Research Paper: Investigation of Semantic System Defects in Adult Aphasic Patients Following Stroke

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ABSTRACT

Introduction: Semantic system plays a key role in all areas of language including understanding and expression of language. Based on a traditional view, the left hemisphere is dominant for processing of various linguistic information, including semantic information. It is believed that lesions in the left hemisphere impair the semantic component of language. In this study, we aim to study different types of semantic impairment in patients with aphasia; so that with early diagnosis of these sematic impairment we can identify patients who need treatment.

Materials and Methods: This is a cross-sectional, descriptive-analytic study. A total of 39 subjects, comprising 13 patients with left cerebral ischemic stroke in the temporoparietal region and 26 healthy subjects, were evaluated using pyramids and palm trees test, concrete and abstract word synonym test, and Bilingual Aphasia Test (BAT).

Results: In concrete and abstract word synonym test, patients with left hemisphere damage had lower performance than the normal group. Only in the verbal version of the pyramids and palm trees test, patients with left hemisphere damage obtained significantly lower scores than the normal participants. In the BAT test, patients with left hemisphere had a heterogeneous performance.

Conclusion: Based on these findings, although a large part of semantic processing is performed by the dominant hemisphere of the brain, the right hemisphere has a complementary role in semantic processing.

1. Introduction

One of the key communication methods in human societies is speaking with its key aspect, language. Language consists of five areas of Phonology, Morphology, Syntax, Pragmatics, and Semantics. Semantics not only determines the meaning of words and sentences and their relationship to the outside world, but also studies the relationship between different elements of language. Generation and comprehension of words depend on semantic processing and as a result this subject has been researched extensively [1]. In this regard,

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damage to the left hemisphere may result in aphasia that can significantly affect semantic processing [2].

Brain damage resulted from a stroke is the third most common cause of death worldwide with 794 cases in 100000 people, and it claims between 160 to 200 thousand lives each year in the developed countries [3]. Patients with brain damage suffer from memory and movement problems and may require rehabilitation to live a relatively normal life [4]. Between 30% and 40% of stroke patients develop aphasia which results in debilitating cognitive issues. This, in turn, severely affects their quality of life as well as the level of care they require [5]. Aphasia is an acquired language impairment caused by stroke that affects the person's ability to comprehend and express ideas [6].

In stroke-caused aphasia, the brain tissue in the vicinity of sylvian aqueduct gets damaged. It harms the entire language network, causing impairment in all aspects of language abilities of the patient [7]. Aphasia affects different levels of language including semantics, which plays a central role in verbal and/or visual expression and comprehension [8]. In addition to spoken and written expression, semantics may be accessed by comprehension modalities. In fact, semantics is processed and accessed in separate regions. As a result, a stroke can damage it selectively, a theory that is the basis of the current study [9]. Based on this theory, semantics may get damaged independent of other language systems. Aphasic patients suffering from semantics impairment exhibit difficulties in performing tasks such as word comprehension (visual or verbal), gesture identification, and picture identification [10].

Language comprehension requires syntax and semantics processing. After damage to the semantics system, any form of communication gets affected and in severe cases no communication would be possible. It is possible that neurological damage results in disruptive semantic performance, which is also the case in patients suffering from Alzheimer, Parkinson, and concussion patients [11].

Distinguishing between syntax and semantics has led to the development of different testing systems for each system. Semantics deficit is the most common impairment in patients with temporal lobe damage [12]. Different models have been proposed for generation and comprehension of speech in both word and sentence levels. Although these models differ in many aspects, they all agree in independence of semantics and phonology [12].

Because most aphasic patients suffer from difficulties in semantic processing leading to inability in understanding speech, the present research aims to investigate semantic processing in Farsi speaking aphasic patients in order to lay the foundation for future clinical research and rehabilitation of these patients.

2. Materials and Methods

The study was designed as a cross-sectional descriptive analytic. A total of 39 subjects including 13 aphasic patients suffering from left hemispheric brain damage and 26 healthy subjects were investigated. All subjects were similar in terms of age and educational background. The inclusion criteria for patients was damage in their temporo-parietal lobe, caused by a stroke happened at least 6 months ago. Furthermore patients had to be fluent in Farsi (written and spoken), and able to understand the instructions of the tests. The age range of the patients was between 20 and 65 years and they were all right dominant (Table 1 and 2).

