Research Paper: Lexical Ambiguity Processing in Persian-speaking Patients With Broca and Wernicke Aphasia

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ABSTRACT

Introduction: Wernicke and Broca are two essential types of aphasia in which patients' productive and comprehensive abilities are affected, respectively. Although the lexico-semantic knowledge, as the heart of language comprehension, has been investigated in many research studies, there are still some controversies regarding the nature of probable lexical deficits in these patients. This study tried to delve into this issue and provide a plausible explanation in the Persian setting.

Materials and Methods: In doing so, 6 patients with Broca Aphasia (BA), 6 patients with Wernicke Aphasia (WA), and 12 healthy age- and education-matched monolingual controls were selected. Conducting a lexical decision task, each patient was required to decide whether the third word of an auditory presented triplet was meaningful or not. The first and last words of the triplet were related or unrelated to the ambiguous middle word.

Results: The results showed the similarity of the performance of WA patients to that of healthy control. That is, the context shaped by the first word facilitated the activation of the third word. Thus, they exhibited selected access to different meanings of ambiguous words as the healthy controls did. In contrast, semantic facilitation was not observed in BA patients.

Conclusion: Our results supported the previous findings asserting the intactness of semantic representation in WA patients.

1. Introduction

Patients with Wernicke Aphasia (WA) and Broca Aphasia (BA) have lots of challenges in performing linguistic tasks, though the brain affected and the linguistic function in each type of aphasia is somewhat different. Regarding WA, it should be emphasized that subjects' inability to produce a linguistic expression on the one hand and their deficit in understanding language, on the other hand, lies at the cornerstone of the disease.

To name a few crucial linguistic deficits of WA patients, we can easily detect their inability to recognize the referential meaning of vocabularies, more specifically abstract, bizarre, or phonemically odd words [1,

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2]. It was precisely due to these rudimentary problems that WA patients utilize basic vocabulary items. Some researchers have hypothesized that the language deficit in the case of WA patients should be attributed to the word storage or representation [3, 4]. So, according to some researchers, the major problem of WA patients in finding correct words can be attributed to a disruption in the storage of lexical items. Moreover, in other studies, WA patients' deficits were mainly attributed to the semantic field or lexical knowledge reduction [3-5].

In contrast, in BA, the opposite pattern has been observed. These patients' ability to categorize linguistic items and compare objects demonstrates that they have no problem utilizing the referential use of vocabulary items. They could easily use their representational knowledge to produce and comprehend language [6].

In recent studies, some researchers have questioned the semantic deficit in WA patients [3, 7]. They hypothesized that it might be essential to distinguish between stored lexical knowledge integrity and specific processes required to retrieve them (the dichotomy of storage vs. access). While in some research, the impact of a prime word to facilitate meaning retrieval of target words in patients with WA has been proven, this pattern was not observed in patients with BA. However, when the mode of representations changes, facilitation of target meaning is observed even in BA patients highlighting the important role of task mode [8].

WA and BA patients, when performing lexical decision tasks, display a pattern different from their clinical analysis. On the other hand, their performance in the semantic judgment task was in accordance with their clinical observations. To explain the subjects' differences in lexical decision and semantic judgment tasks, it is more plausible to envisage different processes required to access words to justify patients' improper performance rather than their abilities to integrate semantic knowledge [9]. These studies, making a distinction between volitional and automatic control, have shown that WA patients can perform very well in the lexical decision task when guided by facilitation priming. However, they still have lots of problems in easy semantic judgment tasks due to their problems in attention deficits. In the case of BA patients, a different pattern is observed. That is, while they perform at chance in a lexical decision task, surprisingly, they do not show any particular deficit in tasks requiring volitional processing [10, 11].

