Syntactic Comprehension in Persian-Speaking Agrammatics: Further Proof of Trace Deletion Hypothesis

Research Article

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Abstract

So far, there have been three important theories explaining the nature and extent of grammatical deficit in agrammatic aphasia. In this respect, while the two mainly performance-based theories of agrammatics, i.e. trade-off hypothesis (TOH) and mapping hypothesis (MH), provide a very broad account of this deficit, the trace deletion hypothesis (TDH) presents a much narrower stance on the nature of the deficit as well as on the question of modularity. This research, being the first one in the Persian context, tries to test this theory in four gender-, education-, and age-matched Persian-speaking agrammatics and the same matched controls via executing a grammatical judgment test. For the purpose of evaluating our participants' performance, 90 pairs of sentences, composed of well-formed and ill-formed ones, were presented to the subjects in a random-

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ized manner, based on which participants were supposed to express their opinions regarding their grammaticality in a grammatical judgment task. The types of sentences being testified included active agentive, object cleft, subject cleft, agentive passive, psychological passive and object WH-constructions. Our findings, in line with the predictions of TDH, indicated that agrammatics faced many challenges with constructions in which constituent movements are involved. In contrast, their comprehension remained intact in agentive constructions. The theoretical and psychological implications of the findings are discussed.

Keywords: aphasia, processing, neurological, modular, TDH

Introduction

Within the last decades, there have been lots of researches whose major objective was to analyze grammatical characteristics of linguistic performance of agrammatics. These pioneering off-line tasks held different stances on both the extent of grammatical deficit and its nature, some of which even cast doubt on the existence of a separate modular deficit in Broca's aphasia as agrammatism and also on its autonomy or interdependence (Beeke et al., 2007; Garraffa & Grillo, 2008; Goodglass & Menn, 1985; Linebarger et al., 1983).

Regarding particular stance they have held on the nature of grammatical deficit, these models should be classified into two major models of modular and interactive. While the former emphasizes the separation of grammatical module asserting that syntactic, semantic, and pragmatic properties are encapsulated modules (Caramazza & Berndt, 1985; Friederici & Frazier, 1992; Grodzinsky & Santi, 2008; Grodzinsky et al., 1985), regarding the latter, it has been widely held that there are not different separate parsing mechanisms for word comprehension on one hand and sentence comprehension on the other hand. That is, they claim a single unitary processing route for word and sentence comprehension suffices (Bates, 1998; Chapman, 2000; Faust et al., 1995; Guo et al., 2010; McClelland, 1987). As a matter of fact, the latter view of language holding a constraint-satisfaction perspective claims that it might be logical to assume that, for a plausible interpretation of a sentence, all contextual, syntactic as well as morphological properties go hand in hand (Mondini et al., 2014; Tan, 2007). Thus, in as much as one constraint met the logical interpretation possible, parsing will terminate; that is, for the listener, it would be redundant to parse all linguistic elements of the sentence from the first to the end (Shetreet, et al., 2016). Henceforth, even in the strictest off-line tests, devoid of contextual cues, the listener or reader would recover the eliminated linguistic context by which he/she could present a parsimonious plausible interpretation (Austin et al., 2015; Frazier, 1995; Seidenberg & MacDonald, 2001).

Within these two broad views of sentence comprehension, three important theories have emerged. The trade-off hypothesis (Frazier & Friederici, 1991; Kristinsson et al., 2020; Nedergaard et al., 2020), the mapping hypothesis (Linebarger, 1995; Mack et al., 2019; Malyutina & Zelenkova, 2020) and the trace deletion hypothesis (Grodzinsky, 1995b; Hickok et al., 1992; Sung et al.,

2020) were among the three important hypotheses which have attracted lots of researchers in the field.

Among these aforementioned hypotheses, the first one asserts that agrammatics' good performance on grammatical judgment tasks on one hand, and their at chance performance on sentence to picture matching task on the other hand, could be explained via additional cognitive load required for the sentence comprehension task compared to the grammatical judgment task (Harun, 2020; LaCroix et al., 2020; Sahraoui & Nespoulous, 2012; Salimi & Dadashpur, 2012; Sample & Michel, 2014).

