Journal for Re Attach Therapy and Developmental Diversities
eISSN: 2589-7799
2024 March; 7(3): 29-36

Working Memory And Inhibition In People With Broca's Aphasia

Dr. Belhaouchet Karim[1*], Dr. Kerdja Meriem[2]

[1]Language – Cognition – Interaction laboratory, Blida2 University. Department of Speech therapy, Mouloud Mammeri. University of Tizi Ouzou, Algeria, karim.belhaouchet@ummto.dz
[2]Language – Cognition – Interaction laboratory, Blida2 University. Department of Speech therapy, Mouloud Mammeri. University of Tizi Ouzou, Algeria, meriem.kerdja@ummto.dz

[*]**Corresponding Author:** Dr. Belhaouchet Karim
[*]Language – Cognition – Interaction laboratory, Blida2 University. Department of Speech therapy, Mouloud Mammeri. University of Tizi Ouzou, Algeria, karim.belhaouchet@ummto.dz

Received: 13/10/2023 **Accepted: 24/02/2024** **Published: 26/03/2024**

Summary:

Language and cognitive functioning allow human beings to interact and adapt to the demands of the world around them; in this sense, people with Broca's aphasia (PWBA) present a deficit which can seriously hamper their social autonomy. The interest of the present study is to evaluate cognitive functions relating to working memory (WM), and inhibition in 15 people with Broca's aphasia (PWBA group), in comparison with 15 healthy people (healthy group), which have the same characteristics. The analysis of intergroup differences shows that there is indeed a deficit in these functions in the PWBA group. The decline in the ability to maintain information at the WM level seems to explain the difficulties observed for the inhibition of distractors and attentional control. Age in the PWBA group is an aggravating factor. The speech therapy treatment provided to PWBA must take into consideration the deficits of these functions, which are strongly involved in language, in order to guarantee good language recovery.

Keywords: Working memory; inhibition; people with Broca's aphasia.

1- Introduction

Aphasia is a language disorder, due to neurological damage in the dominant language hemisphere, which presents in all linguistic modalities, oral and written; characterized by a loss of the ability to understand or produce language (Berg et al, 2022). According to the same authors, there is no consensus on the diffuse or focal nature of the attack, although the latter criterion is more commonly used. The brain damage is localized in Broca's or Wernicke's area, which are lateralized in the majority of cases in right-handed subjects in the left hemisphere compared to 60% of cases in the right hemisphere for left-handers (Perrotta, 2020). Other studies highlight that aphasia affects men much more than women. This can be explained by the bilateral distribution of language in the brain in women (Baron-Cohen, et al., 2005; Hausmann, 2016), in equal proportions the impairment seems more severe in men compared to women (Sharma et al, 2019). Among the causes answered are strokes, transient ischemic attacks, cerebral hemorrhages (Berthier,2005; Funakoshi et al, 2020), which is explained by a significant increase in strokes in the general population (Modig et al, 2019; GBD 2019 Stroke Collaborators, 2021). The prevalence of post-stroke aphasia varies according to the different studies, ranging from 15% to 68% (Wallentin, 2018) or from 7% to 77% (Frederick et al, 2022). Language recovery is possible, but can take several months (Pedersen et al, 1995). The age of injury is an important factor for recovery (Kristinsson et al, 2022) and the extent of the initial lesion (Benghanem et al, 2019).
Aphasia can seriously affect the psychological balance of the subject, particularly when the use of language is essential for the patient (Laures-Gore et al, 2020; Lin et al, 2023), and lead to family imbalance (Bousebta, 2012).
For Perotta (2020), aphasias are divided into two distinct groups, fluent aphasias marked by fluent speech unlike non-fluent aphasias marked by elementary syntactic production limited to a few words, where the use of gesture compensation is responded as we can see this in Broca's aphasia. This type of aphasia corresponds to the involvement of Broca's area, defined as the posterior parts of the inferior frontal gyrus, that is to say the pars triangularis and the opercular zone (Rogalsky et al, 2008). The damage extends to the subcortical territory limited to the putamen and the internal capsule (Perotta, 2020). The language disorder is widely present in speech produced with agrammatism, syntactic reduction and phonemic confusion. The recall of verbs seems to impair much more than nouns (Kambanaros et al, 2013). According to Schoeman and Van der Merwe (2010) Broca's aphasia constitutes the classic form of non-fluent aphasia first described in 1861 by Paul Broca. The term Broca's aphasia is the one used in the Boston classification (Blom Johansson, 2012); it is defined when there is a speech disorder or loss, with a good understanding of the spoken language. Aphasia is non-fluent