Due to some controversies in the literature, Prather et al. suggested that instead of speaking about the disruption of lexical processing in aphasics, it might be better to propose a "slowed activation hypothesis." Based on this concept, both groups of aphasics do need more time compared with the healthy controls to access lexical information. Although in the case of non-fluent WA patients, initial fast activation has been observed, they demonstrate protracted priming over a continuum of delays [12]

As Blumstein et al. have correctly mentioned, one major methodological reason why WA patients perform very well in the lexical decision task might be due to highly associative words employed in these tasks [13]. So, words like Cat and Dog are so extremely associated with each other that patients are capable of accessing them even without pointing to their referential meanings. In this regard, subjects' linguistic processing abilities or their power of word manifestation to decide correctly should be discarded.

Considering all these theoretical and methodological problems, homonyms, as specific sorts of words comprising multiple unrelated meanings, could be envisaged as better tools to scrutinize lexical representations as well as different processes to access those manifestations. The common ground of all models of language processing is that when a person detects a word, all meanings would be available. In this regard, the context would have a facilitative role. However, the controversy has remained as to whether frequency or dominant meaning affects the choice or meaning selection is an automatic or volitional process. Moreover, all models would agree that the executive function of suppression plays an important role here; that is, they emphasize that after the subject chose a specific meaning, redundant meaning could be suppressed automatically [14].

The design employed by the subject to select meaning was exhibited in many research studies [15-18]. Presenting a triad and asking subjects to decide correctly on the third target word, they showed that meaning facilitation affects when a relevant prime preceded the final target word to the target (coin, bank, money) or a neutral one (night, bank). However, when the target word was preceded by irrelevant meaning to the target word, the subjects perform poorly (river, bank, money).

In the Persian setting, no specific research has yet investigated lexical ambiguity processing in aphasia patients. The only research was that of Yadegari et al. [19]. These researchers, trying to testify Frame theory, conducted a case study in a patient with left hemisphere lesion. Performing the articulatory phonetics method and analyzing

403 syllabi of their patient production, they concluded that their patient's performance proved a frame without a content pattern. However, in their research, nothing was asserted to divulge the impact of ambiguity in aphasic's processing.

In the current study, we adopted the Milberg framework (1987). According to this theory, those words which appear to be similar, but have different incongruous meanings could be envisaged as more reliable tools whereby lexical integrity, as well as lexical manifestations, could be more plausibly explored. In this framework, it is believed that semantically ambiguous words manifest a very challenging task for the subjects to access semantic knowledge. In doing so and achieving our primary goal, three stages were designed to see whether their structure of semantic knowledge remains intact, whether they are capable of accessing that knowledge, and ultimately whether they could access that information selectively. Moreover, as to achieve our second goal, the subjects' reaction time to the stimuli was also taken into account.

2. Materials and Methods

Study subjects

Twelve healthy individuals and 12 monolingual Persian-speaking aphasics (6 BA and 6 WA aphasia type) were recruited from Saraye Mehr Center and Peyman Hospital, respectively. All subjects presented a written consent to take part in the test. All patients were diagnosed as having different types of aphasia based on the Persian version of the Boston Diagnostic Aphasia Exam (BDAE) administered by speech pathologists [20] and also a clinical review of patients by neurosurgeons. Thus, at the first stage, 16 aphasic patients were chosen, among whom, those patients performing at chance level in the auditory subtest, were excluded in the main test. Ultimately, 12 aphasic patients were selected to participate in the research. No alcohol or wine addiction was observed in their clinical profile. Moreover, these patients did not suffer from any neurodegenerative diseases.

Having administered BDAE, and based on the general evaluation of patients in the production mode (5646) (56.46), compared to comprehension one (2604) (26.04), 6 patients were selected as WA patients exhibiting more severe problems in comprehension mode than in production one. In this group, paraphasia, poor naming ability, reduced reading comprehension, naming, and oral reproduction were among the most negatively affected linguistic areas in patients. Furthermore, these patients signaled empty utterances in their speech producing lengthy but meaningless expressions. On the other hand, the general assessment of BA patients demonstrated the mean performance of 3203 32.03 in the production mode as compared to the mean of 610161.01 in the comprehension one, corroborating the accuracy of the selection process.