That is, the first task by its very nature would entail the subjects to be familiar with the task requirement enabling them to store gradual steps necessary to accomplish the task in their mind and then perform the task correctly, all the steps which agrammatic aphasia patients seem to be incapable of administering correctly (LaCroix et al., 2020). This theory is also called the theory of constraint satisfaction highlighting the crucial point that, in so far as the required syntactic, pragmatic, or semantic condition for the plausible interpretation of the sentence is met, parsing would take place automatically (Brown et al., 2019; Frazier & Clifton, 1996; Gibson & Pearlmutter, 1998; Linebarger et al., 2007; McElree & Griffith, 1998).

However, another group of researchers adapted mapping hypothesis (MH), according to which, like TOH additional, cognitive burden on the part of the addressee is necessary to analyze sentence to picture task compared to the grammatical judgment task. As a matter of fact, MH deviates from TOH via divulging the nature of working memory responsible for participants' poor performance on the task. Therefore, according to their viewpoints, agrammatics suffer a specific language register to advocate thematic role assignment. Hence, they assign linguistic competence deficit to the patients (Marshall, 1995; Mitchum et al. 1995; O'Grady & Lee, 2005).

Ultimately, the final hypothesis attracted by many researchers like us, is the trace deletion hypothesis (TDH) which considers agrammatism as a modular subcategory of syntactic competence (Aziz et al., 2020; Hanne et al., 2011). Hence, according to this hypothesis, the pattern of deficit observed in the production and comprehension of agrammatics and also their improper theta role assignment all could be explained via this hypothesis. Hence, two stages, namely phonetic form (PF) and logical form (LF) should be taken into consideration in the analysis of a sentence. It is only within LF stage that agrammatics' understanding would collapse due to their incapability to build connections between the constituents' traces and their antecedents (Sung et al., 2020).

As a matter of fact, there are some important reasons triggering us to select TDH among the aforementioned theories for our investigation of Persian-speaking agrammatic's performance on the syntactic task. First, regarded as a competence theory of sentence comprehension and unlike the two aforementioned hypotheses- TOH which is purely a performance theory, and MH which is also a partial performance theory though partially a competence one- TDH

holds a much narrower and restricted theory of sentence comprehension (Grodzinsky, 1995a) and in doing so, its accuracy and predictions could better be tested in different languages (Wang et al., 2020).

Secondly, as Grodzinsky, the highly renowned scholar who initially proposed the theory, himself pointed out, even within a restricted and modified version of TDH, some counterarguments in diverse languages have been observed (Grodzinsky & Friederici, 2006). To name a few, discourse representational theory of Avrutin (Avrutin, 2000) or the proposal made by Hagiwara (Hagiwara, 1993) could be enumerated. Consequently, as the trace deletion hypothesis pays attention to both intra-lingual and inter-lingual differences among languages of the world meticulously, it could be envisaged as a more reliable and plausible account of syntactic comprehension (Maruszewski, 2017).

The third important point worthy of consideration here, which was the primary impetus for the adaptation of TDH to analyze diverse sentences, was its clearer, more defined and also more systematic explanation of the theory following the linguistic doctrine of generative grammar and more specifically Government and Binding or GB's principle or Minimalist Program (Chomsky, 2014; Fyndanis et al., 2013). As a matter of fact, in this study, we utilized the crucial assumptions of GB and more specifically its newest development, that is, MP. It has been asserted that minimalism developed out of GB (Lasnik, 2002). In other words, once the theory of GB was supposed to have tackled the basic Plato's problem (poverty of stimulus) via proposing different conditions based on which parameters could be set culminating in the creation of diverse languages, then the issue was which GB theory could be regarded as the best. Hence, once the enterprise of explanatory adequacy had been accomplished, an opening was created for the emergence of a model which could concentrate on the dimensions of elegance, naturalness, and parsimony. Within such atmosphere, the minimalist program has emerged (Hornstein et al., 2005, p. 18). According to this model, the general rule of "move alpha" would culminate in the creation of two types of non-canonical structures. While the first category of sentences is the result of A-bar movement (wh-questions, topicalization, relativation), the second category of the sentences is the outcome of A-movement (passives and raising constructions). Taking this theoretical account, in our research, two types of stimuli (agentive passives and psychological passives) are classified as A-movement categories and two types (object wh-questions and object clefts) should be categorized as A-bar movement categories according to MP (Karimi, 2008).

