1.1.5 Treatment

Basic treatment in schizophrenia depends on antipsychotic and neuroleptic drugs. For most schizophrenia patients, it is challenging to conduct an effective rehabilitation program without these agents (Lehman et al., 2004; Patel et al., 2014). Prompt intervention with drugs is crucial. Because this period is the time when the most changes occur in the brain (Lehman et al., 2004), thanks to this prompt drug therapy, the patient can reduce hospitalization time and return to normal daily life functioning such as sleeping and eating. Then, the proper dosage of the drugs could be adjusted depending on the response of the people with schizophrenia (Crismon et al., 2014).

Chlorpromazine was the first drug in this category for schizophrenic patients and was discovered in the 1950s, and Haloperidol was the antipsychotic drug called "first-generation." Nevertheless, these drugs had some limitations on the recovery of schizophrenic patients whose 25% were resistant to treatment, depending on the studies (Brenner et al., 1990). The first "second-generation" antipsychotic was clozapine, which could be more effective than the "first-generation" drugs (Kane et al., 1988). Later, many "second-generation drugs" were developed through the years, such as olanzapine, amisulpride, risperidone, quetiapine, and aripiprazole (Edlinger et al., 2005). The "second-generation antipsychotic drugs" block dopamine D2 receptors and thus reducing dopamine transmission and act on serotonin receptors in schizophrenia (Waddington, 2003).

Pharmacotherapy is the main intervention for schizophrenia and many other psychotic illnesses. However, residual symptoms may resist improvement (Dickerson & Lehman, 2011). For this reason, other treatment techniques such as psychotherapy could also be important (Dickerson & Lehman, 2011). This approach may be divided into three forms: individual, group, and cognitive-behavioral (Chrismon et al., 2014). Cognitive-behavioral therapy (CBT) has been suggested as one of the most effective in schizophrenia spectrum disorder. In a meta-analysis, it was found that a pooled effect size in both positive (-0.37 in 32 studies) and negative symptoms (-0.44 in 23 studies) (Wykes et al., 2007). Another meta-analysis conducted by the National Collaborating Centre for Mental Health (NCCMH) (http://www.nccmh.org.uk/) (the National Institute for Health Care Excellence for Schizophrenia Guideline NICE, 2009) revealed small and not significant effect sizes for both positive and negative symptoms. On the other hand, it is supported that CBT effectively reduces the duration of hospitalization, improves social functioning, and helps people with schizophrenia remain adherent to their medication (Lindenmayer et al., 2009). Family therapies also has been supported with many studies and are evidence-based (Turkington & Lebert, 2017). Other new theraphy tehcniques in schizophrenia consist of eye movement desensitisation and reprocessing (EMDR), acceptance and commitment therapy (ACT), metacognitive therapy, mindfulness,

cognitive adaptation training, positive psychology interventions and transdiagnostic therapy based on the method of level (Turkington & Lebert, 2017).

1.2 Schizophrenia and Language

1.2.1 Thought, Language, Speech and Communication Relationship

There is an autonomous system in the brain for language. It could be said that this does not mean that language and thought do not feed each other developmentally, with many mental operations embodied with language from the age of two (Piaget, 1954; Vygotsky, 1934). In a woman with global aphasia in which language is damaged, preserved thinking ability will probably be seen. This woman may figure out complex algebra problems or accomplish other cognitive tasks requiring thought without language. However, these are not entirely independent because some cognitive functions are acquired with or through languages, such as numbers, time, and spatial perception. For instance, the Piraha language does not contain specific words for numbers, with its speakers demonstrating approximate but inexact cognition in one-to-one matching tasks about number perception (Everett, 2005; Gordon, 2004). Within studies of the English and Mandarin languages, Mandarin speakers displayed faster perception than their English counterparts of the concept of March coming before April when presented with the information vertically rather than horizontally, because the Chinese language possesses words for expressions of time not only horizontally, such as *qián/front* and *hòu/back***,** but also vertically, such as *shàng/up* and *xià/down* (Boroditsky, 2001).

Nonetheless, this idea of *relativism* has gathered objections from *universalist* linguists and philosophers, such as Noam Chomsky (1975), Jerry Fodor (1975), Steven Pinker (1994), and Lila Gleitman (1990), who propose that analyzing thought by merely focusing words is misleading. They argue that humans are born with a universal capacity for thought and can express different thought concepts through different languages, but this does not mean that those thought concepts will be varied; the mind is not a blank slate at birth; for instance, humans possess thought concepts on colors. For example, in a community there can be two words for colors and in another community with fifteen words. According to the universalist, this would not mean the community having only two words for colors retained fewer thought concepts because they would still perceive all of the colors (Heider & Olivier, 1972). In other saying, these are inborn and obtained before language acquisition. Although these objections appear persuasive, arguments around whether language shapes thought or vice-versa remain fascinating when supplemented by studies and ideas born from contemporary technological innovation. For instance, Dan Slobin (1996) proposes in his *thinking-for-speaking* hypothesis that the effect of language on thought can be seen especially in the process by which people convey their thoughts into language, or in other words, at the point in time just before they speak. When requiring language to express their thoughts, people need to take care of the language's spoken word capacity and structure. For this reason, they focus on those features of the concepts they are talking about before they begin speaking. To analyze this theory, Anna Papafragou and colleagues (2008) studied the attention focuses of both English and Greek-speaking participants. The results revealed that an American person observing a boy entering a tent by running gave greater consideration to the child running because when described in English, the language

uses a verb showing how the move is performed. By comparison, a Greek person observing the same event gives more attention to the child entering the tent because the Greek language uses a verb showing the direction of the movement. Therefore, people with different mother tongues afforded attention to different aspects of the same event.

When exploring the absolute relationship between speech disorders or thought disorders in schizophrenia, what professionals evaluate with scales is another problem (language, speech, or thought). Bleuler (1911) and Kraepelin (1921) viewed "communication as the primary vehicle through which disordered thought is conveyed," with Bleuler explicitly stating that "we are forced to deduce most of the anomalies from the oral and written production of the patients" (p.39). Kraepelin (1921) not only used derailments in thought but preferred to use "derailments in the expression of thought in speech," focusing on *linguistic expression* in thought. However, Chaika (1982), a famous linguist who studies schizophrenia and language relationships for decades, proposed that what was defined as a thought disorder (TD) in schizophrenia should instead be considered a speech disorder. Recognizing the autonomy of the linguistic system in the brain -or the rule-governed arrangement of phonology and syntax- and its arbitrary connection with the real world, for example, in onomatopoeic words, Chaika (1982) argued that structurally normal speech did not mean that a person might lack a TD or vice versa. Asserting that not all speech conveys thought, for example, as in the case of a greeting, Chaika attempted to comprehend the concept of thought by criticizing its very conception (Chaika, 1982). Furthermore, Chaika emphasized observing disordered speech in patients possessing merely adequate *thought processing* (Chaika, 1982). Chaika's position is very useful

that there is no one-to-one mapping between thought and speech, with speech an observable phenomenon but thought an abstract one. However, as Lanin-Kettering and Harrow (1985) emphasized, it could be said that considering schizophrenic speech to be a speech disorder rather than a TD could restrict the analysis into schizophrenia research. TD needs to be rethought, particularly within the framework of schizophrenia. It should be expressed that disordered speech is *mostly* a potential indicator of a TD as this perspective should prove promising for schizophrenia research. Disturbed speech results from both impairment in language and thought; both are related to each other.

Furthermore, it may prove helpful to discriminate between speech and language for understanding the nature of TDs by considering that "[s]peech is about how we say sounds and words, but language is about the words we use to share *ideas* and get what we want" (ASHA, 2020). For instance, if a person says speech sound /t/ instead of /k/ because they are unable to make the latter sound but can differentiate between the two sounds aurally, this is a problem of articulation, or in other words, a speech problem. However, in a person with global aphasia, basic problems could be seen in talking, writing, and understanding language, or a language problem related to thought and linguistic *content*, indicating a unique cognitive system (ASHA, 2020). That is why the problem in schizophrenia is a broader language and communication problem rather than a speech disorder (Lanin-Kettering & Harrow, 1985; Levy et al., 2010).

Lastly, although still under consideration, speech and language therapy interventions for people with schizophrenia appear increasingly promising and may corroborate

that crucial link between language and thought. In studies where language therapy is provided for people with schizophrenia, it can be identified that the progress is not only in language but also in thought and social skills. In one case study, after a year of interdisciplinary rehabilitation, the participant's speech intelligibility had improved, she had started taking more time to express her thoughts during group sessions, her social behavior had changed, and she had started to socialize with other people when previously she had preferred to stay in her room throughout the day. The study concluded that not only had her disorganized thought improved but also her disorganized and weird language (Novak & Kapolnek, 2001; Joyal, Bonneau, & Fecteau, 2016).

1.2.2 Thought Disorder

Defined as "any disturbances that affect the form of thinking, including the organization, control, processing, or expression of thoughts" (Hart & Lewine, 2017), TD has remained a complicated and complex phenomenon for centuries. This arises because there is no single definition for TDs; however, over the last few years, there has been some development on this issue. Some scientists use the term to broadly describe disorganized speech, hallucinations, and delusions (Andreasen, 2016), while others restrict it to refer to disorganized thought and communication disorders alone (Andreasen, 2016).

In the clinical environment, it was considered beneficial to create a simplified model for the TD phenomenon. With this aim, Frank Fish (1962) defined four cognitive abnormalities -the "perceptual disorder, disorders of the content of thought, disorders of the process of thought and disorders of the form of thought"- thus providing a

form of categorization for TDs. Perceptual disorders present as an impairment to perceptual experience, as in the case of a hallucination. In the content of TDs, there is an impairment to the belief and interpretation of daily-life experience, as can be seen in a delusion. Process of TDs include impairments to language and idea formation prior to speaking, for example, in the case of pressured speech. Lastly, the form of thought or Formal Thought Disorders (FTD) exhibit impairment to the spoken or written language of thoughts manifesting in disorganized language output, for example, tangentiality (Andreasen, 2016).

FTD, whose abbreviated usage within the literature could be used interchangeably with the TD, occurs across many psychiatric populations, such as in schizophrenia, mania, depression, and personality disorders (Kircher et al., 2014), but also within their mentally healthy counterparts (Morgan, 2017), where it can be observed in individuals without psychosis (Nagels et al., 2016). When establishing the rate of prevalence -which are often dependent on the methods used for measurement- it can be seen that it is most often seen in the schizophrenic population (50-80%), followed by those with schizoaffective disorders (60%), depression (53%), and then mentally healthy individuals (6%) (Cavelti et al., 2018). In contrast, its prevalence in mania is still under discussion, with some reports showing higher percentages while others present lower figures compared to schizophrenia (Roche et al., 2015). For this reason, FTDs should be understood as both an entity of speech and language pathology and a trait-marker in psychosis (Roche et al., 2015). FTDs are multidimensional and consequently can be categorized amongst the following subjectively, as in the case of thought interference, and objectively, through practitioner observation; qualitatively, within neologisms or new word formations

lacking lexical values, as with kaliku (Kircher et al., 2014), and quantitatively, through either poverty of speech or problems regarding the *amount* of spontaneous speech, so answers to given questions are brief, definite, and unelaborated (Kircher et al., 2014); and positively, as with tangentiality, containing ideas that deviate from a straight path, or negatively, as with rumination, wherein the patient mainly deals with unpleasant topics (Kircher et al., 2014) which have a separate neural mechanism.

It is important to use a comprehensive scale to evaluate TD in detail. TD is heterogeneous and has a multilayered structure which includes disturbances in social cognition, language, and thought (Thomas & Frazer, 1994). It is emphasized that psychosis in schizophrenia is "like a price that humans paid for the function of language" (Thomas & Frazer, 1994). So, impaired language skills can show impaired thought processing. Even if language and thought are different entities, language and thought are closely related, and language could be taken as a key that can open the door of thoughts. With this aim, many researchers have created different scales which evaluate thought and language disorders with many aspects, such as the Thought, Language, and Communication Scale (Andreasen, 1979), Thought Disorder Index (Solovay et al., 1986), Bizarre-İdiosyncratic Thinking Scale (Marengo et al., 1986), The Thought and Language Index (Liddle et al., 2002; Ulaş et al., 2007), Formal Thought Disorder Scales (Barrera et al., 2008) and Thought and Language Disorder Scale (Kircher et al., 2014; Mutlu et al., 2019).

1.2.3 Sub-types of Thought Disorder

TD has a complex and heterogeneous system. Throughout history, many scientists and clinicians have tried to classify and categorize it in many ways. To construct systematized steps and analyze TD's heterogeneous nature to enlighten the pathologies like schizophrenia, one of the current attempts is to divide thought disorder into positive and negative categories. People working within this area now think this distinction is more helpful and useful than others. Because some research indicated that negative TD is much more parallel with the main symptoms of schizophrenia and also can provide a poorer prognosis, on the other hand, positive one is linked with mania mostly and also can provide a better outcome (Roche et al., 2015).

Negative symptoms occur at the early age of onset, have a poor response to treatment, have much evidence of brain abnormalities and cognitive dysfunction; on the other hand, positive symptoms occur mainly later age of onset, have a good response to treatment, have good cognition and a normal brain structure (Crow, 1980). Negative symptoms in the context of through disorder are poverty of speech, poverty of content of speech, blocking, and perseveration. Positive thought disorders are derailment, incoherence, tangentiality, illogicality, clanging, neologism, pressured speech, and distractible speech (Andreasen, 2016). Furthermore, together with patients' detailed subjective descriptions of their experiences which are related to TD (e.g., poverty of content of speech), it was shown that TD has subjective (e.g., blocking, rumination) and objective (e.g., derailment, perseveration) dimensions besides positive and negative dimensions (Barrera et al., 2008; Kircher et al., 2014).

