Research Paper: Comprehension of Complex Structures by Persian-speaking Aphasics: The Role of Cognitive Load

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ABSTRACT

Introduction: So far, many studies have investigated the extent and nature of the grammatical deficit in aphasia. However, to the best of our knowledge, this research is the first in the Persian language to inspect the comprehension of patients with Broca's aphasia on diverse syntactically complex structures.

Materials and Methods: To scrutinize the impact of task on aphasics' performance, four age-, education- and gender-matched Persian-speaking patients with Broca's aphasia were compared with their healthy matched controls regarding the two different tasks of grammatical judgment and figurine act-out task. The structures used to examine the subjects' performance included agentive passive, subject cleft, object cleft, object relative clause, and object experiencer psychological verbs.

Results: Our results which supported the trade-off hypothesis, showed that our subjects generally performed better in grammatical judgment task than in figurine act-out task (P≤0.05). Particularly in the second task, as our inner task comparison, the patients' problems were more severe in object cleft, object experiencer, and object relative clauses: all structures whose interpretations need more cognitive load.

Conclusion: Our findings put more weight on the interactive or constraint-based model of language processing.

Keywords: Aphasia, Cognition, Broca's aphasia

1. Introduction

Although the quality and quantity of grammatical defects in Broca's aphasia have been tackled by many researchers [1-7], there is no unanimous agreement over the degree of deficit in these patients and their origin of problems. Part of this contradiction of the findings might be due to the employment of diverse tasks in these studies, which have sometimes culminated in opposing results [8-11]. Also, it might be due to the adaptation of different theoretical frameworks with which the researchers tried to explain their subjects' performance [12-18].

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In this regard, different theoretical models have attempted to provide a plausible explanation of Broca's aphasics' comprehension of sentences utilizing their unique theoretical lenses. For example, the mapping hypothesis considers a two-stage model of syntactic processing. It asserts that at the syntactic concatenation level, in which syntactic information, including syntactic positions of linguistic items, is brought, no particular deficit is observed. However, it is at the second stage of thematic role assignment that patients' grammatical problems would emerge. Adhering to such a perspective, they try to attribute subjects' poorer performance on sentence to picture matching task than in grammatical judgment task to the additional cognitive load caused by the task's requirement of theta role assignment [16, 17, 19, 20]. In the grammaticality judgment task, the participants were required to express their opinions on the grammaticality of a sentence saying true or false, for example, the ill-formed sentence "the pen who you bought" vs the well-formed sentence "the pen which you bought was nice". While in the syntactic comprehension task, the participants were expected to manipulate the objects to correspond to the situation or action described by a particular sentence. For example, in the sentence "the child followed the man", an accurate drawing describing the situation in which a child was following a man was placed in front of the participant, while the incorrect depiction of the situation presented by that sentence exhibited the reversed pattern, that is, a man followed a child.

Interestingly enough, similar observation has been corroborated in healthy and aphasic subjects [21-23]. On the other hand, the second model, i.e., the trace deletion hypothesis, attempts to explain Broca's aphasics' performance on grammatical judgment tasks by adopting a narrow theoretical stance. In this stance, chain disruption in the middle of processing syntactically complex structures would culminate in patients' poor performance. Hence, envisaging an encapsulated grammatical module of language, they assign poor performance of Broca's aphasics to their grammatical competence deficit: the main culprit of which is the negligence of co-referential relationships between moved linguistic elements and their traces [14, 24, 25-27].

However, the third important model which has been elaborated by some researchers is the trade-off hypothesis. In contrast with the aforementioned theoretical models, this model attempts to explain that an additional cognitive load is required for the accurate performance of some tasks. This load is regarded as the first culprit of the ungrammatical performance of subjects. Cognitive load is defined as the amount of working memory resources an individual uses while performing a specific task. So, it is believed that enriching knowledge about the limitations and functions of the working memory could boost the quality of the instructional stimuli utilized by speech therapists [27]. In other words, in the viewpoints of the proponents of this theory, the poor performance of Broca's aphasics in tasks that only requires grammatical judgment on the part of subjects versus tasks entailing semantic interpretation is attributed to the minimally required cognitive processing on the former task relative to the latter [29-37]. According to those research studies, the main culprit of aphasics' poor performance is their working memory malfunction. In a most recent study by Harun [38], a cross-linguistic comparison of Bangla, Japanese, and German as free order types of languages on the one hand and English as a fixed word-order type of languages, on the other hand, demonstrated that the production of non-canonical structures was more difficult than canonical structures cross-linguistically while a less severe type of grammatical deficit was also observed in the canonical structures. The crucial role of working memory in the linguistic performance of the aphasics was also emphasized in other studies in a way that it was concluded the reinforcement of working memory and cognition could culminate in the better linguistic capabilities of aphasic patients [39].

