Word Processing Deficits in Persons with Right Hemisphere Damage: Evidence from in-Depth Analyses of Verbal Fluency Tasks

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Abstract: The role of the right hemisphere (RH) in word processing continues to interest the neuroscientists. Occasional explorations of the word retrieval functions of the RH with verbal fluency tasks have shown poor performance in persons with right hemisphere damage (RHD). However, there are differing views on the mechanism underlying the poor performance in this population. Some investigations attribute the deficient performance on verbal fluency task to the lexico-semantic deficits, whereas, others ascribe it to deficient cognitive agility. To illustrate these differing views, we performed in-depth analyses of (i.e., accuracy scores, clusters, switches, & time course of word retrieval) a group of 22 participants with RHD on eight semantic and three phoneme fluency tasks. Comparisons with the neuro-typical participants yielded evidence in favor of the linguistic rather than cognitive deficits as the mechanism behind poor word retrieval skills in persons with RHD.

Keywords: Right hemisphere, word retrieval, lexico-semantic deficit, verbal fluency, cluster, switch, time course analysis.

1. INTRODUCTION

In the last five decades, several investigations provided compelling evidence in favor of the right hemisphere's (RH's) capacity to process words. However, there exist contrasting views on the mechanism(s) underlying deficient word processing in persons with right hemisphere damage (RHD). For instance, some authors argue that the poor performance on word processing (e.g., retrieval) tasks is linguistic in nature (e.gs. [1,2]), whereas, others believe that such deficits arise from poor cognitive agility (e.gs., [3,4]). In this context, the current study investigated this issue by employing a series of verbal fluency tasks in a group of persons with RHD. Our results supported the linguistic rather than cognitive nature of underlying deficits leading to poor word processing skills in persons with RHD.

Ever since Gazzaniga, *et al*. (1962) [5] reported that the RH of split-brain patients is capable of processing simple and concrete words, a plethora of investigations provided evidence in support of the word processing skills of the RH. Such evidence was largely accumulated from both normal and various clinical populations (e.gs., persons (a) with RHD [1,2,6]; (b) with left hemispherectomy [7], and (c) who undergo Wada test [8]. While some investigations failed to yield supportive evidence in this regard (e.gs. [9-11]), among those studies that provided supportive evidence, a consensus on the mechanism underlying poor word processing skills in the RH did not emerge as the poor performance on word processing tasks following RHD was attributed to either linguistic or non-linguistic (i.e., cognitive) deficits.

Perhaps, a potential source of these dichotomous explanations of the word processing deficits in RHD could be the nature of tasks employed in earlier investigations. Traditionally, picture (i.e., visual confrontation) naming is the most commonly used task in research and clinical practice. While the naming task is undoubtedly sensitive to linguistic deficits, it may potentially fail to differentiate the mechanism(s) behind poor performance on this task. Stated differently, either cognitive or linguistic deficits could lead to impaired performance on picture naming task. To disentangle the nature of the underlying naming deficit, it is often necessary to interpret the results in light of the findings from cognitive examination. In the absence of such testing, administration of even standardized naming tests (e.g., [12]) could lead to inaccurate diagnoses.

Another commonly used task in the examination of the word processing skills in the brain-injured population, including those with RHD, is the verbal fluency task (or controlled oral word association test). In contrast to the confrontation naming task, which

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requires the generation of a single response to a given stimulus (e.g., picture naming task), this divergent task elicits multiple response alternatives to a given response criterion within a stipulated time (usually 60s) [13]. Two major variants of the verbal fluency tasks are semantic and phoneme fluency tasks. In semantic verbal fluency tasks, participants retrieve names of exemplars from the given semantic category (e.g., animals), whereas, in phoneme fluency tasks, words starting with a given phoneme (e.g., /s/) are retrieved. Further, in phoneme fluency tasks, participants are instructed to avoid retrieval of serial words (e.g., sixty, sixty-one, etc.) as well as proper names. In both tasks, the globally employed outcome measure is the total number of correct exemplars retrieved in the response period [13].

Unlike the picture naming task, the verbal fluency task requires faster retrieval of several response alternatives in a time-restricted manner. It essentially invites a hoard of non-linguistic cognitive functions such as attention and executive functions. Owing to this reason, the verbal fluency tasks are necessary ingredients of both linguistic (e.g., [14]) and cognitive (e.g., [15]) test batteries.