The damaged region of the brain was determined by CT scan or MRI and reported by the neurologist. Exclusion criteria were vision and hearing problems not corrected with glasses or hearing aid, presence of auditory and visual agnosia, uncooperative in the study, and a score of 0 to 2 in Mini-Cog test indicating cognitive impairment. Patients were selected from teaching rehabilitation centers. The sample size was determined based on similar studies as well as 5% acceptable error. The patients were included in the study after getting a signed informed consent. Persian WAB test was performed to ensure the presence of aphasia [13]. Furthermore, Mini-Cog test was performed on all subjects to ensure subjects were not suffering from cognitive impairments.

The following three tests were performed within this study; pyramids and palm trees, concrete and abstract words synonym test, Bilingual Aphasia Test (BAT). Pyramids and palm trees test is a semantic test. It assesses the ability to access semantic information about words and images in detail and is utilized for evaluation of cognitive abilities in brain damage, semantic dementia, Alzheimer disease, and aphasia.

The validity and reliability of the Farsi version of the test have been proved by Radaei and associates [14]. The picture version of the test has a sensitivity of 0.86 and specificity of 0.94, and those of the word version are 0.93 and 0.94, respectively. Reliability of this test based on Cronbach α score values are 0.96 and 0.97, respectively for the picture and word versions. This test has been adopted in the UK, Spain, France, and Italy as well [15-18]. During the test, the subject is shown a stimulus, and then is asked to match it to one of the two words or pictures shown to him/her afterwards.

Although there is no time limit for the original test, the time needed by each subject to complete the 52 items of the test is usually about 30 minutes. All the answers are recorded by the examiner and each correct answer is given 1, while each incorrect answer is given 0. Seyyedin and associates developed the Persian version of the concrete and abstract words synonym test [19]. Because this test has been categorized into different difficulty levels, it is sensitive to subtle semantic impairment as well.

Contrary to concrete words, abstract ones have lower image ability, make their assessment somewhat limited using image and word matching task. On the other hand, in order to assess language perception, both types of words (concrete and abstract) have to be checked because patients suffering from brain damage (such as aphasic patients) react differently to these two stimuli and usually exhibit more difficulty in abstract words compared to the concrete counterpart [20]. The pyramid and palm trees test assesses semantic memory and its Persian version has been evaluated and proven to be reliable by other researchers.

It assesses the ability to access semantic information of words and images in detail and is utilized for evaluation of cognitive abilities in brain damage, semantic dementia, Alzheimer disease, and aphasia. Radaei et al. proved the validity and reliability of the Farsi version of the test [14]. The concrete and abstract words synonym test as the name suggests has two sections. The test does not have a time limit and is conducted as a visual-auditory assessment. The test begins with an example and if the subject understands the example, then the main test begins. The target phrase is typed on top of the card with two other words, one being the synonym and the other a decoy printed on the bottom of the card.

The card is shown to the subject (visual part of the test). The instructions given by the examiner are the auditory part of the test where he/she can read the words to the subject and ask for the synonym. Again the scoring is done by either assigning 0 or 1 which are summarized once the test has been finished. The maximum score in each concrete or abstract test is equal to 30. The reliability of this test using Cronbach α values for concrete and abstract words are 0.79 and 0.96, respectively [19]. Again this test has been widely adopted in the UK, Spain, France, and Italy [15-18].

The BAT test is among tools assessing the semantic and syntax aspects of the language. This test was used as a complimentary tool to particularly evaluate language perception without the limitations of the other two methods at the single word level for both the abstract and concrete words. The test was first proposed by Paradise et al. in 1987, and the Farsi version was developed by Nilipour et al. in 1988 [21, 22]. In the present study, 6 subtests were used in the BAT including semantics, paronym and non-paronym synonyms, antonym words, meaning acceptance, and semantic antonyms. There were 40 items inclusive of all the subtests and the scoring, similar to the previous tests, was using 0 and 1. Reliability of the test has been found satisfactory and its internal consistency has been evaluated between 63% and 83% [21].

