Psychological Assessment

Psicologia: Teoria e Prática, 26(1), ePTPPA15610. São Paulo, SP, 2024.
ISSN 1516-3687 (print), ISSN 1980-6906 (electronic version). **Evaluation system:** double-blind review.
https://doi.org/10.5935/1980-6906/ePTPPA15610.en
Universidade Presbiteriana Mackenzie

Performance of Adults After Stroke with and Without Aphasia on Neupsilin-L

Joice Dickel Segabinazi[1], Maxciel Zortea[2], Luciene Lima dos Santos Garay[3], Denise Ren da Fontoura[4], Jerusa Fumagalli de Salles[5], and Jaqueline de Carvalho Rodrigues[6]

[1] Pontifical Catholic University of Rio Grande do Sul (Pontifícia Universidade Católica do Rio Grande do Sul [PURS)]], Porto Alegre *Campus*, Porto Alegre, Rio Grande do Sul, Brasil
[2] University of Vale dos Sinos (Universidade do Vale do Rio dos Sinos [Unisinos]), Porto Alegre *Campus*, Porto Alegre, Rio Grande do Sul, Brasil
[3] Lutheran University of Brazil (Universidade Luterana do Brasil [Ulbra]), Guaíba *Campus*, Canoas, Rio Grande do Sul, Brasil
[4] Hospital of Moinhos do Vento (Hospital Moinhos de Vento, Porto Alegre, RS, Brazil
[5] Federal Univerisity of Rio Grande do Sul (Universidade Federal do Rio Grande do Sul [UFRGS]), Porto Alegre, Rio Grande do Sul, Brasil
[6] Pontifical Catholic University of Rio de Janeiro (Pontifícia Universidade Católica do Rio de Janeiro [PUC-Rio]), Rio de Janeiro, Rio de Janeiro, Brasil

Received: October 4th, 2022.
Accepted: August 18th, 2023.
Section editor: Juliana Burges Sbicigo.

Author Note

Joice D. Segabinazi https://orcid.org/0000-0002-7670-2362
Maxciel Zortea https://orcid.org/0000-0002-2360-9252
Luciene L. S. Garay https://orcid.org/0000-0002-0685-749X
Denise R. Fontoura https://orcid.org/0000-0002-1146-1932
Jerusa F. Salles https://orcid.org/0000-0003-0877-488X
Jaqueline de C. Rodrigues https://orcid.org/0000-0001-9947-4705

Correspondence concerning this article should be addressed to Joice Segabinazi, Av. Ipiranga, 6681 - Prédio 81 - 6º andar - sala 603 - Partenon - Porto Alegre/RS, Brazil. CEP 90619900. Email: jsegabinazi@gmail.com

Acknowledgements: The authors would like to thank the State of Rio Grande do Sul Research Support Foundation (Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul [FAPERGS]) for funding this research through the Notice for the Research Program for the SUS [Sistema Único de Saúde]: Shared Health Management – PPSUS [Programa de Pesquisa para o SUS] (Edital Programa de Pesquisa para o SUS: Gestão Compartilhada em Saúde – PPSUS), and the Foundation for Science and Technology (Fundação para a Ciência e Tecnologia [FCT], Portugal).

Abstract

The preliminary psychometric properties of the Brief Neuropsycholinguistic Assessment Instrument NEUPSILIN-L were analyzed in patients with and without expressive aphasia. This study included 94 adults: 11 with brain damage in the right hemisphere (RHD), 38 with brain damage in the left hemisphere (LHD), and 45 neurologically healthy. The group with LHD presented lower scores than the other groups, mainly in the language tasks, as well as the sample with aphasia. Clinical groups performed better on the NEUPSILIN-L in tasks with motor response options, about oral responses. The NEUPSILIN-L items had a Cronbach's alpha of 0.931 and McDonald omega of 0.950. The results of the groups in the NEUPSILIN-L showed that the instrument presents evidence of validity based on the relationship with criteria and high internal consistency. Future studies intend to expand the evidence of validity of the instrument and provide normative data for the Brazilian population.

Keywords: test validity, neuropsychological assessment, aphasia, language disorders, cerebrovascular accident

DESEMPENHO DE ADULTOS APÓS ACIDENTE VASCULAR CEREBRAL COM E SEM AFASIA NO NEUPSILIN-L

Resumo

Analisaram-se as propriedades psicométricas preliminares do Instrumento de Avaliação Neuropsicolinguística Breve NEUPSILIN-L, em pacientes com e sem afasia expressiva. Participaram 94 adultos, sendo 11 com lesão cerebral no hemisfério direito (LHD), 38 no hemisfério esquerdo (LHE) e 45 neurologicamente saudáveis. O grupo com LHE apresentou os menores escores, principalmente nas tarefas de linguagem, em relação aos demais grupos, assim como a amostra com afasia. Grupos clínicos apresentaram melhor desempenho no NEUPSILIN-L nas tarefas com opções de resposta motora, em relação às respostas orais. Os itens do NEUPSILIN-L apresentaram alpha de Cronbach de alpha de Cronbach de 0,931 e ômega de McDonald de 0,950. Os resultados dos grupos no NEUPSILIN-L demonstraram que o instrumento apresenta evidências de validade baseadas na relação com critério e alta consistência interna. Estudos futuros pretendem ampliar as evidências de validade do instrumento e oferecer dados normativos para a população brasileira.