Over the years, several additional analysis procedures have been used in verbal fluency tasks. For instance, analyses of the time course of response retrieval [3], as well as the clusters of words retrieved within a given criterion and the switches between clusters [16], provide additional information on the cognitive agility of the participants. Clusters refer to groups of sequentially generated items from the same subcategory (e.g., retrieval of domestic animals followed by wild animals during a semantic verbal fluency task with the criterion ‘animals' or retrieval of items from the same semantic category in a phoneme fluency task (i.e., /p/ - pen, paper, pencil, …) and switches refer to the cluster-to-cluster transitions [16]. When exercised in well-designed investigations, such additional analyses could potentially differentiate cognitive from linguistic deficits, the principal assumption behind this study.

Returning to the word processing skills of the RH, in the past, application of the verbal fluency task yielded mixed results. Some investigations failed to show a significant difference between RHD and neuro-typical groups [11] on verbal fluency performance. Among those studies that reported supportive evidence for the impact of RHD on verbal fluency tasks (e.gs. [17,18]), some attributed it to the underlying cognitive deficits (e.g., [18]), whereas, others ascribed it to linguistic deficits [1,2]. For instance, [19] performed detailed analysis of the time course of word retrieval in a group of persons with RHD. In this type of analysis, the response time is divided into two or more equal intervals. In Joanette *et al*.'s (1988) [19] study, participants with RHD showed a reduction in performance only after 30 seconds of the total (60s) response time. Based on this observation, these authors proposed that the decrease in word production following RHD is due to the insufficient automatic exploration of the semantic field. In line with this argument, [4] opined that poor performance on verbal fluency tasks in persons with RHD might be indicative of the underlying cognitive inflexibility arising from broader cognitive failures rather than poor lexico-semantic deficits, per se.

Finally, there are differing views on the profile of deficits exhibited by persons with RHD on verbal fluency tasks. Joanette and Goulet (1986) [18], for instance, observed that semantic fluency tasks are more sensitive than phoneme fluency tasks in RHD. However, [20] refuted Joanette and Goulet’s arguments that such differential effects between the variants of verbal fluency tasks seldom exist in this population. Thus, additional investigations are necessary to disambiguate such contrasting arguments, an objective of this investigation.

To sum up, several uncertainties exist in the literature on word processing skills of the RH. First, the mechanism of deficient performance in word processing task is not fully elucidated (i.e., linguistic vs. cognitive deficit). Second, the verbal fluency tasks in persons with RHD have yielded mixed results. While some investigations failed to show a significant difference between RHD and neuro-typical participants, studies reporting poor performance in the RHD group differed on their explanation of underlying deficits. It may also be noted that the in-depth analyses of performance on verbal fluency tasks has been limited to the time-course analysis. In this backdrop, the current study aimed to compare the performance of a group of persons with RHD to a matched group of neuro-typical participants on a comprehensive set of verbal fluency tasks to find the nature (i.e., linguistic vs. cognitive) of deficits in the former group, if any.

2. METHODS

2.1. Participants

A group of 22 right-handed (18 males & 4 females; mean age: 61.91 years [SD = 11.73]; mean years of schooling: 6 [SD = 4.11]), Kannada-speaking (a Dravidian language spoken in Karnataka, a southern state of India) people (i.e., clinical group) with first-ever stroke in the distribution of right middle cerebral artery was selected based on neurological examination and CT/MRI investigation. All of them experienced stroke between 2-6 months before their inclusion in this study. None of them suffered any cardinal linguistic impairments (e.g., aphasia) and were able to communicate adequately in their daily life. All participants had a normal or corrected-to-normal vision and good speech intelligibility permitting unambiguous perceptual judgment of the verbal responses. The demographic and lesion data of the clinical group is available in the online supplementary materials (Appendix A).

Another group of 22 age-, gender-, handedness-, and literacy-matched Kannada-speaking neuro-typical participants served as the control group. While matching the age, two years were relaxed and on education, one year of schooling was relaxed (See Appendix B: Online Supplementary Materials). Signed consent was obtained from all participants (or their proxies) in both groups, and the institutional ethical committee approved this study.