Fourth, our motive for the selection of TDH was that this theory has been much more attested in different on-line priming studies which have proven its psychological reality (Fiebach et al., 2001; Grodzinsky et al., 1991; Hanne et al., 2011; Love & Swinney, 1996; Nicol & Swinney, 1989).

Fifth, different difficult structures whose interpretations were difficult for agrammatics like VP ellipsis, WH-head agreement, reflexives, and tag questions, expressed in the Mapping Hypothesis (Linebarger et al., 1983) yet not ex-

plained systematically, could then be explained well according to this theory. Moreover, concerning TOH, it should also be asserted that its failure to designate and define working memory or, as Ingram asserted, its indifference to defining what type of working memory is responsible for agrammatic's sentence comprehension could all be regarded as reliable evidence whereby TDH could be selected as a more favorite candidate for the evaluation of participants' performance (Ingram, 2007).

Taking all these considerations, and observing the existing gap in the Persian studies, this research tried to probe agrammatics' performance in the designated syntactic task and explain their behaviors within the framework of TDH. More specifically, the current study aimed to investigate which types of sentences are more difficult for agrammatics, if any, and in doing so, discover the observed pattern explaining it within co-indexing relations between constituents and their antecedents.

Review of Literature

Trace Deletion Hypothesis (TDH)

First proposed by Grodzinsky in 1984, Trace Deletion Hypothesis (TDH) was then subject to some modifications by scholars. For example, in 1995, Grodzinsky, holding a much narrower stance, asserted that only traces which were located in theta position could be disrupted in agrammatics (Grodzinsky, 1995a). In his second modification of the theory, he maintained that agrammatics would only utilize heuristics strategy when faced with a referential NP at their forefronts, provided this NP encompasses no theta role (Grodzinsky, 1995b). In other words, borrowing this adaptation from the work of previous researchers (Hickok & Avrutin, 1995), Grodzinsky asserts that there should be a distinction between binding chains and government chains. Thereafter, he claims that agrammatics' problems would only emerge where there is a sort of binding chain in the sentence created by which-N, rather than when there is a government chain created by wh phrases (Friedmann, 2008).

Meanwhile, researchers like Rizzi (1985), attempting to correlate agrammatics' productive as well as comprehensive modes, asserted that linguistic categories which are subject to theta role assignment including both assigners and assignees are not subject to syntactic disruption in agrammatics (Rizzi, 1985). However, it seems that Rizzi' s analysis is even narrower than his predecessor (Grodzinsky, 2000) as it is quite crystal clear that agrammatics exhibit a variety of asyntactic behaviors in their performance. Needless to say, the data from which he generalized his conclusions were extremely limited. Other scholars like Hagiwara (1993) proposed that those functional categories in the lower positions (DP & CP) are less prone to disruption than those standing in the higher positions (IP, NP, Ag P & TP). In this regard, characters like Reznik (1995) modified Rizzi's claims, saying that those functional categories possessing some contents are better preserved because they exist both in the phonetic form (PF) and logical form (LF).

However, regarding the theoretical notions elaborated on this theory, it could be regarded as a much more attested theory in different on-line priming studies which have proven its psychological reality (Fiebach et al., 2001; Grodzinsky et al., 1991; Hanne et al., 2011; Uddén et al., 2020; Wanner, 2019).

When words are moved from their original canonical positions in the sentence depending upon the type of canonical structure we have, which is of course manifested differently in languages with diverse typological characteristics, these traces would be created. Although these traces could be properly co-indexed with their referents by normal controls, they would collapse when agrammatic aphasics try to comprehend these structures. (Maviş, et al., 2019; Xu et al., 2019). Thus, the longer the chain, the more difficult the structure would become for the subjects explaining subjects' more severe problems in object WH-questions and object cleft constructions. Hence, Grodzinsky recommended that diverse configurations of agrammatism be seriously taken into account in any kind of research on agrammatism (Grodzinsky, 2000). Accordingly, once the syntactic dependency between relative pronouns and their place-holders are disrupted, these patients would not automatically be able to assign appropriate thematic roles to the syntactic categories. Through this novel perspective, different problems that mapping hypothesis assigns to thematic role violations on one hand, and trade-off hypothesis attributes to working memory limitations on the other hand, could then be explained homogeneously in a much consistent manner via trace deletion hypothesis (Schilling, 2019)