As explained before, part of different results or rather controversy in the literature regarding the performance of Broca's aphasics is due to diverse theoretical models that have attempted to explain subjects' performance through their theoretical lenses. This condition unintentionally permits some gaps in the literature.

In the light of these observations, this research tries to scrutinize the performance of Persian-speaking patients with Broca's aphasia on diverse syntactically complex structures. In this regard, our motives for conducting this research were multifold.

First, there has not been any research in the Persian context investigating Broca's aphasics' performance in the light of the trade-off model. So this study could be the first to endeavor this mission.

Second, unlike previous studies, through employing both sentences to picture and grammatical judgment tasks, we could have a much more profound picture of Broca's patients' performance and, in doing so, better

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examine the predictions of the theory and maybe enhancing its validity.

Third, though English and Persian belong to the Indo-European family of languages, the idiosyncratic typological characteristics of Persian language as an SOV language with a floating structure [40, 41] is in sharp opposition with English as a language with a fixed syntactic structure in which the positions of syntactic elements, albeit for pragmatic implications, are fixed. So, we could put into investigation any possible impact of typological difference on patients' performance.

Ultimately, as for the clinical significance of the research and given the prevalence of Broca's aphasics in Iran who have lots of challenges in comprehending their families and relatives' performance [42, 43], the findings of this research could demonstrate exactly which types of sentences are prone to more comprehension disruption in Broca's patients. In doing so, we can find which speech strategy and sentences are more fruitful for the patients. Overall, it could culminate in the ease of communication and interaction and boost the patients' chance of normal living. The organization of this paper is as follows: in the "Participants and Methods" section, the demographic characteristics of the patients and the criteria for their selection are initially introduced. Then, we recruited two tasks to provide more reliable and probable converging evidence for monitoring the participants' grammatical deficits. In the "Result" section, we analyze our data using appropriate inferential statistics. Ultimately in the "Discussion" section, our findings are discussed within the framework of the trade-off hypothesis.

2. Materials and Methods

Study subjects

After analyzing the neuropsychiatric profile of all participants and their medical records (CT scan, EEG, and neuropsychological tests), four age- and education- and gender-matched patients with Broca's aphasia were selected. Then, eight matched healthy individuals as our control Group were recruited. We utilized a convenient sampling method to choose our participants. The inclusion criteria were the lack of addiction to alcohol or drug and being monolingual (Persian as their mother tongue). None of the patients had any visual or auditory deficits so that they could perceive auditory or visual stimuli very easily. Patients suffering from neuropsychiatric diseases like anxiety, depression, and cardiovascular diseases were excluded from our sam-

ple. Those suffering from neurodegenerative diseases like Alzheimer or Parkinson were also excluded.

Table 1 presents the lesion descriptions of each patient. Our selected subjects were within the age range of 52-65 years and the minimum educational background of diploma. Noteworthy to mention, a written consent verifying patients' satisfaction to participate in the study was taken from all participants. Having translated and modified the aphasia diagnostic test of Boston Diagnostic Aphasia Examination (BDAE) [44] in Persian, we examined its reliability and validity for screening our subjects' aphasia type. Furthermore, a review of neuroradiology of patients corroborates our evaluation, demonstrating the accurate classification of patients. The common characteristics of all these patients were their fruitful, telegraphic, ungrammatical speech, and relatively intact syntactic comprehension capabilities. This observation is not surprising because it has been scientifically proven that agrammatism is typically a syndrome of aphasia patients [45].

Besides, though lesion site description of each patient has been presented in Table 1, as Ingram asserted, no designated and compartmentalized lesion site might culminate in agrammatism, and it has been scientifically attested that interaction of cell assemblies is involved in this syndrome. So, the properties of agrammatism could well be defined via psycholinguistic tests rather than clinical observations [46]. Taken this important scientific consideration, we could understand more of the nature of agrammatism in patients with Broca's aphasia through conducting a syntactic comprehension test.