1.2.4 Language Disorder

Language could be analyzed by dividing it into some core subparts: lexicon, phonology, morphology, syntax, semantics, and pragmatics. Phonology, which stands for the sound system of language, is mostly unaffected in schizophrenia (Covington et al., 2005). Phonology includes all individual sounds in a word, such as the /w/ in "[w]ord." This is surprisingly preserved in schizophrenia. One of the earliest observations about phonetics and phonology in schizophrenic patients was done by Bleuler (1950). According to him, speech of people with schizophrenia include "unmotivated speed and volume changes such as doubled voices," and they have monotonous tones (Thompson, 1971). In other words, these patients have flattened intonation (i.e., aprosody), and their speech is like a speech of a telephone speaker (Lucarini et al., 2020). Besides, there is a phenomenon called clanging, which could be related to phonology in schizophrenia. People with schizophrenia can use a pattern of speech driven by sounds rather than meaningful content. One example from an interview with Andreasen (1979) proves clanging: "I'm not trying to make noise. I'm trying to make sense. If you can make sense out of nonsense, well, have fun. I'm trying to make sense out of sense. I'm not making sense (cents) anymore. I have to make dollars*"* (Andreasen, 1979). Here is the word "sense" that is confused for "cents." It can be understood that this the topic shifts suddenly to money -dollars- which is related to cents. Although this is not deeply related to phonology, it is still an important aspect of schizophrenic language. Another language feature in schizophrenia that is under the realm of phonology could be echolalia. Echolalia is senseless repetitions of words and sentences without regard to their meaning and semantic function. The patients "echo" the word and sentences of the people with whom they talk. An example from Kircher's TALD Manuel (2014)

would be given: interviewer asking “I would like to speak to you for a few minutes.” and the patient responding with “Minutes, minutes, minutes, speak to you for a few minutes.” Here, phonology is important because echolalia is produced by the sounds of a word and short phrases rather than the structure of content.

Deficits in morphology are also uncommon in schizophrenia (de Boer et al., 2020). Morphology refers to the structure of words. It deals with how words are formed and related to other words. Morphemes are the most basic unit of language which is meaningful. For instance, “old town” can be divided into two morphemes, “old” and “town.” A lexeme allows for the extension of morphemes to represent new meanings. So, “old town” could be taken as its own lexeme. Both “old” and “town” have separate meanings, but they are put together, and it creates a new one (McGregor, 2015). Chaika describes the possible morphological errors when a patient substitutes the word “medicate” for “medicine” (Chaika, 1990). On the other hand, this error is not necessarily because of morphology. The root of error could be a word-finding problem or even a syntax problem -i.e., substitute a verb instead of a noun-. However, one of the rare morphology-related abnormalities could be word approximation, in which patients could use different words with similar meanings but are imprecise and incorrect. Andreasen (1979) discusses this by giving an example: they can use “time vessel” instead of “watch” or “hand shoes” for “gloves.

Syntax defines sentence structures via using a set of rules. In other words, it is about how people put together sentences: “The fat girl went to the gym” is a syntactically correct sentence; however, “The girl fat the to went the gym” may convey the correct meaning when we think a while but its syntax is incorrect. In general, overt syntactic

errors can not be seen in the language of schizophrenia (Covington et al., 2005; Çokal et al., 2019). Besides, some syntactical errors that deserve to be talked about can be observed, such as a higher percentage of simple sentences and fewer usage of embedded clauses (DeLisi, 2001; Tavano et al., 2008; Çokal et al., 2019). Applying transcribed interviews and qualitative syntactic coding, Fraser and her colleagues proved that people with schizophrenia use simplified, albeit correct syntactical structures in their sentences compared to control (Fraser et al., 1986). At the same time, it was demonstrated that they use reduced relative clauses in their sentences. Another study that supports the "simplified syntax model" added a new point of view to the literature about syntactic complexity in the language of schizophrenic patients. In this study, Thomas and his colleagues (1987) searched the possible link between syntactical complexity and positive/negative symptoms, and they found a strong correlation between negative symptoms and syntactic complexity (Thomas et al., 1987). Further research has occurred that reduction in syntactic complexity is linked with chronicity of schizophrenia diagnosis. This means that the longer the exposure to schizophrenia, the more the language is affected in terms of syntactic complexity (Thomas et al., 1990). Lastly, it could be important to emphasize that impaired syntactic production and comprehension could result from impairment in cognitive sequence processing (Lelekov et al., 2000).

Lexicon, which refers to the vocabulary in one's repertoire (McGregor, 2015), is another component of language affected in schizophrenia. The first lexicon analysis in schizophrenia has appeared an overall reduction in speech volume. Using the Scale for Thought, Language and Communication, Andreasen and Grove (1986) observed "poverty of speech" -i.e., the deficit in the volume of produced language-

and “poverty of content of speech” -i.e., diminished actual content in the produced language- in people with schizophrenia compared to control group. Further quantitative research has shown an overall reduction in the number of distinct words which schizophrenic patients use even after controlling for the total number of words used (Allen et al., 1993).

Word-finding difficulties can occur in people with schizophrenia (McKenna, 2007). It could be seen in poverty of speech. Also, when they could not manage to find correct words in their lexicon, they can make word approximations. Another area in which word-finding difficulties may occur is neologism (McKenna, 2007). Neologism is a new word formation that does not correspond to the lexical convention, so it does not belong to a language’s dictionary (Andreasen, 1979; Kuperberg, 2010). It is still debated whether neologism is a type of word-finding difficulty or manifests a unique phenomenon in schizophrenia. Some forms of neologism can be comprehensible, such as “crusady” coming from “crusade,” but others could be completely odd words, such as “mersku,” which do not belong to any real word (Andreasen, 1979; McKenna, 2007).

Semantics is one of the most damaged areas in the linguistics of schizophrenia (McKenna, 2007). It describes the meanings of words and phrases (McGregor, 2015), and it gives the answer to this question: “what does X mean?”. In a case study (Oh et al., 2002), the researcher asked, “How is life in the hospital like?” and the patient answered, “Oh, it was superb, you know, the trains broke, and the pond fell in the front doorway.” It can be said that there is a clear semantic error because, in a doorway, a pond can not fall. Furthermore, it does not give a convenient and

meaningful answer to the question. Besides, the patient shows increased semantic priming (also called hyperpriming) as abnormal semantic processing compared to healthy controls (Almeida & Radanovic, 2021). For instance, in a Lexical Decision Task, the patient is expected to report what they see, whether a word "*car*" or nonword "*crit*". The semantic priming version of the task consists of subliminally presenting a semantically-related primer, like "*wheel*", for a period prior to presenting the target word, and therefore if the target is a word and related to the primer the decision will be faster than without the primer. Activating one word activates all the related words and concepts after a brief time, and so the detection threshold decreases as people recognize the target faster without requiring the primer. Some research shows increased semantic priming and the automatic activation of the semantic network (Manschereck et al., 1988; Almeida & Radanovic, 2021). Another phenomenon related to severe semantic error is the "word salad" situation. In this situation, the number of words used is too many for the context, and all of them are irrelevant and completely incomprehensible (Andreasan, 2016).

Furthermore, it includes verbosity and empty content with verbal descriptions teaming with pronouns often without antecedents (e.g., using many irregular sentences with many pronouns and making them mixed in the situation in which one pronoun is enough). Moreover, their productions often include deictic terms with no clear referents and verbs that make their discourse vague and ambiguous (Andreasen, 1979). An example from Andreasen's interview with a patient proves this: "Interviewer: 'What do you think about current political issues like the energy crisis?' Patient: 'They're destroying too many cattle and oil just to make soap. If we need soap when you can jump into a pool of water, and then when you go to buy

your gasoline, my folks always thought they should get pop" (Andreasen, 1979). The words in this conversation are very unrelated to each other, and there is no meaning. Another abnormality related to semantics could be seen in semantic verbal fluency scores (Allen et al., 1993). People with schizophrenia typically show lower performance than healthy controls; furthermore, they could use inappropriate words, which is known as category violation, or use the word they used before, also known as perseveration error (Allen et al., 1993). However, these difficulties could result from word-finding difficulties, which are also related to not only language but also executive functions.

Pragmatics is another severely damaged area in the language of people with schizophrenia (McKenna, 2007; Parola et al., 2020). Pragmatics is how a context of a speech of written paragraph constructs all meaning (Covington et al., 2005), and it gives the answer to this question: "what do you mean by saying X?". This is one of the complex forms of linguistics, and it involves tones, participants in the conversation, the main topic, and the flow of the language, which is related to what came before and after and how to determine the conversation (Covington et al., 2005). As a part of pragmatics, tone can be taken as the pitch at which people create their speech, and this is important in social interactions. Depending on the research, schizophrenic speech is mostly described as flat and monotone voice (Stein, 1993; Parola et al., 2021). Furthermore, they have trouble comprehending tone and inflection (Rieber & Vetter, 1994). Another failure occurs in reference patterns as a result of abnormal discourse cohesion (Docherty et al., 1996; Çokal et al., 2018). Appropriate referencing is required to understand what the speaker says in a suitable

context so that the listeners can comprehend who “her” is, or what location is being referred to in utterances such as “I will swim *there*”.

Pauses in speech is needed for cooparativity in speech by facilitating turn-taking and providing content-cues (Thomason & Hopper, 1992). It is known that patients with schizophrenia present altered distribution of pauses, emphasizing reduced contextual constraint in language and altered discourse planning compared to healthy controls who use context-dependent and predictable pauses in their speech (Çokal et al., 2019).

Circumstantiality and tangentiality are other areas in which errors in pragmatics can manifest. Thinking in circumstantiality is circuitous and minor issues that are inessential cannot be separated from the main issues, and you can get lost in “details” (Kircher, 2014). In tangentiality, ideas do not follow a straight path. The content in the speech slowly drifts away from the main idea, and the patient can not remember where he started. In both situations, even though the meaning of each sentence can be intact, the main context of the speech is lost, and the sentences do not follow each other logically (Kircher, 2014). Derailment, also called “loose association,” is another main pattern of speech that is about pragmatics. Ideas in the pattern of spontaneous speech slip off the track onto other thoughts which are obliquely related (Kircher, 2014). In this situation, there could be a vague connection between the sentences, but in severe conditions, it can be seen no connection to the question being asked. The presence of “loose association” is strongly related to positive symptoms such as hallucinations and delusions (Kay, Flszbein, & Opfer, 1987). In one study, the patient with negative symptoms regularly flouts to all maxims, which

is about the principles of language usage except the maxim of relation (Corcoran & Firth, 1996). In another study in which five pragmatic aspects were used -"topic, speech acts, turn-taking, lexical and nonverbal"-, it was found that the schizophrenic patients had a high degree of inappropriate pragmatic ability (Meilijson et al., 2004).

It is also important to check comprehension in the language of schizophrenia. It is well known that people with schizophrenia have problems in understanding complex language and abstracts concepts such as metaphors, proverbs, and idioms (Kuperberg, 2010). Not only can they not produce syntactically complex sentences, but also they can not understand syntactically complex sentences (Condray et al., 2002; Perlini et al., 2012). Condray and his colleagues (2002) analyzed comprehension in syntactically complex sentences, and they found that when the complexity increases, people with schizophrenia have a hard time understanding these sentences compared to control groups.

Another important area in comprehension is related to irony, proverbs, and metaphors in the language of schizophrenia (Rossetti et al., 2018). According to Kuperbeg (2010), people with schizophrenia tend to use incomplete, concrete interpretations of proverbs, metaphors, and irony.

1.3 Using Language as a Possible Endophenotype in Schizophrenia

1.3.1 Cognitive Endophenotypes in Schizophrenia

Genetics depends on the relationship between genotypes and manifested phenotypes. Defining illness-related genes has been successful in many situations where the disease manifestation is homogenous. In contrast, psychotic disorders have vague

diagnostic criteria and have no distinct boundaries. There is no biological test, and diagnosis is based on symptom description and doctor's observation. Many genetic studies have been conducted in schizophrenia literature to define candidate genes underlying the phenotypes. Even though schizophrenia has genetic components, discovering particular genes related to clinical phenotypes in schizophrenia has not been easy as the disease has a complex nature.

Because of this, researchers have started to analyze a phenomenon called "endophenotype." This was first introduced by Gottesman and Shields in 1972 and was designed to create quantitative measures that are "intermediate," meaning functionally important bridge between genetics and clinical expression of the illness (Gottesman & Shields, 1972). The terms such as biomarker, intermediate phenotypes, and vulnerability marker could be used interchangeably instead of endophenotypes. It could be said that one of the important strategies to analyze the complicated nature of schizophrenia is the analysis of endophenotypes, including language deviations and in other aspects of cognition that are seen in the patients and their first-degree relatives.

Many criteria have been proposed for defining the validity of candidate endophenotypes (Gottesman & Gould, 2003; Waldman, 2005), including that endophenotypes should be heritable, state-independent, and associated with illness in the population. Within families, endophenotypes and illness should co-segregate. The last one indicates that the marker could be disrupted in the healthy family members of people with schizophrenia compared to non-family members (Joo, 2008).

Because schizophrenia is associated with the decline in several cognitive domains, it is possible to think of them as possible endophenotypes that give rise to the symptoms of schizophrenia. Cognition in schizophrenia which is active in the temporal and prefrontal lobes is significantly affected, which results in impaired verbal learning, declarative and working memory deficits, and altered executive functions (Joo, 2008; Zanelli et al., 2019; McCutcheon et al., 2023). Increasing evidence has indicated that some specific cognitive functions could be validated endophenotypes in schizophrenia (Ragland, 2003; Sheffield, 2018). It was found by Consortium on Genetics of Schizophrenia (COGS) that attention, working memory, and verbal declarative memory could be taken as endophenotypes in schizophrenia (Gur et al., 2007).

Attention is considered to have no one single concept, being a homogenous system containing many layers and functions, such as alerting (e.g., maintaining a maximum level of sensitivity to incoming input); orienting (e.g., focusing on selective information from incoming input); and executive control/selection mostly related to thoughts (e.g., exercising a control mechanism for solving the conflict between feelings, thoughts, and responses) (Posner and Petersen, 1990). Deficits in attention have been seen in schizophrenia since its description was done first (Bleuler, 1911). People with schizophrenia have difficulty sustaining focused attention, and it has been proven many times thanks to reliable tools such as the Continuous Performance Test (CPT) (Rosvold et al., 1956). CPT, which is done with degraded stimuli and focuses on perceptual attention, requires a patient to identify blurred numbers or letters. Its other version, requires the participants to identify the same stimulus in

consecutive trials. The experiments conducted with CPT have shown that deficits in attention are a trait-like situation that is unrelated to the clinical symptoms and are unaffected by medication status (Cornblatt et al., 1989). It was also seen in the offspring of schizophrenia who later develop schizophrenia, which is consistent with the criteria of being endophenotypes (Cornblatt et al., 1999).