2.2. Tasks

We employed a set of 11 verbal fluency tasks (semantic – 8: animals, vegetables, birds, fruits, vehicle, clothes, furniture, & verbs (concrete action words); phonemic – 3: /*p*/, /*a*/, & /*s*/) in the current study. Distinct from the western studies that employ phonemes /*f*/, /*a*/, and /*s*/ under the phoneme fluency tasks, we substituted the phoneme /*f*/ with /*p*/, as the former criterion resulted in considerably smaller number of responses (M = 6) in a pilot study on three native young normal Kannada speakers. However, all could retrieve more than 15 words starting with the phoneme /*p*/.

2.3. Procedure

Before the administration of the verbal fluency tasks, we administered the Kannada version of Addenbrooke's Cognitive Examination [21]. ACE is designed to assess five domains/components of cognitive function including attention and orientation, memory, fluency, language, and visuospatial processing.

The scheme of administration of the verbal fluency tasks was identical for both clinical and control groups. Participants were instructed to generate as many exemplars as possible from each category (1 minute/category). They were encouraged to use the full length of the response period. Following instructions, they were given two trial categories (one semantic & one phonemic) for familiarizing with the tasks. After this, the semantic and phoneme fluency tasks were administered randomly. In the clinical group, all but six participants completed the entire categories in a single sitting, and the remaining finished it in two sessions. However, all participants in the control group completed the tasks in a single session. After each task, a brief break was provided, if desired by the participants. Each participant was tested individually, and responses were audio-recorded using a handheld portable audio recorder (Sony P-370) for later transcription.

2.4. Response Analyses

The performance on Kannada version of ACE was analyzed as per the instructions provided in the manual. Three native Kannada-speaking speech-language pathologists orthographically transcribed the responses from verbal fluency tasks. For the analyses of clusters and switches, we followed the guidelines of [16], and for the time course analysis, we used [19] method. Detailed descriptions of in-depth analyses employed in the current study are provided below:

1. The total number of correct exemplars retrieved under each criterion (i.e., semantic & phonemic)
2. The mean cluster size in semantic and phoneme fluency tasks (i.e., one number less than the total number of items in a cluster, where, a cluster is defined as a group of successively generated words belonging to the same subcategories, [16]
3. The average number of switches in semantic and phoneme fluency tasks (switch – the transition from one cluster to another as well as to single words, [16]
4. The time-course of word retrieval (i.e., the number of correct exemplars generated in each quadrant of 60-second duration) [19].

2.4.1. Transcription Reliability

To ascertain the inter-transcriber reliability, we used all three transcribers' transcriptions on two tasks (semantic fluency – 1: animals & phoneme fluency – 1: /a/). Further, to assess the intra-transcriber reliability, we required all three transcribers to re-transcribe the responses obtained from two categories (semantic fluency – 1: vehicles & phoneme fluency – 1: /s/) between 7-14 days from the date of initial transcription. For both types of reliability analyses, we used the responses of only five participants with RHD.

For all statistical comparisons, we used only accurate responses. Paired sample *t*-test was used for between-group (within-task) comparison of the mean values and repeated measures ANOVA for the time course analysis. The reliability analyses were carried out with the intraclass correlation coefficient (ICC). All analyses were performed with SPSS 16 for Windows.

3. RESULTS

3.1. Cognitive Measures

Comparison of the performance of the two participant groups on Addenbrooke's cognitive examination (ACE) revealed significant differences in two (of 5) domains (see Table **1**). The clinical group obtained significantly lower scores on (verbal) fluency and language compared to the control group, whereas, their performance was on par with that of the control group on attention and orientation, memory, as well as on visuospatial skills.

3.2. Transcription Reliability

The inter-transcriber (ICC: Animals = 0.762; /a/ = 0.778) and intra-transcriber (ICC range: Vehicles – 0.863-0.9; /s/ - 1) reliability was sufficiently high for further analyses and interpretation of the responses.

3.3. Verbal Fluency Tasks

Participants with RHD obtained significantly poorer accuracy scores in the semantic and phonemic conditions compared to the control participants. Similarly, the mean semantic cluster size in the RHD group was significantly smaller than the control group, although in the phoneme conditions the two groups did not show such difference. Further, the comparison of switches did not show any difference between the groups both in the semantic and phonemic conditions (see Table **2** for details).