if speech is hesitant and slow with numerous pauses and a lack of articulatory precision and prosody in speech. Some speakers are very non-fluent and have severe apraxia of speech. The dimension of fluidity is closely related to the anatomy of non-fluid forms of lesions anterior to the Rolandic fissure. Spontaneous speech is non-fluent, slow and effortless, with short sentences (Kearns, 2005). According to Blom Johansson (2012) Difficulties finding words (anomie) are common, particularly for verbs. Grammar is often incorrect, with agrammatism which would be linked to a deficit in syntactic construction (Sam, 2017), in particular function words (prepositions, conjunctions and articles) and endings are missing or incorrectly used. The ability to write is similarly compromised. Language comprehension is also affected, particularly when it comes to more complex grammar, but usually not to the same extent as speaking and writing skills.
Different studies highlight a significant deficit in executive functions, short-term memory (STM), and attention (Bruki et al, 2012; Majerus et al, 2015; Villard & Kiran, 2017), as well as WM (Wright & Shisler, 2005; Mayer & Murray, 2012), with a significant correlation between the severity of aphasia and the deficit in mental flexibility as well as in working memory for recall tasks such as digit span forward and backward (Lee & Pyun, 2014). Recall that WM according to Dehn (2008), supports cognitive processing including language as an interface between perception, STM, long-term memory (LTM) and goal-directed action. According to Nouani (2003, 2007), language is correlated with cognitive functioning, particularly in its symbolic dimension, which involves WM. This can be explained by the multi-component model of WM proposed by Baddelley (Demir, 2021), with a central management module and two slave modules, one for the entry of verbal and acoustic information (phonological loop), the other for the input of visual and spatial information (Visio-spatial notebook), with a fourth component, the episodic buffer or interface module between the slave modules and the LTM.
Akkad et al (2023), raise the issue of evaluating executive functions (EF) and WM in PWBA, from the moment when the cortical territories limited to Broca's area and the left inferior frontal cortices (LIFC) is particularly cognitively relevant. Damage to Broca's area, which encompasses Brodmann's area BA 44 and BA 45, is involved in cognitive processing including language, in fact according to Duncan (2013) Broca's area is not specialized in speech and language, but rather is part of a broader network of general cognitive processes that includes, but is not limited to, language. It constitutes the resource of verbal WM (Martin, 2003).
WM is involved in our ability to inhibit a distractor such as in the Stroop interference effect (Long & Prat, 2002), which involves the active and attentional maintenance of several operations, such as maintaining task goals and information relevant to interference or conflict resolution between competing responses; different studies link the capacity of WM to the inhibition of distractors (Kane & Engle, 2003; Unsworth et al, 2004), which can be explained by the limited capacity of WM (Lavie & Fockert, 2005); according to several authors, Broca's area (left inferior frontal gyrus) is significantly activated during the conflicting interference effect observed in the Stroop spot (Derrfuss et al., 2005; Chen et al., 2013; Guha et al, 2020).
The involvement of cortical territories relating to Broca's area, in language, verbal WM and inhibition, leads us to question the capacity of WM at the level of verbal retention (phonological memory span), as well as inhibition of distractors and conflict management in PWBA.

2- Methodology :

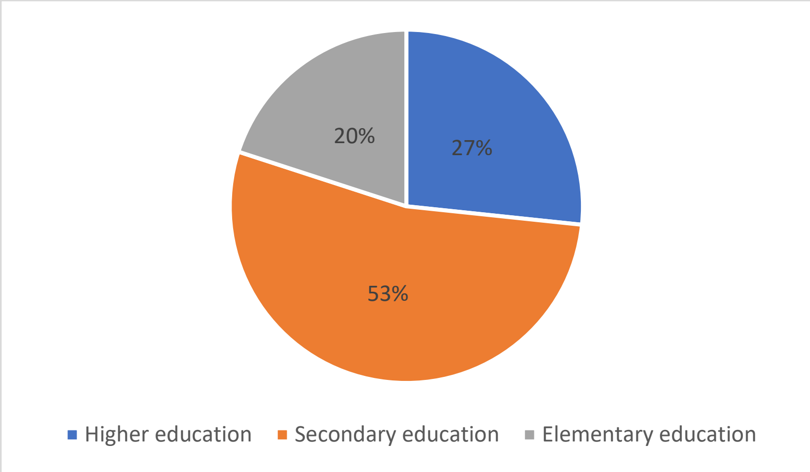
2-1- Method :
In this study, we will seek to evaluate the size of the phonological memory span in its passive form relating to STM and active form relating to WM, as well as the inhibition of distractors in people with Broca's aphasia. We believe that localized damage at the level of cortical territories BA44 and BA45 would hamper the capacities of WM in terms of retention and inhibition.

2-2- Sample :
Our study includes two working groups, a first group composed of 15 people with Broca's aphasia (PWBA group), a second group composed of 15 healthy subjects (healthy group), N=15. The age range in both groups is from 36 years to 70 years. We wanted to respect the same characteristics between the two groups with regard to gender and level of education.
People with Broca's aphasia was contacted at the Tizi Ouzou University Hospital, for some, for others at private speech therapy booths. The characteristics of the PWBA and healthy group are shown in Table 1. Figure 1 explains the instructional profile of the PWBA group.

