

Lexical-Semantic and Phonological Processing Deficits in Wernicke's Aphasia *

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ABSTRACT: This study investigates the lexical-semantic and phonological processing deficits in Wernicke's aphasia by comparing with healthy controls aiming to shed light on the causes of impairment. Identifying and Picture-Naming, Lexical-Semantic Association and Rhyme Recognition Tests were used to assess the processing. The results showed that Wernicke's aphasics have the inability to retrieve a name associated with a picture but they were able to match the semantic prime with the associated target image similar to the control group. The results revealed that Wernicke's aphasics are capable of dealing with lexical-semantic processing and semantic judgment. Rhyme Recognition Test results revealed that Wernicke aphasics have partially preserved comprehension of printed language. The results of this study also showed that Wernicke's aphasics performed significantly lower accuracy than controls on the phonological test and performed comparably on the semantic test. It is concluded that their deficits are likely to be related to access to the phonological representations of words.

Keywords: Wernicke's Aphasia, Lexical-Semantic Processing, Phonological Processing, Semantic Priming

Wernike Afazisinde Sözcüksel-anlambilimsel ve Sesbilimsel İşleme Bozuklukları

ÖZ: Bu çalışma, Wernike afazili bireyleri sağlıklı bireylerle karşılaştırarak sözcüksel-anlambilimsel ve sesbilimsel işleme bozukluklarını incelemeyi amaçlamaktadır. İşleme bozukluğunun nedenlerini araştırmak için Tanımlama ve Resim Adlandırma Testi, Sözcüksel-anlambilimsel İlişkilendirme Testi, Uyak Tanıma Testi değerlendirilmiştir. Çalışmanın sonuçları Wernike afazili bireylerin resimde bulunan bir kelimeyi

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hatırlamada ve telaffuz etmekte başarısız oldukları halde önceden anlamsal bağ kurmaları için gösterilen resimle anlamsal ilişkide olan hedef resmi seçmekte başarılı olduklarını göstermiştir. Çalışmanın sonuçları Wernike afazili bireylerin sözcüksel-anlambilimsel işlemede başarılı olduklarını göstermiştir. Uyak Tanıma Testi sonuçları ise Wernike afazili bireylerin yazılı dili tanıma yeteneklerinin kısmen korunduğunu göstermiştir. Çalışmanın bulguları ayrıca Wernike afazili bireylerin sesbilimsel teste anlamlı düzeyde düşük sonuçlar gösterdiğini buna rağmen sözcüksel-anlambilimsel teste kontrol grubuna benzer sonuçlar gösterdiğini vurgulamaktadır. Wernike afazili bireylerin işleme bozukluğunun *nedenin* kelimenin sesbilimsel temsiline ulaşmayla ilişkili bir sorun olabileceği düşünülmektedir.

Anahtar sözcükler: Wernicke afazisi, sözcüksel-anlambilimsel işleme, sesbilimsel işleme, anlamsal hazırlama

1 Introduction

Aphasia is an impairment of language functions due to stroke which affects the production or comprehension of speech. The pattern of language and speech deficits varies depending on the affected brain regions (Clark & Cummings, 2003). It typically results from lesions in the left hemisphere. Aphasia can be very severe even it can be sometimes impossible to communicate with an aphasic patient but sometimes aphasia can be very mild, only a single aspect of language may be affected. The main classifications of aphasia include Broca's Aphasia, Wernicke's Aphasia, Conduction Aphasia, Global Aphasia, Anomic Aphasia and the Transcortical Aphasia. These aphasic types are identified according to the pattern of deficits in comprehension, production, fluency, repetition and naming. Depending on the location and the size of the damaged area there may be a loss of the capability to comprehend spoken and written language. Aphasia usually coexists with motor, sensory or cognitive abnormalities (Dronkers & Baldo, 2010; Devaraj et. al., 2018, Ingram, 2007, Armstrong, 2000).