The time course analysis showed a comparable reduction of responses with the progression of time under the semantic and phonemic conditions in both groups of participants (see Table **3**). The results of repeated measures ANOVA showed significant main effects only for participant groups in the semantic (F (3, 126) = 469.99, p < 0.001) (η^2 = .918) and phonemic conditions (F (3, 126) = 291.64, p < 0.001) (η^2 = .874), but not for the time quadrants under these two conditions.

The results, in general, showed poor performance of the RHD group on accuracy scores in the semantic and phonemic conditions. While the mean cluster size in the RHD group was significantly smaller compared to that of the control group in the semantic fluency task, it did not differ between the groups in the phoneme fluency task. Switches did not differ between the two groups of participants on semantic and phonemic fluency tasks. Finally, the time course analyses showed

Table 1: Descriptive Statistics and between-Group Comparisons of the Clinical and Control Groups on Addenbrooke's Cognitive Examination (Kannada). Values in Parentheses Indicate the Maximum Possible Score under each Domain

Domain	Independent groups			Group comparison				
	Group	Mean	SD	CI (95%) Lower	CI (95%) Upper	*df*	*t*-value	*p*
Attention & Orientation (18)	Clinical	16.73	0.7	-0.56	0.19	21	-1.00	> .05
	Control	16.91	.97					
Memory (26)	Clinical	23.95	1.36	-0.78	0.06	21	-1.78	> .05
	Control	24.32	1.28					
Fluency (14)	Clinical	6	1.41	-3.74	-2.9	21	-16.46	< .05*
	Control	9.32	1.84					
Language (26)	Clinical	21.86	2.71	-1.39	-0.69	21	-6.24	< .05*
	Control	22.91	2.33					
Visuospatial (16)	Clinical	14.32	1.17	-1.58	-0.51	21	-4.04	> .05
	Control	15.36	0.66					

Table 2: Descriptive Statistics and the between-Group Comparisons of the Mean Accurate Scores, clusters, and Switches

Variables	Criterion	Independent groups			Group comparison				
		Group	Mean	SD	CI (95%) Lower	CI (95%) Upper	*df*	*t*-value	*p*
Accurate score	Semantic	Clinical	9.4	1.35	-3.63	-2.57	21	-12.9	< .001
		Control	12.5	1.8					
	Phonemic	Clinical	6.98	2.09	-2.1	-0.68	21	-4.09	< .05
		Control	8.38	2.74					
Cluster size	Semantic	Clinical	1.80	0.29	-0.37	-0.02	21	-2.27	< .05
		Control	1.99	0.28					
	Phonemic	Clinical	1.81	0.98	-0.88	0.45	21	-0.66	> .05
		Control	1.94	0.89					
Switches	Semantic	Clinical	26.68	4.26	-0.98	0.71	21	-0.34	> .05
		Control	26.82	4.00					
	Phonemic	Clinical	3.68	1.86	-1.52	0.16	21	-1.69	> .05
		Control	4.36	2.06					

Table 3: Descriptive Statistics of the Mean Accurate Scores of the Clinical and Control Groups Across the Time Quadrants

Criterion	Quadrant (seconds)	Group	Mean	SD
Semantic	1 (0-15)	Clinical	4.76	0.97
		Control	5.29	0.73
	2 (16-30)	Clinical	3.05	0.54
		Control	3.78	0.79
	3 (31-45)	Clinical	1.19	0.43
		Control	2.02	0.67
	4 (46-60)	Clinical	0.27	0.18
		Control	0.93	0.47
Phonemic	1 (0-15)	Clinical	3.55	1.08
		Control	4.03	1.25
	2 (16-30)	Clinical	2.3	0.66
		Control	2.48	0.88
	3 (31-45)	Clinical	0.79	0.65
		Control	1.12	0.58
	4 (46-60)	Clinical	0.35	0.33
		Control	0.68	0.42

difference only in terms of the participant group on semantic and phonemic conditions, but not in the time of retrieval. In the following sections, these findings are discussed in light of earlier relevant investigations.