After controlling the testing conditions, the subjects entered a well-lit and quiet room. They sat on an adjustable comfortable chair. Because of the several tests each subject had to take, avoiding tiredness, and effect of two variations (i.e. image and word version) of the pyramids and palm trees test on each other, the researcher took the tests in two separate sessions, one week apart. Test selection was completely random and during each session one of the two pyramids and palm tree tests was administered.

For ethical considerations, the patients were reassured that their information would remain confidential and were instructed on how to treat their aphasia based on their impairment. For the healthy subjects, a small reward was given to them as a sign of gratitude. It should be noted that informed consent forms were signed by aphasic patients as well as their families. During the first session, the participants' personal information was recorded, and then Mini-Cog Test, Edinburg handedness test, as well as the Persian BAT test were taken from all subjects. The analytic tests of the study (i.e. pyramids and palm trees, and the concrete and abstract words synonym tests) were randomly taken from the subjects during the first or the second session depending on their tiredness.

It should be noted that normal distribution of both datasets were verified using Kolmogorov-Smirnov test, and that the significance level in all the tests was chosen to be 5%. The obtained data were analyzed in SPSS V. 21. For comparison of the mean value of parametric and non-parametric data, the Student's T-distribution Test and Mann-Whitney test were used, respectively.

3. Results

In the present study, 39 subjects in two groups of patients with left hemispheric brain damage, and healthy subjects underwent tests of semantic processing. Subjects were selected in such a manner to eliminate the effect of age on the results of the study. As mentioned before, three tests of concrete and abstract words synonym, pyramid and palm trees, and bilingual aphasic tests were utilized to assess the semantic processing capabilities of subjects.

Since the data sets obtained by the concrete and abstract words synonym tests, and the pyramid and palm trees tests have a normal distribution, the Student's t-distribution test was used for their analyses. In the case of BAT, Mann-Whitney was used due to the non-normal distribution of the data. Based on the obtained data, the patients with left hemispheric brain damage have a significantly lower performance in the words version of the Pyramids and Palm Trees test (PPT) as well as the concrete and abstract words synonym test (compared to the healthy subjects (Table 3).

Because of the data obtained by BAT subtests do not have a normal distribution, Mann-Whitney test was used to compare two groups. The data obtained from the aforementioned analysis is presented in Table 4. Findings suggest that 4 out of 6 conducted subtests show significant difference between two groups. These subtests included synonyms ($P<0.05$), paronym antonyms ($P<0.05$), non-paronym antonyms ($P<0.05$), and meaning acceptance ($P<0.05$).

4. Discussion

The present study aimed to compare different aspects of semantic processing in patients with brain damage in the temporoparietal lobe in the left hemisphere, and assessments were based on the results of pyramids and palm trees, concrete and abstract synonym words, and bilingual aphasic tests. In the subtests of concrete and abstract synonym tests, patients suffering from the aforementioned brain damage exhibited significant semantic impairment (Figures 1 and 2). Khatoonabadi et al. (2008) studied concrete and abstract word processing in patients with left and right hemispheric brain damage and concluded that abstract word processing takes place in the left hemisphere, whereas the right hemisphere does processing of both abstract and concrete words [23].

This finding is in agreement with the findings of this study and confirms that right and left hemispheres differ with respect to the processing of concrete words. In another study, Seyyedin et al. compared patients with damage in the left temporal region with those who had damage in non-temporal region as well as a group of healthy subjects using concrete and abstract synonym words test. Their findings suggest that those with left temporal brain damage have greater impairment in the semantic processing of concrete and abstract words compared to the other two groups [19].

Based on certain viewpoints, comprehension of concrete and abstract words takes place at different places of the left brain hemisphere. Based on the distributed neural activity model, processing of concrete and abstract words takes place as a result of the activity of different neural groups within this hemisphere. Study of brain scans has revealed that left temporal base is responsible for concrete word processing and abstract word processing occurs somewhere superior to this region [24].