Palavras-chave: validade do teste, avaliação neuropsicológica, afasia, distúrbios da linguagem, acidente cerebrovascular

DESEMPEÑO DE ADULTOS DESPUÉS DE UN ACCIDENTE CEREBROVASCULAR CON Y SIN AFASIA EN EL NEUPSILIN-L

Resumen

Se analizaron las propiedades psicométricas preliminares del Instrumento de Evaluación Neuropsicolingüística Breve NEUPSILIN-L en pacientes con y sin afasia expresiva. Participaron 94 adultos, 11 con lesión cerebral en el hemisferio derecho (LHD), 38 en el hemisferio izquierdo (LHI) y 45 neurológicamente sanos. El grupo con LHI presentó las puntuaciones más bajas, principalmente en las tareas de lenguaje, en relación a los demás grupos, así como la muestra con afasia. Los grupos clínicos obtuvieron mejores resultados en NEUPSILIN-L en tareas con opciones de respuesta motora, en relación a las respuestas orales. Los ítems de NEUPSILIN-L tuvieron un alfa de Cronbach de 0,931 y McDonald's omega de 0,950. Los resultados de los grupos en el NEUPSILIN-L mostraron que el instrumento presenta evidencias de validez basada en la relación con criterios y alta consistencia interna. Futuros estudios pretenden ampliar las evidencias de validez del instrumento y proporcionar datos normativos para la población brasileña.

Palabras-clave: validación de test, evaluación neuropsicológica, afasia, trastornos del lenguaje, accidente cerebrovascular

The choice of an instrument in neuropsychology practice and research contexts must be directly related to the set of psychometric properties the test possesses. A quality test should provide evidence of validity and reliability for the target population (AERA, APA, & NCME, 2014). The validity of an instrument refers to the degree to which evidence is accumulated and corroborates the interpretation of a test according to its specific purpose. Among the different types of evidence, validity based on the relationship with external variables (criteria) has proven important in clinical practice by demonstrating that the results on the instrument are related to predicting an outcome or are related to similar constructs. Reliability, on the other hand, refers to the accuracy with which test scores and interpretations are maintained, regardless of the conditions in which the instrument is used (AERA, APA, & NCME, 2014). Therefore, extensively researched instruments with positive results should be prioritized.

One of the neuropsychological instruments, directed toward psychology and speech therapy professionals with adequate psychometric properties in the Brazilian context is the Brief Neuropsychological Assessment Instrument NEUPSILIN (Fonseca, Salles, & Parente, 2009). However, most of the NEUPSILIN subtests require verbal responses from the patient, making it impossible to assess individuals with communicative difficulties such as aphasia, mutism, and specific language disorders. Accordingly, neuropsychological deficits can be demonstrated by tasks with verbal responses in patients with expressive challenges due to their linguistic impairment, making it essential to provide visual response options to compensate for these difficulties (Crivelli et al., 2023). To overcome this limitation, the Brief Neuropsycholinguistic Assessment Instrument NEUPSILIN-L (Fontoura, Rodrigues, Fonseca, Parente, & Salles, 2011) was adapted from the NEUPSILIN (Fonseca et al., 2009) to assist in evaluating patients who have difficulty expressing themselves verbally.

The reason behind the adoption of of this instrument was because several studies have demonstrated adequate psychometric properties of the NEUPSILIN for the Brazilian population, such as evidence of content validity (Fonseca et al., 2009), convergent and concurrent construct validity (Pawlowski et al., 2008), criterion and incremental validity in neurological assessment (Pawlowski et al., 2014). Furthermore, the NEUPSILIN presents evidence of test-retest and inter-rater reliability (Pawlowski, Parente, & Bandeira, 2013a) and normative data for adolescents to older adults (Fonseca et al., 2009). These data demonstrated that this would be an instrument suitable for adaptation to another context, such as for patients with expressive language difficulties.

The NEUPSILIN-L assesses the same neuropsychological functions as the NEUPSILIN: orientation, attention, memory (verbal and visual episodic, prospective, and working memory), perception, language (oral and written), praxis, arithmetic skills, and executive functions. To analyze the psychometric properties of the NEUPSILIN-L, it was first sought to adapt its items with verbal responses (oral) by adding multiple-choice response options (motor). Studies with the NEUPSILIN-L demonstrated that this instrument provides evidence of content validity and criterion-related validity, showing that the inclusion of motor responses maintained the primary neuropsychological function to be assessed by the tasks and differentiated the performance of patients with and without expressive aphasia after left cerebral hemisphere cerebrovascular injury (Fontoura, Rodrigues, Mansur, Monção, & Salles, 2013).

