

Non-linguistic cognitive abilities as a predictor of language recovery among Algerians with Broca's aphasia

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Abstract:

Our study aimed to investigate the predictive factors and the effect of non-linguistic cognitive abilities on language recovery in people with Broca's aphasia. Cognitive flexibility, planning, Visuospatial working memory, and oral language tasks were administered to 30 patients with Broca's aphasia. The statistical prediction model reported only cognitive flexibility as a significant predictor of language recovery in people with Broca's aphasia. There were no significant predictors of planning and, Visuospatial working memory. Cognitive flexibility contributes to predicting language recovery because it is the basis of executive functioning and cognitive processing.

Keywords: Broca's aphasia; Non-linguistic cognitive abilities; Visual-spatial memory; Cognitive flexibility; Planning; language recovery.

Résumé:

Notre recherche vise à étudier les différents facteurs prédictifs et l'effet des capacités cognitives non-verbales sur la récupération du langage chez les personnes atteintes d'aphasie de Broca. Les tâches de flexibilité cognitive, de planification, de mémoire de travail visuo-spatiale et du langage oral ont été administrés à 30 patients atteints d'aphasie de Broca. Les modèles prédictifs ont reporté que seule la flexibilité cognitive était un prédicteur significatif de la récupération du langage chez les personnes atteintes d'aphasie de Broca, et que la planification ainsi que la mémoire de travail visuo-spatiale ne sont pas des prédicteurs significatifs. A flexibilité cognitive contribue à prédire la récupération du langage, car c'est la base du fonctionnement exécutif du traitement cognitif.

Mots-clés: Aphasie de Broca; Capacités cognitives non-verbales; Mémoire de travail visuo-spatiale; Flexibilité cognitive; Planification; Récupération du langage.

Introduction

Aphasia is considered one of the most severe symptoms resulting from brain injuries common in adulthood and aging. People affected by stroke lose the ability to speak and have problems with cognitive and motor abilities in most cases. Aphasia is characterized by problems in linguistic and non-linguistic, verbal and non-verbal communication, comprehension and production of oral and written language, dysfunction in cognitive processes and motor disorders. Linguistic and non-linguistic cognitive abilities interact with aphasia disorder, with linguistic cognitive skills being affected more than non-linguistic cognitive abilities, while non-linguistic abilities remain unaffected. Language processing necessitates integrating and interacting cognitive abilities with language comprehension and production. (Gilmore et al., 2019; Peach, 2017). Evidence has shown that deficits in cognitive processing negatively impact the effectiveness of recovery, as aphasia is associated with cognitive disorders such as executive functions and higher-order thinking skills (Burgio et Basso, 2017; Beeson et al., 1993; Helm-Estabrooks, 2002; Kauhanen et al., 2000). Comprehensive rehabilitation and language therapy is regarded as one of the approaches of cognitive-motor linguistic training that focuses on repairing damaged functions and compensating for them using the patients' strengths in the hope of recovery due to functional neuroplasticity. Language deficits in aphasia patients are caused by a misallocation of non-linguistic cognitive resources rather than impaired language representations. (Seniów et al., 2019). Language impairments in people with aphasia originate not from faulty language representations but rather from improperly distributed nonlinguistic cognitive resources. (Gilmore et al., 2019) Since non-linguistic cognitive abilities account for the variance in responsiveness to therapy in aphasia, evidence from recent research has demonstrated the influence of cognitive abilities on language recovery as well as the recovery of linked cognitive and motor abilities. Treatment results are influenced by pre-treatment linguistic and non-linguistic cognitive abilities. Nevertheless, it has not been quite evident what role certain non-linguistic cognitive skills have in the effectiveness of language treatment. (Bonini & Radanovic, 2015; El Hachoui et al., 2014; Code et al., 2010). There is not sufficient evidence to clarify the role of non-linguistic cognitive abilities in Language recovery in someone with Broca's aphasia and whether they are predictive of language recovery, as Seniów, Litwin, & Leśniak (2009) contributed to determining whether post-stroke aphasia is associated with impairments in non-linguistic cognitive abilities (visuospatial