Working memory could be described as the ability to retain short-term, goal-oriented information which is needed for the execution of a specific task. Weschler Memory Scale III and Letter-Number Sequencing (LNS), which "consists of showing to a participant a series of letters or numbers, should be repeated in the order they were presented (known as a forward condition), or in ascending/alphabetical order (known as reordering condition)" are among the methods which quantify working memory deficits (Donati et al., 2020). People with schizophrenia (regardless of their clinical state) and their healthy siblings showed worse performance in the experiment done with LNS than healthy control groups without any history of any mental illness. So, working memory could be a possible endophenotype in schizophrenia (Lee & Park, 2005; Horan et al., 2008). At the same time, genetic studies proposed powerful results which support this assertion. Depending on the research, it was stated that the COMT gene and D1 dopamine receptors, which have been implicated in schizophrenia, are involved in regulating working memory (Gao et al., 2001). So, this result strengthens the hypothesis about the link between working memory and its neurobiological underpinnings, which is related to being an endophenotype.

Verbal declarative memory is a subtype of long-term memory which emphasizes the ability to recall events that occurred to the individual (known as episodic memory) or

facts learned by the individual (known as semantic memory) (Donati et al., 2020). Any dysfunction in verbal declarative memory is linked with higher rates of forgetting, inability to recall words or encoding deficits. Although there is a significant correlation between verbal declarative memory and negative symptoms in schizophrenia, it is also known that this type of memory deficit has been seen in people with schizophrenia and is mostly independent of the duration of symptoms, length of medication, and positive symptoms (Cirillo & Seidman, 2003; Aleman et al., 1999). Verbal declarative memory deficits are also present in the unaffected first-degree relatives of people with schizophrenia to a lesser degree, as well as in the subjects who have a high risk for developing psychosis (Sitskoorn et al., 2004). Thus, in the framework of endophenotype, this suggests the strong association between verbal declarative memory deficit and the genetic risk of developing psychosis and schizophrenia.

1.3.2 Thought and Language and First-Degree Relatives Studies: Trait or State Marker?

The family study is a valid method for searching endophenotypes in schizophrenia. Within this domain, thought and language could be quantifiable trait markers known as an endophenotype (Corcoran et al., 2018; de Boer et al., 2018; de Boer, Brederoo, et al., 2020). However, there are not many studies that focus on language in this field. The presence of cognitive slippage (less severe cognitive disturbances), which is one of the four core schizotypal source traits (Meehl, 1977) in healthy siblings of people with schizophrenia, has been emphasized for many years (Bleuler, 1950). The first studies of thought and language disorders in healthy relatives were done by McConaghy (1959) and Rosenthal (1962). According to their sample, it can be said

that at least one parent of 15 people with schizophrenia showed thought and language slippage (Levy et al., 2010). Since then, the studies which proved the mild thought and language disorder in the first-degree relatives of schizophrenic patients have continued to be published (Hain et al., 1995; Perry et al., 2003; Shenton et al., 1989; Solovay et al., 1987). These studies' main features were idiosyncratic verbalizations, mainly conducted with the Thought Disorder Index (Johnston & Holzman, 1979; Shenton et al., 1989). Besides, communication deviances as a part of thought and language slippage were reported in the biological relatives of schizophrenic patients (Hirsch & Leff, 1975; Singer & Wynne, 1965; Wynne et al., 1977). For instance, in Docherty's studies, elevated language deviance was found in healthy parents of people with schizophrenia with the instrument Communication Deviance Index (CDI). Furthermore, higher CDI scores indicated that the parents were associated with greater severity of schizophrenia in probands (Docherty, 1993; Docherty, Gordinier, Hall, & Cutting, 1999; Docherty et al., 1997; Docherty et al., 1998).

In one of the current thought and language-based studies, Pawelczyk et al. (2018) experimented with 34 first-episode psychosis patients, 34 parents of the patients, and 32 healthy controls. The language was evaluated with Right Hemisphere Language Battery. The results showed that first-episode psychosis patients differed from the control group in "comprehension of inferred meaning, emotional prosody, discourse dimension, overall language and communication and the general knowledge of component of language processing," and these patients differed from their own relatives in discourse dimension. These findings suggested that pragmatic

dysfunctions can reflect genetic vulnerability and could be possible neurolinguistics endophenotype in schizophrenia.

In another study that focused on linguistics, Baskak et al. (2008) preferred to analyze peculiar word usage in people with schizophrenia, their siblings, and the healthy control group. They applied the Controlled Word Association Test's Turkish and modified version and used these data as a norm to compare peculiarity and word association's degree among all the groups. They also analyzed the relationship between peculiar word use and word association patterns such as semantic versus phonologic and FTD. People with schizophrenia and their siblings were worse than the control group, and they also produced more peculiar words, all of which relied on fewer semantic associations. So, they concluded that peculiar word usage could be linked to deficits in the use of semantic classifications in verbal fluency tasks, which could rely on more sound-based associations. Also, these results showed peculiar word use could be a possible trait marker in schizophrenia.

Referential communication disturbances could be another neurolinguistic trait-marker factor in schizophrenia (Docherty et al., 2004). The researchers assessed six types of referential communication disturbances –"vague reference, confused reference, missing information reference, ambiguous word meaning, wrong word reference, and grammatical unclarity"– of the speech of 32 schizophrenic patients, 23 of their healthy siblings, and 27 control subjects. The siblings of people with schizophrenia did more frequent reference failures in all types compared to the control group, and this did not differ from the patient group on most of the referential types. In only one of them –"missing information reference" – which is so typical in

schizophrenic speech, patients showed more deviance compared to their siblings and control group. On the contrary, in "vague reference," siblings showed more deviance than the patient group. So, these results supported that the referential deviances show vulnerability to schizophrenia (Docherty et al., 2004).

The researchers still do not know whether this co-familiarity is because of genetic factors, environmental factors, or the factors that occur from their interaction (Levy et al., 2010). However, twin and adoption studies could figure out this phenomenon. In one study in which abbreviated version of Scale for the Assessment of Thought, Language and Communication (TLC) was used, it was found that there was no difference between intra-class correlations of MZ and DZ twin pairs that one participant of the pairs was schizophrenic and their results showed that there is a resemblance but thought and language disorder was not under genetic liability (Berenbaum et al., 1985). On the other hand, in another study done with twin pairs, Docherty and Gottesman (2000) used CDI and calculated referential communication disturbances. They found a higher frequency of missing references as a linguistic unit in non-schizophrenic MZ twins than in DZ twins (Docherty & Gottesman, 2000).

1.4 Using Language for Defining Phenotypes in Schizophrenia: Natural Language Processing

Language is a crucial tool known by healthcare professionals for diagnosing schizophrenia (SZ) (de Boer et al., 2020). Furthermore, collecting language data is easy and inexpensive. Traditionally, expert opinions, clinical ratings, and manual linguistic analyses have been used for analysing language. Although informative,

they have some limitations. The results of clinical ratings can be affected by incomplete response sets and clinical judgments, which often lack precision. Furthermore, in manual linguistic analyses, researchers must put significant effort into analysing even a single person's data making large-scale studies challenging to conduct (Corcoran et al., 2020). Nowadays, linguistic markers are more trackable with the advances in natural language processing (NLP) based technologies (Foltz et al., 2016; Corcoran et al., 2018; Rezaii et al., 2019). NLP provides fast and accurate extraction of features related to language (de Boer et al., 2020; Voppel et al., 2021).

Many different NLP techniques have been used to identify language changes in SZ. In one of the first studies, Elvevåg et al. (2007) applied Latent Semantic Analysis (LSA) to quantify coherence. They found that the patients who got a high score on the Assessment of Thought, Language, and Communication (TLC) lost coherence more quickly. LSA could discriminate SZ patients from healthy control participants (HC) with 80-82% accuracy while detecting decreased cohesion (Elvevåg et al., 2007). In a recent study, Tang et al. (2021) utilized word-level and sentence-level analyses such as Parts of Speech tagging (POS) and Bidirectional Encoder Representations from Transformers (BERT). The results showed that NLP measurements of language disturbances in SZ could discriminate better between HC and SZ compared to clinical ratings alone (Tang et al., 2021). In another study, the usage of quantitative speech variables such as utterances and words was higher in SZ than HC, and these variables could classify, based on machine learning algorithms, SZ with 90-100% specificity and 80-90% sensitivity (Tan et al., 2021). NLP is also critically important in predicting conversion to psychotic disorders in the studies of clinically high-risk (CHR) populations. According to these studies, less usage of

complementizers and reduced sentence length which correlated with negative symptom severity (Bedi et al., 2015) and low semantic density (Rezaii et al., 2019) could predict psychosis in CHR population with high accuracy. Other successful techniques in NLP can be ordered in graph analysis (Mota et al., 2017) and automated metaphor detection (Gutiérrez et al., 2017). However, all of these studies were done in Indo-European languages. That is why, it is still crucial to define possible languague-related common phenotypes in schizophrenia.

In this thesis, two separate studies were conducted to find out whether language and thought features are state-markers or trait-markers in schizophrenia and to define phenotypes in schizophrenia which facilitate early diagnosis besides endophenotype studies. For endophenotype studies (neuropsychological), siblings of schizophrenic patients and healthy control groups were also assessed. For phenotype study (computational), siblings were not included.

1.5 Main Aim and Research Questions of the Current Study

My aim is here to explore language as a possible biomarker/endophenotype in schizophrenia. Besides, I analyzed phenotypes in schizophrenia, which could facilitate endophenotype studies by showing which factors are critical and discriminative in the nature of schizophrenia. Also, while analyzing phenotypes, I wanted to search whether the possible language differences in schizophrenia is same in a non-Indo European language, Turkish, compared to Indo European languages to decide the abnormalities in schizophrenia is language-dependent or -independent. I evaluated language ability in people with schizophrenia and their siblings with healthy controls using two complementary research approach: 1) I used a

comprehensive neuropsychological test battery to assess language ability among healthy controls, chronic schizophrenia and their siblings as a high-risk group; 2) The interviews taken from schizophrenia patiens and healthy controls via conducting Thought and Language Disorder Scale (Kircher et al., 2014) were used for Natural Language Processing (NLP) to discrimiate schizophrenia patients from healthy control group. So, I could define which language features are important and specific to schizophrenia patients and we could see these language features are language-dependent or -independent.

The main objective of the thesis was to investigate the nature of language impairments in patients with schizophrenia and their first-degree unaffected relatives. If the unaffected relatives show similar impairments to those that I would expect to see in the patients then this would suggest that the impairments could serve as biomarkers of vulnerability in the future with implications for prediction and treatment. Also, I aimed to define language-specific phenotypes by using Natural Language Processing, which could help endophenotype studies by showing which features are important units. The two specific objectives of the proposed research, uniquely focused research predictions were: (1) Language functions would be significantly impaired in the chronic schizophrenia and the familial high-risk group compared to healthy controls, and (2) NLP could discriminate schizophrenia patients with high accuracy and the differences in language of Turkish-speaking schizophrenia patients would be mostly language-independent.

CHAPTER 2

EXPERIMENT 1

2.1 Methods

2.1.1 Participants

Three groups of participants were included in the study consisting of a schizophrenia group, siblings of patients with schizophrenia, and healthy controls. The SZ sample consisted of 24 individuals consulting the Community Mental Health Center of Etimesgut Şehit Sait Ertürk State Hospital between September 2019 and September 2020. The patients were enrolled in the study when their psychiatrist (EM) determined they met the DSM-V criteria for SZ. The patients were clinically stable, and no patient had undergone electroconvulsive therapy (ECT) treatment in the last year. In order to determine the disease severity and prominent clinical features, the scoring of the Clinical Global Impression Rating Scale (Guy, 1976), and the age of illness onset were collected from the patient's charts. Daily doses of antipsychotics were converted into chlorpromazine equivalents using an equivalency table provided

by Gardner et al. (2010). The SIB group comprised 24 subjects who were the sibling of SZ, and their agedifference with patients was a maximum of two years. The inclusion criteria of the SIB group comprised no somatic disease, no Traumatic Brain Injury (TBI), no other neurological disease and no psychotropic drug usage (ruled out by way of self-report). Furthermore, SIB group did not have any psychosis history, which met DSM-V criteria when they participated in the study. The healthy control group comprised 24 subjects. The inclusion criteria of the healthy control group comprised no psychiatric history, no family history of psychiatric illness, no TBI or any other neurological disease, no somatic disease, and no psychotropic drug usage.

The exclusion criteria for all participants comprised any history of neurological or chronic somatic disorder, mental retardation, alcohol or substance abuse or dependence, head injury. The groups were matched with regard to age and education. All participants were right-handed, native speakers of Turkish, and of Turkish nationality. All participants provided written informed consent. The study was approved by the Bilkent University Ethics Committee.

2.1.2 Data Collections Tools and Application Procedure

An expert speech and language therapist (TÇ) tested all the participants during one session.

2.1.2.1 Verbal Fluency Test

Verbal fluency test involves two subassessments which are phonemic and semantic. Participants are asked to produce words within one minute. In a silent room, firstly, it

was expected for the participants to produce words that start with the /k, a, s/ (Tunçer, 2011) (Turkish version of /f, a, s/) (Lezak, 1995) and secondly, words from the animal category as a semantic category. The standard procedure was followed, and necessary information was presented (i.e., please do not use the proper name and inflexional suffixes that do not change words' meaning). During the test, the errors were taken as a violation. The participants' speech was recorded via audio recorder and later transcribed for analysis.

In the total word count, repetitions, synonyms, and out-of-category words were not included. Inflectional suffixes were ignored when evaluating phonemic fluency. In semantic fluency, sub-categories were only accepted as correct if the participant used both the main category and sub-category (i.e., if the participant said *fish* and then continued *anchovy*, *bass*, and *salmon*).

2.1.2.2 Boston Naming Test

Boston Naming Test (BNT) was developed by Kaplan et al. (1983), and its Turkish language adaptation was made by Ekinci-Soylu and Cangöz (2018). The test involves 60 pictures and is used to evaluate the functions of identification and naming. The assessment started from the 30th picture because the ages of patients with schizophrenia, their siblings, and the healthy controls were more than ten years old and were not aphasic. For some conditions, semantic cues were given to the participants depending on the instructions from the manual. The number of the pictures named as accurate was recorded as the total score.

2.1.2.3. Thought and Language Disorder Scale (TALD)

The Thought and Language Disorder Scale (TALD) was developed by Kircher et al. (2014) and adapted to the Turkish language by Mutlu et al. (2019) (TALD-TR). The Turkish language version of TALD showed adequate and effective psychometric properties with high Cronbach's Alpha values and high inter-rater reliability in parallel with the original version (Mutlu et al. 2019, Kircher et al. 2014).