Table 1. Description of demographic variables in the study groups

Type of Damage	Sample Size	Sex		Age, y
		Male	Female	
Left hemisphere brain damage	13	7	6	53.26
No brain damage	26	14	12	54.19
Total	39	21	18	53.72

JMR

Table 2. Average age (years) in the two groups for age variable normalization

Type of Damage	Quantity	Mean (SD)	t	df	Sig.
Left hemisphere brain damage	13	53.62(10.85)	0.179	37	0.859
No brain damage	26	54.19(8.73)			

JMR

Table 3. Comparison between two groups of synonym words test and PPT

Type of Damage	Assessment Tools	Quantity	Mean (SD)	t	Sig.
Concrete word synonym	Left hemisphere damage	13	20.92(3.79)	4.53	≤0.001
	Healthy subject	26	25.96(2.98)		
Abstract word synonym	Left hemisphere damage	13	21.85(5.01)	2.99	0.01
	Healthy subject	26	25.42(2.50)		
Pyramid and palm trees-picture version	Left hemisphere damage	13	43.69(2.84)	1.30	0.57
	Healthy subject	26	45.12(3.37)		
Pyramid and palm trees-word version	Left hemisphere damage	13	41.69(3.75)	2.60	0.03
	Healthy subject	26	44.85(3.47)		

JMR

Fiebach and Friederici studied a word decision task under fMRI on a sample of 30 normal subjects and concluded that the lower left temporal lobe had the greatest activity in semantic processing of concrete words [25]. Binder et al. conducted a meta-analysis on 120 neural imaging studies of the semantics, and showed that 7 regions in the left hemisphere of the brain form a semantic processing network where processing of concrete and abstract words take place [26]. These results are in agreement with the findings of the current study suggesting that the left hemisphere and the temporal cortex in particular play a dominant role in concrete and abstract word processing.

Results of the pyramids and palm trees test indicate that the significant difference was in the word version of the test and despite lower performance of aphasic patients, the difference was not found to be significant (Figures 3 and 4). As previously mentioned, the word version of the test evaluates the semantic relationships through writing, and as such the left hemisphere plays a more dominant role in this aspect of semantic processing.

Anastasia et al. used the Florida semantic tasks (which is the basis of the pyramids and palm trees test), in which 12 semantic categories are covered and reported that aphasic patients would exhibit impairment in selection categories [27]. Jodzio et al. used 6 semantic categories in their study on aphasic patients' ability in comprehension of individual words. They concluded that a certain category damage was observed in aphasic patients related to the semantic-word category [28].

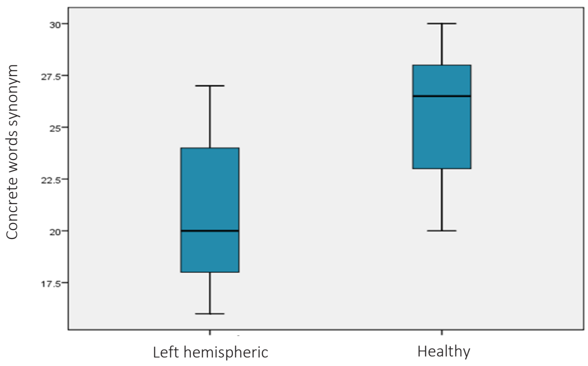

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Figure 1. Comparison between tow groupas with regard to concrete words synonym test

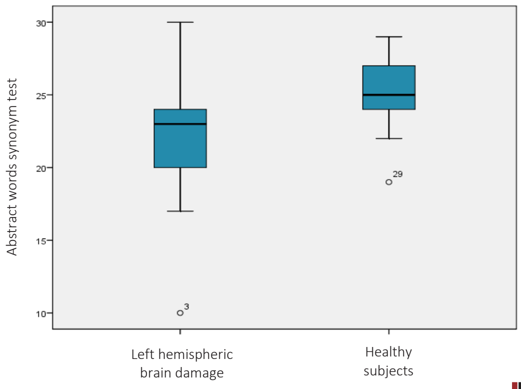

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Figure 2. Comparison between tow groupas with regard to abstract words synonym test