Table1: *Characteristics of working groups*

	Men	Women	Age (years)	Type of accidents	Age of accident on the date of assessment in months
Group1	12	3	36-68	ischemic stroke	7-13
Group2	13	2	39-70	////////////////	//////////////////

Figure 1. *The PWBA group training profile*



The level of education seems sufficient to us, particularly for elderly subjects, for a good understanding of the instructions for examinations assessing phonological memory span and inhibition.
The diagnosis of Broca's aphasia was initially made on the basis of MRI, which reveals non-diffuse focal damage more or less extended to the posterior and medial part of the F3 and subcortical areas. No temporal or occipital damage was detected. The language examination with the Montreal Toulouse Algerian MTA (Zellal, 2002), the Boston Diagnostic Aphasia Examination BDAE (Goodglass & Kaplan, 1972), associated with the Token (De Renzi and Faglioni, 1978) confirms the non-fluent nature of the language with good preservation of understanding.

2-3- Assessment tools :

2-3-1- Assessment of working memory:

To assess WM, we used the digit recall test of the Wechsler Adult Intelligence Scale-Revised (WAIS-R). This subtest has two parts :

- Digit recall in order (DSF): composed of seven series of digits ranging from three digits in the 1st to nine digits in the seventh. Each series has two trials. This test is specific to the passive backup of the STM.
- Reverse digit recall (DSB): composed of seven series of digits ranging from two digits in the 1st to eight digits in the seventh. Each series has two trials. This test is specific to active WM backup.

Scoring is one point per attempt. The award is stopped after two successive failures in the same series.

2-3-2- Assessment of inhibition:

The STROOP test. This test assesses inhibition, which refers to the ability to prevent the generation of an automatic response. The test consists of three boards A, B and C:

- Test 1: Board A: Read as quickly as possible as many words as possible printed in black and white on-board A in 45 seconds.
- Board B: Read as quickly as possible as many words as possible printed in various colors on board B in 45 seconds
- Board C: Name the color of as many rectangles as possible on-board C in 45 seconds. Matches naming results.
- Plate B: Presentation of plate B a second time. The subject must name as many colors as possible on card B in 45 seconds. Corresponds to interference results.

The interference score is the difference between the naming results, minus the interference results.

3- Results :

We collected the raw results relating to WM, DSF and DSB, as well as those of the interference score of the PWBA group, and the healthy group; In order to carry out a comparison of means, and a correlation study, we have poured the previous results into the IBM SPSS Statistics 20 software.

3-1- Comparison of WM means and interference score:

The t test for the intergroup comparison allowed us to obtain the results indicated in tables 2 and 3.

Table 2: *Interference score averages, DSF; DSB*

	Groups	N	Average	Standard deviation	Average standard error
Interference score	Healthy	15	41.8667	5.87813	1.51773
	PWBA	15	60.3333	10.39001	2.68269
DSF	Healthy	15	5.63	0.625	0.161
	PWBA	15	4.56	1.259	0.325
DSB	Healthy	15	4.37	0.353	0.091
	PWBA	15	3.43	0.986	0.255