This study focuses on the cognitive-linguistic features of Wernicke's aphasia also known as 'fluent aphasia'. Carl Wernicke in 1870 reported that damage to the 'posterior speech cortex' or Wernicke's area of the brain cause comprehension difficulties. For this reason, people with Wernicke's aphasia can produce grammatically correct sentences using many words as their production of speech is not affected but, what they say doesn't make a lot of sense (Yule 2010). Their reading and writing skills are severely impaired but individuals can have preserved intellectual and cognitive capabilities (Hartman et al. 2017). Their comprehension deficit has been considered as a distinctive feature. They demonstrate impaired comprehension and repetition of sentences. People with Wernicke's aphasia can't read and understand the written text. They can write but their writing is nonsense as well as their speaking. They cannot name the objects (Binder 2017; Yagata 2017). Wernicke's aphasics use

functional words and grammatical inflections. Their utterances are at normal length. Although they have poor comprehension, they are unaware of this deficit (Ingram 2007).

Psycholinguists have been trying to reveal the mechanisms that Wernicke aphasics use in comprehension and production. Many researchers reported that individuals with Wernicke aphasia perform highly fluent speech but display impaired language comprehension. Robson et al. (2017) stated that impaired phonological perception leads to reduced semantic access in Wernicke's aphasia. Hartman et al. (2017) stated that patients with Wernicke aphasia do not have a defect in thinking or reasoning. The important deficit is accepted as the impairment of phonology, in other words, the ability to translate sounds to the meaning of words. Although comprehension deficits are well documented in Wernicke's aphasia, comprehensive measures of both phonological and semantic processes have been little investigated. Detailed measures may offer further insight into the nature of aphasic deficits. The conversational analysis enables researchers to explore the interactions in details in order to attain further understanding of the communication process and the human cognitive system. The purpose of this study is to investigate the lexical-semantic and phonological processing of Wernicke's aphasics. For this reason mechanisms regarding the lexical-semantic processing and phonological processing will be discussed.

1.1 Lexical-Semantic Processing

Lexical-semantics is concerned with the systematic study of word meanings. Lexical-semantic processing comprises access to the lexicon and the semantic system. Lexical processing involves processes in which listener recognizes the phonological forms of the words, identifies and perceives the meaning and investigates other properties stored in his mental lexicon. Mental lexicon stores not only sounds, spellings of words and grammatical properties but also morphological properties of words. Word recognition involves both bottom-up sensorial information and top-down contextual information. Listeners' expectations, memory and attention play a crucial role in processing the word (Hagoort, 1998). The semantic and lexical systems are functionally independent in other words each word has a phonological and semantic representation (Hillis 2001; Miller 1999). The processing of lexical-semantic processing is mainly depend upon the left temporal neocortex but the right hemisphere enhances the left hemisphere's work (Cappa et. al. 2003).

When an information about the meaning of a stimulus is given in advance of its actual appearance, the processing time is frequently reduced and this processing facilitation is called semantic priming effect (Rosch, 1975). Semantic effects may be as a result of conscious expectations established by

the participant by means of an explicit instruction. The prime is accepted as a clue in processing (Sperber et. al. 1979). Semantic priming paradigms examine priming effects on lexical stimuli which can be a word that provides semantic connections with the target stimuli. In semantic priming paradigms, the target presentation is preceded by a prime creating connections. Researchers discuss whether semantic priming effects in Wernicke's aphasia preserved or not. There are studies which show that patients with Wernicke's aphasia are able to use semantic knowledge and they perform similar patterns to the controls in terms of semantic priming effect (Milberg & Blumstein, 1981, Milberg et al. 1987; Salles et. al. 2012).

There are two hypotheses about the lexical-semantic processing deficits in Broca's and Wernicke's aphasics. One view is that the degree of activation of lexical items. It is hypothesized that while the overall activation in the lexicon is reduced in Broca's aphasics it is increased in Wernicke's aphasics (Milberg et al., 1987; Blumstein & Milberg, 2000; Janse, 2006). The other view supports the idea that there is a delay in the time course of lexical activation for Broca's aphasics (Swinney et al., 1989; Prather et. al., 1997). On the other hand, it is suggested that there is a delay in lexical deactivation for Wernicke's aphasics (Prather et al., 1997). Both hypotheses predict that semantic priming in Broca's aphasia is impaired. Because the overall activation level of a word is reduced and the system is unable to work. Conversely, both hypotheses suggest that semantic priming occurs in Wernicke's aphasics as during processing lexical items stay active for a long time (Yee et. al. 2008).