TALD is a 30-item semi-structured scale with operationalized definitions of symptoms and symptom ratings, directed questions, and examples for discrimination of objective and subjective symptoms from each other. The factor analysis of TALD revealed four factorial structures, namely *Objective Positive, Subjective Negative, Objective Negative,* and *Subjective Positive* factors (Kircher et al. 2014). *The Objective Positive* factor was best represented by circumstantiality, derailment, and neologism which were described as positive or disorganization symptoms of thought and language disorder in the previous scales (i.e., The Scale for the Assessment of Thought, Language and Communication TLC; Andreasen, 1986). *The Objective Negative* factor includes observable negative symptoms such as slowed thinking, poverty of speech, and concretism. Subjective factors distinguish TALD from other thought and language disorder scales. *The Subjective Negative* factor consists of introspective negative symptoms best manifested by a poverty of thought, expressive speech dysfunction, and blocking. *The Subjective Positive* factor includes two items: thought interference and pressure/rush of thought.

The interview of TALD comprises two parts. The daily life events or interests such as hobbies are discussed by open-ended questions in the first part (part a) so that the

rater can detect objective symptoms and further query to code symptom severity. In the second part (part b), the subjective symptoms are questioned in detail. The rater assesses each subjective symptom following standard procedures (Kircher et al 2014) and explores and notes the presence of any subjective symptoms (e.g., for rush/pressure of thoughts: *"Do you sometimes feel that so many ideas come into your mind quickly, one after the other or even at the same time, that you lose control of your thoughts"*). If necessary, the rater can ask more questions or give additional explanations to be sure that questioned subjective phenomena are understood.

In this study, the responses to parts a and b were audio recorded in a 40-minute session. All participants gave informed consent for their interview sessions to be voice recorded. The rating was completed immediately after the interview by an expert speech and language therapist (TÇ). The grading of each item, such as *derailment*, *tangentiality,* and *perseveration,* was analyzed according to the definitions of that item in the manual (Kircher et al., 2014; Mutlu et al., 2019).

2.1.2.4 Scale for Scoring the Inclusion and the Quality of the Parts of the Story

In the Scale for Scoring the Inclusion and Quality of the Parts of the Story (SSIQPS) developed by Harris and Graham (1996) and adapted to Turkish language by Coşkun (2005), eight-story elements (main characters, setting, time, initiating event, aim, attempt, consequence, reaction) are counted, and these elements are evaluated over a total of 19 points. This scale is based on the calculation of the elements of the stories, and the stories in this study were based on the 8 Thematic Apperception Test (TAT) cards. Basic instructions were given to the participants (i.e., please create a story by

using these pictures). The elements in the scale were scored based on the criteria by Harris and Graham (1996).

2.1.2.5 Thought and Language Index (TLI)

Thought and Language Index (TLI) is a standardized instrument developed by Liddle (2002) and adapted to Turkish language by Ulaş et al. (2007) for assessing formal thought disorder. The patients are required to produce eight 1-min speech samples in response to eight black and white pictures/stimuli from TAT (Murray, 1943). The speech samples are assessed according to eight types of abnormality (poverty of speech, weakening of goal, looseness, peculiar word, peculiar sentence, peculiar logic, perseveration, distractibility) which are related to positive and negative symptoms of schizophrenia. The data were scored followed the standard procedures for this task.

2.1.3 Statistical Analyses

Statistical analyses of the thought and language tests were carried out by the STATA version 14 (StataCorp, 2017). To compare demographic and clinical characteristics, the SPSS version 22 (SPSS Inc., Chicago, Illinois, USA) was preferred. The continuous variables were checked using probability plots, histograms, and the Kolmogorov–Smirnov test to assess the normality of data distributions. In the demographic and clinical characteristics, the Chi-square test was performed to analyze categorical variables, and one-way ANOVA was performed to analyze continuous variables. I ran multinomial logistic regression to explore whether our main thought and language variables (i.e., TLI, verbal fluency) would be the best predictors and discriminators of the grouping variable (SZ, SIB, HC). Thanks to this analysis, the probability of being a member of a particular group (e.g., schizophrenia

patient or healthy) could be found. 3-level group variable was constructed reflecting the hypothesized order of thought and language disorder, with HC (coded 0), SIB (coded 1), and SZ (coded 2). Group was a dependent variable, and TLI, phonemic and semantic verbal fluency, Boston Naming Test and Scale for Scoring the Inclusion and the Quality of the Parts of the Story were added to the model as independent variables. In order to avoid multicollinearity, TALD-TR and its factors were not included in this model. Furthermore, to address the non-independence of observations within families (i.e., SZ and SIB groups) (Rabe-Hesketh et al., 2001), standard errors were corrected for clustering of siblings and patients within the same family, using the Stata' cluster' option. A *p* value below 0.05 was accepted for statistical significance.

2.2 Results

2.2.1 Demographic and Clinical Characteristics

Demographic and clinical characteristics are summarized in Table 3. The groups did not differ in age and education. However, significant differences were observed in gender and marital status. Besides, two siblings had major depression and anxiety disorder history.

Table 3
Demographic and clinical characteristics of patient with schizophrenia, their siblings and healthy control group (*N*=72)

	Patients with Schizophrenia *N*=24 (%)	Siblings *N*=24 (%)	Controls *N*=24 (%)	*χ2*	df	*p*
Gender						
Male	22 (91.7)	9 (37.5)	11 (45.8)	16.8	2	**<0.001**
Marital status						
Married	6 (25)	17 (70.8)	15 (62.5)	14.77	4	**<0.005**
Paid Employment						
Yes	13 (54.2)	15 (62.5)	17 (70.8)	1.42	2	0.491
	Mean (SD.)	Mean (SD.)	Mean (SD.)	*F*	df	*p*
Age	37.5 (7.84)	37 (7.91)	37.29 (8.28)	0.02	2	0.977
Education (years)	9.96 (2.98)	11.96 (3.67)	11.79 (3.92)	2.34	2	0.104
Duration of illness (years)	16.5 (7.97)	N/A	N/A			
Age at illness onset	20.92 (4.92)	N/A	N/A			
Medication (ECPZ-mg)	563.21 (226.42)	N/A	N/A			
CGI-Illness severity	3.83 (0.91)	N/A	N/A			

χ2: Chi-square, df: degree of freedom, *F:* ANOVA, SD = Standard deviation, ECPZ: equivalent dose of chlorpromazine, The CGI = Clinical Global Impression Scale-Severity, N/A = Not applicable

2.2.2 Group Differences in Thought and Language Tests

The results of ANOVA with post-hoc pairwise comparisons (Table 4) showed that BNT, fluency tests, SSIQPS scores were significantly impaired in both SZ and SIB groups compared to HC group. TLI was significantly impaired in SZ compared to HC. TALD-TR total and factor scores showed a distinct pattern of thought disorder severity. SZ group exhibited the highest scores in the TALD-TR total score, the subjective negative, the objective negative and the subjective negative factor scores. SIB group showed milder impairment than SZ group, whereas both SZ and SIB groups significantly differed from HC. The objective positive factor score was similar between SZ and SIB group, and, as expected, higher than the HC group. The results of the first multinominal logistic regression analysis (Table 5) indicated that both SZ and SIB groups differed from HC on the variables of Thought and Language Index, Boston Naming Test, Scale for Scoring the Inclusion, and the Quality of the

Parts of the Story and Semantic Verbal Fluency scores. The Relative Risk Ratio (RR) indicates that with one unit increase in the named variable, the relative risk of belonging to the named group as opposed to the HC group increases depending on the number under RR in Table 5. For example, Thought and Language Index (TLI) was a significant predictor in the SZ (RR = 17.58; 95% CI = 5.49, 56.3, p = 0.001) and SIB (RR = 4.41; 95% CI = 1.35, 14.42, p = 0.05) group rather than HC. Thus, one unit change in TLI factor was associated with a 17.58 increase in the relative risk of belonging to the SZ group compared to the HC group and a 4.41 increase in the relative risk of belonging to the SIB group compared to the HC group. A lower Boston Naming Test (SIB vs. HC: RR = 0.91; 95% CI = 0.85, 0.97, p = 0.05. SZ vs. HC: RR = 0.83; 95% CI = 0.75, 0.92, p = 0.001), Scale for Scoring the Inclusion and the Quality of the Parts of the Story (SIB vs. HC: RR = 0.68; 95% CI = 0.6, 0.976, p = 0.001. SZ vs. HC: RRR = 0.45; 95% CI = 0.45, 0.46, p = 0.001) and Semantic Verbal Fluency Test scores (SIB vs. HC: RR = 0.89; 95% CI = 0.88, 0.9, p = 0.001. SZ vs. HC: RR = 0.91; 95% CI = 0.89, 0.93, p = 0.001) were a significant predictor of being in the SZ or SIB group.

Furthermore, I analyzed the Turkish version of the Thought and Language Disorder Scale (TALD-TR) factors (Table 6) in a second multinominal logistic regression model. According to the results of this multinominal logistic regression analysis, objective negative factor is the best predictor of both SIB (RR = 25.42; 95% CI = 6.58, 98.22, p = 0.001) and SZ (RR = 37.51; 95% CI = 9.70, 144.96, p = 0.001) group compared to the HC group.

Table 4
Group and pairwise comparisons of the results of thought and language tests

Comparison	Patients with Schizophrenia (SZ) Mean (SD.)	Siblings (SIB) Mean (SD.)	Controls (HC) Mean (SD.)	*p*	Significant Pairwise (SPC)
Boston Naming Test	42.33 (9.62)	48.08 (5.71)	52.67 (6.34)	**<0.001****	HC>SZ HC>SIB
Phonemic Fluency	21 (13.52)	29.38 (11.33)	42.29 (16.03)	**<0.001****	HC>SZ HC>SIB
Semantic Fluency	13.92 (6.27)	16.38 (4.12)	21.04 (4.31)	**<0.001****	HC>SZ HC>SIB
SSIQPS	2.17 (2.12)	3.50 (1.95)	5.79 (2.97)	**<0.001****	HC>SZ HC>SIB
TLI	0.82 (0.52)	0.71 (0.24)	0.51 (0.37)	**<0.05***	HC<SZ
TALD-TR Total	33.88 (11.18)	16.75 (5.93)	2.04 (2.42)	**<0.001****	HC<SZ SIB<SZ HC<SIB
TALD-TR SN	16.54 (6.77)	7.62 (4.56)	0.91 (1.31)	**<0.001****	HC<SZ SIB<SZ HC<SIB
TALD-TR OP	5.91 (5.63)	4.37 (4.45)	0.58 (1.88)	**<0.001****	HC<SZ HC<SIB
TALD-TR ON	7.45 (5.49)	2.79 (2.20)	0.16 (0.48)	**<0.001****	HC<SZ SIB<SZ HC<SIB
TALD-TR SP	3.66 (1.65)	1.75 (1.79)	0.37 (0.64)	**<0.001****	HC<SZ SIB<SZ HC<SIB

SD = Standard deviation, N/A = Not applicable, SPC = For variables with significant differences according to Kruskal-Wallis test: post hoc Bonferroni tests, $p<0.05$, TALD-TR = The Turkish language version of the Thought and Language Disorder Scale, SSIQPS = Scale for Scoring the Inclusion and Quality of the Parts of the Story, TLI = Thought and Language Index, SN = Subjective Negative, OP = Objective Positive, ON = Objective Negative, SP= Subjective Positive, Bold values indicate significance either at level *$p<0.05$ or **$p<0.001$, *** Higher scores in TLI, TALD-TR Total, TALD-TR SN, TALD-TR OP, TALD-TR ON, TALD-TR SP reflect lower performance

Table 5

The results of thought and language tests and their associations with schizophrenia risk

	Schizophrenia Risk = 0 (Controls) Reference Group	Schizophrenia Risk = 1 (Siblings)				Schizophrenia Risk = 2 (Patients)			
		Wald	df	RR (%95 CI)	*p*	Wald	df	RR (%95 CI)	*p*
Thought and Language Index	-	2.46	1	4.41 (1.35-14.42)	**<0.05**	4.83	1	17.58 (5.49-56.3)	**<0.001**
Boston Naming Test	-	-2.55	1	0.91 (0.85-0.97)	**<0.05**	-3.49	1	0.83 (0.75-0.92)	**<0.001**
Story (SSIQPS)	-	-6.45	1	0.68 (0.6-0.76)	**<0.001**	-126.1	1	0.45 (0.45-0.46)	**<0.001**
Phonemic Fluency	-	0.24	1	1 (0.96-1.04)	0.8	0.25	1	1 (0.96-1.04)	0.8
Semantic Fluency	-	-28.73	1	0.89 (0.88-0.9)	**<0.001**	-8	1	0.91 (0.89-0.93)	**<0.001**

Model $\chi 2 = 47.25$ $df = 5$, $p<0.001$

CI = confidence interval, df = degrees of freedom, *χ2:* Chi-square, RR = relative risk ratio, SSIQPS = Scale for Scoring the Inclusion and the Quality of the Parts of the Story

Table 6

Associations between TALD-TR factors and schizophrenia risk (*N*=72)

	Schizophrenia Risk = 0 (Controls) Reference Group	Schizophrenia Risk = 1 (Siblings)				Schizophrenia Risk = 2 (Patients)			
		Wald	df	RR (%95 CI)	*p*	Wald	df	RR (%95 CI)	*p*
Subjective Negative	-	22.18	1	2.53 (2.35-2.75)	**<0.001**	27.94	1	3.22 (2.96-3.49)	**<0.001**
Objective Positive	-	10.31	1	2.44 (2.06-2.90)	**<0.001**	13.37	1	3.19 (2.69-3.79)	**<0.001**
Objective Negative	-	4.69	1	25.42 (6.58-98.22)	**<0.001**	5.26	1	37.51 (9.70-144.96)	**<0.001**
Subjective Positive	-	1.65	1	4.62 (0.74-28.60)	0.1	2.13	1	7.27 (1.17-45.04)	**<0.05**

Model $\chi 2 = 118.79$ $df = 4$, $p<0.001$

CI = confidence interval, df = degrees of freedom, *χ2:* Chi-square, RR = relative risk ratio, TALD-TR = The Turkish language version of the Thought and Language Disorder Scale

2.3 Summary of Results

The present study evaluates thought and language disorder as a potential endophenotype in patients with schizophrenia and their unaffected siblings. My

hypothesis that thought and language disorder is seen in patients with schizophrenia (SZ), and milder disorder is also present in their unaffected siblings (SIB) was confirmed except from one test score (phonemic verbal fluency). In my study, not only SZ but also the SIB group demonstrated that overall lower level of thought and language functioning compared to our reference group, HC (Thought and Language Index, Boston Naming Test, Scale for Scoring the Inclusion and the Quality of the Parts of the Story, semantic verbal fluency, Thought and Language Disorder Scale). Besides, thought and language disorder resulted in a higher relative risk in the SZ group and a milder but increased risk in the SIB group. However, this finding was reversed for Boston Naming Test and SSIQPS, although SZ and SIB's RRs were near each other. This could be because of my relatively low number of participants (Burmesiter & Aitken, 2011).