Table 3: *Value of the t test for independent samples and their significance*

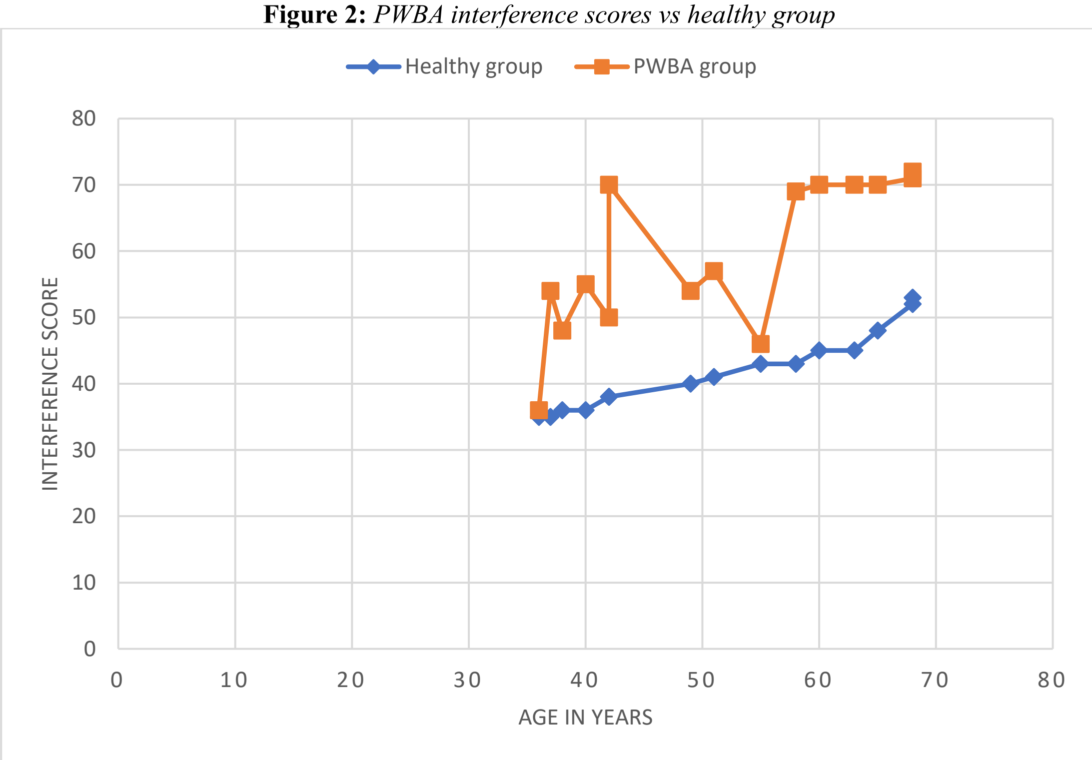
t	ddl	Sig. (bilateral)	Average difference	Difference standard deviation
-5.991	28	0.000	-18.46667	3.08226
-5.991	22.129	0.000	-18.46667	3.08226
2.957	28	0.006	1.073	0.363
2.957	20.509	0.008	1.073	0.363
3.457	28	0.002	0.935	0.270
3.457	17.524	0.003	0.935	0.270

We notice from tables 2 and 3 that there are significant differences ($p<0.05$) between the different variables:

1. Difference between interference scores: the PWBA group is higher than the healthy group with a difference of + 18.46, interference is greater in the PWBA group.
2. Difference between DSF scores: the healthy group is higher than the PWBA group with a difference of +1.07, the DSF is greater in the healthy group.
3. Difference between DSB scores: the healthy group is higher than the PWBA group with a difference of +0.93, the DSB is greater in the healthy group.

These differences are shown in Figure 2.

Figure 2: *PWBA interference scores vs healthy group*



Note first of all that the value of the interference scores increases with chronological age in both groups, however these scores are greater in the PWBA group compared to the healthy group. The values of the 1st case and the 9th of the PWBA group are close to the healthy group, unlike the other cases, particularly the 6th, with much higher scores closer to older subjects in the same group.

3-2- Correlation between the interference scores with those of the DSF and the DSB in the PWBA group:
The results of the correlation study are shown in Table 4, below.

Table4 : *Pearson correlation value*

		Interference	forward	Backwards
Interference	Pearson correlation	1	-0.816**	-0.776**
	Sig. (bilateral)		0.000	0.001
	N	15	15	15
DSF	Pearson correlation	-0.816**	1	0.912**
	Sig. (bilateral)	0.000		0.000
	N	15	15	15
DSB	Pearson correlation	-0.776**	0.912**	1
	Sig. (bilateral)	0.001	0.000	
	N	15	15	15

** The correlation is significant at the 0.01 level (two-tailed).

This correlation is shown in Figure 3.

Figure 3: *Correlation between interference scores and digit span forward and backward*