As a result, it might be logical to assert that the important hypothesis that agrammatism is a language specific syndrome should never be dismissed given diverse languages of the world with different typological characteristics which could affect subjects' performance (Dimmendaal et al., 2019; Soroli et al., 2012).

The study of the syntactic comprehension of agrammatics within the framework of trace deletion hypothesis has been the subject of investigation by many researchers in diverse languages like Mandarine (Su et al., 2007), Korean (Sung et al., 2020), Italian (Barbieri et al., 2013), Malay (Aziz et al., 2020), German (Maviş et al., 2019), Arabic (Diouny, 2010), to name a few. The common ground of all these researches is that agrammatics have lots of challenges comprehending those syntactically complex sentences in which constituents are transformed from their canonical positions. Therefore, as the constituents are moved from their canonical positions to the initial positions of the sentences, it will become challenging for agrammatic patients to parse them. Yet, in some researches, the psychological reality of this hypothesis was not corroborated, and contradictory results were reported (Arslan & Felser, 2018; Hanne et al., 2011)

Meanwhile, in Persian setting, the aphasic patients' syntactic comprehension was tackled by some scholars. For example, Nilipour & Raghibdoust (2001), via the investigation of linguistic deficits of seven native Persian-speaking patients with different etiologies, enumerated major morphosyntactic as well as agrammatic deficits attributing them to the size and site of the lesion. Ameri and her colleagues (Ameri et al., 2008) tried to scrutinize the relation

between cognitive parameters and syntactic complexity in Broca's patients, and demonstrated how cognitive deficit could affect these patients' comprehension negatively. They concluded that the reinforcement of Broca's patients' ability to process complex cognitive sequencing improves their comprehension of atypical syntactic structures. Shiani et al. 2019 also analyzed the impact of sentence complexity on Persian-speaking aphasic patients, and demonstrated how cognitive deficit could affect these patients' comprehension. Utilizing a binary sentence-to-picture matching task, they tried to scrutinize the performance of 6 non-fluent aphasic patients. Their results showed that these patients have difficulty understanding non-canonical syntactic structures including clefts and relatives. They attributed patients' weak performance to the malfunction of cognitive resources, specifically, working memory. Ultimately, the production of some types of syntactically complex sentences, including wh-questions, topicalized constructions and passives was scrutinized by Mehri and her colleagues (Mehri et al., 2016). The results of their study showed that aphasics have lots of challenges comprehending topicalized and focused sentences. They concluded that sentences with argument movements are among the most difficult types of sentences for the patients.

As stated above, despite the fact that some researchers tried to analyze Persian-speaking aphasics' syntactic comprehension, and employed different stimuli and methodologies to evaluate patients' performance, they did not utilize diverse tasks for this objective. Nor did they adapt trace deletion hypothesis to explain their patients' understanding. In some cases, they only concentrated on the productive rather than comprehensive abilities of the patients. In this study, observing this gap in the literature, and recruiting two diverse tasks for the assessment of our patients' performance to analyze the effect of task type, and also following the framework of trace deletion hypothesis, we scrutinized the comprehension of Persian-speaking agrammatics.

Method

Subjects

Having reviewed the neuropsychiatric profile of the patients, and conducted a psycholinguistic test, four gender-, education-, and age-matched Broca's patients were selected. Moreover, our participants in the control group were also matched according to the aforementioned socio-demographic parameters. The study is engaged to apply ethics of research, based on Declaration of Helsinki in 2000 (Riis, 2000). Moreover, it was committed to employ ethics of research based on American Pychological Association's Ethical Principles of Psychology (Hadjistavropoulos, 2002). All participants signed the written informed consent for contribution. The confidentiality of the information obtained from the participants, and the preservation of the names of participants were considered using coding. The lesion site descriptions of each patient are presented in Table 1. Our selected subjects were all male, in the age range of 50-65 years. Moreover, as for their educational backgrounds, they had at least a diploma. The diagnostic test to assess aphasics was the Boston Diagnostic Aphasia Exam-