A sensitivity analysis of the NEUPSILIN-L task items was also conducted to determine which ones better differentiated the performance of post-stroke adults and neurologically healthy individuals (Rodrigues et al., 2019). Analyses based on Item Response Theory using the Rasch model demonstrated that several items in the instrument presented discriminative power between individuals with and without neuropsychological deficits. Analyses using Receiver Operating Characteristic (ROC) plots indicated that the cognitive dimensions of orientation, oral language, academic skills (reading, writing, and arithmetic), and executive functions were the ones that best differentiated between clinical and healthy groups. These results reinforce the evidence of criterion-related validity for the NEUPSILIN-L.

Considering the scarcity of validated neuropsychological instruments in Brazil, especially for evaluating non-verbal patients with expressive oral language difficulties (e.g., mutism, aphasia, specific language disorder, speech disorder, catatonia, autism spectrum disorder, and neurocognitive disorders affecting language), the present study aimed to analyze preliminary data on the psychometric properties of the NEUPSILIN-L by comparing the performance of adults who had experienced unilateral stroke, with and without expressive aphasia, to that of neurologically healthy adults. Specific objectives included analyzing evidence of criterion-related validity by a) comparing the performance of post-stroke adults and neurologically healthy adults; b) comparing performance between post-stroke groups with and without predominantly expressive aphasia; c) comparing performance between oral and motor (multiple-choice) responses to the subtests that encompass these alternatives in the NEUPSILIN-L in groups with left cerebral hemisphere damage (LHD) and right cerebral hemisphere damage (RHD); and d) analyzing the internal consistency and reliability of the instrument.

It was hypothesized that adults with stroke and LHD would present lower performance in the NEUPSILIN-L subtests related to language tasks (Rapp, 2011; Rodrigues et al., 2013, 2019; Rodrigues, Bandeira, & Salles, 2020) and praxis tasks (Rodrigues et al., 2011) compared to healthy individuals. Another hypothesis is that adults with stroke, specifically those with RHD lesions, would present lower performance in the NEUPSILIN-L subtests related to visuospatial processing, visual perception, constructive praxis, and inference processing in comparison to healthy adults (Rapp, 2011; Rodrigues et al., 2013, 2020; Tynterova, Perepelitsa, & Golubev, 2022). Furthermore, in comparisons between groups with and without aphasia, it is possible that language impairments may affect the ability of aphasic participants to respond to verbal tasks and result in lower scores (Fontoura et al., 2013). On the other hand, developing alternative tasks involving motor responses for some functions, a unique feature of the NEUPSILIN-L, should facilitate the response process for patients with language impairments. Therefore, it is assumed that LHD patients, whose language impairments are expected, will have higher scores in subtests involving motor response than oral response.

Method

Participants

The study included adults (over 18 years of age), of both sexes, divided into three groups: a) 45 neurologically healthy individuals, b) 11 with post-stroke RHD, and c) 38 with post-stroke LHD. The final sample consisted of 94 adults, 52 of them female. The healthy, RHD, and LHD groups did not show statistically significant differences in sex, age, and years of education. The post-stroke patients exhibited a heterogeneous profile based on the types and locations of their lesions. Table 1 provides descriptive data for each group.

Table 1

Sociodemographic and clinical data of the study participants (n = 94)

	Healthy *n* = 45 *M* (*SD*)	RHD *n* = 11 *M* (*SD*)	LHD *n* = 38 *M* (*SD*)	F/ χ^2	*p*
Age (years)	56.13 (9.95)	52.45 (9.66)	60.24 (10.23)	2.219	0.115
Sex (Fe/Ma)	25/20	7/4	20/ 18	0.420	0.811
Years of education	9.56 (4.36)	9.45 (3.33)	8.32 (4.68)	0.838	0.436
Time since stroke (months)	-	27.00 (10.03)	47.03 (35.17)	3.427	0.071
Frequency of cerebrovascular lesion data and types of aphasia.					
I/ H/ NR	-	5/ 5/ 1	26/ 7/ 5		
Cor/ Sub/ CS/ NR	-	3/ 2/ 5/ 1	7/ 9/ 9/ 13		
Broca's aphasia	0	0	8		
Mixed transcortical aphasia	0	0	1		
Motor transcortical aphasia	0	0	6		
Unspecified aphasia	0	0	1		

Note. Fe = female; Ma = male; I = ischemic; H = hemorrhagic; NR = not reported; Cor = cortical; Sub = subcortical; CS = cortico-subcortical; *M* = mean; *SD* = standard deviation; LHD = left hemisphere damage; RHD = right hemisphere damage.

All participants were Brazilian, monolingual, and had at least four years of formal education. For the healthy group, individuals without any history of stroke or other neurological conditions were included. Post-stroke patients could have up to two episodes of lesions in the same cerebral hemisphere (right or left). They should not have neurological damage resulting from other diseases, such as tumors or traumatic brain injuries, confirmed by neuroimaging exams and neurological assessments.