4. DISCUSSION

In the present study, we compared the performance of a group of persons with RHD to a matched set of neuro-typical (control) participants on a series semantic and phoneme fluency tasks. The outcome measures included accuracy scores, clusters, switches and the time course of word retrieval. In general, the comparison of accuracy scores showed that persons with RHD performed poorly on both semantic and phonemic conditions compared to their control counterparts and these differences were statistically significant (see Table **2**). Interestingly, our findings from the phoneme fluency task contradicted that of Joanette and Goulet (1986) [18] who reported that persons with RHD perform poorly under the semantic, but not in the phonemic criterion, thus supporting the findings of Albert and Sandson (1986) [20]. Additionally, our results also showed that the phonemic condition yielded overall poor scores compared to the semantic condition, irrespective of the participant groups. This may be attributed to the lower literacy levels of our participants as literacy level influences the word retrieval [22].

4.1. Cluster and Switch Analyses

Analyses of clusters and switches provided additional insights into the influence of RHD in word retrieval process. On an average, the RHD group retrieved 0.19 clusters less than the control group in the semantic condition, and this difference was statistically significant. Similarly, in the phonemic condition, they retrieved 0.13 clusters lesser than the control group, though this difference was not statistically significant (see Table **2**: Cluster size). Together, these observations show that irrespective of the task criterion, the participants with RHD retrieved a lesser number of clusters in the verbal fluency task. Considering the assumptions behind clusters in verbal fluency tasks that these involve accessing the word store as well as retrieving items from it [23], the reduced number of clusters in persons with RHD could be considered as evidence for their impaired access and retrieval of category exemplars from the word store. Additionally, our results from cluster analysis are also in accordance with the findings of Villardita (1987) [24] that damage to the RH could result in impairment in semantic clustering.

Analysis of the switches primarily dissolved the prevailing ambiguity on the underlying mechanisms of poor performance in verbal fluency tasks in persons with RHD. Some investigators propose that the poor performance on verbal fluency tasks stems from deficient lexico-semantic deficits [24], whereas, others attribute it to poor cognitive agility [3,6]. Switches reflect the ability to shift efficiently from one cluster to another, which in turn, indicates the cognitive flexibility [16]. In the current study, the mean number of switches in the two groups of participants did not differ in the semantic and phonemic conditions (see Table **2**: Switches). Thus, it is apparent from these findings that persons with RHD did not differ from the control participants in terms of the cognitive strategies employed while searching the mental lexicon during the word retrieval process.

Combining the results from the analyses of switches, clusters, and the accuracy scores generated across the verbal fluency tasks, it becomes apparent that the RHD group retrieved a lesser number of items and smaller clusters, yet with a comparable number of switches to that of the control participants. These observations signify that the poor performance of the RHD group on the verbal fluency task is due to the underlying word retrieval deficits (i.e., the lesser number of accurate items generated as well as smaller clusters) and not due to any underlying cognitive deficits (i.e., switches).

4.2. Time Course Analysis

The analysis of the time course of word retrieval revealed that both RHD and the control groups retrieved items in a similar pattern (see Table **3**). That is, participants in both groups retrieved maximum number of items in the first quadrant (of the 60s response period) followed by the second and so forth. It is also evident from Table **3** that across the time quadrants, the RHD group retrieved significantly fewer exemplars compared to the control group under both semantic and phonemic conditions. This observation is also in accordance with the findings from the analysis of switches. That is, both RHD and control participants did not differ in the strategic retrieval of items across the time. Additionally, the time-course analysis extends [19] study by confirming one of the two hypotheses proposed by these authors. That is, Joanette *et al*. (1988) [19] observed a reduction in the retrieval of exemplars under the semantic conditions after the initial 30s of the total 60s response period. They attributed it to the less automatic exploration of the semantic field either due to the impaired scanning process or due to the discrete semantic impairments that prevent efficient scanning of the field. The findings of this study are in favor of the second proposal that the observed reduction after 30s in Joanette *et al*.'s (1988) [19] study might have been due to the discrete semantic impairments as the current study did not show any difference in the strategic search (i.e., switches) employed by the RHD participants in comparison to their control counterparts.