Materials and procedure

Our stimuli consisted of one hundred sentences of five Group types. The first type included agentive passive constructions /ketâb (tavassote mard) nevešte šod/ rendered in English as "the book was written (by the man)". As seen in Persian, unlike English, agentive by-phrase occurs in the pre-verbal position, which could also be optionally deleted. Another critical property worthy of consideration here is that Persian belongs to OV or head-final Group of languages—unlike English categorized as VO or head-initial Group of languages— it is the object which precedes the verb in the canonical syntactic structure [40]. The second Group of sentences included subject cleft constructions in which the main verb follows the subject observing the canonical syntactic structure. For example, /Ɂin doxtar bud ke sib ra xord/ is rendered in English as "it was the

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girl who ate the apple". The third Group includes object cleft structures which, unlike subject cleft, canonical linear syntactic structure is disrupted in a way that it is the object rather than the subject which occupies the initial position of the sentence, i.e., /ʔin pesar bud ke doxtar donbalesh kard/. The fourth type encompasses object experiencer verbs. These structures, compared to the subject experience verbs, deviate even from the canonical linear heuristics in the way that it is the less default and remote object in the syntactic structure substitutes for the subject. For example, /mard zan ra tarsand/ rendered in English as "the man frightened the woman". Ultimately, the last Group included object relative types of sentences. This type had those constructions in which on par with the canonical syntactic structure in Persian, as discussed earlier, the object promoted to the subject position. For instance, /gorbeʔi ke sag donbalesh kard sefid bud/ rendered as "the cat which the dog followed was white".

Study tasks

The tasks utilized in our research included figurine act-out and grammaticality judgment tasks. The content validity of both tasks was confirmed by independent specialists. Furthermore, the reliability of grammaticality judgment and figurine act-out tasks was confirmed with the Cronbach α values of 0.92. and 0.95, respectively.

Figurine act-out task

At the first stage, to evaluate our subjects' performance on syntactic comprehension and their capability to process syntactic constituents, a figurine act-out task was administered, and all subjects were expected to act out and sort a set of randomized toy figurines after hearing a Group of diverse sentences. Utilizing two types of tasks would allow us to have a better insight into the grammatical deficit of the patients and evaluate the impact of task type upon their performance.

Study procedure

The subjects were told that they should manipulate the toy figurines so that the action or the state expressed by the verb could be easily detected. Moreover, for subjects' familiarity with the task, four practice trials were performed initially. However, if the subject demanded the experimenter repeat the sentence, it was uttered for the second time. Furthermore, following the procedure employed by Linebarger, Schwartz, and Saffran [47] and also to minimize the impact of prosodic and into-

nation properties on patients' performance, all stimuli were uttered by the same experimenter observing approximately similar intonation pattern. For example, the sentence /mard zan ra tarsand/ was pronounced with the falling intonation while the words /mard/, /zan/, and /tarsand/ are pronounced with the primary stress, and the intonation pattern of this sentence was similar for all the participants. Furthermore, all stimuli were recorded by the experimenter and then transcribed for analysis.

Grammaticality judgment task

To depict a more realistic and insightful in-depth picture of syntactic knowledge of aphasics and to comprehend the results of two different tasks, a second grammatical judgment task with the same type of stimuli was conducted to exactly understand whether tasks that demand cognitive load as predicted by trade-off hypothesis could affect the subject's performance. Had the patients performed better and more efficiently on the grammaticality judgment task than on the syntactic comprehension task, the predictions of the trade-off hypothesis are supported [45]. Besides, administrating the second task could boost the reliability and validity of our results. As mentioned, there have been lots of research studies that have emphasized task demands on agrammatics' performance [34, 48].

Study procedure

Upon hearing each sentence, the subject was supposed to judge on the grammaticality of each sentence saying "correct" or "incorrect". The stimuli consisted of one hundred pairs of well-formed and ill-formed sentences arranged in a randomized manner. Again, the order of randomization and the intonation pattern across stimuli were the same. However, to eliminate the possible impact of subjects' familiarity with the stimuli, other stimuli from the same categories were utilized in the task. Moreover, the number of distribution of sentences across each category type was the same. The ill-formed sentences included those structures in which either word order or morphosyntactic violations could be detected. For example, regarding ill-formed subject cleft structures, the expression of /*pesari ke sib ra xordam boland qad bud/ was utilized. This sentence is rendered in English as "*the boy who I ate the apple was tall". The above expression could be regarded as an instance of a deviated form in which the morphosyntactic feature of Persian is violated through an additional redundant clitic, i.e., "m". Also, the ill-formed subject cleft structures, such as the expression of /*gorbeyi ke dombaleš