Exclusion criteria for all groups (healthy and post-stroke) included a current or previous history of substance abuse (alcohol and illicit drugs) and self-reported psychiatric or sensory disorders (uncorrected hearing and/or visual impairments). Adults with moderate to severe depressive symptoms, as indicated by their responses on the depression scales selected according to the participant's age (described in the instruments section), were also excluded. Additionally, for the neurologically healthy group, evidence of cognitive decline assessed through the Mini-Mental State Examination (Folstein et al., 1975) was an exclusion criterion, following the cutoff points proposed by Kochhann et al. (2010), which vary according to education level.

Data collection procedures and Instruments

The study participants were part of a project that obtained approval from the Research Ethics Committee of a general hospital in Porto Alegre, under number 100149, and of a public university in Rio Grande do Sul (authorization number 2009028). All participants signed the consent form. The stroke patients were contacted by telephone after being referred by doctors and residents at the general hospital or after an analysis of their medical records. The neurologically healthy participants were from the general community. The following instruments were administered:

a) Health and sociodemographic conditions questionnaire: produced by the research group, consisting of questions about age, years of education, gender, substance use history, and history of psychiatric and neurological diagnoses (sensory and others). The questionnaire was used for sample characterization and to relate data such as age and education to neuropsychological performance.

b) Brief Neuropsycholinguistic Assessment Instrument – NEUPSILIN-L (Fontoura et al., 2011): this instrument consists of a battery of 33 neuropsychological tasks, assessed with options for oral responses (OR), motor responses (MR), or both. The instrument assesses temporal-spatial orientation (OR - 8 points and MR - 8 points), attention (reverse counting - 20 points OR; digit sequence repetition - 7 points OR and 7 points MR), visual perception (verification of line equalities and differences - 6 points; visual hemineglect - 1 point; face perception - 3 points; face recognition - 2 points), working memory (backwards digit ordering - 10 points MR; auditory word span in sentences - 28 points MR), episodic-semantic verbal memory (immediate, delayed, and recognition - 40 points OR), long-term semantic memory (5 points OR and 5 points MR), short-term visual memory (3 points), arithmetic skills (8 points), oral language (naming - 4 points; repetition - 10 points; comprehension - 3 points; inference processing - 3 points OR and 3 points MR), written language (reading - 12 points; comprehension - 3 points; spontaneous writing - 2 points; copied writing - 2 points; dictated writing - 12 points), praxis (ideomotor - 3 points; constructive - 16 points; reflective - 3 points), and executive functions (problem-solving - 2 points OR and 2 points MR; orthographic and semantic verbal fluency - score dependent on the number of words evoked). Tasks that assess neuropsychological functions visually do not have OR options. Tasks that depend on speech are answered in both OR and multiple-choice (MR) forms, always in this order. Tasks of verbal memory and language do not have MR options since this form of response would alter the target function being assessed. The NEUPSILIN-L scoring is done separately based on the number of correctly verbalized and pointed items, with scores extracted for both tasks and functions (task groups).

c) Boston Aphasia Diagnostic Test - Short version (Goodglass, Kaplan, & Barresi, 2001; Radanovic, Mansur, Azambuja, Porto, & Scaff, 2004): applied exclusively to the post-stroke adult group by a speech therapist experienced in clinical diagnosis to classify the type of aphasia presented by the patient. It consists of a battery with 28 tasks that assess oral comprehension, oral agility, repetition, naming, oral reading, reading comprehension, and writing. This test was used only for the characterization of the sample, as it is a reference for aphasia diagnosis and for dividing the groups into those with and without predominantly expressive aphasia.

d) Geriatric Depression Scale - GDS-15 (Almeida & Almeida, 1999): a 15-item instrument with yes/no responses, answered only by participants aged 60 and over, to exclude those with moderate to severe depressive symptoms (score of 11 points or more). This scale was applied only to ensure that participants met the study's inclusion criteria.

e) Beck Depression Inventory (BDI, Cunha, 2001): Completed by adults up to 59 years of age to exclude participants with moderate to severe depressive symptoms. The BDI has 21 items, in which the participant indicates whether they have experienced depressive symptoms in the past few weeks, with scores ranging from zero to four. This instrument was applied only to ensure the study's inclusion criteria, with participants with a score of 20 points or higher being excluded.

f) Mini-Mental State Examination (Folstein et al., 1975): A screening instrument used to check for signs of cognitive decline. This test was only administered to neurologically healthy adults to ensure the inclusion criteria, using cutoff points for education according to Kochhann et al. (2010).

The assessments took place in rooms at the research institution or in the participants' homes (four post-stroke adults) in case of difficulty with transportation. The assessments were conducted in quiet, well-lit environments with no interruptions in both situations. Participants completed the entire assessment in an average of two sessions, each lasting approximately one hour and thirty minutes.