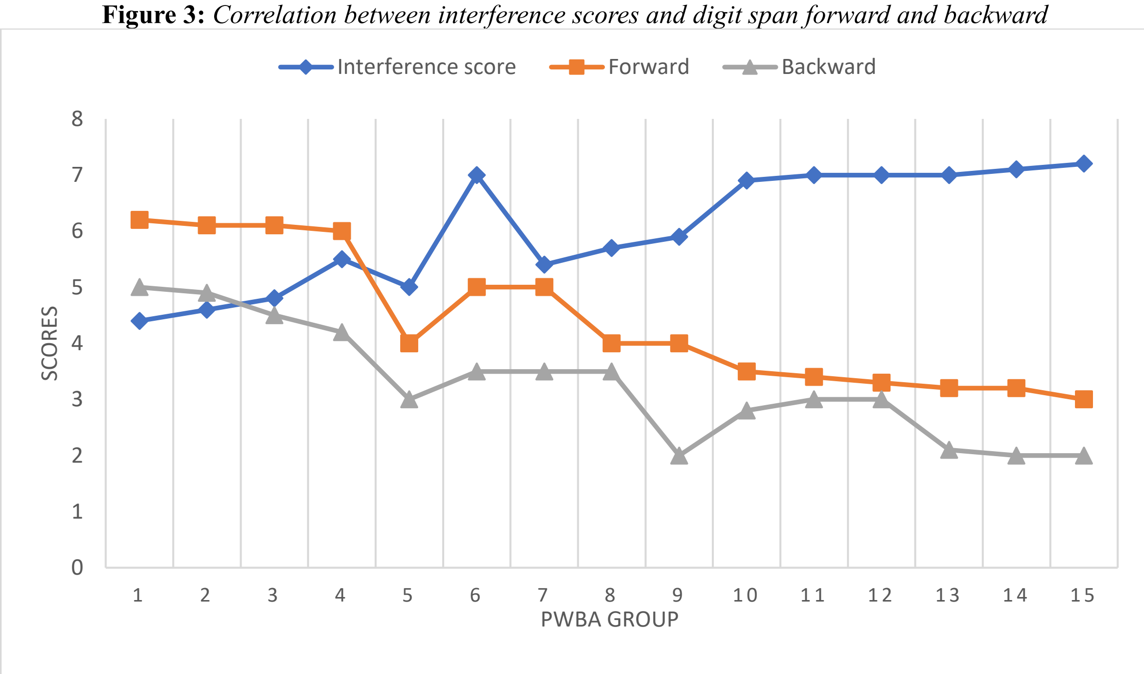


Table 4 shows us that there is a significant correlation proportionally inverse between the interference scores and those of the DSF and DSB. As Figure 3 explains, the more the interference scores increase, the more the size of the forward and backward phonological memory span decreases. Note that this negative relationship is not observed for the first four cases between the interference score and those of the DSF, unlike the DSB, with a drop in scores clearly visible from the 5th case.

4- Analysis and discussion :

The intergroup comparison shows that there are significant differences between the PWBA group and the healthy group, in favor of the latter (healthy group > PWBA group), for the interference score, the DSF and the DSB, with differences in respective averages estimated at 18.46. 1.07. 0.93. PWBA seem to have greater difficulty maintaining attentional focus on the required task, while inhibiting interference, with a significant degradation in the capacity to save the phonological memory span relating to the STM, or that of the WM. With greater difficulties for WM and a lower capacity as shown by the DSB score. Kessels et al (2008), as well as Laures-Gore et al (2011), emphasize that backward tasks are generally more difficult than forward tasks, both in healthy and clinical populations. The latter mainly depend on the phonological loop, while the manipulations necessary to reverse the order in backward tasks require the commitment of the central administrator, therefore a much greater cognitive effort. Different studies have shown significant correlations between WM performance, STM and the severity of Broca's aphasia (Howard & Nickels,2005; Potagas et al, 2011; Wright and

Shisler, 2005; Mayer and Murray, 2012). With localization of the STM involvement at the level of the inferior frontal gyrus. Kasselimis et al (2018) found decreased verbal WM performance (in DSF) in PWBA with lesions in the inferior frontal gyrus.

Figure 2 shows that the effect of age is an aggravating factor, the more the age of the subject increases, the more their capacity to both inhibit interference and save data of a passive (STM) or active (WM) nature decreases. This effect is clearly observable from the age of 55, although this deterioration effect is natural in view of the curve relating to the healthy group (Grégoire & Van der Linden, 1997), aphasia seems to be an aggravating factor. The correlation observed in the PWBA group, between the interference scores and those of the DSF and DSB, could be explained by the interaction of the two operations, in fact the capacity to inhibit distractors and favor the target object relating to the requested task. requires sufficient backup capacity, the lower the latter, the more pronounced the interference effect. The effect of age also seems unfavorable (Van der Elst et al., 2006), although the meta-analysis carried out by Verhaeghen and De Meersman (1998) does not support this idea. Note here that the involvement of WM in the processing of verbal language is more important than that of STM (Baddeley, 2012), it also intervenes in attention and executive functioning such as updating, moving and inhibition of verbal information, (Murray, 2012; Martin & Allen, 2008), different studies put a direct link between the capacity of WM and the inhibition of distractors (Kane & Engle, 2003; Unsworth, et al, 2004; Lavie et al, 2004), which is explained by the limited capacity of WM (Lavie & Fockert, 2005). The damage to Broca's area in aphasic subjects, more precisely at the level of the left inferior frontal cortex (LIFC), affects not only language production but also cognitive functioning at the level of executive functions and WM (Martin, 2003; Akkad et al., 2023; Duncan, 2013).

Conclusion:

PWBA show, even after several months of the stroke, a clear deficit in the ability to inhibit distractors and maintain attentional focus, as well as the ability to maintain verbal information in its passive and active form. Damage to Broca's area not only causes difficulties in language production, but also cognitively. This is explained by the involvement of the left lower frontal area relating to BA44 and 45, in particularly active general cognitive functioning (Top down), such as conscious manipulation. The limited maintenance capacity observed in people with Broca's aphasia adversely impacts attentional control. The effect of age, although present in the healthy group, seems more aggravating in PWBA subjects. The results relating to this study lead us to no longer limit Broca's aphasia to an impairment of language production, taking into consideration the decline in cognitive functioning. An assessment of cognitive functions in these subjects as well as the monitoring of their evolution seems imperative to any speech therapy treatment and to a large extent multidisciplinary.