CHAPTER 3

EXPERIMENT 2

3.1 Methods

3.1.1 Participants

Two groups of participants were included in the study: schizophrenia (SZ), and healthy control (HC). The SZ sample consisted of 38 outpatients of the Community Mental Health Center of Etimesgut Şehit Sait Ertürk State Hospital and Hacettepe University Hospital between September 2019 and December 2022. The patients who met the DSM-5 criteria for SZ were enrolled in the study. The patients were clinically stable and had not undergone electroconvulsive therapy (ECT) in the last year. To determine the disease severity and prominent clinical features, the scoring of the Clinical Global Impression Rating Scale (Guy, 1976), and the age of illness onset were collected from the patient's charts. Daily doses of antipsychotics were converted into chlorpromazine equivalents using an equivalency table provided by Gardner et al. (2010). The HC group comprised 38 carefully matched for age, gender, and education to SZ participants. The inclusion criteria of the healthy control

group comprised no psychiatric history, no family history of psychiatric illness, no traumatic brain injury or any other neurological disease, no somatic disease, and no psychotropic drug usage.

The exclusion criteria for all participants included any history of neurological or chronic somatic disorder, mental retardation, alcohol or substance abuse or dependence, or head injury. All participants were right-handed, native speakers of Turkish, and Turkish nationality. All participants provided written informed consent. Twenty-four SZ and 24 HC of participants from the whole sample had previously been included in another study (Çabuk et. al., 2023); however, the current study utilized one common data collection tool and different analysis techniques.

3.1.2 Data Collection Tools and Speech Sampling

3.1.2.1 Thought and Language Disorder Scale (TALD)

The Thought and Language Disorder Scale (TALD) was developed by Kircher et al. (2014) and adapted to the Turkish language by Mutlu et al. (2019) (TALD-TR). The Turkish language version of TALD showed adequate and effective psychometric properties with high Cronbach's Alpha values and high inter-rater reliability parallel to the original version (Mutlu et al. 2019, Kircher et al. 2014).

The TALD is a 30-item semi-structured scale with operationalized definitions of symptoms and symptom ratings, directed questions, and examples for discriminating objective and subjective symptoms from each other. The factor analysis of TALD revealed four factorial structures, namely Objective Positive (i.e., circumstantiality, derailment), Subjective Negative (i.e., poverty of thought, blocking), Objective

Negative (i.e., poverty of speech, concretism), and Subjective Positive factors (i.e., thought interference, pressure/rush of thought) (Kircher et al. 2014).

The interview of TALD comprises two parts. Description of daily life events (e.g., "What do you like to do on the weekends?") or interests such as hobbies (e.g., "Which kind of movies do you like to watch?") are discussed by open-ended questions in the first section (Section A) so that the rater can detect objective symptoms and further query to code symptom severity. The subjective symptoms are questioned in detail in the second section (Section B). The rater assesses each subjective symptom following standard procedures (Kircher et al. 2014) and explores and notes the presence of any subjective symptoms (e.g., for rush/pressure of thoughts: "Do you sometimes feel that so many ideas come into your mind quickly, one after the other or even at the same time, that you lose control of your thoughts"). If necessary, the rater can ask more questions or give additional explanations to be sure that questioned subjective phenomena are understood.

In this study, the responses to sections *A* and *B* were audio recorded in a 20-minute session. All participants gave informed consent for their interview sessions to be voice recorded. The rating was completed immediately after the interview by an expert speech and language therapist (TÇ) who was blind to the participants' clinical assessment. The grading of each item, such as derailment, tangentiality, and perseveration, was analysed according to the definitions of that item in the manual (Kircher et al., 2014; Mutlu et al., 2019).

3.1.2.2 Speech Sampling

Speech was elicited using a 20-minute semi-structured interview reflecting sections *A* and *B* of TALD. The questions were designed to elicit spontaneous speech with general issues and thought processing (please see: *2.1. Clinical assessment*). All interviews were conducted by an expert speech and language therapist (TÇ). The elicited verbal samples were audio-recorded and later transcribed. The transcriber (TÇ) was blind to the participants' group. The ethics committee of Bilkent University approved the procedures.

3.1.3 Methodology for Natural Language Processing

3.1.3.1 Natural Language Processing Hypothesis-Driven Part

In the first part of analysis, where NLP techniques were used, total completed words and first-person singular pronoun usage were averaged over the participants. The standard deviations of these statistics were also considered to identify the distinct trends between SZ and HC groups. Moreover, the average length of the participants' sentences was analysed. Lastly, the Moving average type-token ratio (MATTR) to identify variability in lexicon usage was calculated for all participants (Covington & McFall, 2010) by dividing the number of distinct words by the total number of words in a specified moving window whose length was 50. For example, when the window length was selected as 50, the type-token ratio (TTR) for words from 1 to 50 was calculated. Then, the TTR was calculated for words from 2 to 51, then from 3 to 52, and so on until the end of the transcribed speech data. In TTR, I did not use lemmatization. For the final score, calculated TTRs were averaged (Fergadiotis et al., 2015). All analyses for this section were done in the Natural Language Tool Kit (NLTK) library of Python programming language.

3.1.3.2 Natural Language Processing Exploratory Part

More advanced methods were utilized in the second part of the NLP analyses. First, through parts-of-speech tagging (POS), the number of uses for parts of speech (i.e., noun, verb, and adjective) was calculated per 100 words for each participant. A few units are used in basic sentences, such as one noun and one verb (i.e., "Ben geldim/I came") whereas various parts of speech are contained in complex sentences (i.e., "Ben geldim ama bu kötü ortam beni rahatsız etti/I came here, but this bad atmosphere disturbed me"). A pre-trained transformer model, RoBERTa (Liu et al., 2019), was used for the POS tagging task.

Second, the Word2Vec embeddings were used to obtain more detailed information about the transcribed speech data (Mikolov et al., 2013). These embeddings are vector representations of words in a high-dimensional space. In this high-dimensional space, the word vectors carry semantic information acquired through training with large textual data. The core assumption underlying these semantic vector representations is that the meaning of a word can be derived from its context. Here, 'context' reflects the other words that are close to the target word. By traversing all the textual data, the semantic similarity between words can be determined by inspecting how similar the contexts for these words are.

To assess the semantic similarity of each subject's speech, the mean similarity of the transcribed speech data was defined. The mean similarity was calculated by taking the average of word similarity between consecutive words in the participant's speech. The similarity metric, in this case, was the cosine similarity between word vectors. Cosine similarity between the two word vectors was between -1 and 1. A

cosine similarity of 1 means these two words are completely similar, whereas a cosine similarity of -1 means there is no relationship between the two words. Here, I used the term *semantic similarity* rather than *semantic coherence* when employing cosine similarity (Alonso-Sánchez et al., 2022). Moreover, a methodology with a clustering algorithm was also utilized for this study by using Word2Vec embeddings trained on Turkish corpus (Köksal, 2018). The embedding vectors for each word in a participant's speech were retrieved. The stop words were defined according to the NLTK default stop words and were removed before this procedure. Later, to have one distinct vector for each participant, the word vectors from each participant's speech were summed up, known as the "Bag of Words" approach. Bag of Words is a feature extraction technique from text data where the word occurrences are considered. Since it is easy to implement, intuitive, and flexible, this technique is widely preferred in NLP applications (Mikolov, 2013). Bag of Words approach was also utilized in detection and classification of schizophrenia through speech data (Castellani, 2012; Rezaii, 2019).

The output of Bag of Words would be a distinct and individual vector for each participant, called 'document embeddings'. An unsupervised clustering algorithm, "K-Means" (MacQueen, 1967), was applied to these document embeddings to evaluate how much information these document embeddings carry regarding the group membership of the participant (SZ vs. HC). In other words, my main aim was not to develop a generalizable classifier but rather to use the K-Means to describe my dataset. For this aim, I used n=2 clusters in the K-Means algorithm as I have two groups (SZ and HC) (Figure 1).

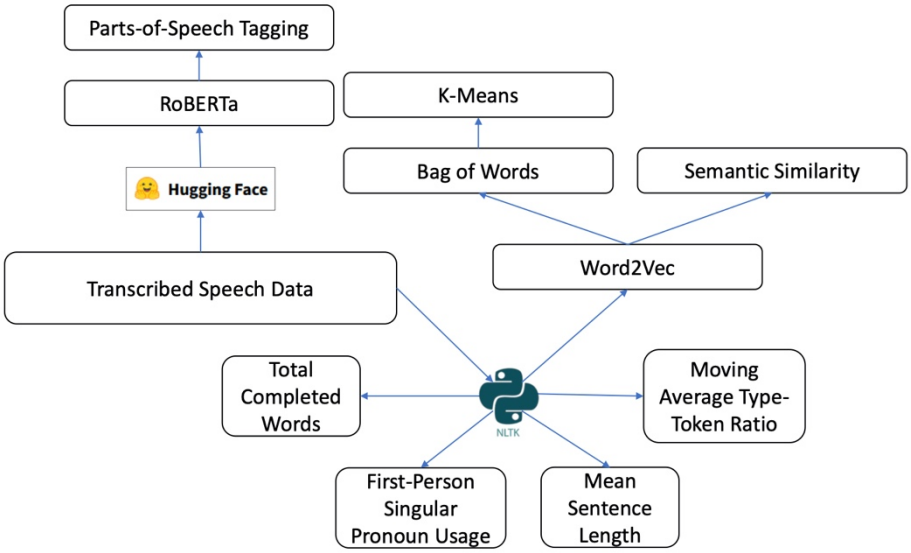

Fig. 1. The visualization of the methodology that includes Natural Language Processing techniques. Hypothesis-driven analyses part consist of total completed words, first-person singular pronoun usage, mean sentence length, and moving average type-token ratio. Parts-of-speech tagging and Word2Vec (semantic similarity and K-Means) are for exploratory analyses part.

3.1.4 Statistical Analyses

The SPSS version 22 (SPSS Inc., Chicago, Illinois, USA) was used to compare demographic and clinical characteristics. The continuous variables were checked using probability plots, histograms, and the Kolmogorov–Smirnov test to assess the normality of data distributions. In the demographic and clinical characteristics, the Chi-square test was performed to analyse categorical variables, and independent samples *t*-test was performed to analyse continuous variables. For the NLP analyses (parts 1 and 2), independent samples *t*-test and Mann Whitney *U* were used for normally distributed and non-normally distributed data, respectively. Pearson's correlations were performed to assess the possible correlations between NLP measurements and TALD (Total) and its four factors scores. The number of eigenvalues equal to or greater than 1 was determined as 3 using principal

component analysis using the values of the variables in the hypothesis-driven NLP analyses part and POS, part of exploratory NLP analyses part (Machado, 2007). Thus, the adjusted significance threshold α was determined as 0.018 and 0.014 for the hypothesis-driven NLP analyses part and POS, part of the exploratory NLP analyses part, respectively.

3.2 Results

3.2.1 Demographic and Clinical Characteristics

Demographic and clinical characteristics are summarized in Table 7. The groups did not differ in age, education and gender. HC showed higher paid employment and marriage rates. SZ were rated worse in TALD (Total) and its factor dimension scores.

Table 7
Demographic and clinical characteristics of patients with schizophrenia and healthy control group (*N*=76)

	SZ *N*=38 (%)	**HC** *N*=38 (%)	***χ2***	**df**	***p***
Gender					
Male	21 (55.3)	20 (52.6)	0.053	1	0.81
Marital status					
Married	10 (26.3)	23 (60.5)	9.05	1	**0.003****
Paid Employment					
Yes	18 (47.4)	30 (78.9)	8.14	1	**0.004****
			t	**df**	***p***
Age	38.82 ± 8.16	37.97 ± 7.96	0.45	74	0.65
Education (years)	10.66 ± 3.21	12.11 ± 3.60	-1.84	74	0.07
TALD (Total)	25.79 ± 1.97	1.97 ± 2.42	10.64	74	**0.001***
TALD (Objective Positive)	5.26 ± 5.26	0.66 ± 1.77	5.11	74	**0.001***
TALD (Subjective Positive)	2.55 ± 2.11	0.24 ± 0.54	6.54	74	**0.001***
TALD (Objective Negative)	5.92 ± 4.87	0.32 ± 0.48	6.98	74	**0.001***
TALD (Subjective Negative)	11.92 ± 7.94	0.76 ± 1.12	8.56	74	**0.001***
Duration of illness (years)	17.3 ± 7.85	N/A			
Age at illness onset	21.61 ± 6.86	N/A			
Medication (ECPZ-mg)	504.39 ± 220.29	N/A			
CGI-Illness severity	3.66 ± 1.02	N/A			

χ2 = Chi-square, df = degree of freedom, *t: t*-test, SD = Standard deviation, TALD = Thought and Language Disorder Scale, ECPZ = the equivalent dose of chlorpromazine, The CGI = Clinical Global Impression Scale-Severity, N/A = Not applicable, Bold values indicate significance either at level *$p<0.001$ or **$p<0.005$

3.2.2 Natural Language Processing Results for Hypothesis-Driven Part

Table 8 shows the differences between groups for all variables in NLP analyses (i.e. hypothesis-driven). Apart from total completed words, which did not differ between schizophrenia patients and healthy controls, the remaining variables did differ significantly in schizophrenia patients compared to healthy controls. Mean sentence length and MATTR were lower, but average first-person singular pronoun usage was higher in schizophrenia patients than in healthy controls. I found significant negative correlations between TALD scores, mean sentence length, and MATTR. Average

first-person singular pronoun usage (i.e. *ben*) was correlated with both TALD subjective negative and objective negative scores (Table 9).

Table 8
The results of hypothesis-driven NLP analyses part

Variable	SZ (*N* = 38)	HC (*N* = 38)	Test Statistics	*p*	Effect Size
Fluency					
Mean Sentence Length	4.681 ± 1.492	6.571 ± 1.684	5.178	**0.001*[a]**	1.19
Lexical Richness					
Total Completed Words	410 (210 – 820)	415 (240 – 540)	0.197	0.843[b]	0.022
Moving Average Type-Token Ratio	0.814 (0.766 – 0.845)	0.839 (0.817 – 0.866)	2.639	**0.008*[b]**	0.303
Grammar					
Average First-Person Singular Pronoun Usage (i.e. *ben*)	6 (3 – 16)	3 (1 – 6)	3.076	**0.002*[b]**	0.353

Bold values indicate significance at level **p*<0.018. [a]: *p* value was obtained from *t*-test. [b]: *p* value was obtained from Mann Whitney *U* test.