Data analysis

Initially, descriptive analyses of the participants' performances in the NEUPSILIN-L were conducted. As the data did not follow a normal distribution, non-parametric analyses were performed using Kruskal-Wallis tests, with corrections for multiple comparisons, to compare the three groups (LHD, RHD, and healthy adults) and their scores in the NEUPSILIN-L subtests. Mann-Whitney U tests (non-parametric) were used to compare the groups of patients with and without aphasia. Wilcoxon Signed-Rank tests were used for intra-group task comparisons. Furthermore, reliability was estimated using internal consistency analysis by calculating Cronbach's alpha and McDonald's omega for all subtests of the instrument. Spearman correlations were also conducted only with tasks that showed modifications in the instrument adaptation, as the unmodified tasks had already demonstrated reliability in other studies (see Pawlowski et al., 2008). The statistical significance level for all analyses was set at $\alpha < 0.05$. Analyses were performed using the SPSS (Statistical Package for the Social Sciences) version 27.0 software.

Results

a) Comparative groups (LHD, RHD, and neurologically healthy adults) in the NEUPSILIN-L

In the comparison between groups, as shown in Table 2, it was identified that patients with LHD had lower scores compared to both the RHD group and healthy adults in tasks related to temporal-spatial orientation ($p = 0.010$; $p < 0.01$), time orientation ($p = 0.008$; $p < 0.001$), and spatial orientation ($p < 0.01$; $p = 0.015$), in both motor response (MR) and oral response (OR). Additionally, the LHD group performed worse than the other groups in tasks related to working memory ($p = 0.014$; $p < 0.001$), auditory word span in sentences ($p = 0.033$; $p = 0.001$), oral language ($p = 0.009$; $p < 0.001$), written language ($p = 0.015$; $p < 0.001$), repetition ($p = 0.004$; $p < 0.01$), automatic language ($p = 0.005$; $p < 0.001$), inference processing (OR) ($p = 0.001$; $p < 0.001$), written comprehension ($p = 0.034$; $p < 0.001$), spontaneous writing ($p = 0.022$; $p < 0.001$), dictated writing ($p = 0.036$; $p < 0.001$), and orthographic ($p = 0.007$; $p < 0.001$) and semantic ($p = 0.039$; $p < 0.001$) verbal fluency. The RHD and healthy groups did not differ in these tasks.

The LHD group had lower scores only compared to the healthy adult group in tasks related to attention (OR and MR; $p < 0.001$), reverse counting ($p < 0.001$), digit sequence repetition ($p < 0.001$), backward digit ordering ($p < 0.001$), episodic-semantic verbal memory ($p = 0.028$), immediate recall ($p = 0.001$), semantic (OR; $p = 0.002$), visual ($p = 0.017$), and prospective ($p = 0.017$) memory, arithmetic skills ($p < 0.001$), naming ($p = 0.001$), and ideomotor ($p = 0.024$), constructive ($p = 0.002$), and reflective ($p = 0.034$) praxis. The LHD and RHD groups did not differ in these tasks.

The RHD group performed worse than the healthy adults ($p = 0.002$) and the LHD group ($p = 0.042$) in the line perception task and worse than the healthy adults in visual perception ($p = 0.038$). The hemineglect task reached a ceiling effect, meaning that none of the participants in the sample scored zero.