working memory and abstract thinking) and whether these impairments negatively influence language recovery. They found that patients' non-linguistic cognitive abilities were impaired in general, visuospatial working memory was associated with the degree of improvement in both aspects of language communication functions: naming and comprehension. No relationship has been found between language recovery and abstract reasoning ability. Nicholas, Hunsaker, & Guarino (2017) contributed to exploring the relationship between non-verbal cognition and language abilities in a group of people with aphasia. The results showed that the non-verbal perception subtests predicted quality of life and linguistic abilities. Executive functions such as visual memory, cognitive flexibility, visual planning, and inhibition emerged as significant predictors. Gilmore et al., (2019) contributed to revealing whether pre-rehabilitation of non-verbal cognitive abilities predicts linguistic naming abilities in people with aphasia. They found that both linguistic and non-linguistic cognitive predicted the magnitude of treatment-related change in sentence or naming comprehension. There was an interaction between non-linguistic cognitive factors and treatment type, such that pre-treatment Non-linguistic cognitive skills had a smaller impact on the naming therapy than sentence comprehension. Executive function and visual short-term memory significantly predicted improvement immediately after treatment in naming and the gains persisted. The treatment of aphasia is affected by rehabilitation according to each case, as effective learning is a prerequisite for functional change during the recovery process and is affected by a variety of factors. The effects of many of these factors, such as non-linguistic cognitive abilities, on the recovery process have been evaluated. (Seniów et al., 2019). Cognitive functioning interacts with the efficiency of verbal and nonverbal linguistic communication, so that cognitive processing contributes to improved language function; evidence has shown that aphasia is associated with cognitive deficits that affects the patient's efficiency and the course of recovery and rehabilitation. Executive functions, such as cognitive flexibility, planning, and working memory, are non-verbal cognitive tasks that are based on visual attentional processing. It is essential for comprehension and producing language and communication, and even enhances the success of rehabilitation and recovery. To what extent can these skills contribute to language recovery in aphasia, and which non-verbal cognitive skill is most influential and predictive of language recovery in Broca's aphasia. Our study aimed to investigate predictive factors for language recovery, we investigated which non-verbal cognitive ability was the most predictive of recovery among cognitive flexibility, planning and Visuospatial working memory among patients with Broca's aphasia.

Method:

Participants:

Thirty Arabic-speaking Algerian patients with Broca's aphasia, aged between 30 and 74 years (mean age 45), were recruited from a hospital establishment specialized in rehabilitation and functional rehabilitation of RAS EL MA-SETIF Algeria who were taking motor therapy and speech therapy in a comprehensive treatment program.

Materials and procedures:

Nonlinguistic Cognitive assessment:

Cognitive flexibility task: The Trail Making Test (Reitan, 1958) is a neuropsychological test designed to evaluate the cognitive performance of people with brain damage. It involves visual scanning and working memory. It includes assessing executive functions, cognitive flexibility, and cognitive control.

Visuospatial working memory and Planning tasks: Rey–Osterrieth complex figure Test It is a neuropsychological test designed by Rey (1941) and then standardized by Osterrieth (1944). The test is used to evaluate visual abilities, attention, fine motor coordination, visual-spatial perception, planning, organization, and spatial orientation.

Language assessment:

The Montreal-Toulouse Algerian battery, adapted to the Algerian environment, is a set of tests for examining aphasia, which aims to assess the psycholinguistic cognitive disorders of aphasia, includes oral & writing language comprehension and production apraxia and agnosia task:

Results:

Visuospatial working memory, planning, and cognitive flexibility as predictors of language recovery in Broca's aphasia. After processing the data statistically for the performance of the aphasia cases on the study tasks, the statistical processing showed that we find that the probability value is equal to zero (0.000), which is less than the significant level of 0.01. The regression is significant and therefore there is an effect of the independent variables on the dependent variable, meaning that the dependent variable can be predicted through the independent variables. This explains the relationship between language recovery, Visuospatial working memory, planning, and cognitive flexibility. In order to know this relationship, a multiple linear regression model was used (see Table No. 1), in which the variables of Visuospatial working memory, planning, and cognitive flexibility were considered as independent (predictive) variables, and the language recovery variable was considered as a dependent variable. The results showed the significance of the regression model through the value of (F) of

(126.81) in terms of (0.000); that is, smaller than the level of significance (0.01). From the results obtained, the independent (predictive) variables as explaining 93.6% of the variance occurring in language recovery, given the coefficient of determination (R).