Table 9
Correlations of the TALD factors and variables in hypothesis-driven NLP analyses part (*N*=76)

Variable	TALD Objective Positive	TALD Subjective Negative	TALD Objective Negative	TALD Subjective Positive	TALD Total
	r, p	*r, p*	*r, p*	*r, p*	*r, p*
Fluency					
Mean Sentence Length	**-0.282, 0.014***	**-0.319, 0.005****	**-0.269, 0.019***	**-0.312, 0.006****	**-0.367, 0.001****
Lexical Richness					
Total Completed Words	0.002, 0.989	0.096, 0.412	0.094, 0.421	-0.055, 0.637	0.072, 0.530
Moving Average Type-Token Ratio	**-0.234, 0.042***	**-0.284, 0.013***	-0.170, 0.141	**-0.300, 0.008****	**-0.296, 0.009****
Grammar					
Average First-Person Singular Pronoun Usage (i.e. *ben*)	0.183, 0.114	**-0.284, 0.013***	**0.253, 0.028***	0.116, 0.319	0.263, 0.020

TALD = Thought and Language Disorder Scale, **p*<0.05 ***p*<0.01

3.2.3 Natural Language Processing Results for Exploratory Part

Table 10 shows the differences between groups for all variables in POS. Among all variables (Adjective, adjective, coordinating conjunction, determiner, noun, verb, pronoun), the coordinate conjunction differed significantly in schizophrenia patients compared to healthy controls. Schizophrenia patients produced fewer coordinating conjunctions.

Schizophrenia patients had higher semantic similarity than healthy controls ($U = 527$, $p = 0.043$). The document embeddings were fed to the K-Means algorithm. The formed clusters matched with the true labels with 86.84% accuracy. Figure 2 shows the participants whose true labels matched and whose labels did not match with the clusters that were formed by K-Means. In order to visualize the participants' clusters on a 2-D plane, t-SNE (Hinton & Roweis, 2002) technique was used to lower the dimension of the document embeddings. Looking at the figure, HC and SZ groups were also clearly separable through inspection. However, some of the participants from SZ group were closer to the HC group, so K-Means algorithm could not determine the correct cluster for them.

Table 10
The results of parts-of-speech tagging (exploratory NLP analyses part)

Variable Size	SZ (N = 38)	HC (N = 38)	Test Statistics	p	Effect
Adjective	4.10 (2.44 – 6.92)	6.21 (4.78 – 8.04)	2.348	0.019[a]	0.269
Adverb	8.56 (4.41 – 11.89)	9.62 (7.70 – 12.00)	1.158	0.247[a]	0.133
Coordinating Conjunction	7.17 (3.90 – 8.57)	9.14 (6.67 – 12.00)	2.717	**0.007*[a]**	0.312
Determiner	2.83 (1.71 – 4.12)	3.39 (2.45 – 4.00)	1.434	0.152[a]	0.165
Noun	15.54 ± 7.61	18.51 ± 6.98	-1.772	0.081[b]	0.406
Verb	14.94 (7.30 – 23.33)	14.51 (10.00 – 19.35)	-0.431	0.666[a]	0.049
Pronoun	7.55 ± 3.62	7.55 ± 3.31	0.002	0.998[b]	0.000

Adjectives are words that typically modify nouns and specify their properties or attributes, e.g., big/*büyük,* one/*bir,* blue/*mavi. Adverbs* are words that typically modify verbs for such categories as time, place, direction, or manner. They may also modify adjectives and other adverbs, e.g., she read *well*/*güzel* okudu. *Coordinating conjunctions* are words that link words or larger constituents without syntactically subordinating one to the other and express a semantic relationship between them, e.g., and/*ve,* or/*ya da,* but/*ama*. *Determiners* are words that modify nouns or noun phrases and express the reference of the noun phrase in context, e.g., this/*bu,* that/*şu,* a-an/*bir*. *Nouns* are a part of speech typically denoting a person, place, thing, animal or idea, e.g., girl/*kız,* cat/*kedi,* tree/*ağaç*. *Verbs* are members of the syntactic class of words that typically signal events and actions, can constitute a minimal predicate in a clause, and govern the number and types of other constituents which may occur in the clause, e.g., run/*koş,* eat/*yedi*. *Pronouns* are words that substitute for nouns or noun phrases, whose meaning is recoverable from the linguistic or extralinguistic context, e.g., I/*ben,* you/*sen,* everybody/*herkes* (Universal Dependencies, 2023). Bold values indicate significance at level *p<0.014. [a]: p value was obtained from Mann Whitney U test. [b]: p value was obtained from t-test.

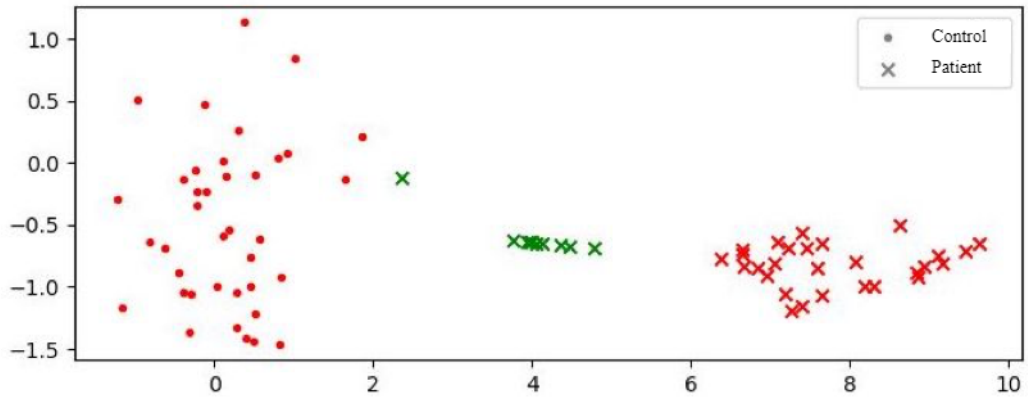

Fig. 2. The visualization of document embeddings where t-SNE algorithm was used to project the vectors to a lower dimensional space. The green marks show the participants to which K-Means did not assign a cluster that matched with their true label and the red marks show the participants whose clusters matched with their true label.

3.3 Summary of Results

In this study, I applied multiple NLP techniques to find linguistic features in Turkish, in a non-Indo European language, related to schizophrenia patients and found almost similar significant differences with other studies done in Indo-European languages (Manschreck et al., 1985; de Boer 2020; Hitczenko et al., 2020; Tang et al., 2021; Alonso-Sánchez et al., 2022). NLP measurements reported here appear to be sensitive to detecting 'the language of schizophrenia' with high accuracy and significance level.

To our knowledge, this is one of the most comprehensive studies evaluating language disturbances in SZ via using numerous NLP measurements together, and this is the first in the Turkish language with many aspects, such as utilizing POS and Word2Vec. The studies analysing 'the language of schizophrenia' by applying NLP or, in a more general sense, computational methods, and manual linguistic analyses are very limited in Turkish language. In one of the first studies, Mete et al. (1993) examined the language content in acute phase psychosis by using computer content analytic procedure and found that the speech content of Turkish patients with SZ is considerably similar to the speech content of American subjects, which was previously investigated, but certain dissimilarities appeared to reflect the impact of culture on the manifestations of SZ. Recently, Çokal et al. (2022) focused on referential noun phrases in Turkish-speaking SZ with and without formal thought disorder by performing manual linguistic analyses. Their findings confirmed that the language in SZ manifests through specific linguistic effects in the referential structure of meaning as mediated by grammar. Within this framework, my findings

are promising to describe the language in schizophrenia, showing that the results of the NLP analyses in Turkish are mostly language-independent (e.g. lower mean sentence length and lexical diversity, higher usage first-person singular pronoun, higher semantic similarity in schizophrenia patients and discrimination of the language of schizophrenia with high accuracy via utilizing Word2Vec with K-means clustering algorithm) with some possible language-dependent exceptions (e.g. coordinating conjunctions) as we do not have any finding in other languages and propose that NLP measurements may allow for rapid and objective measurements of linguistic features, many of which are hard to detect by human raters.

CHAPTER 4

GENERAL DISCUSSION

4.1 Interpretation of Results and Theoratical Explanations

In this current thesis project, I explored language as a possible endophenotype in schizophrenia. Specifically, I evaluated language ability in people with schizophrenia and their siblings and compared it to healthy controls using two complementary research approaches: 1) I used a comprehensive neuropsychological test battery to assess language ability among healthy controls, chronic schizophrenia, and their siblings as a high-risk group; 2) The interviews taken from schizophrenia patients and healthy controls via conducting Thought and Language Disorder Scale (Kircher et al., 2014) were used for Natural Language Processing (NLP) to discriminate schizophrenia patients from healthy control group.

In Experiment 1, parallel with the literature, the thought and language disorder assessed with TLI (Baskak et al., 2008; Demjaha et al., 2017) was successful in detecting the possible risk for schizophrenia in the SIB compared to the HC group. In

other words, thought and language disorder in SIB was qualitatively similar to that of people with SZ, but moderate in severity compared to people with SZ and HC group. This test score was more discriminatory than the other language tests in the model (Boston Naming Test, SSIQPS, phonemic verbal fluency, semantic verbal fluency). This finding may be related to the fact that thought and language tests not only focus on specific dimensions of language but also cover thought disturbances (Liddle, 2002; Kircher, 2014).

To my knowledge, this is the first study to evaluate thought and language disorder with all factors using TALD in unaffected siblings of SZ. My results showed that TALD could detect milder thought and language disorders in SIB group in detail. In addition, each TALD factor represents a different level of schizophrenia risk according to Risk Ratios (RRs) in the multinominal logistic regression analysis (Table 4). RRs were the highest for the presence of *Objective Negative* symptoms in both SZ and SIB groups (RRs in SZ vs SIB groups were 37.5 and 27.4, respectively). The second highest RRs were observed for the presence of *Subjective Positive* symptoms (RRs in SZ vs SIB groups were 7.3 and 4.6, respectively). Schizophrenia risk level was followed by *Subjective Negative* and *Objective Positive* symptoms with similar RRs in the multinominal regression analysis (Table 4). *Objective Negative* symptoms *(i.e., poverty of speech, slow thinking, and concretism)* are related to lower syntactical complexity (Thomas et al., 1987). *Subjective Negative* symptoms *(i.e., poverty of thought, inhibited thinking, and dysfunction of thought initiative and intentionality),* and *Objective Positive* symptoms *(i.e., derailment and crosstalk)* were discussed within the scope of damaged discourse previosuly (Kuperberg, 2010). Therefore, thought and language disorder may be examined in a

hierarchical model which the unique four-factorial structure of TALD could capture. However, it should be kept in mind that these results refer to chronic SZ patients who are in a stable period (duration of illness (years): *M* = 16.5, *SD* = 7.97; CGI-illness severity: *M* = 3.83, *SD* = 0.91 (between "mildly ill" and "moderately ill"). With respect to this, my results should be compared with the studies of participants with first-episode psychosis. Besides, as Kircher et al. (2014) pointed out the positive and negative factors and subjective and objective factors are crucial to fully comprehending thought and language functioning in schizophrenia and may serve as useful endophenotypes for this disorder.

Another finding in this study is that semantic verbal fluency in SIB is significantly lower than in HC group. This situation was not significant in the phonemic verbal fluency test (Chen et al., 2000; Henry & Crawford, 2005). Semantic verbal fluency is related to semantics, a subfield of linguistics (Verma & Howard, 2012; Whiteside et al., 2016), and when I consider that semantics is damaged more than phonetics and phonology in SZ. (Phillips et al., 2004; Kircher et al., 2018), this result is not surprising. To the best of my knowledge, the critical contribution of this study to the thought and language research field in SZ and SIB is that accessing words from the mental lexicon, naming and *aiming to convey more information in a given context to the listeners beyond using grammatical sentences* (i.e., discourse) as indexed by the Boston Naming Test and SSIQPS scores were significantly discriminating both SZ and SIB from the HC group. SSIQPS is scored based on the stories created by the participants from the TAT pictures presented to them. Storytelling can be examined within the scope of discourse (Thornborrow, 2011). It is known that discourse is one of the most damaged areas of language in SZ. (Kircher et al., 2018; Çokal et al.,

2018; Çokal et al., 2019). Also, Berenbaum et al. (2008) showed that the Boston Naming Test relates to discourse in SZ. Within this scope, it was shown for the first time that this disorder was also seen in the SIB group.

In Experiment 2, NLP measurements reported here appear to be sensitive to detecting 'the language of schizophrenia' with high accuracy and significance level. Mean sentence length is about sentence complexity. Greater length indicates more complex sentences related to syntax (de Boer et al., 2020). SZ used less complex sentences compared to HC with lower length. As I predicted, mean sentence length was negatively correlated with TALD scores. These findings support a "simplified syntax model" (Thomas et al., 1987; Özcan & Kuruoğlu, 2018; de Boer 2020) in schizophrenia. As SZ in this study had relatively high negative thought and language symptoms (TALD-Subjective Negative *M:* 11.92 *SD:* 7.94; TALD-Objective Negative *M:* 5.92 *SD:* 4.87), I found strong correlations between TALD (Total) score and mean sentence length. However, the correlation results of TALD four factors scores showed that not only negative factors but also positive factors scores had negative correlations with mean sentence length. The MATTR calculates lexical diversity (Covington & McFall, 2010). Parallel with the literature (Manschreck et al., 1981; Manschreck et al., 1985), SZ speech had low lexical diversity, pointing to increased repetitiousness.

Many other studies have noted differences in first-person singular pronoun usage, carrying information about 'the self' (Maatz, 2014; Birnbaum et al., 2019; Hitczenko et al., 2020; Tang et al., 2021; Lundin et al., 2023). In the analysis of the Twitter language of SZ users, Birnbaum et al. (2019) found increased use of first-person

singular and plural pronouns among posts from SZ. In an exploratory study, Tang et al. (2021) highlighted that a high percentage of participants with schizophrenia spectrum disorders preferred first-person singular pronouns in their speech. The current study also shows that SZ used significantly more first-person singular pronouns than HC, and this result was correlated with negative factors in the scores of TALD. This finding could result from social factors relevant in SZ such as social isolation and a lower sense of social connectedness (Lundin et al., 2023) or suicidal thoughts and behaviors across diagnoses (Fineberg et al., 2016; Homan et al., 2022).