Table 4. Comparison of scores obtained by the two subject groups in the BAT test

Assessment Tools	Type of Damage	Quantity	Mean (SD)	Average Rank	Mann-Whitney Value	Sig.
Meaning group subtest	Left hemisphere damage	13	3.85(1.28)	21.00	36.50	0.08
	Healthy subject	26	4.54(0.58)	28.04		
Synonym words subtest	Left hemisphere damage	13	3.54(0.87)	14.77	64.00	0.001
	Healthy subject	26	4.54(0.58)	30.42		
Paronym antonyms subtest	Left hemisphere damage	13	4.25(0.66)	29.38	154.50	0.62
	Healthy subject	26	4.74(0.7)	17.27		
Non-paronym antonyms subtest	Left hemisphere damage	13	3.43(1.32)	18.81	79.00	0.004
	Healthy subject	26	4.23(0.71)	32.73		
Meaning acceptance subtest	Left hemisphere damage	13	8.39(1.65)	25.12	93.00	0.03
	Healthy subject	26	9.33(1.21)	29.08		
Antonym subtest	Left hemisphere damage	13	8.15(1.86)	23.46	38.00	0.23
	Healthy subject	26	8.85(1.00)	28.29		
Total BAT score	Left hemisphere damage	13	24.15(6.91)	15.67	42.00	0.07
	Healthy subject	26	31.42(1.03)	19.29		

JMR

Jefferies et al. studied 5 transcortical sensory aphasic patients (caused by stroke) and 5 subjects with dementia and the word and picture version of the pyramids and palm trees test was used for their analyses. All the subjects with left hemispheric brain damage exhibited lower performance in the semantic processing which these findings in the case of the picture version was not in agreement with the current study [29]. In a different study, Jefferies et al. investigated semantic damage in 8 aphasic patients using the pyramids and palm trees test and reported that semantic category was damaged in these patients [30]. Soni et al. used the picture version of

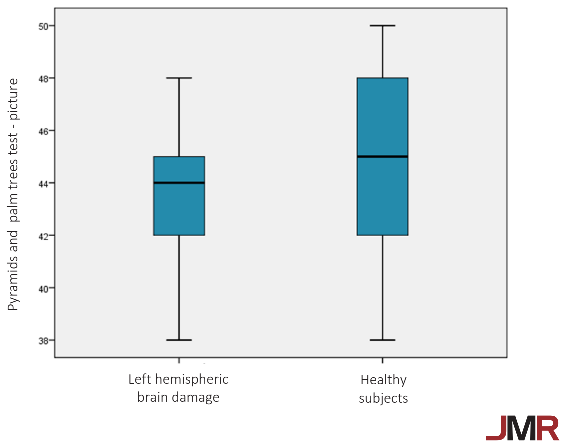

Figure 3. Comparison between two groups with regard to PPT (picture version)

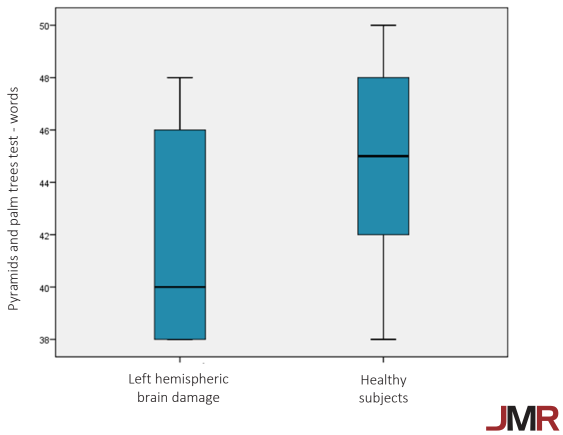

Figure 4. Comparison between two groups with regard to PPT (word version)

pyramids and palm trees test to evaluate semantic skills in 7 aphasic patients and reported that all patients had severe damage in semantic tests [31].