Bibliographic list :

1. Akkad, H., Hope, T. M. H., Howland, C., Ondobaka, S., Pappa, K., Nardo, D., Duncan, J., Leff, A. P., & Crinion, J. (2023). Mapping spoken language and cognitive deficits in post-stroke aphasia. *NeuroImage. Clinical*, *39*, 103452. https://doi.org/10.1016/j.nicl.2023.103452
2. Baron-Cohen, S., Knickmeyer, R. C., & Belmonte, M. K. (2005). Sex differences in the brain: implications for explaining autism. *Science (New York, N.Y.)*, 310(5749), 819–823. https://doi.org/10.1126/science.1115455
3. Benghanem, S., Rosso, C., Arbizu, C., Moulton, E., Dormont, D., Leger, A., Pires, C., & Samson, Y. (2019). Aphasia outcome: the interactions between initial severity, lesion size and location. *Journal of neurology*, 266(6), 1303–1309. https://doi.org/10.1007/s00415-019-09259-3
4. Berg, K., Isaksen, J., Wallace, S. J., Cruice, M., Simmons-Mackie, N., & Worrall, L. (2022). Establishing consensus on a definition of aphasia: an e-Delphi study of international aphasia researchers. *Aphasiology*, 36(4), 385–400. https://doi.org/10.1080/02687038.2020.1852003
5. Berthier M. L. (2005). Poststroke aphasia: epidemiology, pathophysiology and treatment. *Drugs & aging*, 22(2), 163–182. https://doi.org/10.2165/00002512-200522020-00006
6. Blom Johansson, M. (2012). *Aphasia and Communication in Everyday Life: Experiences of persons with aphasia, significant others, and speech-language pathologists*. [PhD dissertation, Acta Universitatis Upsaliensis]. Retrieved from https://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-173130
7. Bousebta, Y. (2012). Les liens familiaux à l'épreuve de l'aphasie. *Cahiers de sociologie*, 1(1), 151–174. https://www.asjp.cerist.dz/en/article/204394
8. Brucki, S. M. D., Machado, M. F., & Rocha, M. S. G. (2012). Vascular Cognitive Impairment (VCI) after non-embolic ischemic stroke during a 12-month follow-up in Brazil. *Dementia & neuropsychologia*, 6(3), 164–169. https://doi.org/10.1590/S1980-57642012DN06030009
9. Chen, Z., Lei, X., Ding, C., Li, H., & Chen, A. (2013). The neural mechanisms of semantic and response conflicts: an fMRI study of practice-related effects in the Stroop task. *NeuroImage*, 66, 577–584. https://doi.org/10.1016/j.neuroimage.2012.10.028