ination (Goodglass & Kaplan, 1972). Farsi version of Aphasia Test developed by Nilipour (1994) was adopted to screen the subjects' aphasia type. Moreover, the review of neuroradiology testified our evaluation demonstrating that our classification was in line with the classical Broca's type. As a matter of fact, the main reason why we chose Broca's patients in our research was fundamentally the fact that it has been scientifically proven that agrammatism is a symptom of Broca's aphasia (Tesak & Code, 2008)

Noteworthy to say, though the lesion site description of each Broca's patient has been presented, as Ingram asserted, no designated lesion site could culminate in agrammatism and it has been scientifically attested that an interaction of cell assemblies is involved in this syndrome. Thus, the properties of agrammtism could well be defined via psycholinguistic tests rather than clinical observations (Ingram, 2007). Taking this important scientific consideration, we could understand more of the nature of agrammatism in Broca's aphasiac patients through conducting a syntactic comprehension test, and why administering such a test could be fruitful.

Table 1
The Lesion Site Descriptions of Patients

Patient	Aphasia Type	Description
OF	Broca's	OF is a male suffering a stroke in 1990. An MRI taken that year exhibited a diffuse lesion including posterior frontal lobe.
BD	Broca's	BD is a male suffering a stroke due to an accident in 1992. The lesion site involved was the inferior anterior parietal lobe.
SF	Broca's	SF is a male suffering a stroke in 1995. A CT scan taken that year indicated lesions in inferior frontal gyrus as well as insular cortex area.
TU	Broca's	TU is a male suffering an accident in 1994. The study of CT scan taken that year showed the involvement of lesion sites including left temporal lobe as well as inferior portion of BA.

Instruments and Procedure

As mentioned in the previous section, Farsi version of Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1972), already normalized and standardized by Nilipour (1994), had been administered to screen our subjects' aphasia type. Also, a written consent form proving our patients' satisfaction to participate voluntarily in the study had already been taken. Nevertheless, the primary tool to assess our patients' knowledge of syntactic comprehension was a grammaticality judgment task.

Grammaticality Judgment Task

In order to depict a realistic, insightful, and in-depth picture of the syntactic knowledge of aphasics, a grammatical judgment task was conducted to exactly understand whether syntactic comprehension of aphasics was intact. One ma-

jor rationale for the selection of the grammaticality judgment task and favoring it to the well-known figurine-act task was that it has been previously attested that the former task relies on less cognitive processing than the latter. As a result, their reliance on the working memory to parse the sentence would diminish (Brown et al., 2019; Charles et al., 2008; Murray, 2018; Schwering & MacDonald, 2020).The procedure for the task administration was as follows. Ninety pairs of sentences of six group types composed of well-formed and their ill-formed counterparts were presented to the subjects. The first type included those sentences in which the subject is regarded as the agent of the sentence (agentive group); for example, "ali sib rɒ xord" rendered in English as "Ali ate the apple". An important typological property worthy of consideration here is that the default syntactic structure of Persian is SOV. Endowed with an SOV order in the main and subordinate clauses when the object is phrasal, and with a very strong tendency to utilize the SVO order when the object is clausal, Persian enjoys some typological features similar to both OV and VO types of languages. So some scholars like Dabi-Moghaddam (2013) categorized it as a mixed group of languages - unlike English categorized as VO group of languages- meaning it is the object which precedes the verb in the canonical sentence structure. The second type of sentences included object cleft structures. The type of cleft construction utilized in our study belongs to it-cleft category. In Persian, clefting occurs when the focused constituent of the sentence moves from its unmarked default position to the initial position of the sentence and is followed by a copula and a ke (that) relative clause (Karimi, 2008; Mahmoudi, 2019). These sentences are normally used by native speakers of a language to emphasize their focal points, in this case, object. For instance, (TP"ʔin ketɒbi bud ke (TPali ti moʔtɒleʔe kard")) rendered in English as "(TP It was this booki which (TPAli studied ti))". The third group encompassed subject cleft sentences in which, again for the goal of emphasis, yet this time, subject, is singled out to stand at the forefront of the addressee, namely sentences like "ʔin marjam bud ke televizijun ro roʃan kard" rendered in English as "It was Maryam who turned on the TV". The fourth group of the sentences included agentive passive constructions in which it is the patient which occupies the subject position of the sentence rather than the typical subject placed at the end of the sentence. For example, "(TPmaqɒlei tavassote (TPali neveʃte ʃod ti)") which is rendered in English as "(TPthe paperi (TP Ø was written ti by Ali))". The fifth group includes psychological passive types. Psychological verbs are those expressing our inner feelings or psychological states like "tarsidæn, azijat kardan, randʒɒndan" rendered in English as "frighten, annoy and resent" respectively. In the canonical type of psychological verb construction, the doer of the action occupied the subject position, but the person or thing affected occupies the object position producing sentences like "jaʔqub marjam rɑ tarsɒnd" rendered as "Jacob frightened Mary". Yet, in the passive forms of psychological constructions, the object substitutes for the subject occupying its position resulting in the sentences like "(TPmarjami tavassote (TPjaʔqub tarsɒndeh ʃod ti))" rendered in English as "(TPMaryi (TPØ was frightened ti by Jacob))". Ultimately, our sixth group included object wh-questions, that is, the structures in which the object is questioned and moved to the initial position of the sentence. These