The larger sample size used in the present study improves the reliability of the obtained data, and similar to the findings of aforementioned studies, semantic processing impairment is present in patients with left hemispheric brain damage. However, no significant difference was observed in the visual semantic processing, as opposed to the other studies. Taking into consideration the role of the occipital cortex in image processing and the presence of dual routes for this type of processing, it is necessary to evaluate the effect of temporal and parietal lobe damage separately [32].

With regard to BAT test, out of the 6 subtests, 4 exhibited significant difference and the other 2 were the same among the two study groups. The four subtests included synonyms, paronym antonyms, non-paronym antonyms, and meaning acceptance. Comprehension of synonym words, as part of the semantic processing, is carried out by the left hemisphere of the brain, and as such the synonym subtest of BAT is suitable for the study of the role of the left brain hemisphere in this function.

In the case of paronym antonyms, the current study showed that the performance of patients suffering from left hemispheric brain damage differs from the normal subjects suggesting that in this aspect of semantic processing, left hemisphere of the brain plays the dominant role. The same may be said about non-paronym antonyms as well. According to Mann-Whitney test results, scores of meaning acceptance indicate a significant difference between the two groups. A study by Duncan et al. using brain imaging has showed that semantic processing is controlled by a network in the brain which includes the frontal cortex in the left hemisphere, left parietal fissure, left temporal region, and motor cortex in the left hemisphere [33-35].

Based on these findings, it can be hypothesised that meaning acceptance is essentially the same function as what is known as “semantic judgement.” This function is part of the processing performed by the aforementioned network of meaning control based on the functional interconnections between the anterior frontal regions and the mid-temporal regions of the left hemisphere [36]. Based on certain cognitive neuroscience theories, the right hemisphere plays a more important role in holistic and summative processing [37].

Neuroscientific findings indicate that the right hemisphere has a general role in semantic processing whereas the left hemisphere is involved in some specific and delicate processing, and as such in recalling synonyms the left temporal region is of outmost importance [30, 38]. This study aimed to investigate the semantic processing, thus all the relevant tests were considered. In this regard, BAT test is for the study of bilingual subjects, and no similar study was found for comparison purposes. However as the results of BAT also confirm the findings of the two previous tests, it may be a suitable tool for assessment of semantic impairment, too.

In this study, all the available semantic processing tests were used for the assessment of semantic impairment in the subjects. Patients suffering from left hemispheric brain damage had a lower performance in processing of concrete and abstract words suggesting that the processing of such words is carried out in the left brain hemisphere. Furthermore, Those patients show impairment in semantic relations using the word version of the pyramid and palm trees test, which also suggests that semantic relations of written nature is accessed by the left hemisphere of the brain. These finding were also reaffirmed by the results of the BAT test suggesting that the processing of antonym and meaning acceptance is also processed by the left hemisphere of the brain.

Ethical Considerations

Compliance with ethical guidelines

The present study was approved by the Ethics Committee of University of Social Welfare and Rehabilitation Sciences under the ethics code IR.USWR.REC.1394.353.

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Conflict of interest

The author of this article certify that they have no affiliations with or involvement in any organization or entity with any financial or nonfinancial interest in the subject matter or materials discussed in this manuscript.

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References

[1] Hallowell B, Chapey R. Introduction to language intervention strategies in adult aphasia. In: Chapey R, editor. Language Intervention Strategies in Aphasia and Related Neurogenic Communication Disorders. South Holland: Wolters Kluwer; 2008.

[2] Goodglass H, Kaplan E, Barresi B. The assessment of aphasia and related disorders. Philadelphia: Lippincott Williams & Wilkins; 2001.

[3] Adams RD, Vander Eecken HM. Vascular diseases of the brain. Annual Review of Medicine. 1953; 4(1):213-52. [DOI:10.1146/annurev.me.04.020153.001241] [PMID]

[4] Adler R, MacRitchie K, Engel GL. Psychologic processes and ischemic stroke (Occlusive cerebrovascular disease): I. Observations on 32 Men with 35 strokes. Psychosomatic Medicine. 1971; 33(1):1-30. [DOI:10.1097/00006842-197101000-00001] [PMID]

[5] Gresham GE, Stason WB, Duncan PW. Post-stroke rehabilitation. Pennsylvania: Diane Publishing; 1997.