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Table 1. The demographic and clinical characteristics of the patients

Name	Diagnosis Based on Boston Diagnostic Aphasia Examination (BDAE) and Clinical Consensus	Lesion Site Information
OS	Broca's OS is a male suffering a cardiovascular stroke in 1991.	An MRI taken that year exhibited a diffuse lesion, including the anterior frontal lobe.
BM	Broca's BM is a male suffering a stroke due to an accident in 1997.	The lesion site was the inferior anterior parietal lobe.
SP	Broca's SP is a male suffering a cardiovascular accident in 1998.	The study of CT scan taken that year showed the involvement of lesion sites in perisylvian and Broca's areas.
SN	Broca's SN is a male suffering a cardiovascular accident in 1997.	A CT scan taken that year proved the involvement of the inferior frontal gyrus and insular cortex area.

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sag kard siyah bud/ is rendered in English as "*The cat which the dog followed him was black" could be envisaged as an instance of a sentence in which canonical word order has been violated. All the stimuli were recorded and transcribed for a detailed analysis by the researcher. Again, to minimize the impact of prosodic features upon our participants' performance, all stimuli were uttered with the same intonation pattern.

Data analysis

As our data showed normal distributions, we utilized a parametric t-test. Furthermore, to compare the performance of the patients in each sentence type and to analyze the impact of the task type upon our subjects' performance, we utilized 1-way Analysis of Variance (ANOVA). We employed SPSS, version 16.0, to analyze the obtained data.

3. Results

Table 2 presents the performance of each participant in each structure of the grammaticality judgment task.

As the Table shows, the performance of our first subject (OS) on subject cleft and object cleft structures was 95% and 90% correct responses, respectively, meaning significantly above chance. As for agentive passive constructions, his performance was above chance with 85% correct responses. Also, this above chance pattern was observed in object experiencer psychological constructions, with subjects exhibiting 80% correct responses. However, his performance in object relative structures, unlike the former ones, was significantly below chance and demonstrated 40% correct responses.

Subject two (BM) performed above chance at 86% of the subject cleft constructions. Similarly, as with object cleft constructions with 82% correct responses and concerning agentive passives and object experiencer constructions, a similar pattern was observed with 78% correct responses in the former and 71% correct responses in the latter. However, he performed below chance in object relatives with 34% correct responses.

Subject three (SP) performed above chance in subject cleft with 85% correct responses and object cleft constructions with 80% correct responses. As with agentive passive and object experiencer, a relatively similar pattern was observed with 77% correct responses in the former and 79% correct responses in the latter. Also, he performed above chance in object relatives with 68% correct responses.

Ultimately, subject four (SN), like previous subjects, performed above chance in both subject cleft with 79% correct responses and object cleft constructions with 82% correct responses. As with agentive passives and object experiencer constructions with 79% correct responses in the former and 80% in the latter, he exhibited a similar pattern of performance. Yet, like other subjects, his performance in object relatives with 19% correct responses was significantly below chance. Regarding our Group of patients, 1-way repeated-measures ANOVA for the five sentence types demonstrated no main effect of sentence type ($F_{39}=0.88$, $P=0.25$). This finding was not surprising because our participants had above-chance performance in all structures except the object relatives. Even in this structure, our third subject (SP) had an above-chance performance. As regarding our control, all participants performed above-chance in all structures ($F_{39}=0.78$, $P=0.54$).

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Table 2. The performance of each participant in the grammaticality judgment task

Sentence Type	Participant	Statistics
Subject cleft	OS	$t(20)=3.92$, $P=0.0005$
	BM	$t(20)=2.92$, $P=0.005$
	SP	$t(20)=2.56$, $P=0.014$
	SN	$t(20)=2.54$, $P=0.005$
Object cleft	OS	$t(20)=3.48$, $P=0.001$
	BM	$t(20)=2.62$, $P=0.005$
	SP	$t(20)=2.76$, $P=0.005$
	SN	$t(20)=2.71$, $P=0.005$
Agentive passive	OS	$t(20)=3.25$, $P=0.001$
	BM	$t(20)=2.61$, $P=0.005$
	SP	$t(20)=2.60$, $P=0.005$
	SN	$t(20)=2.61$, $P=0.005$
Object experiencer	OS	$t(20)=2.95$, $P=0.0005$
	BM	$t(20)=2.51$, $P=0.005$
	SP	$t(20)=2.52$, $P=0.005$
	SN	$t(20)=2.48$, $P=0.005$
Object relatives	OS	$t(20)=2.30$, $P=0.205$
	BM	$t(20)=1.83$, $P=0.835$
	SP	$t(20)=2.40$, $P=0.005$
	SN	$t(20)=2.17$, $P=0.854$

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Figurine act-out task

In Table 3, the performance of all participants in each structure of the figurine act-out task is shown.