so-called object-wh questions start with "ʧe" like "ʧekasi" or "ʧe ʧizi" rendered in English as "whom" or "what" respectively. For example, this group includes sentences like "(TPʧe kasii rɒ (TPdidid ti))" rendered in English as "(CP Whomi did (TPyou see ti))?" or "(CPʧe ʧizii rɒ (TPpejdɒ kardid ti))" rendered in English as "(CPwhati did (TPyou find ti))?"

It is noteworthy to say, in order to eliminate the effect of the context upon our subjects' performance, no contextual clues were utilized. Having randomized and recorded the stimuli, a native speaker of Persian presented them to the subjects. Furthermore, for the purpose of subjects' familiarity with the experiment, three training sentences of each type were presented to the subjects. When presented with different stimuli, each subject was required to judge upon their grammaticality asserting whether the sentences were "ill-formed" "bad" or "well-formed" "good". In fact, each well-formed structure was paired with its ill-formed counterpart. The experiment took place in a quiet room, and all stimuli were presented to the participants in written printed forms. Each participant was tested individually. Also, all sentences were randomized. That is, in order to avoid repetition of the sentence, all stimuli, composed of grammatical and ungrammatical structures, were counterbalanced across participants, and Furthermore, for the fulfillment of decreasing the impact of prosodic features on subjects' performance , in line with Linebarger and his colleagues' procedure, all the sentences either well-formed or ill-formed were pronounced by the researcher with the same intonation pattern (Linebarger et al., 1983). Moreover, for the aim of neutralizing the probable impact of the variable of "length" upon our participants' comprehension, we also controlled the number of words included in each sentence which ranged from five to nine. Also, all sentences were presented out of context to exclude the impact of contextual features upon subjects' performance.

Data Analysis

The data were analyzed by Spss software (version 16; SPSS Inc., Chicago, IL, USA). We analyzed the inter-rater-reliability of the responses. As a result, all responses of each participant were scored initially by the researcher, and at the next stage, by a trained autonomous judge. Point to point consensus ranged from 92 to 100 % (Mean = 96). Since both control group and our patients were homogenous, the data were analyzed at the group level. As the data demonstrated normal distributions, parametric tests were used. Utilizing an independent T-test, we compared the performance of the control group with the performance of aphasics. Using one-way repeated measures ANOVA for the six types of sentences, we compared our patients' performance. Moreover, in order to examine the effect of the sentence type upon our patients' comprehension, we employed paired T-test.