[6] Spreen O, Risser AH. Assessment of aphasia. Oxford: Oxford University Press; 2003. [PMID]

[7] Caplan D, Hildebrandt N, Makris N. Location of lesions in stroke patients with deficits in syntactic processing in sentence comprehension. Brain. 1996; 119(3):933-49. [DOI:10.1093/brain/119.3.933] [PMID]

[8] Kirshner HS. Handbook of neurological speech and language disorders. Milton Park, Didcot: Taylor & Francis; 1994.

[9] Nelson K. Explorations in the development of a functional semantic system. Child Psychology; 1979.

[10] Duchan R, Linda J, Garcia AK, Lyon JG, Simmons Mackie N. Life participation approach to aphasia: A statement of values for the future. In: Chepy R, editor. Language Intervention Strategies in Aphasia and Related Neurogenic Communication Disorders. South Holland: Wolters Kluwer; 2001

[11] Pourshahid G. Clinician Perspectives on AAC: Current Barriers and New Opportunities [PhD Dissertation]. Toronto: University of Toronto; 2011.

[12] Marslen-Wilson W, Tyler LK. The temporal structure of spoken language understanding. Cognition. 1980; 8(1):1-71. [DOI:10.1016/0010-0277(80)90015-3]

[13] Nilipour R, Pourshahbaz A, Ghoreyshi ZS. Reliability and validity of bedside version of Persian WAB (P-WAB-1). Basic and Clinical Neuroscience. 2014; 5(4):253-8. [PMID] [PMCID]

[14] Radaei M, Mehri A, DastjerdiKazemi M, Jalaei S. [Determination of validity and reliability of Persian picture version (Persian)]. Journal of Modern Rehabilitation. 2013; 7(3):18-23.

[15] Callahan BL, Macoir J, Hudon C, Bier N, Chouinard N, Cossette Harvey M, et al. Normative data for the pyramids and palm trees test in the Quebec-French population. Archives of Clinical Neuropsychology. 2010; 25(3):212-7. [DOI:10.1093/arclin/acq013] [PMID]

[16] Gamboz N, Coluccia E, Iavarone A, Brandimonte MA. Normative data for the Pyramids and Palm Trees Test in the elderly Italian population. Neurological Sciences. 2009; 30(6):453. [DOI:10.1007/s10072-009-0130-y] [PMID]

[17] Howard D, Patterson KE. The Pyramids and Palm Trees Test: A test of semantic access from words and pictures. Bury St Edmunds: Thames Valley Test Company; 1992.

[18] Rami L, Serradell M, Bosch B, Caprile C, Sekler A, Villar A, et al. Normative data for the Boston Naming Test and the Pyramids and Palm Trees Test in the elderly Spanish population. Journal of Clinical and Experimental Neuropsychology. 2008; 30(1):1-6. [DOI:10.1080/13803390701743954] [PMID]

[19] Seyyedin S, Mehri A, DastjerdiKazemi M, Jalaei S. Development of a valid and reliable Concrete and Abstract Word Comprehension Synonym Test in Persian aphasic patients. Journal of Modern Rehabilitation. 2016; 9(5):49-58.

[20] Warrington Pat McKenna Lisa Orpwood EK. Single word comprehension: A concrete and abstract word synonym test. Neuropsychological Rehabilitation. 1998; 8(2):143-54. [DOI:10.1080/713755564]

[21] Nilipour R, Pour Shahbaz A, Ghoreishi ZS, Yousefi A. [Reliability and validity of Persian Aphasia Battery Test (Persian)]. Iranian Journal of Ageing. 2016; 10(4):182-91.

[22] Paradis M, Libben G. The assessment of bilingual aphasia. New York: Psychology Press; 2014. [DOI:10.4324/9781315802138]

[23] Khatoonabadi AR, Hovsepian A, Harley T, Kahlaoui K, Marsolais Y, Joanette Y. The impact of left-and right-hemisphere lesions on the processing of concrete and abstract words in Farsi. Brain and Cognition. 2008; 67(1):25-6.