Table 1: shows the statistical data

Dependent Variable	Independent Variable	R	R Square	F Value	F Sig	Beta	T	Sig	VIF Factor
language recovery	Visuo-spatial working memory	0,967	0,936	126,818	0,000	,20	1,463	,155	8,090
	Planning					-,04	-,271	,788	8,641
	Cognitive flexibility					-,89	-15,87	,000	1,281

Visuospatial working memory as predictor of language recovery:

We find that the probability value P.Value is equal to 0.155, which is greater than the significance level (0.05). Therefore, we accept the null hypothesis that the coefficient of the Visuospatial working memory in the estimated regression model is not significant, meaning that the dependent variable (language recovery) cannot be predicted through the independent (predictive) variable Visuospatial working memory, which is the opposite of what the research hypothesis proves. That there is a statistically significant effect of Visuospatial working memory on language recovery in Broca's aphasia, and that we can predict it in the latter's language recovery.

Planning as predictor of language recovery:

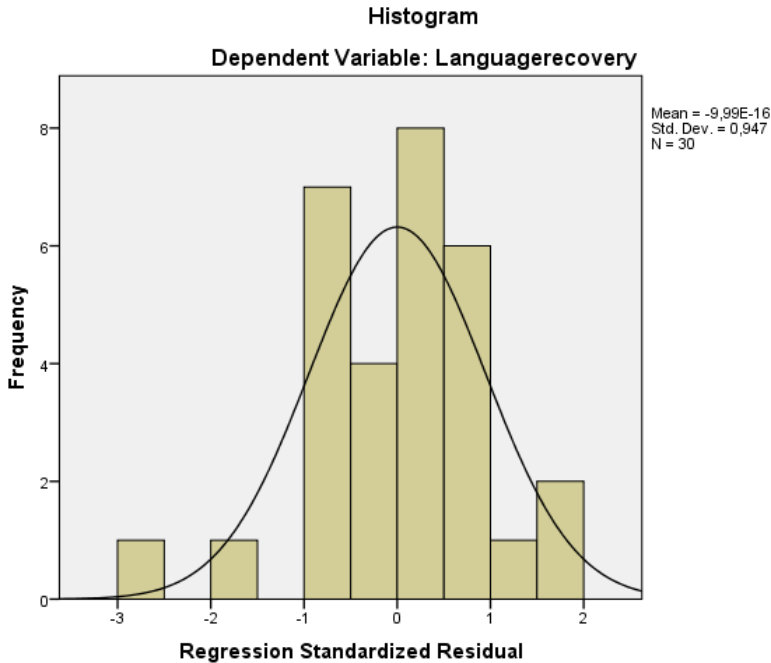
In addition, the beta value for the planning variable was (-0.04), which is not statistically significant, through the value of (t) (-0.27), while the probability value P was equal to 0.788, which is greater than the significance level of 0.05. Therefore, we accept the null hypothesis that the coefficient of the planning variable in the estimated regression model is insignificant. It does not prove the research hypothesis that there is a statistically significant effect of planning on the language recovery of Broca's aphasia, and that it can predict his language recovery.

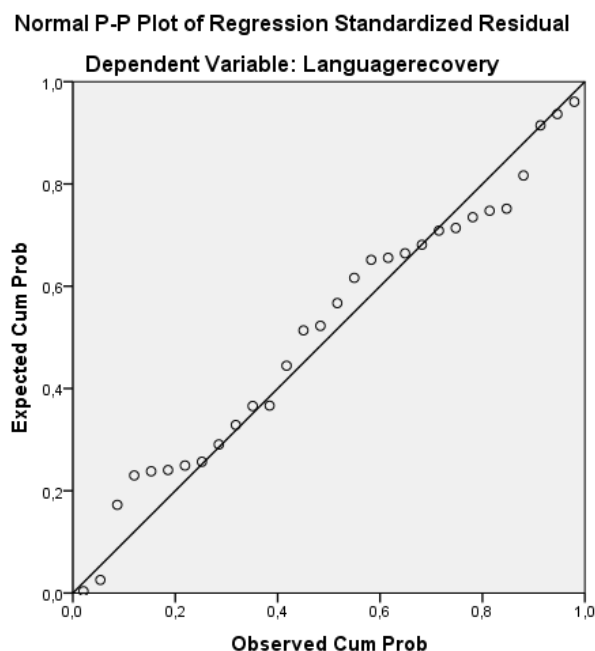
Cognitive flexibility as predictor of language recovery:

As for the beta value of the independent variable, cognitive flexibility, it came at a value of (-0.89), which is statistically significant, as this can be deduced from the

value of (t) (-15.87) and the significance associated with it. This means that whenever cognitive flexibility improves by one unit, the level of language recovery improves by one unit (-0.89). We find that the probability value P is equal to zero (0.000), which is less than the level of significance (0.01). Therefore, in this case, we reject the null hypothesis that the constant amount in the coefficient of the cognitive flexibility variable in the regression model is not significant or statistically significant, and we accept the alternative hypothesis that the significance of the regression model is proven at a significance level less than (0.01). It proves the research hypothesis that there is a statistically significant effect of cognitive flexibility on language recovery in Broca's aphasia, meaning that the dependent variable (language recovery) can be predicted through the independent variable (cognitive flexibility), and thus the research hypothesis of cognitive flexibility is verified.