1.2 Phonological Processing

Phonological processing is the use of sounds of a language in order to understand spoken and written language. Phonological processing consists of three different but connected competences: phonological awareness, phonological memory and phonological retrieval (Anthony et al., 2007, Wagner & Torgesen, 1987). Phonological awareness is the awareness of the sound structure of a language and also it is the ability to focus on segments of speech such as words, syllables and phonemes (Wagner & Torgesen, 1987; Gillon, 2004). It is the ability to manipulate speech sounds cognitively. Phonological awareness has been defined by phonological sensitivity, segmental awareness, rhyme sensitivity such as breaking words into syllables, identifying the phonemes at the beginning and end of words, isolating, blending, deleting and substituting phonemes within words (Anthony & Lonigan, 2004). Phonological memory involves storing phoneme information in a short-term memory store and it is ready to use when it is needed during phonological awareness tasks. Phonological retrieval is the ability to recall the phonemes related to graphemes. It can be assessed by rapid naming tasks. Naming speed tasks are described by an individual's ability to name

visually presented stimuli such as letters, objects, numbers, colors rapidly (Wolf et al. 2000).

Most of the models on lexical access suggest that semantic and phonological processes are activated separately at different levels during single-word comprehension or production. It is claimed that during picture naming, word production begins at a conceptual level, (e.g. recognition of visual features of a pictured object, orange) and the conceptual knowledge activates semantic attributes of the target word from the lexical-semantic system (e.g. ‘fruit’, ‘is food for humans’). Phonological codes of the target word form are then selected from long-term storage within the phonological lexicon. In the end, short term maintenance of phonological segment occurs in the phonological buffer prior to articulation (Meier et. al. 2016).

There is a debate among researchers regarding the level of interaction between semantic and phonological stages during lexical access. One view is that lexical access proceeds in a separate fashion and each stage of processing happen in sequence (Indefrey & Levelt, 2004; Levelt et al., 1999). While the other view supports the idea that the stages of semantic and phonological access interact and affect each other and they process in a parallel fashion (Dell et. al., 1997; Foygel & Dell, 2000; Schwartz et. al. 2006). Studies have shown that semantic access is influenced by a variety of factors such as familiarity (Funnell & Sheridan, 1992); lexical frequency (Kittredge et al. 2008) and word length (Nickels, 1995; Ellis et. al., 1983). Studies have also shown that phoneme position (Romani et al., 2011), frequency, familiarity (Howard & Gatehouse, 2006) impact the processing of the phonological output in aphasic patients. It is also found that the lexical-semantic factor of typicality, category prototype influence both accuracy and reaction times both in healthy controls and aphasic patients (Silveri et al., 1997; Hampton, 1979; Samson et al., 1998; Kiran et al., 2005; Vigliocco et al., 2002; Sandberg et al., 2012, Spezzano & Radanovic, 2010).

The purpose of this observational study was to investigate how Wernicke aphasics communicate in natural interactions and to investigate their lexical-semantic and phonological processing mechanisms. For this reason, this study addressed several questions.

The main research questions include:

1. What are the differences between Wernicke’s aphasics and healthy controls in processing lexical-semantic and phonological tests according to accuracy?
2. Does the impaired phonological system lead to reduced lexical-semantic access?
3. Does semantic priming have a facilitative effect on processing the semantically related words?

2 Methodology

2.1 Participants

The data of the study were collected from a group of Wernicke's aphasia who were treated both in a university neurology clinic and a private physiotherapy center in Western Turkey and from a group of healthy controls.

The neuropsychological assessment gives opportunities to evaluate patient's performance across a range of tests. By the help of the tests, patients' perceptual, cognitive and linguistic abilities or deficits are identified. In this study, all Wernicke's aphasic participants were evaluated according to a standard language examination, GAT-2 test (Tandırdağ et al., 2011). GAT-2 test was used as a pre-test to evaluate the presence of aphasia and each aphasic participant was run individually which lasted approximately an hour, with no time limit. All participants had sufficient cooperation and comprehension level to understand the instructions of the test. Participants who had a score of at least 75% of correct answers of seven subsets of GAT-2 language examination were included in the study. Three of Wernicke's aphasic participants were excluded from the study because they scored below 75% in GAT-2 test.