In POS, SZ used fewer coordination conjunctions (i.e., and, or, but) than HC. Less usage of coordinating conjunctions in SZ suggests that SZ used less complex sentences, and this is correlated with negative symptoms (Hitczenko et al., 2020). I am the first to report a significant decrease in coordinating conjunction among SZ. My methodology utilizing Word2Vec showed that SZ had higher semantic similarity than HC. This could depend on the process in lexical selections of SZ. Alonso-Sánchez et al. (2022) found in their study that higher semantic similarity in SZ could be the result of failure in interference control as they detected a significant association between semantic similarity and Stroop Task scores. In this sense, it could be proposed that lexical selections of SZ can contribute to redundant discourse with reduced information content (Alonso-Sánchez et al., 2022). K-Means clustering algorithm could differentiate between SZ and HC into two distinct groups in the context of semantic similarity with high accuracy, 86.84%. The algorithm in this methodology is sensitive to the content of the transcribed speech data rather than the true labels (SZ vs. HC), which is important in training supervised learning algorithms. However, as seen in Figure 2, it missed some patients. This phenomenon

implies that schizophrenia should be regarded as a spectrum where some patients show fewer deficits than others in their speech.

4.2 Limitations and Further Studies

The main limitation of Experiment 1 is the relatively low number of participants, followed by having only clinical participants in a relatively stable phase of schizophrenia, not assessing antipsychotic response and side-effects, and not controlling premorbid intelligence, which can affect the results in the patients. Furthermore, I could not exclude the possibility that some of the SIB might develop psychosis later. Also, thought and language tests were collected and conducted by one speech and language therapist (TÇ) which may cause potential assessment bias. However, the rater was blind to participants' clinical characteristics as they were assessed by another researcher (EM). The detailed assessment of thought and language by TLI, TALD, and language tests are strengths of my study. Future studies should focus on the relationship between language disorder and earlier stages of schizophrenia with larger samples. Furthermore, they should use micro-linguistic analysis such as analysing cohesion and syntactical complexity and computational methods such as Natural Language Processing. This has many advantages for the patient's life: (I) it could shorten the duration of untreated psychosis (II) it could boost the psychological and social wellbeing (III) it could create new treatment strategies such as speech and language therapy (Clegg et al., 2007; Joyal et al., 2016; Mac-Kay et al., 2018).

The limitations of of the Experiment 2 are the following. The number of participants is modest. Having only clinical participants in a stable phase of schizophrenia (i.e.,

patients with more pronounced negative symptoms) may limit the generalizability of my findings to this population. I could not assess antipsychotic side-effects with a rating scale, and not control premorbid intelligence, which can affect the results in the patients. K-Means could capture hidden language patterns in the speech as it does not need pre-established labels of the groups (i.e., SZ and HC). However, because of this exact reason, the language patterns that distinguished the groups could become vague and hard to interpret in the light of psychopathology. It is not possible to say clearly on what basis the algorithm makes the decisions in the speech samples. In this current digital era, ethical points of representatives of using artificial intelligence to deal with language patterns, such as data responsibility and privacy, explainability, and trust should also be considered. Future studies should aim to collect larger samples, to compare the results of participants in different phases of the illness (e.g., first-episode schizophrenia), and to conduct crossdiagnostic studies in different languages. The last one is also important because using various language samples with different linguistic backgrounds can enrich NLP literature in SZ (Hitczenko et al., 2020) and provide crosslinguistic facts.

4.3 Conclusion

To conclude, this study shows that there are language-related phenotypes in schizophrenia, which are mostly language-independent, and these phenotypes are not only seen in schizophrenia patients, also seen in their siblings. This statement proves that thought and language disorder could be an endophenotype in schizophrenia.

These results are important for several reasons. First, as schizophrenia is a complex disease, there could be a long and complicated pathway between candidate genes and

clinical diagnosis. Even though it is well known that schizophrenia has substantial genetic components, the discovery of particular genes manifesting various clinical phenotypes in schizophrenia has been challenging. At that point, defining language as a vulnerability marker in schizophrenia could accelerate early detection, which is critical for a positive disease prognosis. Second, in contrast to gene analyses, which can be expensive, gathering and analyzing language data from schizophrenia patients and individuals at high risk is relatively cheap. This could be important, especially for psychiatrists wanting to make differential diagnoses for schizophrenia in a short time and in a clinical environment. Finally, the current study implies that while the spoken languages around the world are very different grammatically from each other, the disordered language patterns in both schizophrenia and their sibling are somewhat common.

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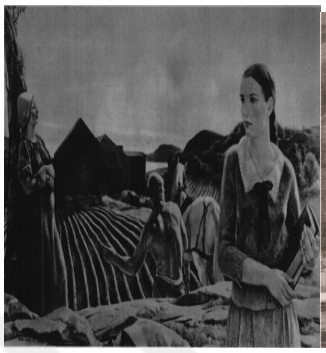
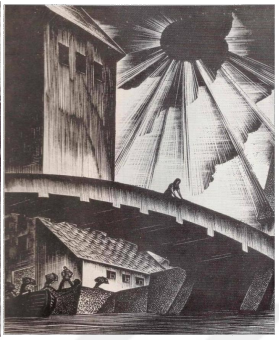
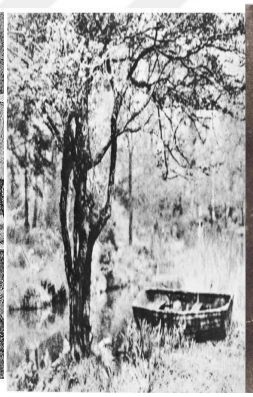
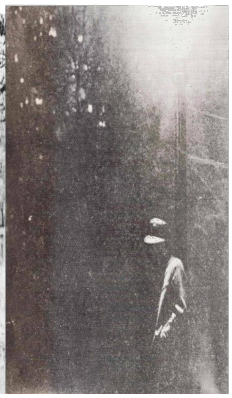
APPENDICES

APPENDIX A THE PICTURES OF THEMATIC APPERCEPTION TEST (TAT)







APPENDIX B THOUGHT AND LANGUAGE INDEX (TURKISH VERSION)

Maddelerin Tanımlanması Ve Derecelendirme İçin Protokol:

1-Düşüncenin Fakirleşmesi

a-Konuşmanın Fakirleşmesi:

Bu madde konuşma miktarında azalmayı yansıtır. Resimlere verilen tepkiler ve sorulara verilen yanıtlar kısadır ve ayrıntıdan yoksundur. (Eğer sıfat, zarf veya niteliksel bilgi eksikliği varsa; konuşma fakirleşme puanına ek olarak amacın zayıflaması da 0,25 olarak puanlanabilir.)

DDÖ'nün diğer maddelerinden farklı olarak bu madde, her bir soru ya da uyarıya verilen yanıtın uzunluğuna ilişkin anormalliğin ortaya koymak yerine, niceliksel bir değerlendirme gerektirir.

Her bir resme verilen genel cevap için 0, 0.25, 0.5, 0.75 ya da 1 şeklinde puan verilir.

0 Birey uzun duraklamalar olmaksızın 1 dakika boyunca konuşur, en az dakikada 50 sözcük hızını başarır. 1 uyarıya kadar izin verilir.

0.25 1 dakikada konuşulan kelime sayısı 40 ile 49 arasındadır. Bir uyarı kabul edilebilir.

0.5 Cümleler kısadır. Konuşma akışını sağlayabilmek için bir veya daha fazla uyarı gerekir.

0.75 Birkaç kısa cümle veya cümlecikten sonra ilk uyarı gerekir ve uyarıların çoğuna tek bir cümle ya da daha azı ile cevap alınır.

1.0 Tek bir kısa cümleden sonra ilk uyarı gerekli olur ve tüm uyarılara kısa bir cümleyle cevap alınır ya da hiç cevap alınmaz.

b-Amacın Zayıflaması:

Amacın zayıflaması; düşünce dürtüsünün kaybını yansıtır ve düşünceler olması gereken ayrıntılardan yoksundur. Bilgi vermeyen genellemeler kullanılır ve çok az bilgi içeren boş konuşmalar olur. Çok sayıda birbiriyle yarışan hedeften birine odaklanamama sorunu olan amacın istikrarsızlığından (çağrışım çözüklüğü gibi olgularda kendini gösterir) farklı bir durumdur. Aksine, amacın zayıflaması düşünce miktarında azalmayla ilişkilidir. Böylece amacı zayıflamış hastanın konuşmasının başlıca özelliği, gerekli detayların olmaması ve/veya az bilgi içeren boş cümleciklerin aşırı kullanılmasıdır.

Normal konuşmada çok az bilgi taşıyan kalıplar bir dizi bilgilendirici kalıplar arasına serpiştirilmiştir. Bu ise düşünceler sıralanırken konuşan ile dinleyici arasındaki iletişimin sürekliliğini sağlar. Böylesi boş cümleciklerin kullanımı ancak tüm konuşmanın büyük bir kısmını oluşturduğunda anormal olarak kabul edilir. Amacın zayıflamasına konuşma fakirliği de eşlik edebilir, (konuşma miktarının azalması) ama bu gerekli değildir. Asıl gereken; konuşulan kelime sayısına oranla çok az bilginin aktarılmasıdır.

Değerlendirme yaparken; aşağıdaki ölçeğe göre her resme verilen tüm cevaplar için tek bir puan veriniz.

0 *Normal:*

Söylenenlerin çoğunluğu özgün bilgi taşır ve bazı niteliksel bilgiyi içerir.

0.25 *Ayrıntılandırılmamış düşünceler:*

Düşünceler normal gelişimden yoksundur. Konuşmada az sayıda sıfat, zarf veya değiştirici cümlecik kullanılır. Örneğin bir resmi tanımlarken, hasta, bir seri

cümleyle resmin içeriğini listeler: “burada ……. vardır.”, ancak nesnelere ait hiçbir niteliği tanımlamaz. (Düzeltilen yanlış başlangıçları değerlendirmeyiniz)

0.5 *Genelleme:*

Konuşma özgül değildir ve az bilgi içeren üstü kapalı genellemelerle karakterizedir. Örneğin bir resmi tanımlarken hasta, “bir şeyler oluyor” diyebilir; ancak ne olduğuna dair hiçbir fikir bildirmemektedir.

1.0 *Boş konuşma:*

Neredeyse bütün konuşma, normalde düşünceler sıralanırken dinleyenle konuşan arasındaki iletişimi sürdürmekte kullanıldığı gibi bilgi içermeyen kalıplardan oluşur(“biliyorsunuz”, “durun/bir dakika” gibi). Denek açık bir amacı olmaksızın cümleye başlayabilir ve sonra cümleyi tamamlamayı başaramaz. Ancak, deneğin yanlış başlayıp, ardından cümleye yeniden başlayıp açıklanacak düşünceyi açıkça ortaya koyduğu durumları dışlayınız.

c-Düşüncelerin Tekrarlanması:

Düşüncelerin veya temaların anlamsız biçimde tekrarı. Tekrarların gösterilen resme bağlı uyarıdan bağımsız olarak geliştiği anlara ağırlık veriniz.

Tekrarın bir dayanağı olup olmadığına karar vermek gereklidir. Örneğin, aşağıdaki koşullarda düşüncelerin ya da sözcüklerin tekrarı genellikle düşünce perseverasyonu olarak puanlanmaz:

1. hemen ardından düzeltilen yanlış başlamaların tekrarında (kekemeliği değerlendirmeyin)
2. vurgulamak amacı ile kasıtlı yapılan tekrar

3.yeni materyalin eklenmesi ile oluşan düşüncelerin tekrarında

4. bilinçli özetlemede
5. görüşmecinin uyarısı düşünceye itiraz gibi yorumlanarak hasta tarafından aynı düşüncenin tekrar edilmesi

0.25 Basit Tekrar:

Resme cevap verirken daha önce açıklanan düşüncenin tekrarı. Bir düşünce defalarca tekrarlanıyorsa, her tekrarı ayrı bir durum olarak sayınız. Daha önceden açıklanmış bir düşünce ayrıntılandırılıyorsa bunu saymayınız. Örneğin aşağıdaki durum tekrar sayılamaz. “Adam tarlayı sürüyor. Adam tarlayı düz arıklarla sürüyor.” Ayrıca uyarı sonrası daha fazla bilgi vermek için bilinçli olarak fikrin tekrarlaması durumlarını da dışlayınız. Örnek “daha önce söylediğim gibi.”

0.5 Desteksiz Tekrar:

Resmin bir bölümüne ilişkin (ya da önceki herhangi bir resmin) daha önceden dile getirilen özgün bir düşüncenin, resmin başka bir bölümü ya da parçasına yeterli bir gerekçe olmadan uygulanması. Ancak, bu yanlış uygulama resimdeki kanıtla çelişmez. Örnek, (resim 1) mantıklı bir gözlemle “ağaca dayanan kadın hamile”, " şu cümleyi iddia ediyor, "kitabı tutan kız hamile". Her ne kadar bu iddiayı destekleyecek ya da yadsıyacak kanıt olmasa da.

1.0 Karşıt tekrar:

Resmin bir bölümüyle (veya daha önceki resimle) bağlantılı olarak önceden açıklanmış bir düşünce, resimde görülene zıt olmasına veya resimle ilgili olmamasına rağmen tekrarlanır. Örneğin; 3. resme karşılık verirken (köprüde insan figürü) "kadın ata biniyor" (açıkça görüldüğü gibi birinci resimden türetilmiş bir fikrin tekrarı: "adam ata biniyor")

2-Düşünce Dağınıklığı:

a-Çözülme:

Düşünceler arası bağlantı çok azdır veya yoktur ya da düşünce akışına konudışı düşünceler girer. Çözülme, spontan konuşma akışı sırasında ortaya çıkabilir; (Andreasen tarafından raydan çıkmak olarak adlandırılmıştır.) veya sorulara uygunsuz veya teğetsel cevaplar vermek şeklinde görülebilir (Andreasen tarafından teğetsellik-teğet geçme olarak adlandırılmıştır).

0.25 Rastgele Yorumlar

Bağlantıları çok az olan veya bağlantısız düşüncelerin doluşması, ancak denek hızla orijinal düşünce akışına döner. Saplantının dış bir uyaran tarafından oluşması durumundaki dikkat dağılmasını dahil etmeyiniz, (aşağıya bakın).