These patients in oral reproduction, repetition, naming, oral reproduction, and naming subsections performed poorly though in the auditory comprehension subsection had a relatively intact performance. After all these phases, 6 patients were selected as WA, and 6 as BA patients. Table 1 demonstrates the mean of the BDAE auditory subtest, mean age, native language statue, and CT scan of lesion sites and means of production and comprehension subsections.

Materials

In sum, our test was composed of 14 concordant triplets (/madeye qazaee/ "nutrient," /shir/ "milk," /nushidaniye mofid/ "a useful drink"), 14 discordant triplets (/heyvane jangal/ "a wild animal," /shir/ "lion," /nushidaniye mofid/ "a useful drink"), unrelated (/gol/ " flower," /tala/ "gold," /nushidaniye mofid/ "a useful drink"), neutral (/miz/ "desk," /shir/ "milk," /nushidaniye mofid/ "a useful drink"). The rationale behind this classification is that if aphasic patients show facilitation effect in the case of concordant and neutral sets compared with baseline sets, it could be concluded that not only their semantic knowledge was intact but also their access was selectively affected by the previous context. Alternatively, if concordant, discordant, and neutral stages all facilitated the target words compared with the baseline

Table 1. Lesion sites, mean age, language statue, and auditory subtest mean

Auditory Subtest Mean	Age (Mean±SD)	Native Language	Lesion Site
76	38±3	Persian	Frontal lobe (Broca)
82	45±6	Persian	Temporal lobe (Wernicke)

stage, it could be concluded that semantic information had remained intact but was no longer selectively affected by the context. Ultimately, if neither of these stages demonstrated the facilitation effect, then it could be asserted that the structures of semantic information, as well as word manifestation, were disrupted.

Study procedure

Each test lasted approximately 30 min for each individual. The specific software to assess subjects' reaction time was DMDx. Each subject sits at a computer and confronts a movable response board. He was asked to press "Yes" or "No" buttons on a dynamic response board. All subjects were told they would be presented some plausible and implausible Persian words grouped in triplet series. Having heard two initial words, they should decide if the last target one is a word (Yes) or non-word (No). No feedback was presented to the subject, and ultimately if the subjects could not conduct the test, the testing session would be terminated. .All tests' stimuli were recorded by a technician in a sound-proof room on an advanced tape recorder and digitized at a sampling rate of 9 kHz and 10-bit quantization. The data were analyzed by SPSS v. 24.

3. Results

Reaction time and the number of errors were separately analyzed for both control subjects and aphasic patients. Through analyzing subjects' reaction time, we intended to find how long it took for our subjects to respond correctly after hearing the stimuli. Hence, any possible unsatisfactory delay in their performance could be more easily observed. A significant effect of prime was observed ($F_{4,59}$=8.34, P<0.01). Moreover, based on Newman-Keuls procedure and post hoc analyses, a significant level of 0.05 was observed, indicating that the neutral condition culminated in quicker reaction times compared with the baseline.

The same result was also observed in the case of concordant primes. The neutral condition, compared with the discordant one, exhibited a significantly slower reaction time. Generally, in the lexical decision task, error rates were significantly low for the healthy subjects (mean of 4 errors for each priming condition) and were not different ($F_{4, 56}$=1.32, P>0.11).

In the case of aphasic patients, similar to the Milberg finding, WA patients answered more slowly compared with the BA patients ($F_{1, 12}$=4.653, P<0.07). As for priming conditions, a significant effect was observed ($F_{4, 35}$=5.32, P<0.001). Moreover, significant joint priming and group interaction were observed ($F_{4, 34}$=6.85, P<0.001). Based on these results, the performance behavior of aphasic groups in each priming type was different.

In Table 2, mean errors in aphasics in each priming condition are presented. A two-way ANOVA indicated that the number of errors committed by WA patients was more significant than those committed by BA aphasics ($F_{1, 10}$= 24.57, P<0.001). These results agree with previous research results demonstrating that WA patients performed more poorly compared to BA aphasics in lexical decision tasks.