Consequently, on the basis of the clinical and neurological examinations, the patients were diagnosed as Wernicke's aphasia. In order to be included in the study, participants with aphasia met current diagnostic criteria. They were all native speakers of Turkish. They were all right-handed. They were all literate and at least graduated from primary school. They didn't have any auditory and visual deficiency and they didn't have any psychiatric disease. All the participants had sufficient comprehension level to understand the instructions of the test. All aphasic participants' lesion damage in the left hemisphere was evaluated by a neurologist using radiological imaging techniques. Wernicke aphasic group comprised of eleven participants; six female, five male. Mean age was 63.73 years (SD = 7.60) (range 48-75). Healthy controls comprised of twelve participants; six of the participants were female, six participants were male. Mean age was 62.33 years (SD = 9.89) (range 45-76). Healthy controls were asked for a history of neurological or psychological illness and they were at normal limits. All healthy volunteers met the following criteria: normal or corrected to normal vision and auditory perception, right-handed dominance, use of Turkish as a native language, no history of language and learning disabilities. They were all literate. They were closely matched for age, year of education and gender with the aphasic group (Table 1).

Table 1. Demographic data of the participants. T= Temporal, P= Parietal, F= Frontal Lobes

	Age	Sex	Education	Site	Interval (Months)
Wernicke Aphasic Participants					
1	62	F	Literate	T+P	16
2	71	F	Primary	T+P+F	17
3	68	M	Primary	T+P	13
4	54	F	High School	T+P	9
5	48	M	University	T+P	11
6	59	M	High School	T	14
7	63	F	High School	T+P	13
8	75	F	Primary	T+P	14
9	72	F	Primary	T+P	16
10	64	M	Primary	T	15
11	65	M	High School	T+P	15
Mean	63.73± 7.60				13.91±2.23
	Age	Sex	Education	Site	Interval (Months)
Control Participants					
1	45	F	University	NA	NA
2	65	F	High School	NA	NA
3	64	M	Primary	NA	NA
4	76	F	High School	NA	NA
5	70	M	High School	NA	NA
6	68	M	Primary	NA	NA
7	72	M	Primary	NA	NA
8	49	F	University	NA	NA
9	54	F	Primary	NA	NA
10	67	F	Literate	NA	NA
11	49	M	High School	NA	NA
12	69	M	Primary	NA	NA
Mean	62.33± 9.89				

2.2 Procedure

Video recording, researcher's notes and the results of the tests were used to collect the data. The study was approved by Institutional review board. Informed consent was taken from each participant or legal guardian. The data was collected between May 2018 and January 2019. In investigating the lexical-semantic and phonological processing deficits in Wernicke's aphasia, three tests were used. A pilot study was held to evaluate methodological handicaps and material problems. The test design and the sequence of the materials were organized

according to the pilot study. Participants were run individually and the interview took approximately 40 minutes. The interview was performed in a silent room.

Wernicke's aphasics and control group performed three different linguistic tests: Identifying and Picture-Naming Test, Lexical-Semantic Association Test, Rhyme Recognition Test. These tests showed the underlying construct of phonological and lexical-semantic processing. The participant's score on each task was the total number of correct responses.

2.2.1 Identifying and Picture-Naming Test

Picture-Naming tests involve various cognitive processes, from visual perception to lexical-semantic retrieval to articulation. Identifying and Picture-Naming Test aimed to evaluate both the ability to comprehend of a concrete object and pronouncing its name. For Identifying and Picture-Naming Test, one of the sub-tests of Bařkent Afazi Test (Dokur, 2013), Picture Naming test was used. Bařkent Afazi Test consisted of eight sub-tests, including spontaneous speech, comprehension, repetition, naming, reading, writing, apraxia, picture tasks and calculations. Picture Naming Test consisted of twenty pictures of a concrete object. Participants were shown the pictures respectively and asked to say its name orally. For example, a picture of a tree was shown and asked them to tell what they saw in the picture. Flashcards and verbal questions were used as stimuli. Twenty concrete objects were presented respectively.