10. De Renzi, E., & Faglioni, P. (1978). Normative data and screening power of a shortened version of the Token Test. *Cortex; a journal devoted to the study of the nervous system and behavior*, 14(1), 41–49. https://doi.org/10.1016/s0010-9452(78)80006-9
11. Dehn, M. J. (2008). *Working memory and academic learning assessment and intervention*. John Wiley & Sons, Inc.
12. Demir, B. (2021). Working Memory Model and Language Learning. *Shanlax International Journal of Education*, 9, (S2), 1–8. https://doi.org/10.34293/ducation.v9iS2-Sep.4366
13. Derrfuss, J., Brass, M., Neumann, J., & von Cramon, D. Y. (2005). Involvement of the inferior frontal junction in cognitive control: meta-analyses of switching and Stroop studies. *Human brain mapping*, 25(1), 22–34. https://doi.org/10.1002/hbm.20127
14. Duncan J. (2013). The structure of cognition: attentional episodes in mind and brain. *Neuron*, 80(1), 35–50. https://doi.org/10.1016/j.neuron.2013.09.015
15. Frederick, A., Jacobs, M., Adams-Mitchell, C. J. & Ellis, C. (2022). Global rate of post-stroke aphasia (Frederick et al., 2022). ASHA journals. Online resource. https://doi.org/10.23641/asha.21183478.v1Baddeley A. (2012). Working memory: theories, models, and controversies. Annual review of psychology, 63, 1–29. https://doi.org/10.1146/annurev-psych-120710-100422
16. Funakoshi, Y., Imamura, H., Tokunaga, S., Murakami, Y., Tani, S., Adachi, H., Ohara, N., Kono, T., Fukumitsu, R., Sunohara, T., Omura, Y., Matsui, Y., Sasaki, N., Fujiwara, S., Fukuda, T., Akiyama, R., Horiuchi, K., Yoshida, K., Kajiura, S., Shigeyasu, M., … Sakai, N. (2020). Carotid artery stenting before surgery for carotid artery occlusion associated with acute type A aortic dissection: Two case reports. *Interventional neuroradiology: journal of peritherapeutic neuroradiology, surgical procedures and related neurosciences*, 26(6), 814–820. https://doi.org/10.1177/1591019920925690
17. GBD 2019 Stroke Collaborators (2021). Global, regional, and national burden of stroke and its risk factors, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet. Neurology*, 20(10), 795–820. https://doi.org/10.1016/S1474-4422(21)00252-0
18. Goodglass, H. & Kaplan, E. (1972). *The Assessment of Aphasia and Related Disorders*. Lea & Febiger.
19. Grégoire J. & Van der Linden, M. (1997). Effect of age on forward and backward digit spans, Aging. *Neuropsychology, and Cognition*, 4(2), 140–149, https://doi.org/ 10.1080/13825589708256642
20. Guha, A., Spielberg, J. M., Lake, J., Popov, T., Heller, W., Yee, C. M., & Miller, G. A. (2020). Effective Connectivity Between Broca's Area and Amygdala as a Mechanism of Top-Down Control in Worry. *Clinical Psychological Science*, 8(1), 84–98. https://doi.org/10.1177/2167702619867098
21. Hausmann M. (2017). Why sex hormones matter for neuroscience: A very short review on sex, sex hormones, and functional brain asymmetries. *Journal of neuroscience research*, 95(1-2), 40–49. https://doi.org/10.1002/jnr.23857
22. Howard, D., & Nickels, L. (2005). Separating input and output phonology: semantic, phonological, and orthographic effects in short-term memory impairment. Cognitive neuropsychology, 22(1), 42–77. https://doi.org/10.1080/02643290342000582
23. Kambanaros, M., Grohmann, K. K., & Michaelides, M. (2013). Lexical retrieval for nouns and verbs in typically developing bilectal children. *First Language*, 33(2), 182–199. https://doi.org/10.1177/0142723713479435
24. Kane, M. J., & Engle, R. W. (2003). Working-memory capacity and the control of attention: the contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of experimental psychology. General*, 132(1), 47–70. https://doi.org/10.1037/0096-3445.132.1.47
25. Kearns, K. (2005). Broca's Aphasia. In LaPointe LL (Eds.), *Aphasia and related neurogenic language disorders (3rd ed., pp. 117-141)*. Thieme.
26. Kessels, R. P., van den Berg, E., Ruis, C., & Brands, A. M. (2008). The backward span of the Corsi Block-Tapping Task and its association with the WAIS-III Digit Span. *Assessment*, 15(4), 426–434. https://doi.org/10.1177/1073191108315611
27. Kristinsson, S., Busby, N., Rorden, C., Newman-Norlund, R., den Ouden, D. B., Magnusdottir, S., Hjaltason, H., Thors, H., Hillis, A. E., Kjartansson, O., Bonilha, L., & Fridriksson, J. (2022). Brain age predicts long-term recovery in post-stroke aphasia. *Brain communications*, 4(5), fcac252. https://doi.org/10.1093/braincomms/fcac252
28. Laures-Gore, J. S., Dotson, V. M., & Belagaje, S. (2020). Depression in Poststroke Aphasia. *American journal of speech-language pathology*, 29(4), 1798–1810. https://doi.org/10.1044/2020_AJSLP-20-00040
29. Laures-Gore, J., Marshall, R. S., & Verner, E. (2011). Performance of Individuals with Left-Hemisphere Stroke and Aphasia and Individuals with Right Brain Damage on Forward and Backward Digit Span Tasks. *Aphasiology*, 25(1), 43–56. https://doi.org/10.1080/02687031003714426
30. Lavie, N., & De Fockert, J. (2005). The role of working memory in attentional capture. *Psychonomic bulletin & review*, 12(4), 669–674. https://doi.org/10.3758/bf03196756
31. Lavie, N., Hirst, A., de Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of experimental psychology. General*, 133(3), 339–354. https://doi.org/10.1037/0096-3445.133.3.339