Before concluding, a note on the distribution of lesions in our participant with RHD deems necessary. All participants, barring one (participant A1, see Appendix A: Online Supplementary Materials), had

APPENDIX A

Table A: Demographic and Lesion Data of the Participants with Right Hemisphere Damage

Participant	Age (years)/ Gender	Education (years)	RH site of lesion	Months post-onset
A1	28/Male	13	Posterior temporo-occipital infarct in the MCA-PCA distribution	3
A2	75/Male	5	Extensive fronto-parietal lesion in the MCA-ACA distribution	5
A3	56/Female	4	Extensive right fronto-parietal lesion in the MCA distribution	4
A4	58/Male	10	Fronto-parietal intraparanchymal lesion in the MCA distribution	4
A5	60/Male	12	Fronto-temporal infarct	6
A6	50/Male	3	Frontal infarct	4
A7	77/Female	4	Fronto-temporal infarct	6
A8	63/Male	12	Frontal infarct	4
A9	71/Male	Non-literate	Frontal infarct	6
A10	44/Male	14	Frontal infarct	2
A11	67/Male	7	Fronto-temporo-parietal infarct	6
A12	55/Male	5	Frontal infarct	6
A13	67/Male	15	Frontal infarct	3
A14	71/Male	4	Frontal infarct	2
A15	62/Female	Non-literate	Fronto-parietal cortico-subcortical infarct	6
A16	59/Male	8	Fronto-temporo-parietal	3
A17	77/Male	2	Fronto-parietal including subcortical (BG & internal capsule)	4
A18	68/Male	5	Fronto-parietal including subcortical	4
A19	51/Female	4	Frontal infarct	2
A20	66/Male	7	Fronto-temporo-parietal infarct	5
A21	63/Male	4	Frontal infarct	6
A22	74/Male	Non-literate	Frontal infarct	5

APPENDIX B

Table B: Demographic Data of the Participants in the Control Group

Participants	Age (years)/Gender	Education (years)
B1	30/Male	12
B2	74/Male	4
B3	55/Female	4
B4	58/Male	10
B5	60/Male	12
B6	48/Male	4
B7	75/Female	4
B8	61/Male	10

(Appendix B). continued.

Participants	Age (years)/Gender	Education (years)
B9	71/Male	Non-literate
B10	45/Male	12
B11	65/Male	7
B12	55/Male	4
B13	68/Male	14
B14	71/Male	4
B15	60/Female	Non-literate
B16	60/Male	7
B17	75/Male	3
B18	66/Male	4
B19	50/Female	4
B20	65/Male	7
B21	64/Male	4
B22	75/Male	Non-literate

injuries in the frontal lobe or frontal + parietal and/or temporal lobes in the distribution of right middle cerebral artery. Although precise anatomo-clinical correlation is not possible due to the broader distribution of lesions across the participants in the clinical group, it may be possible to infer the association between the right frontal lobes and deficient performance on verbal fluency task from our participants.

To conclude, the present study explored the nature of lexical retrieval deficits in persons with RHD through the traditional as well as in-depth analyses of performance on verbal fluency tasks. The findings were suggestive of the linguistic rather than the cognitive nature of word retrieval deficits in persons with RHD.

REFERENCES

[1] Krishnan G, Rajashekar B, Karanth P. Lexico-semantic deficits in persons with right hemisphere damage: evidence from convergent naming tasks. J Neurolinguist 2015; 35: 13-24. https://doi.org/10.1016/j.jneuroling.2015.01.002

[2] Gainotti G, Caltagirone C, Miceli G, Masullo C. Selective semantic-lexical impairment of language comprehension in right-brain-damaged patients. Brain Lang 1981; 13: 201-211. https://doi.org/10.1016/0093-934X(81)90090-0

[3] Joanette Y, Lecours AR, Lamoureux M. Language in right-handers with right-hemisphere lesions: a preliminary study including anatomical, genetic, and social factors. Brain Lang 1983; 20: 217-248. https://doi.org/10.1016/0093-934X(83)90043-3

[4] Varley R. Lexical-semantic deficits following right hemisphere damage: evidences from verbal fluency tasks. Eur J Disord Commun 1995; 30: 362-371. https://doi.org/10.3109/13682829509021448

[5] Gazzaniga MS, Bogen JE, Sperry RW. Some functional effects of sectioning the cerebral commissures. Proc Natl Acad Sci USA 1962; 48: 1765-1769. https://doi.org/10.1073/pnas.48.10.1765