2.2.2 Lexical-Semantic Association Test

Lexical-Semantic Association Test aimed to answer whether Wernicke aphasics comprehend the image and match the semantically related corresponding image given along with it. The effects of priming on semantically related word processing were assessed. Twenty pro-types in four semantic categories (fruit, sport, vehicle, food) were presented respectively. Semantic proto-types of these categories which were stated at Gökmen's (2013) study were used. Aphasic participants were asked to choose the semantically related pro-type with the target image among the triplet series of images. In other words, after priming with an image of an item belonging to one of the four categories, they were presented with groups of three images and asked to match the semantically related image with the primed item. Participants were evaluated whether they create a logical relationship with the image and the corresponding image semantically. For instance, the image of a car was presented as a prime followed by three images one of which belongs to the vehicle category. Two images were semantically unrelated with the prime. Semantic priming effect was evaluated according to the correct responses to the targets in given triplets.

2.2.3 Rhyme Recognition Test

Phoneme awareness is accepted as the best predictor of reading skills. To test the phonological processing of written words, written words were both presented orally and visually. ‘Rhyme Recognition Test’ which was modified from one of the sub-tests of Başkent Afazi Test (Dokur, 2013) was used. In ‘Rhyme Recognition Test’ initial phonemes of twenty words were substituted. Although the initial phonemes of the words were different, all words were meaningful. For example masa-tasa-kasa, darı-sarı-karı, kar-nar-zar, saç-taç-maç, yol-kol-sol, yel-kel-sel, yaş-taş-kaş, para-kara-tara. The participants were asked to find the correct written form matching with the picture among the three minimal groups. For example, a picture of a table was shown and pronounced orally and asked to find the written form among the three rhyming words. This test aimed to evaluate whether presenting a picture’s visual image of an object simultaneously with the written symbolic form elicits an association between these two.

2.3 Statistical Evaluation

All data regarding the results of the lexical-semantic and phonological tests of both Wernicke’s and control group were archived in Microsoft Excel format. The total number of correct and or other responses were summed. All data were transferred to PASW Statistics 18 software. After descriptive analysis, comparisons of the groups were made. Normal distribution was checked using the Kolmogorov-Smirnov Test. As the distribution was not normal, a non-parametric test for comparing independent groups was planned. A Mann-Whitney U test was held. Statistical significance was accepted when $p < 0.05$.

3 Results

This study examined the nature of lexical-semantic and phonological processing in Wernicke’s aphasia by comparing healthy control participants. All three tests provide a comprehensive look into the underlying mechanism of lexical-semantic and phonological processing.

3.1 Identifying and Picture-Naming Test

A Mann-Whitney U test showed that there was a significant difference ($U = 0$, $p < 0.01$) between the Wernicke Aphasia group compared to the control group in correct responses to visual stimuli. The median correct response was 20 in the control group while it was 0 in the Wernicke Aphasia group; suggesting that the naming process is severely impaired in Wernicke aphasics.

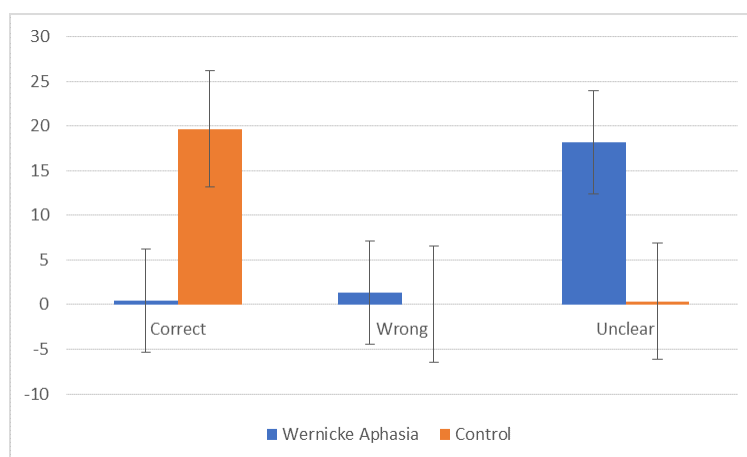
A Mann-Whitney U test showed that there was a significant difference ($U = 0$, $p < 0.01$) between the Wernicke Aphasia group compared to the control group

in unclear responses to visual stimuli. The median unclear response was 0 in the control group while it was 18 in the Wernicke Aphasia group; suggesting that their speech is incomprehensible, unclear (Table 2), (Figure 1).