Table 2

Comparisons of the Performance between the Groups in the NEUPSILIN-L

NEUPSILIN- L	Healthy *n* = 45 *M* (*SD*)	RHD *n* = 11 *M* (*SD*)	LHD *n* = 38 *M* (*SD*)	*H*	*p*
Temporal-spatial orientation (OR)	7.96^{a} (0.30)	7.64^{a} (1.21)	6.08^{b} (2.26)	30.126	<0.001*
Time	3.98^{a} (0.15)	3.82^{a} (0.60)	2.61^{b} (1.60)	30.868	<0.001*
Space	3.98^{a} (0.15)	4.00^{a} (0.00)	3.00^{b} (1.63)	18.967	<0.001*
Temporal-spatial orientation (MR)	7.98^{a} (0.15)	8.00^{a} (0.00)	6.74^{b} (2.05)	18.995	<0.001*
Time	3.98^{b} (0.15)	3.82$^{a.b}$ (0.60)	3.47^{a} (0.86)	14.294	0.001*
Space	4.00^{b} (0.00)	4.00$^{a.b}$ (0.00)	3.74^{a} (0.64)	11.013	0.004*
Attention					
Reverse counting	19.27^{a} (2.61)	18.09$^{a.b}$ (4.04)	12.74^{b} (9.08)	19.321	<0.001*
Digit sequence repetition (OR)	3.07^{a} (1.75)	2.64$^{a.b}$ (1.43)	1.51^{b} (1.28)	18.338	<0.001*
Digit sequence repetition (MR)	3.00^{a} (1.99)	2.55$^{a.b}$ (2.02)	1.19^{b} (1.10)	21.011	<0.001*
Perception	10.39^{b} (1.38)	9.36^{a} (1.03)	9.89$^{a.b}$ (1.62)	6.752	0.034*
Verification of similarities and differences between lines	5.36^{b} (0.93)	4.27^{a} (0.90)	5.03^{b} (1.24)	11.557	0.003*
Face perception	2.14^{a} (0.90)	2.45^{a} (0.52)	2.08^{a} (0.75)	1.825	0.402
Face recognition	1.91^{a} (0.28)	1.64^{a} (0.67)	1.79^{a} (0.41)	3.625	0.163
Memory					
Working memory	19.60^{a} (6.19)	19.18^{a} (6.34)	12.87^{b} (5.63)	21.070	<0.001*
Backward digit ordering	4.60^{a} (1.96)	4.09^{a} (2.16)	2.55^{b} (1.67)	19.549	<0.001*
Auditory word span in sentences	15.09^{a} (5.08)	15.09^{a} (5.22)	10.32^{b} (4.69)	15.476	<0.001*
Episodic-semantic verbal memory	21.95^{a} (5.61)	22.36$^{a.b}$ (4.96)	18.38^{b} (5.85)	8.117	0.017*
Immediate recall	4.56^{a} (1.42)	4.36$^{a.b}$ (1.36)	3.22^{v} (1.86)	14.390	0.001*
Delayed recall	2.19^{a} (2.11)	2.36^{a} (1.86)	1.19^{a} (1.58)	6.447	0.040
Recognition	15.21^{a} (2.91)	15.64^{a} (3.01)	13.95^{a} (3.47)	3.837	0.147
Semantic memory (OR)	4.82^{a} (0.49)	4.82$^{a.b}$ (0.40)	3.58^{b} (2.03)	12.835	0.002*
Semantic memory (MR)	4.84^{a} (0.47)	4.82^{a} (0.40)	4.58^{a} (0.76)	4.891	0.087
Short-term visual memory	2.75^{a} (0.65)	2.73$^{a.b}$ (0.65)	2.34^{b} (0.91)	8.226	0.016*
Prospective memory	1.73^{a} (0.58)	1.36$^{a.b}$ (0.81)	1.26^{b} (0.86)	8.230	0.016*
Arithmetic skills (OR)	7.27^{a} (1.40)	6.64$^{a.b}$ (2.20)	4.68^{b} (3.25)	15.783	<0.001*
Language					
Oral language (OR)	26.13^{a} (1.24)	26.09^{a} (0.94)	19.76^{b} (7.76)	28.841	<0.001*
Oral language (MR)	23.51^{a} (0.81)	23.36^{a} (0.81)	18.37^{b} (6.90)	22.246	<0.001*

Table 2

Comparisons of the Performance between the Groups in the NEUPSILIN-L

NEUPSILIN- L	Healthy *n* = 45 *M* (*SD*)	RHD *n* = 11 *M* (*SD*)	LHD *n* = 38 *M* (*SD*)	*H*	*p*
Naming	3.98[b] (0.15)	3.82[a.b] (0.40)	3.11[a] (1.52)	12.349	0.002
Repetition	9.89[a] (0.32)	9.91[a] (0.30)	7.47[b] (3.37)	25.714	<0.001*
Automatic	4.00[a] (0.00)	4.00[a] (0.00)	2.95[b] (1.43)	25.824	<0.001*
Oral comprehension	2.87[a] (0.34)	2.91[a] (0.30)	2.61[a] (0.64)	5.645	0.059
Inference processing (OR)	2.62[a] (0.65)	2.73[a] (0.47)	1.45[b] (1.11)	29.443	<0.001*
Inference processing (MR)	2.78[b] (0.51)	2.73[a.b] (0.65)	2.24[a] (0.91)	12.381	0.002*
Written language	28.67[a] (2.09)	28.60[a] (1.65)	19.05[b] (10.92)	23.606	<0.001*
Reading aloud	11.76[a] (0.48)	11.70[a] (0.48)	8.05[b] (4.80)	22.403	<0.001*
Written comprehension	2.91[a] (0.29)	2.91[a] (0.30)	2.34[b] (0.85)	16.872	<0.001*
Spontaneous writing	1.60[a] (0.54)	1.64[a] (0.50)	0.84[b] (0.90)	17.524	<0.001*
Copied writing	1.78[a] (0.42)	1.82[a] (0.40)	1.54[a] (0.69)	2.907	0.234
Dictated writing	10.70[a] (1.32)	10.45[a] (1.03)	6.35[b] (4.66)	24.696	<0.001*
Praxis	18.16[b] (2.81)	16.80[a.b] (2.70)	14.3[a] (4.91)	14.038	0.001*
Ideomotor	3.00[a] (0.00)	3.00[a.b] (0.00)	2.76[b] (0.71)	7.694	0.021*
Constructive	12.89[a] (2.34)	11.91[a.b] (2.88)	10.00[b] (3.75)	11.788	0.003*
Reflective	2.29[a] (1.03)	2.30[a.b] (1.06)	1.61[b] (1.28)	6.859	0.032*
Executive Functions					
Problem-solving (OR)	1.67[a] (0.47)	1.82[a] (0.40)	1.37[a] (0.63)	7.563	0.023
Problem-solving (MR)	1.67[a] (0.47)	1.82[a] (0.40)	1.45[a] (0.64)	4.340	0.114
Orthographic verbal fluency	20.51[a] (7.55)	15.09[a] (4.41)	5.97[b] (7.15)	47.797	<0.001*
Semantic verbal fluency	24.76[a] (8.84)	20.45[a] (4.76)	11.34[b] (8.98)	32.844	<0.001*