As mentioned, to examine the predictions of the trade-off hypothesis, based on what cognitive processing is required for the comprehension of complex structures and boosting the validity of this hypothesis, a figurine act-out task was conducted. Furthermore, to have a more realistic picture of subjects' performance, each subject's behavior in different tasks was described individually. In this respect, 1-way repeated-measures ANOVA for the five types of sentences demonstrated a main effect of sentence type ($F_{4, 18}= 31. 97$, $P<0.0001$).

As Table 3 shows, the performance of our first subject on subject cleft and agentive passive was 71% and 68% correct responses, respectively, above chance. In object relatives with 50% of correct responses was at chance. Ultimately, regarding object cleft structures with 42% correct responses and object experiencer psychological constructions with 31% correct responses, his performance was significantly below chance.

Subject two (BM) performed above chance in subject cleft constructions with 76% correct responses and agentive passive constructions with 69% correct responses. His performance at object cleft constructions was at chance with 53% correct responses. Ultimately, in object relative and object experience psychological constructions, his performance was significantly below

Table 3. The performance of each participant in the figurine act-out task

Sentence type	Participant	Statistics
Subject cleft	OS	t (20)=2.68, P=0.001
	BM	t (20)=2.11, P=0.05
	SP	t (20)=2.49, P=0.018
	SN	t (20)=3.18, P=0.005
Object cleft	OS	t (20)= 1.31, P=0.207
	BM	t (20)= -1.41, P=0.835
	SP	t (20)= -1.38, P=0.0826
	SN	t (20)=0.96, P=0.34
Agentive passive	OS	t (20)=2.57, P=0.005
	BM	t (20)=2.01, P=0.05
	SP	t (20)=2.51, P=0.16
	SN	t (20) =2.11, P=0.005
Object experiencer	OS	t (20)= -3.32, P=0.818
	BM	t (20)= -2.60, P=0.835
	SP	t (20)= -3.12, P=0.005
	SN	t (20)= -4.58, P=0.818
Object relatives	OS	t (20)= 0.87, P=0.31
	BM	t (20)= -1.41, P=0.835
	SP	t (20)= -1.38, P=0.0826
	SN	t (20)= -4.58, P=0.818

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chance, with 34% correct responses in the former and 21% correct responses in the latter.

Subject three (SP) performed above chance in subject cleft with 67% correct responses and agentive passive constructions with 69% correct responses. Regarding object cleft, object relative, and object experiencer constructions, his performance was significantly below chance with 21%, 24%, and 18% correct responses, respectively.

Subject four (SN) exhibited above-chance performance in subject cleft constructions with 72% correct responses. Likewise, in the agentive passive constructions, he had above chance performance with 65% correct responses. As with object cleft and object

experiencer, he had an at-chance performance with 46% correct responses in the former and 49% correct responses in the latter. Ultimately, he performed significantly below chance in object relative constructions with 19% correct responses.

In a nutshell, the cross-task comparison corroborated our subjects' better performance in the grammaticality judgment task than in the figurine-act task (P<0.005). In contrast with aphasic participants, regarding the control Group, 1-way repeated-measures ANOVA for the five sentence types demonstrated no main effect of sentence type (F_{39}=0.88, P=0.45). They performed very well on all sentence types of agentive passives, subject clefts, object clefts, object relatives and object expe-

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riencer constructions with 95%, 92%, 90%, 89%, and 85% correct responses, respectively.

4. Discussion

As the results of the two tasks showed, our subjects had a much better performance on syntactic comprehension than in grammatical judgment. This dissociation between subjects' performance on grammaticality judgment and syntactic comprehension tasks has already been attested in various studies [7, 29-31, 35]. This incongruence between subjects' performance in different tasks could be attributed to the recruitment of distinctive processing mechanisms activated at different levels of linguistic processing [7, 28].