Table 2. Mann-Whitney U test, mean rank and medians of the Wernicke and Control groups in Identifying and Picture-Naming Test

		Correct	Wrong	Unclear
Mean Rank	Wernicke (n=11)	6,00	16,36	18,00
	Control (n=12)	17,50	8,00	6,50
Median	Wernicke (n=11)	0	1	18
	Control (n=12)	20	0	0
Mann-Whitney U		0	18	0
Wilcoxon W		66,00	96,00	78,00
Z		-4,23	-3,48	-4,18
Exact Sig.		< ,001	< ,002	< ,001

Figure 1. Mean results of correct, wrong and unclear responses in Identifying and Picture-Naming Test



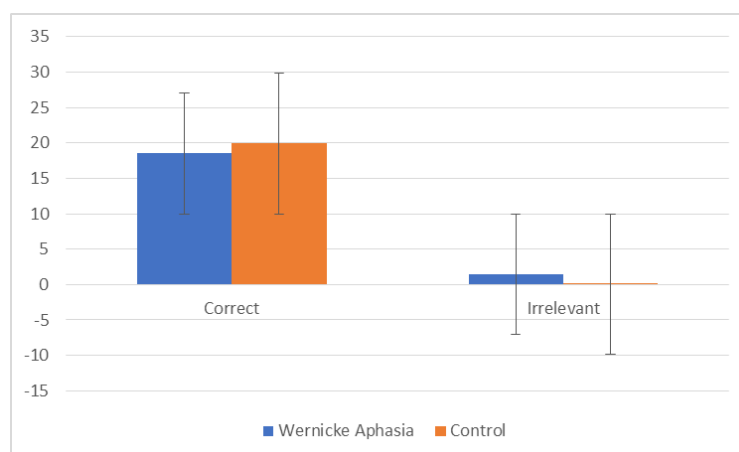
3.2 Lexical-Semantic Association Test

A Mann-Whitney U test showed that there was a significant difference ($U = 14,50$, $p = 0,01$) between the Wernicke Aphasia group compared to the control group in correct responses to relevant stimuli. The median correct response was 20 in the control group while it was 20 in the Wernicke Aphasia group, suggesting that lexical-semantic representation is spared in Wernicke's aphasia (Table 3), (Figure 2).

Table 3 Mann-Whitney U test, mean rank and medians of the Wernicke and Control groups in Lexical-Semantic Association Test

		Correct	Irrelevant
Mean Rank	Wernicke (n=11)	6,00	6,50
	Control (n=12)	17,50	18,00
Median	Wernicke (n=11)	20	0
	Control (n=12)	20	0
Mann-Whitney U		14,50	14,50
Wilcoxon W		92,50	80,50
Z		-3,53	-3,53
Exact Sig.		< ,01	< ,01

Figure 2. Mean results of correct and irrelevant responses in Lexical-Semantic Association Test



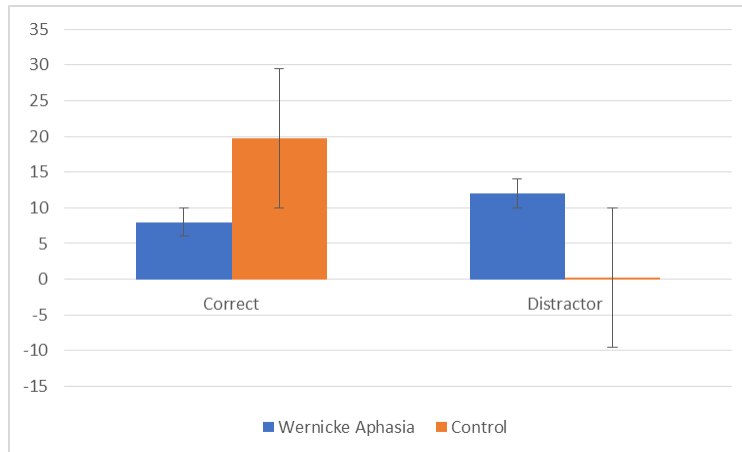
3.3 Rhyme Recognition Test

A Mann-Whitney U test showed that there was a significant difference ($U = 0$, $p < 0.01$) between the Wernicke Aphasia group compared to the control group in correct responses to visual stimuli. The median correct response was 20 in the control group while it was 8 in the Wernicke Aphasia group (Table 4), (Figure 3).