Results

One-way repeated measures ANOVA for the six types of sentences culminated in a main effect of sentence type, $F(4, 38) = 33.96$, $P < .0001$. The performance

of our first subject on subject agent and subject cleft structures was 96 and 91 percent correct responses, respectively, significantly above chance, subject agent: t (20) =3.91, p = .0005; subject cleft: t(20) =3.49, p =.001. As for agentive passive and psychological passive constructions, his performance was at chance with 50 percent correct responses, t (20) = 88, p = .31, below chance with forty-two percent correct responses, t (20) = 1.30, p =.208. Yet, concerning both object WH constructions, 30 percent correct responses, t (19) = -3. 31, p = . 819, and object cleft ones (37 percent correct responses, t(19) = - 3. 34, p = . 818), his performance was significantly below chance, t (20) = - 1. 17, p = . 0711.

Subject 2 (BD) performed above chance at eighty-seven percent of the subject agentive constructions (t (20) = 2. 91, p = . 005). Concerning his performance at subject cleft (eighty 2 percent), a similar observation was made (t (20) = 2. 75, p = . 005), though he carried out the former test better. As for agentive passive, he had at chance performance with sixty percent correct responses (t (20) = .88, p =. 52) and below chance performance with forty-eight percent correct responses in psychological passive constructions (t (20) = 1. 44, p = . 0818). Also, in the object Wh constructions, he had below chance performance with thirty-five percent correct responses (t (20) = 1. 87, p=. 0 837) and 45 percent correct responses at object cleft constructions (t (20) = 1. 48, p = .0 828).

Subject 3 (SF) performed above chance in both subject agentive (eighty-six percent correct responses, t (20) = 2. 56, p = .014) and subject cleft constructions (eighty percent correct responses, t (20) = 2. 14, p=. 0 22). Concerning agentive passive with fifty three percent correct responses (t (20) = . 98, p = . 32) and psychological passive constructions with forty one percent correct responses (t (20) = . 82, p = . 45), he had at chance performance. And finally, as for both object WH constructions with thirty-one percent correct responses (t (20) = 2. 00, p =. 166) and object cleft constructions with forty-six percent correct responses (t (20) = 1. 42, p =. 0818), he had a below chance performance (t (20) = 1. 42, p =. 0 818).

As for subject 4 (TU), again a similar pattern was observed with subjects performing above chance at both subject agent with ninety percent correct responses (t (20) = 3. 26, p =. 0005) and subject cleft with eighty-five percent correct responses (t (20) = 3. 19, p = . 0005). This subject, unlike previous subjects, concerning both agentive passive constructions with forty-five percent correct responses (t (20) = 1. 20, p =. 187) and psychological passives with forty-two percent correct responses (t (20) = 1. 30, p =. 260) had below chance performance. As for object WH constructions, he had a significantly below chance performance with twenty-five percent correct responses (t (20) = - 1. 46, p =.0825). A rather similar pattern was observed in object cleft constructions with thirty percent correct responses (t (20) = - 1. 66, p = . 0817).

In contrast with agrammatics, regarding the control group, one-way repeated measures ANOVA for the six sentence types demonstrated no main effect of sentence type, F(38) = . 87, p = . 44. As a matter of fact, they perform very well

on all sentence types of subject agentive, subject cleft, agentive passive, psychological passive, object cleft and object WH-questions with 98%, 96%, 95%, 92%, 93%, 90% correct responses, respectively.

Discussion

This pattern, in which subject agentive and subject cleft structures are comprehended above chance and are significantly more easily interpreted than object cleft, agentive passive and object WH- constructions, corroborates many reports in the literature of the agrammatic comprehension of complex structures (Friedmann, 2008; Maviş et al., 2019; Xu et al., 2019) further advocating our diagnosis of agrammatic aphasia. In contrast, our results are inconsistent with Linebarger and his colleagues' and Smith's studies, in which, having conducted the same grammatical judgment task, they concluded that agrammtics perform above chance in most syntactically complex sentences (Linebarger et al., 1983; Linebarger et al., 2007; Smith, 2011).