Table No. 1 also shows the results of the multicollinearity test, where the result revealed that the variance inflation factor for the model was (8,090) for the visual spatial memory variable, (8,641) for the planning variable, and (1,281) for the cognitive flexibility variable, which is smaller than (10), which indicates that There is no multicollinearity problem among the model variables. The following graphs show the normality of the distribution of the residuals and collect data about the straight line.





Discussion:

Our study aimed to explore the extent to which non-linguistic cognitive skills predict language recovery in Broca's aphasia. Executive functions related to non-verbal tasks of cognitive flexibility, planning, and Visuospatial working memory were assessed in cases of Broca's aphasia. The results of the regression analysis concluded that cognitive flexibility statistically significantly predicted language recovery more than planning and Visuospatial working memory, whereas planning and Visuospatial working memory were not statistically significant in predicting language recovery. The participants showed significant impairments in planning function more than Visuospatial working memory and cognitive flexibility, respectively, as cognitive flexibility was the least harmful in the cases. Perhaps this explains the statistical significance of cognitive flexibility in predicting language recovery more than planning and Visuospatial working memory. Given the cognitive processing capacity required by planning and visual working memory, limitations in processing stimuli, storing and retrieving stimuli, and cognitive load, as well as mental demands such as logical analysis, problem-solving, and processing stimuli in working memory, the effect of cognitive flexibility in oral language comprehension and production appears more in our study than in planning and visual working memory.

The role and contribution of cognitive flexibility to linguistic retrieval in a person with aphasia as an essential and main component of executive functions, can be explained by its effect on Language recovery in Broca's aphasia, which was significant through the linguistic behaviors associated with it. The effect of cognitive flexibility on language recovery can be explained by the increased demands of language use, as real-world communication requires different skills including understanding and producing language in multiple discursive situations during the process of communication and social interaction. These tasks represent a cognitive load on attention and working memory that are often reduced or impaired in people with aphasia. This persistent impairment is associated with difficulties in understanding auditory and spoken language during communication. (Doedens & Meteyard, 2022). Many studies have explored the relationship between cognitive flexibility and language retrieval in individuals with Broca's aphasia as it has a role in non-linguistic executive functions. Recent research suggests that lesions in the left inferior frontal cortex, including Broca's area, are associated with higher cognitive deficits in aphasia. (Faroqi-Shah & Gehman, 2021). These findings highlight the complex interplay between nonverbal cognitive abilities and language retrieval in Broca's aphasia. This requires further research to explore this relationship in more depth and develop effective interventions for individuals with this type of aphasia (Seniów et al., 2009). Understanding this relationship can lead to more targeted treatment approaches tailored to the individual's type of disability and to improving the accuracy of aphasia prediction models by considering the importance of non-verbal cognitive abilities in treatment. It can also provide more targeted and comprehensive treatment for individuals with Broca's aphasia. This means that language processing dysfunction is not only language impairment but also underlying cognitive deficits that may contribute to communication difficulties. They may include potential interventions or strategies to improve language retrieval based on an understanding of these nonverbal abilities, also, incorporating exercises and activities that target these nonverbal functions can help improve the cognitive skills necessary for language production and retrieval. In addition, therapy sessions can be based on integrating domain-general awareness, action, and conceptual knowledge into language processing. It is important to note that the relationship between nonverbal cognitive deficits and language recovery in individuals with Broca's aphasia can vary within and between individuals, so personalized intervention plans should be developed based on individual strengths, weaknesses, and specific needs. Contrary to previous beliefs that Broca's area is a language-specific area, this study and recent evidence indicate that it is involved in speech production, but is not specific to it. This means that individuals with Broca's aphasia may also suffer from deficits in

higher-level cognitive abilities, as understanding the relationship between these abilities is important. Nonverbal cognitive and language retrieval is critical to developing effective interventions and strategies for individuals with Broca's aphasia. Considering non-verbal cognitive abilities in treatment for individuals with Broca's aphasia is crucial to improving outcomes; by addressing both linguistic and non-linguistic aspects of communication, more comprehensive treatment and support can be provided to individuals with this condition.

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