Table 4. Mann-Whitney U test, mean rank and medians of the Wernicke and Control groups in Rhyme Recognition Test

		Correct	Distractor
<i>Mean Rank</i>	Wernicke (n=11)	6,00	18,00
	Control (n=12)	17,50	6,50
<i>Median</i>	Wernicke (n=11)	8	12
	Control (n=12)	20	0
<i>Mann-Whitney U</i>		,00	,00
<i>Wilcoxon W</i>		66,00	78,00
<i>Z</i>		-4,201	-4,201
<i>Exact Sig.</i>		<,01	<,01

Figure 3. Mean results of correct and distractor responses in Rhyme Recognition Test



4 Discussion

The results of this study showed that patients with Wernicke aphasia have difficulties in comprehension and communication because of the inability to access and use the phonological and semantic information. Findings confirm the critical role of phonological knowledge which shapes the processing system. When compared with healthy control group Wernicke aphasics demonstrated impaired phonological processing whereas they had spared lexical-semantic processing. The results also support the idea that thinking and reasoning abilities of Wernicke aphasics were spared.

When the research questions of this study were evaluated, it can be concluded that the results of the tests revealed significant differences for both groups. The results of the 'Identifying and Naming Test' revealed that Wernicke's aphasics, unlike the control group, could not name the object presented in the picture and their speech was unclear. However, this doesn't mean that they don't cognitively comprehend the image and classify it. Since the results of 'Lexical-Semantic Association Test' showed that Wernicke's aphasics had similar accuracy rates with the control group in matching the semantic prime with the associated target image. The results of the test support the hypotheses that although Wernicke's aphasics have difficulties in naming images, they can comprehend the meaning of the image and match it with its semantically associated correspondent. It can be concluded that semantic priming effects are preserved. Rhyme Recognition Test which evaluated the competence to comprehend both visually and orally presented image and match it with its written form revealed that Wernicke aphasics have partially preserved comprehension of printed language. In conclusion, the results of this study support the idea that the reason why Wernicke's aphasics speech doesn't make sense is because of the deficit in phonological processing. As they cannot understand the speech orally presented, they respond to it absurdly. This study also supports the idea that perceiving the visual image, interpreting, logical judgment, thinking, reasoning mechanisms are spared in Wernicke's area.

The results of the study are in consistence with previous findings suggesting that semantic representations are spared in Wernicke's aphasia. Slobin (1991) stated that Turkish speaking Wernicke's aphasics speech was fluent. They used a wide range of verb forms, all morphosyntactically correct, but semantically odd. He stated that aphasic participants have retrieval problems rather than impairment language system. The results of this study are in consistence with Slobin's study indicating that although Wernicke's aphasics speech was odd, their speech was syntactically correct. They used grammatical morphemes appropriately. Kirshner et al. (1981) examined the language processing in Wernicke's aphasics. They found that Wernicke's aphasics had fluent, paraphasic speech and impaired naming and repetition. They all showed partially preserved comprehension of printed language. Their reading