32. Lee, B., & Pyun, S. B. (2014). Characteristics of Cognitive Impairment in Patients With Post-stroke Aphasia. *Annals of rehabilitation medicine*, 38(6), 759–765. https://doi.org/10.5535/arm.2014.38.6.759
33. Lin, H. L., Sung, F. C., Muo, C. H., & Chen, P. C. (2023). Depression Risk in Post-Stroke Aphasia Patients: A Nationwide Population-Based Cohort Study. *Neuroepidemiology*, 57(3), 162–169. https://doi.org/10.1159/000530070
34. Majerus, S., Attout, L., Artielle, M. A., & Van der Kaa, M. A. (2015). The heterogeneity of verbal short-term memory impairment in aphasia. *Neuropsychologia*, 77, 165–176. https://doi.org/10.1016/j.neuropsychologia.2015.08.010
35. Martin R. C. (2003). Language processing: functional organization and neuroanatomical basis. *Annual review of psychology*, 54, 55–89. https://doi.org/10.1146/annurev.psych.54.101601.145201
36. Martin, R. C., & Allen, C. M. (2008). A disorder of executive function and its role in language processing. *Seminars in speech and language*, 29(3), 201–5. https://doi.org/10.1055/s-0028-1082884
37. Mayer, J. F., & Murray, L. L. (2012). Measuring working memory deficits in aphasia. *Journal of communication disorders*, 45(5), 325–339. https://doi.org/10.1016/j.jcomdis.2012.06.002
38. Modig, K., Talbäck, M., Ziegler, L., & Ahlbom, A. (2019). Temporal trends in incidence, recurrence and prevalence of stroke in an era of ageing populations, a longitudinal study of the total Swedish population. *BMC geriatrics*, 19(1), 31. https://doi.org/10.1186/s12877-019-1050-1
39. Murray L. L. (2012). Attention and other cognitive deficits in aphasia: presence and relation to language and communication measures. *American journal of speech-language pathology*, 21(2), S51–S64. https://doi.org/10.1044/1058-0360(2012/11-0067)
40. Nouani H. (2003). Analyse du processus de traitement de l'information linguistique et étude des activités cognitives chez les cerebro-lésés, T1601/08/2001, CNEPRU, université d'Alger.
41. Nouani H. (2007). Les troubles du langage et les fonctions cognitives connexes, cas de la MT, T1601/08/2005, CNEPRU, université d'Alger.
42. Pedersen, P. M., Jørgensen, H. S., Nakayama, H., Raaschou, H. O., & Olsen, T. S. (1995). Aphasia in acute stroke: incidence, determinants, and recovery. *Annals of neurology*, 38(4), 659–666. https://doi.org/10.1002/ana.410380416
43. Perrotta, G. (2020). Aphasia: Definition, clinical contexts, neurobiological profiles and clinical treatments. *Ann Alzheimers Dement Care,* 4(1), 021–026. https://dx.doi.org/10.17352/aadc.000014
44. Potagas, C., Kasselimis, D., & Evdokimidis, I. (2011). Short-term and working memory impairments in aphasia. *Neuropsychologia*, 49(10), 2874–2878. https://doi.org/10.1016/j.neuropsychologia.2011.06.013
45. Rogalsky, C., Matchin, W., & Hickok, G. (2008). Broca's area, sentence comprehension, and working memory: an fMRI Study. *Frontiers in human neuroscience*, 2, 14. https://doi.org/10.3389/neuro.09.014.2008
46. Sam, N. (2017). Etude du récit de trois sujets aphasiques algériens parlant Arabe à partir d'une série d'histoires insolites. *AL-Lisaniyyat*, 23(2), 9–29. https://www.asjp.cerist.dz/en/article/39795
47. Schoeman, R. & Van der Merwe, G. (2010). Aphasia, an acquired language disorder. *South African Family Practice*, 52(4), 308–311, https://doi.org/10.1080/20786204.2010.10873995
48. Sharma, S., Briley, P. M., Wright, H. H., Perry, J. L., Fang, X., & Ellis, C. (2019). Gender differences in aphasia outcomes: evidence from the AphasiaBank. *International journal of language & communication disorders*, 54(5), 806–813. https://doi.org/10.1111/1460-6984.12486
49. Unsworth, N., Schrock, J. C., & Engle, R. W. (2004). Working memory capacity and the antisaccade task: individual differences in voluntary saccade control. *Journal of experimental psychology. Learning, memory, and cognition*, 30(6), 1302–1321. https://doi.org/10.1037/0278-7393.30.6.1302
50. Van der Elst, W., Van Boxtel, M. P., Van Breukelen, G. J., & Jolles, J. (2006). The Stroop color-word test: influence of age, sex, and education; and normative data for a large sample across the adult age range. *Assessment*, 13(1), 62–79. https://doi.org/10.1177/1073191105283427
51. Verhaeghen, P., & De Meersman, L. (1998). Aging and the Stroop effect: a meta-analysis. *Psychology and aging*, 13(1), 120–126. https://doi.org/10.1037//0882-7974.13.1.120
52. Villard, S., & Kiran, S. (2017). To what extent does attention underlie language in aphasia? *Aphasiology*, 31(10), 1226–1245. https://doi.org/10.1080/02687038.2016.1242711
53. Wallentin M. (2018). Sex differences in post-stroke aphasia rates are caused by age. A meta-analysis and database query. *PloS one*, 13(12), e0209571. https://doi.org/10.1371/journal.pone.0209571
54. Wright, H. H., & Shisler, R. J. (2005). Working memory in aphasia: theory, measures, and clinical implications. *American journal of speech-language pathology*, 14(2), 107–118. https://doi.org/10.1044/1058-0360(2005/012)
55. Zellal N., (2002). *Protocole Montréal-Toulouse 86. Version plurilingue Algérienne*. Centre d'impression, Université d'Alger.