0.5 Sapma

Denek; yavaş biçimde konunun dışına sürüklenerek resimle ilgisi olmayan maddeleri konuşmaya başlar. Gerekirse, uygulamacı deneği resme dönmesi konusunda uyarmalıdır. . Uyarıdan sonra sapmanın tekrarlaması ayrı bir sapma olarak derecelenmelidir.

0.75 Mantıksal Olmayan Bağlantılar

Denek; aralarında yeterli mantıksal bağlantı olmaksızın bir düşünceden diğerine atlar; ancak düşünceler arasında bazı bağlantılar fark edilebilir. Uyaklı (clang) çağrışımlar bu maddenin örneği olarak kabul edilir.

1.0 İlgisiz Yanıtlar

Resimle cevaplar (veya sorgulama) arasında fark edilebilir bir bağlantı yoktur. Karşıt tekrarlar olarak değerlendirilmesi gereken bir önceki resme ait düşünce tekrarlarını dışlayın.

b-Kelimelerin Olağan Dışı Kullanımı

Kelimelerin kullanımı alışılagelmedik biçimdedir veya uydurulmuştur. Tek bir resme cevap verirken bir kelime bir kereden daha çok sayıda kullanılmışsa sadece ilk kullanımı derecelendiriniz, ancak uygunsuz kelime tekrar tekrar kullanıldığında düşünce tekrarları olarak değerlendirmeyi göz önüne alınız.

0.25 Olağan Dışı Kelime Kullanımı

Sıradan kelimeler konu dışında kullanılır veya daha sık kullanılan ve anlamı daha net ortaya koyan kelime yerine daha ender kullanılan bir kelime seçilir.

0.5 *Özel Terminoloji*

Gerçek bir kelimenin geleneksel anlamı dışında kullanılanımı ya da kelimelerin geleneksel olmayan bir şekilde eklenip bir araya getirilmesi ve yeni bir sözcük oluşturulması. Örneğin, "elayakkabı" eldiven anlamında. Kabul gören argo veya konuşma diline ait ifadeleri dışlayınız.

1.0 Neolojizm

Deneğin yarattığı yanlış kelimeler. Yanlış söyleyişleri dışlayın.

c-Olağan Dışı Cümleler:

Cümlelerin yapısı alışılmadıktır. Anlamı ayırt etmeyi zorlaştıran cümle yapılarının olağan dışılığına daha büyük bir ağırlık verilmelidir. Düşük eğitime bağlanabilecek dilbilgisi yanlışlıkları ile oluşturulan cümleler olağan dışı olarak derecelendirilmemelidir.

0.25 Çok resmi veya ukalaca ifadeler

0.50 Cümlelerin tuhaf yapısı

1.0 Anlaşılmaz Cümleler

Cümlelerin uygunsuz bir şekilde yan yana gelmiş parçalardan meydana gelmiş olması nedeniyle anlam taşımaması. Sözcük salatası

d-Mantıksal Olmayan nedenselleştirme (Olağan Dışı Mantık)

Yetersiz kanıtlara veya hatalı mantığa dayanarak sonuçlara ulaşmak. Bir ifadenin olağan dışı bir mantığı yansıttığına, sorgulama evresinden sonra karar verilmelidir. Araştırıcı, serbest yanıt evresindeki tüm alışılagelmedik cevapları not etmeli ve bu düşüncelere dayanarak bir sorgulama yürütmelidir. Akla yatkın spekülasyonlara (tahminlere) izin veriniz. (Örneğin Resim 3'de köprü üstündeki kadının depresif olduğu spekülasyonu akla uygundur). Eğer uygun olmayan bir ifade sadece tekrara dayanıyorsa olağan dışı mantık olarak derecelendirilmez. . Bununla birlikte, eğer bir denek bir tekrar durumu için akla uygun olmayan bir açıklama veriyorsa tekrar ve olağan dışı mantığın ikisi birden kaydedilmelidir.

0.25 Doğrulanmamış Sonuçlar

Denek çok az bir kanıta dayanarak kesin bir iddiada bulunur. Örnek, resim 1 (çiftlik sahnesi) "çiftçiye zarar veren şiddetli bir kuraklık mevcuttur". Deneğin düşüncesinin bir spekülasyon olduğunu kabul ettiği durumları dışlayınız.

0.5 Mantığa Sığmayan Usa Vurma

Herhangi bir mantıksal temeli olmaksızın veya yanlış mantıksal çıkarsamalara dayanarak, denek bir sonuca ulaşır.

1.0 Karşıtlık

Sonuçlar kanıtlarla çelişir.

e-Çelinebilirlik

Dış bir uyarandan kaynaklanan konu dışı fikirlerin zihne doluşması. Çelinebilirliğin kesin olduğu tüm durumlar 1.0 ağırlığındadır.

APPENDIX C THOUGHT AND LANGUAGE DISORDER SCALE (TURKISH VERSION)

Düşünce ve Dil Bozukluğu Ölçeği (Thought and Language Disorder Scale - TALD)

Ad Soyad	Tarih	Toplam Puan
Yaş	Değerlendirici	

Objektif pozitif	0	1	2	3	4
Çevresellik					
Raydan çıkma					
Teğetsellik					
Düşünce çözülmesi (Enkoherans)					
Yandan cevap					
Konuya takılarak tekrarlama (Perseverasyon)					
Basınçlı konuşma					
Çok konuşma (Logore)					
Yapmacık (Manyeristik) konuşma					
Sözcük uydurma (Neolojizm)					
Uyaklı çağrışım					
Düşünce kısıtlanması					

Objektif negatif	0	1	2	3	4
Düşünce yavaşlaması					
Konuşmanın fakirleşmesi					
Somut düşünme					
Düşünce kopması					
Konuşma içeriğinin fakirleşmesi					

Subjektif negatif	0	1	2	3	4
Blok (Düşünce durması)					
Geviş getirme (Ruminasyon)					
Düşünce fakirleşmesi					
Düşünmenin engellenmesi					
Konuşmayı kavrama bozukluğu					
Konuşmayı ifade etme bozukluğu					
Düşüncenin başlatılması ve yönlendirilmesinde bozukluk					

Subjektif pozitif	0	1	2	3	4
Düşüncelerin birbirine karışması					
Basınçlı/hızlı düşünme					

Toplam puana dahil edilecek maddeler	0	1	2	3	4
Anlamsal (Semantik) parafazi					
Sesbirimsel (Fonemik) parafazi					
Sözcük tekrarı (Verbijerayon)					
Yansılama (Ekolali)					

Çevirenler: Emre Mutlu, M. Kâzım Yazıcı, Elif Barışkın, Aygün Ertuğrul, Ş. Can Gürel, A. Elif Anıl Yağcıoğlu

APPENDIX D SCALE FOR SCORING THE INCLUSION AND THE QUALITY OF THE PARTS OF THE STORY (TURKISH VERSION)

Adı ve Soyadı: …… Tarih:……

Öykünün Başlığı: ……

	Puan			
Kim? (Ana Karakter)				
Hikâyede bir ana karakter belirtilmemiştir.	0			
Ana karakter sunulmuş, fakat hakkında çok az bilgi ve ayrıntı verilmiştir.	1			
Ana karakter ayrıntılarıyla betimlenmiş ve oldukça inandırıcı biçimde sunulmuştur.	2			
Ne Zaman? (Zaman)				
Hikâyede bir zaman belirtilmemiştir.	0			
Zaman belirtilmiştir, fakat geleneksel anlatım içinde belirsiz bir zaman olarak ifade edilmiştir. Örneğin; "Bir zamanlar…" veya "Uzun zaman önce…"	1			
Zaman geleneksel olmayan bir anlatım içinde, belli bir vakti ifade edecek şekilde veya tamamlayıcı bilgilerle birlikte belirtilmiştir. Örneğin; "30 Mart günü öğleden sonra" veya "Çok uzun zaman önce, henüz insanoğlu yaratılmamışken…"	2			
Nerede? (Yer/Mekân)				
Hikâyede bir yer belirtilmemiştir.	0			
Yer belirtilmiş, fakat yer hakkında çok az ayrıntı verilmiştir. Örneğin; "Atlanta kasabası"	1			
Yer ayrıntılı bir şekilde betimlenmiş ve sıradan olmadığı belirtilmiştir. Örneğin; "İki nehir arasında 5 km'lik bir alana sahip Atlanta kasabası" veya "yeni gezegen Andromeda"	2			
Başlatıcı Olay				
Hikâyede ana karakterin bir amaç oluşturmasını sağlayan başlatıcı bir olaya yer verilmemiştir.	0			
Hikâyede ana karakterin bir amaç oluşturmasını sağlayan başlatıcı bir olay verilmiştir. Başlatıcı olay, doğal bir olay (heyelan), bir içsel tepki (yalnızlık) veya dışa dönük bir davranış hareket (Yaşlı kadın mücevheri çaldı.) olabilir.	1			
Başlatıcı olay karmaşık (iç içe olaylar halinde), şaşırtıcı veya iyi betimlenmiş bir şekilde sunulmuştur. Örneğin; "Bir meteor dağa çarptı. Bu çarpma köyün, heyelan altında kalmasına neden oldu. Bu yüzden köylüler sahip oldukları her şeyi kaybetti." Veya "Annesi onu günler boyunca evde bırakmıştı. Bu yüzden Can, günlerdir kendini yalnız hissediyordu."	2			
Karakter/Karakterler Ne Yapıyor/Ne Yapmak İstiyor? (Amaç)				
Ana karakterin amacı belirtilmemiştir.	0			
Ana karakterin amacı belirtilmiş, fakat yeterince açık ve anlaşılır şekilde ortaya konmamıştır. Örneğin; Bülent, bir şey yapmaya karar verdi."	1			
Ana karakterin amacı açık ve anlaşılır şekilde ortaya konmuştur. Örneğin; Bülent, arkadaşını kurtarmaya karar verdi."	2			

Açık ve anlaşılır şekilde ifade edilmiş iki ya da daha fazla amaç bulunmaktadır.	3			
Girişim (Olaylar zinciri)				

Hikâyede ana karakterin amacını gerçekleştirmek için yaptığı girişim hiç belirtilmemiştir.	0			
Ana karakterin amacını gerçekleştirmek için girişimin ne olduğu belirtilmiştir.	1			
Girişimler ve olaylar mantıksal bir sıra ile gerçekleşmiştir. (Örneğin; olaylar arasında çelişki yoktur.)	2			
Önceki iki maddeye ek olarak durumlar ve çıkmazlar ustalıkla ve özgün bir şekilde çözülmüştür. Örneğin; "Bill, düşmanları yakalamak için bir lazer yansıtıcı icat etti."	3			
Önceki üç maddeye ek olarak iyi düzenlenmiş birden fazla olay örgüsü var. Örneğin; ana karakterin denediği bir girişim başarısız oluyor ve sonra bir başka girişimde bulunuyor (Ana karakter kaleye hücum ediyor, fakat dökülen kızgın yağ yüzünden geri çekilmek zorunda kalıyor; sonra gizlice bir tünelden geçmeyi deniyor) veya ana karakter, seyahati sırasında bir yere gidiyor, sonra başka bir yere gidiyor…	4			
Hikâye Nasıl Bitiyor? (Son)				
Hikâyede belirli bir son yok, sonuç eksik kalmış ya da hikâye tamamlanmamış görünüyor.	0			
Ana karakterin girişimlerinin uzun vadeli sonuçları ortaya çıkmış, hikâye sonlandırılmıştır; fakat hikâyenin sonu oldukça sıradan bir tarzdadır. Örneğin; "Ondan sonra hep mutlu yaşadılar." veya "Bülent, ejderhayı öldürdü ve prensesi kurtardı."	1			
Ana karakterin girişimlerinin uzun vadeli sonuçları ortaya çıkmıştır. Bunun yanı sıra sonuç şaşırtıcıdır veya bir ahlaki değer içerir. Örneğin; "Kartal, ok ismini işte böylece aldı." Veya "Bunun sonucunda yalan söylemenin sorunları çözemeyeceğini anladı."	2			
Tepki (Öykünün herhangi bir yerinde ifade edilebilir.)				
Ana karakterin tepkileri sunulmamıştır.	0			
Ana karakterin bazı tepkileri ifade edilmiştir. Örneğin; "Çocuk yaptığı işten dolayı mutluydu."	1			
Ana karakterin tepkileri derinlemesine ifade edilmiştir. Örneğin; "Bu kötü günümde herkesten nefret ediyorum. Çok kızgınım. Beni neden küçük düşürdüler!"	2			
TOPLAM:	19			

APPENDIX F ETHICAL APPROVAL

Bilkent Üniversitesi
Akademik İşler Rektör Yardımcılığı

Tarih : 17 Eylül 2019

Gönderilen : Tuğçe Çabuk

Tez Danışmanı : Timothea Toulopoulou

Gönderen : Fatma Taşkın
İnsan Araştırmaları Etik Kurulu Başkanı [redacted]

Konu : *"Analysing Language Ability ..."* çalışması etik kurul onayı

Üniversitemiz İnsan Araştırmaları Etik Kurulu, 17 Eylül 2019 tarihli görüşme sonucu, *"Analysing Language Ability in First-Episode Schizophrenia Patients and Genetic High-Risk Individuals: Neuropsychological and DTI Investigation"* isimli çalışmanız kapsamında yapmayı önerdiğiniz etkinlik için etik onay vermiş bulunmaktadır. Onay, ekte verilmiş olan çalışma önerisi, çalışma yürütücüleri, ve bilgilendirme formu için geçerlidir.

Bu onay, yapmayı önerdiğiniz çalışmanın genel bilim etiği açısından bir değerlendirmedir. Çalışmanızda, kurulumuzun değerlendirmesi dışında kalabilen özel etik ve yasal sınırlamalara uymakla ayrıca yükümlüsünüz.

Etik Kurul Üyeleri:

Ünvan / İsim	**Bölüm / Uzmanlık**	[redacted]
1. Doç.Dr. Fatma Taşkın	İktisat	
2. Prof.Dr. Erdal Onar	Hukuk	
3. Prof.Dr. Haldun Özaktaş	Elektrik ve Elektronik Müh.	
4. Doç.Dr. Işık Yuluğ	Moleküler Biyoloji ve Genetik	
5. Dr. Öğr. Üyesi Gül Günaydın	Psikoloji	
Yd.1.Doç.Dr. Çiğdem Gündüz Demir	Bilgisayar Mühendisliği	
Yd.2. Dr. Öğr. Üyesi A.Barış Özbilen	Hukuk	

Kurul karar/toplantı No: 2019_09_17_03

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