Moreover, our inner-tasks comparison showed that while in the grammaticality judgment task, all our subjects performed above chance in all syntactic structures except for the object relative in which they performed below chance level, in the syntactic comprehension task, they demonstrated poor performance in three syntactic structures of object relative, subject experiencer, and object experiencer. Based on the trade-off hypothesis, our patients' poor performance in some syntactic structures could be conveniently explained.

First, as the theory predicted because syntactic comprehension task requires an outstanding demand, the parsing mechanism would break down. As a result, patients resort to "heuristics" to detect thematic roles [11, 36, 37]. In agreement with this prediction, our subjects performed syntactic comprehension tasks relying upon heuristics to extract the basic propositional content of the sentence. However, this parsing overload seems to be more evident in three syntactic structures of object relative, object cleft, and object experiencer. Now, our patients' particular problems in these three structures should be explained.

Concerning object relative structures, it should be asserted that, unlike its English counterpart, Persian possesses clitics attached to the verb violating the canonical syntactic structures of Persian in a way that the original object would substitute for the subject. Because this structure does not correspond to the default form, its correct comprehension would require an additional parsing strategy based on which semantic role of theme should be assigned to the then subject element of the sentence, which of course could not well be manipulated by the subject.

On the other hand, our patients' poor performance in psychological predicate constructions and, specifically, in object experiencer types results from deviation of these two structures from the canonical syntactic structure. Henceforth, their comprehension regarding the latter Group would escalate as it not only deviates from the typical syntactic structure but also from thematic role hierarchy in that less-agent-like semantic role would occupy the position of semantic agent. It is under these atypical syntactic circumstances that all our subjects performed more poorly in the object experiencer constructions than other sentences.

In light of the trade-off hypothesis, atypical canonical structures, when amalgamated with atypical semantic hierarchy, would distort patients' comprehension via imposing more cognitive load upon them. As hinted above, this problematic situation would escalate once the patients are compelled to utilize additional cognitive load which they are bereft of, to assign thematic roles to the syntactic categories. The importance of the second stage of the theta assignment stage becomes more evident when we see our patients' poor performance in the syntactic comprehension task versus the grammaticality judgment task. So, our findings are consistent with other studies that demonstrate that "computational deficits" are the main culprits of patients' poor performance in the figurine act-out task. Accordingly, patients had many challenges manipulating or accessing their stored knowledge [29-32, 35].

Ultimately, an important caveat should be considered here. Had the variables like sample size and socio-demographic features been controlled differently, our results might have been different. Henceforth, having constrained various socio-demographic characteristics and using different methodologies and recruited patients with varying types of deficits, we could come up with much more reliable conclusions regarding the pattern of grammatical deficits in these patients.

As Frazier asserted, it is the reduction in processing capacity that would result in different manifestations of performance in patients. While comprehending some structures is easier thanks to more devices to detect meaning, understanding others is problematic for patients due to the lack of these meaning detection mechanisms [30].

As the trade-off hypothesis predicts, those structures whose plausible interpretations could be accessed via more existing paths for analysis are more prone to degradation [31]. Following this prediction, we could

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explain our subjects' above-chance performance on figurine act-out tasks. In other words, in the agentive passive constructions due to the existence of by-phrase in our sample on the one hand and in the subject cleft constructions thanks to its adherence to the canonical syntactic heuristics, there were more potential alternatives for the successful interpretation of the sentences. All of these clues facilitated our patients' comprehension. As observed, because these conditions were not available in other complex syntactic structures, our patients performed poorly.

5. Conclusions

So, in favor of trade-off hypothesis predictions, the longer distance dependencies due to the existence of more inferential chains and reductions in cognitive processing capacity would collide, culminating in a much weaker comprehension of our patients. As we employed two tasks in our study to monitor the grammatical deficit of the patients, this cross-task comparison provided more reliable and convincing evidence about the nature of grammatical deficit in the participants. This research was a primary attempt to deepen our knowledge about the grammatical deficit of the Persian-speaking aphasics. However, had we utilized a larger sample size, we could have generalized our results more satisfactorily. Also, if we had used a different sampling method, we could have had different results. Undoubtedly, the recruitment of online techniques like rTMS or eye-tracking technology could illuminate more about the nature of grammatical deficit in the Iranian context. Also, conducting various studies in other languages with different typological characteristics could further our insight into the grammatical malfunction in aphasics.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article.

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Conflict of interest

The author declared no conflict of interest.

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