4. Discussion

As mentioned earlier, according to Milberg theory (1987), words whose pronunciations are the same, but have multiple unrelated meanings, pose major sources of difficulty for aphasics impeding meaning retrieval. These patients who were challenged with multiple meanings are unable to access their mental lexicons and thus perform poorly in lexical decision tasks. Our results agree with the Milberg theory demonstrating subjects' poor performance in unrelated and more challenging conditions.

The mean reaction time in each priming condition was similar to that in Schvaneveldt's research, though the modality of presentation and specific procedure employed were rather different [21]. That is, the unrelated condition resulted in slower reaction time compared with the neutral and concordant priming. Moreover, while the neutral condition resulted in faster reaction time than dis-

Table 2. Mean errors in aphasics across each condition

Condition	Unrelated	Neutral	Discordant	Concordant
Broca Aphasia	1.44	1.52	1.71	1.40
Wernicke Aphasia	6.25	5.42	6. 30	5.19

cordant condition, the results in the case of discordant and neutral were approximately the same.

Our results are in line with some hypotheses regarding lexical processing in both BA and WA patients. WA aphasics committed more errors and answered more slowly compared with the BA patients. The exhibition of facilitation effect in WA patients for both concordant and neutral conditions, compared with the unrelated one, highlights not only lexical manifestation intactness but also sheds light on the proper function of automatic access.

The fact that the provided context influenced semantic retrieval of the priming word verifies that WA patients access multiple meanings of ambiguous words selectively, a pattern similar to that in healthy subjects [22, 23]. However, a caveat should be considered here, that is, compared with the healthy people, the number of errors that WA patients commit is higher, and their reaction time is slower than healthy subjects. This observation can be explained via the fact that these patients demonstrate more lexical processing to understand names and make appropriate semantic judgments. On the other hand, the fact that BA aphasics exhibited no semantic facilitation in any priming setting corroborates their malfunction in semantic information processing.

This result is in line with Newman and Friederici's studies [24, 25]. As Luria et al. have explained, all patients suffering from frontal lobe lesions have a general deficit in parsing stimulus pairs [26]. So, presumably, they are incapable of perceiving the semantic relationship between word pairs. This problem exacerbates, more specifically, when the number of words increases and automatically subjects' sensitivity to meaning relationships decreases, their malfunction in the lexical decision task worsens. Hence, this specific pattern could also be observed in all similar aphasics affecting negatively frontal areas of the brain, like transcortical motor aphasia, global aphasia, etc.

Furthermore, our results agree with Katz (1987), who demonstrated that BA patients exhibited facilitation effect when they were presented with auditory word pairs [27]. So, the results of our study, consistent with Burckhardt's finding, showed that although the lexical manifestation of words might be spared, their processing abilities are affected by some parameters like stimulus number and length [28].

This result, in the case of Broca, verifies the Graded Salience Hypothesis (GSH) of Giora. In this hypothesis, it is the salient meaning of an ambiguous word, which is retrieved more easily and quickly, not the previous context [29, 30]. According to Giora (1999), the salient meaning of a word could be accessed directly from the lexicon regardless of its literality or its metaphorical meaning [31].

Our results are in contrast with Hillert et al. (2001) study, in which semantic facilitation was observed in priming conditions [32]. To justify this difference, we could assume that contextual factors and modality of presentation might determine impacts on the results. However, as our final comment, it should be emphasized that our research was conducted on restricted groups of BA and WA patients, mainly due to the lack of easy access to these patients. Furthermore, even in the case of having access to the required subjects, most of them refrained from taking part in the study, more importantly, due to their inadequate and diminished physical and psychological conditions.

To achieve more comprehensive and conclusive results, other similar and complementary studies with more participants, and also more demographic variables like social class, gender could be taken into consideration. Last but not least, it is through all these considerations that a more realistic picture of lexical processing in BA and WA patients could be depicted. Conducting diverse research in different languages with larger statistical data could find a more convincing answer to this question.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles were considered in this article.

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Authors contributions

All authors contributed in designing, running, and writing all parts of the research.

Conflict of interest

The authors declared no conflict of interest.

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