[6] Varley R. Diectic terms, lexical retrieval and utterance length in aphasia. Eur J Disord Commun 1993; 30: 23-41. https://doi.org/10.3109/13682829309033141

[7] Zaidel E. Auditory vocabulary of the right hemisphere following brain bisection or hemidecortication. Cortex 1976; 12: 191-211. https://doi.org/10.1016/S0010-9452(76)80001-9

[8] Fedio P, August A, Patronas N, Sato S, Kufta C. Semantic, phonological, and perceptual changes following left and right intracarotid injection (Wada) with a low amytal dosage. Brain Cognit 1997; 33: 98-117. https://doi.org/10.1006/brcg.1997.0886

[9] Hier DB, Kaplan J. Verbal comprehension deficits after right hemisphere damage. Appl Psycholinguist 1980; 1: 279-294. https://doi.org/10.1017/S0142716400000564

[10] Rivers DL, Love RJ. Language performance on visual processing tasks in right hemisphere lesion cases. Brain Lang 1980; 10: 348-356. https://doi.org/10.1016/0093-934X(80)90061-9

[11] Khatoonabadi AR, Hovsepian A, Harley T, Kahlaoui K, Masolais Y, Joanette Y. The impact of left- and right-hemisphere on the processing of concrete and abstract words in Farsi. Brain Cognit 2008; 67: S11-S47. https://doi.org/10.1016/j.bandc.2008.02.048

[12] Kaplan E, Goodglass H, Weintraub S. Boston Naming Test. Philadelphia: Lee & Febiger 1983.

[13] Henry JD, Crawford JR, Phillips LH. Verbal fluency performance in dementia of the Alzheimer's type: a meta-analysis. Neuropsychologia 2004; 42(9): 1212-1222. https://doi.org/10.1016/j.neuropsychologia.2004.02.001

[14] Kertesz A. Western Aphasia Battery. San Antonio, TX: The Psychological Corporation 1982.

[15] Mioshi E, Dawson K, Mitchell J, Arnold R, Hodges JR. The Addenbrooke's Cognitive Examination Revised (ACE-R): a brief cognitive test battery for dementia screening. Int J Geriat Psychiat 2006; 21: 1078-1085. https://doi.org/10.1002/gps.1610

[16] Troyer AK, Moscovitch M, Winocur G. Clustering and switching as two components of verbal fluency: evidence from younger and older healthy adults. Neuropsychology 1997; 11(1): 138-146. https://doi.org/10.1037/0894-4105.11.1.138

[17] Hough MS, Pabst MJ, DeMarco S. Categorization skills in right hemisphere brain damage for common and goal-derived categories. Clin Aphasiol 1994; 22: 35-51.

[18] Joanette Y, Goulet P. Criterion-specific reduction of verbal fluency in right brain-damaged right-handers. Neuropsychologia 1986; 24(6): 875-879. https://doi.org/10.1016/0028-3932(86)90087-4

[19] Joanette Y, Goulet P, Le Dorze G. Impaired word naming in right-brain-damaged right-handers: error types and time-course analyses. Brain Lang 1988; 34(1): 54-64. https://doi.org/10.1016/0093-934X(88)90124-1

[20] Albert ML, Sandson J. Perseveration in aphasia. Cortex 1986; 22: 103-115. https://doi.org/10.1016/S0010-9452(86)80035-1

[21] Lokesh B, Krishnan G. Adaptation and standardization of Addenbrooke's Cognitive Examination to Kannada. Manipal University, Manipal 2008.

[22] Tombaugh TN, Kozak J, Rees L. Normative data stratified by age and education for two measures of verbal fluency: FAS and animal naming. Archiv Clin Neuropsychol 1999; 14: 167-177.

[23] Wixted JT, Rohrer D. Analyzing the dynamics of free recall: an integrative review of the empirical literature. Psychonom Bull Rev 1994; 1: 89-106. https://doi.org/10.3758/BF03200763

[24] Villardita C. Verbal memory and semantic clustering in right brain-damaged patients. Neuropsychologia 1987; 25: 277-280. https://doi.org/10.1016/0028-3932(87)90138-2

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