Note: OR = Oral Response; MR = Motor Response; *M* = mean; *SD* = standard deviation.
a, b = letters were used to represent differences between groups. Equal letters indicate that the groups had the same neuropsychological performance. In contrast, different letters indicate that the groups differed, meaning that the group with the lower means had lower neuropsychological performance.

b) Comparisons between groups with and without aphasia

When dividing the LHD group into adults with predominantly expressive aphasia (n = 16) and those without aphasia (n = 22), statistically significant differences were identified between these groups in tasks related to inference processing by OR (U = 246.000; p = 0.039) and MR (U = 248.000; p = 0.033), oral language by OR (U = 251.500; p = 0.024) and MR (U = 244.000; p = 0.045), and reflexive praxis (U = 247.500; p = 0.033), with the first group performing worse than the second.

c) Comparisons between oral and motor responses in post-stroke patients with LHD

For some subtests, motor responses were provided to the patient during the NEUPSILIN-L assessment. According to the results, motor responses for the subtests of temporal orientation, spatial orientation, semantic memory, and inference processing were significantly better than the oral responses for the same subtests (Table 3).

Table 3

Comparison between oral and motor responses for the Temporal orientation, Spatial orientation, Digit sequence repetition, Semantic memory, Inference processing, and Problem-solving subtests for the LHD group (n = 38)

	Oral response			Motor response				
	Mean	***SD***	**Median**	**Mean**	***SD***	**Median**	***Z***	***p***
Temporal orientation	2.61	1.60	3.00	3.47	0.86	4.00	**-3471**	**<0.001**
Spatial orientation	3.00	1.63	4.00	3.74	0.64	4.00	**-2.890**	**0.003**
Digit sequence repetition	1.51	1.28	1.00	1.19	1.10	1.00	-1542	0.123
Semantic memory	3.58	2.03	5.0	4.58	0.74	5.0	**-2869**	**0.004**
Inference processing	1.45	1.11	1.5	2.24	0.91	2.00	**-3857**	**<0.001**
Problem-solving	1.37	0.63	1.00	1.45	0.64	2.00	-1732	0.083

Note: SD = standard deviation; Z = Wilcoxon Signed-Rank Test statistic.

d) Analysis of internal consistency

The items of the NEUPSILIN-L showed a Cronbach's alpha and McDonald's omega of 0.931 and 0.950, respectively. The results of the correlations between the tasks of the NEUPSILIN-L, which underwent modifications compared to the original instrument, are presented in Tables 4 and 5. In the healthy sample, only the semantic memory task (OR) did not show correlations with any task of the NEUPSILIN-L (Table 4). Other subtests showed weak to moderate correlations with each other. In the group of adults with stroke, there were weak, moderate, and strong correlations between all the NEUPSILIN-L tasks (Table 5).

Table 4

Correlations between the NEUPSILIN-L tasks in the healthy group

	OR (MR)	AT (MR)	WM	VM	SM (MR)	PM	AR	OL (MR)	PS (MR)	OVF	SVF
OR (MR)	-										
AT (MR)	0.056	-									
WM	0.242	0.333*	-								
VM	0.221	0.053	0.535**	-							
SM (MR)	-0.050	0.026	0.002	-0.020	-						
PM	0.456**	0.332*	0.373*	0.499**	-0.072	-					
AR	0.137	0.041	0.438**	0.206	0.098	0.033	-				
OL (MR)	0.470**	0.072	0.426**	0.477**	0.034	0.439**	0.275	-			
PS (MR)	-0.107	0.097	0.455**	0.372*	0.167	0.164	0.305*	0.097	-		
OVF	0.273	0.327*	0.537**	0.370*	0.092	0.442**	0.205	0.451**	0.320*	-	
SVF	0.030	0.219	0.583**	0.402**	0.018	0.284	0.218	0.459**	0.325*	0.528**	-

Note: OR = orientation; AT = attention; WM = working memory; VM = verbal memory; SM = semantic memory; PM = prospective memory; AR = arithmetic; OL = oral language; PS = problem-solving; OVF = orthographic verbal fluency; SVF = semantic verbal fluency; MR = motor response.
* = p<0.05
** = p<0.01