[24] Friederici AD, Opitz B, Von Cramon DY. Segregating semantic and syntactic aspects of processing in the human brain: An fMRI investigation of different word types. Cerebral Cortex. 2000; 10(7):698-705. [DOI:10.1093/cercor/10.7.698] [PMID]

[25] Fiebach CJ, Friederici AD. Processing concrete words: fMRI evidence against a specific right-hemisphere involvement. Neuropsychologia. 2004; 42(1):62-70. [DOI:10.1016/S0028-3932(03)00145-3]

[26] Binder JR, Desai RH, Graves WW, Conant LL. Where is the semantic system? A critical review and meta-analysis of 120 functional neuroimaging studies. Cerebral Cortex. 2009; 19(12):2767-96. [DOI:10.1093/cercor/bhp055] [PMID] [PMCID]

[27] Anastasia M, Raymer Y, Leslie Y, Gonzalez R. Impairment of word comprehension and production. In: Chapey R, edi-

tor. Language Intervention Strategies in Aphasia and Related Neurogenic Communication Disorder. Philiadelphia: Lippincott Williams & Wilkins; 2008.

[28] Jodzio K, Biechowska D, Leszniewska Jodzio B. Selectivity of lexical-semantic disorders in Polish-speaking patients with aphasia: Evidence from single-word comprehension. Archives of Clinical Neuropsychology. 2008; 23(5):543-51. [DOI:10.1016/j.acn.2008.05.005] [PMID]

[29] Jefferies E, Hoffman P, Jones R, Lambon Ralpha MA. The impact of semantic impairment on verbal short-term memory in stroke aphasia and semantic dementia: A comparative study. Journal of Memory and Language. 2008; 58(1):66-87. [DOI:10.1016/j.jml.2007.06.004] [PMID] [PMCID]

[30] Jefferies E, Patterson K, Jones RW, Lambon Ralpha MA, Matthew A. Comprehension of concrete and abstract words in semantic dementia. Neuropsychology. 2009; 23(4):492-9. [DOI:10.1037/a0015452] [PMID] [PMCID]

[31] Soni M, Lambon Ralpha MA, Noonan K, Ehsan S, Hodgson C, Woollams AM. "L" is for tiger: Effects of phonological (mis) cueing on picture naming in semantic aphasia. Journal of Neurolinguistics. 2009; 22(6):538-47. [DOI:10.1016/j.jneuroling.2009.06.002]

[32] Arnal LH, Morillon B, Kell CA, Giraud AL. Dual neural routing of visual facilitation in speech processing. Journal of Neuroscience. 2009; 29(43):13445-53. [DOI:10.1523/JNEUROSCI.3194-09.2009] [PMID]

[33] Duncan J. EPS Mid-Career Award 2004: Brain mechanisms of attention. Quarterly Journal of Experimental Psychology. 2006; 59(1):2-27. [DOI:10.1080/17470210500260674] [PMID]

[34] Duncan J. The Multiple-Demand (MD) system of the primate brain: Mental programs for intelligent behaviour. Trends in Cognitive Sciences. 2010; 14(4):172-9. [DOI:10.1016/j.tics.2010.01.004] [PMID]

[35] Duncan J, Owen AM. Common regions of the human frontal lobe recruited by diverse cognitive demands. Trends in Neurosciences. 2000; 23(10):475-83. [DOI:10.1016/S0166-2236(00)01633-7]

[36] Jefferies E, Lambon Ralph MA. Semantic impairment in stroke aphasia versus semantic dementia: A case-series comparison. Brain. 2006; 129(8):2132-47. [DOI:10.1093/brain/awl153] [PMID]

[37] Chechlacz M, Mantini D, Gillebert CR, Humphreys GW. Asymmetrical white matter networks for attending to global versus local features. Cortex. 2015; 72:54-64. [DOI:10.1016/j.cortex.2015.01.022] [PMID] [PMCID]

[38] Robinson GA, Cipolotti L, Walker DG, Biggs V, Bozzali M, Shallice T. Verbal suppression and strategy use: A role for the right lateral prefrontal cortex. Brain. 2015; 138(4):1084-96. [DOI:10.1093/brain/awv003] [PMID]