comprehension was remarkably preserved and their writing was limited to writing certain simple words. The results of the current study are in consistence with Kirshner et al. study because the results of tests revealed that although Wernicke aphasics have impaired picture naming abilities, their visual and reading comprehension are preserved. Meier et al. (2016) examined the nature of semantic and phonological access in aphasia by comparing with healthy control participants. Semantic and phonological tasks were used to assess the difference in processing requirements. They also examined the effects of category and typicality on different stages of semantic and phonological processing. Accuracy and reaction time data were collected. The results of their study showed that persons with aphasia performed significantly lower accuracy than controls on phonological tasks but performed comparably on semantic tasks. Their results align most closely with processing models of lexical processing as category and typicality effects were robust in the semantic tasks but not in any of phonological tasks. The results of this study are in consistence with their study suggesting, aphasic participants demonstrated impaired phonological processing with relatively preserved semantic processing as compared to controls. Hashimoto & Thompson (2010) used the Picture-word interference paradigm which provides a direct, automatic, time-constrained measure of the semantic and phonological processes that are activated during naming to examine naming abilities in aphasic individuals. The results of their study indicated disruptions of the phonological stage in the aphasic group when compared to the matched control group. The results of this study are in consistence with their study. Riley et al. (2018) examined typicality effects in individuals with primary progressive aphasia. They used a semantic category verification task, where participants were asked to decide whether visual or auditory words belonged within a specified superordinate category and they found a typicality effect. They found faster response times for typical vs. atypical items. They found that prototypical items within a semantic category are processed faster than atypical items within the same category. In this study, prototypical items in four semantic categories were used as a semantic prime and similar to control group Wernicke's aphasics were capable of matching the semantically associated correspondent. Robson et al. (2017) investigated the nature of the comprehension impairment in Wernicke's aphasia and found severely impaired phonological perception leads to reduced semantic access in Wernicke's aphasia. In their study, Wernicke aphasic participants were evaluated for semantic association judgment test and achieved more accurately for pictures than written words. The important deficit is the impairment of phonology, in other words, the ability to translate sounds to the meaning of words. The results of this study are aligned with their study suggesting that Wernicke's aphasics are more capable of dealing with lexical-semantic processing and semantic judgment for pictures. Milberg et al. (1987) reported

that Wernicke's and Broca's aphasics performed a lexical decision task and the results of their study indicated that the performance pattern of the Wernicke's aphasics was similar to that of normals showing the semantic representation is spared in Wernicke's aphasics whereas Broca's aphasics demonstrated a processing deficit in accessing the lexical representation of words. Milberg and Blumstein (1981) demonstrated semantic facilitation effects in a visual lexical decision task and Blumstein et al. (1982) attempted to explore these findings in a task where the acoustic-phonetic system was administered. The patients were given a simple lexical decision task in the auditory modality. The results of Blumstein et al. (1982) study showed that aphasic patients demonstrate shorter latencies and fewer errors for lexical decision when a target word is preceded by a semantically related word than a semantically unrelated word. The results of this study are in consistence with their study suggesting that semantic priming have a facilitative effect in lexical-semantic processing. Yee et al. (2008) examined the semantic and lexical processing of Broca's and Wernicke's aphasics with an eye movement device and found that Wernicke's aphasics fixated on the semantically related picture more than the average of the unrelated pictures. The results of this study are aligned with Yee et.al. (2008) and Salles et al. (2012) study suggesting that Wernicke's aphasics are capable of finding the semantically related picture with the semantic prime. The results of this study suggest that semantic priming effect occurs in Wernicke's aphasia. Démonet et al. (1992) assessed brain activation of healthy volunteers in a positron emission tomography aimed to investigate phonological and lexico-semantic processing for auditory comprehension of language. They concluded that phonological processing was associated with activation in the left superior temporal gyrus mainly Wernicke's area. The findings of this study are in consistence with Démonet et al. (1992) study stating that the damage to the Wernicke's area affects the access of auditory input and phonological processing.

5 Conclusion

This study investigates the lexical-semantic and phonological processing deficits in Wernicke's aphasia. To my knowledge, this study is the first study which evaluates both lexical-semantic and phonological processing in Turkish Wernicke's aphasics comparing with healthy controls. The results of this study revealed that Wernicke's aphasics demonstrated a considerable ability for lexical-semantic processing of visual images despite impairment of auditory comprehension. They identified and matched pictures with their semantically related correspondent with a high degree of accuracy. Furthermore, accuracy rates on the lexical-semantic test were significantly similar to controls. Also, the results revealed that Wernicke aphasics have partially preserved

comprehension of printed language. The results of this study showed that Wernicke's aphasics have inability to retrieve a name associated with the picture. It can be assumed that more complex mental tasks involve distributed neural networks which require the using full cognitive resources. Wernicke's aphasics are able to use complex cognitive resources to access the lexical-semantic network but their phonological processing impairment causes lexical access deficits.

Findings of this study contribute to a growing body of research investigating lexical-semantic processing and phonological processing deficits in Wernicke's aphasics, suggesting the reason why Wernicke aphasics' speech is odd. The reasons for deficits should be taken into consideration while planning the future research.

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