Moreover, the fact that our subjects significantly performed poorly on object WH questions or object cleft structures corroborates TDH's predictions that agrammatics' comprehension would be disrupted when faced with a longer chain formed by different NP traces or when traces are not bound accurately by their antecedents. In other words, when words are moved from their original canonical positions in the sentence, which is of course manifested differently in languages with diverse typological characteristics like Persian, these traces would be created. Although healthy people could easily find the referents of these traces, agrammatics would confront with lots of challenges when trying to parse these structures. (Beretta & Munn, 1998; Dimmendaal et al., 2019; Grodzinsky, 1995a; Soroli et al., 2012). Hence, In the light of this research which is of course in line with the predictions of the theory, the longer the chain, the more difficult the structure would become for the subjects explaining their more severe problems in object WH-questions and object cleft constructions (Schilling, 2019; Wanner, 2019).

As observed, as soon as the complexity of syntactic structures increases when linguistic items are dislocated, our agrammatics' parsing problems would escalate (Uddén, et al., 2020). Hence, diverse configurations of agrammatism should also be seriously taken into account in any kind of research on agrammatism (Grodzinsky, 2000). Therefore, once the syntactic dependency between relative pronouns and their placeholders are disrupted, these patients would not automatically be able to assign appropriate thematic roles to the syntactic categories (Brown et al., 2019). Accordingly, through this novel perspective, different problems that mapping hypothesis assigns to thematic role violations on one hand, and trade-off hypothesis attributes to working memory limitations on the other hand, could then be explained homogeneously in a much consistent manner via trace deletion hypothesis (LaCroix et al., 2020; Sahraoui & Nespoulous, 2012; Salimi & Dadashpur, 2012; Sample & Michel, 2014). Proof to our claim comes from our aphasics' inappropriate and poor performance in

this grammaticality judgment task. Despite the fact that we utilized the grammaticality judgment task instead of the figurine-act task to decrease the cognitive demand on the part of our patients, surprisingly they still performed at chance or below chance levels in the structures in which either A-movement (object clefts, agentive passives, and psychological passives) or A-bar movement (object wh-questions) were vivid within the framework of trace deletion hypothesis. Consequently, our findings are inconsistent with the predictions of theoretical accounts like trade-off hypothesis or mapping hypothesis, which emphasized the role of task on the comprehension of aphasics (Kristinsson et al., 2020; Linebarger, 1995; Mack et al., 2019; Malyutina & Zelenkova, 2020; Nedergaard, 2020).

Also, our results corroborate the important hypothesis that agrammatism is a language specific syndrome given diverse languages of the world with different typological characteristics which could affect subjects' performance (Soroli et al., 2012; Tzeng et al., 1991). Noteworthy to mention is the preservation of our subjects' performance in subject cleft structures and the minimal impact of keh upon their interpretations. As a matter of fact, our subjects' rather intact performance could be explained with the consideration of an important syntactic difference between Persian and English in that, while in the latter, the above linguistic element serves as a relative pronoun bearing a particular meaning and theta role in the D-structure, in the former language, as a pure linker, it is void of semantic content not playing a crucial role in subjects' interpretation (Ghomeshi, 1996). Therefore, within this novel statue of keh in cleft structures of the Persian language (Karimi, 2008) and within the predictions of trace deletion hypothesis, in Persian, interpretations of the subject cleft could not be problematic for agrammatics (Ameri et al., 2008).

Furthermore, according to Persian structure, due to the nature of its verb morphology, it is common that a "resumptive" pronoun be attached to the verb as an enclitic which could then be co-indexed with subject and object in subject and object cleft constructions, respectively (Karimi, 2008; Mahmoudi, 2019). Hence, the resumptive counterpart of "in ali bud ke sib rɒ xord" would be "in Ali budeʃ ke sib ra xord". As a matter of fact, It has already been proven that the presence of such morpho-syntactic elements could boost subjects' interpretations (Rahmany et al., 2014). Taken this important psycholinguistically proven factor into account, our main motif for the elimination of this morpho-syntactic cue was to purely evaluate our subjects' grammatical competence, which, as shown, was yet disrupted in the stage of appropriate thematic role assignment.

Thus, taken these cross-linguistic variations into account, conducting diverse researches in different types of languages, and utilizing research with a much larger sample size, when concomitant with on-line neurolinguistic studies in which different techniques like eye-tracking are used, could shed more light on the nature of sentence comprehension, and could provide proof on the validity and psychological reality of the trace deletion hypothesis (Wang et al., 2020).

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