Table 5

Correlations between the NEUPSILIN-L tasks in the stroke group

	OR (MR)	AT (MR)	WM	VM	SM (MR)	PM	AR	OL (MR)	PS (MR)	OVF	SVF
OR (MR)	-										
AT (MR)	0.754**	-									
WM	0.562**	0.584**	-								
VM	0.609**	0.502**	0.538**	-							
SM (MR)	0.308*	0.257	0.327*	0.621**	-						
PM	0.524**	0.486**	0.502**	0.362*	0.253	-					
AR	0.707**	0.725**	0.693**	0.552**	0.335*	0.570**	-				
OL (MR)	0.824**	0.811**	0.523**	0.522**	0.324*	0.505**	0.644**	-			
PS (MR)	0.459**	0.533**	0.303*	0.361*	0.172	0.184	0.494**	0.444**	-		
OVF	0.526**	0.609**	0.647**	0.441**	0.297*	0.336*	0.593**	0.597**	0.349*	-	
SVF	0.619**	0.702**	0.749**	0.403**	0.277	0.486**	0.655**	0.732**	0.367**	0.765**	-

Note: OR = orientation; AT = attention; WM = working memory; VM = verbal memory; SM = semantic memory; PM = prospective memory; AR = arithmetic; OL = oral language; PS = problem-solving; OVF = orthographic verbal fluency; SVF = semantic verbal fluency; MR = motor response.
* = p<0.05
** = p<0.01

Discussion

Comparative groups (LHD, RHD, and neurologically healthy adults) in the NEUPSILIN-L

From the analysis of group comparisons, the hypothesis that adults with LHD would perform worse in the NEUPSILIN-L language subtests compared to the other groups was confirmed. Several studies support the findings of language impairments in post-stroke adults (Basilakos, 2015; Boukrina et al., 2015; Fontoura et al., 2013; Pawlowski et al., 2013; Rapp, 2011; Rodrigues et al., 2019, 2020). Basilakos (2015) found an association between speech apraxia and aphasia with motor cortical regions, somatosensory areas, the temporal lobe, and the prefrontal cortex of the left cerebral hemisphere. Boukrina et al. (2015) identified lower performance in patients with LHD in tasks involving semantic, orthographic, and phonological processing. These findings are consistent with the lower performance of participants with LHD in oral language, repetition, automatic language, inference processing, written language, spontaneous writing, and dictated writing tasks of the NEUPSILIN-L when compared to the RHD and healthy groups. Therefore, the relationship between the processing of oral and written language predominantly performed by the left cerebral hemisphere is evident.

The hypothesis that adults with LHD would perform worse in the praxis tasks was also confirmed. Deficits in reading, spontaneous writing, copied writing, dictated writing, and praxis tasks show correlations with left hemisphere functioning, as well as with each other, as they are all related to social interaction through communication (Pawlowski et al., 2013b; Rodrigues et al., 2011). Accordingly, apraxic deficits and language comprehension impairments are significantly associated with lesions in the left cerebral hemisphere. The NEUPSILIN-L evaluation results also indicated lower performance in the praxis tasks (ideomotor, constructive, and reflective) in the patients with LHD compared to the other groups, showing a relationship between these deficits and the affected hemisphere (Rodrigues et al., 2011).

The results with the NEUPSILIN-L confirmed findings from the original NEUPSILIN when comparing the performance of adults with LHD to neurologically healthy adults (Pawlowski et al., 2013b). Adults with post-stroke LHD showed a significant reduction in performance in language (oral and written), working memory, and ideomotor praxis tasks. The NEUPSILIN-L working memory tasks depend on language (comprehension and expression) to be performed correctly, which justifies the poorer performance of the LHD group.

Another confirmed hypothesis was that adults with RHD would perform worse than healthy adults in the visual perception subtest. Participants with RHD showed poorer performance in the line perception task of the NEUPSILIN-L. Russell et al. (2013) demonstrated that RHD patients had a reduced effective visual field, mainly for identifying items to their left, indicating the importance of the right hemisphere in visual perception processing. Vossel et al. (2013) also showed the emergence of deficits such as hemineglect and agnosia, directly impacting the daily living activities of these patients. Cerebral areas related to this type of deficit were the frontal cortex, cingulate cortex, and white matter of the right hemisphere.

The other visual perception tasks (face perception and recognition), as well as the hemineglect task of the NEUPSILIN-L, did not differentiate the three groups, although it is common for RHD patients to present visual hemineglect after a stroke (Nurmi et al., 2010). It is likely that the small number of items in the instrument, along with the small sample size, compromised the significance of the differences. Additionally, the hemineglect task may have been too easy to execute, not being sensitive to patients with chronic cerebrovascular lesions or more subtle deficits.

The hypotheses that participants with RHD would perform worse in the inference processing and constructive praxis tasks when compared to the healthy group were not confirmed. This fact may be related to the small sample size and the limited variability in the NEUPSILIN-L scores, which were not sensitive enough to detect these difficulties. Qualitative analyses of error types, such as observing whether the drawing suggests hemineglect and whether there are concrete responses in metaphor interpretation, may complement the quantitative analysis of the NEUPSILIN-L and contribute to the understanding of deficit processing.

In general, the results of the comparisons between the three groups (LHD, RHD, and healthy) using the NEUPSILIN-L corroborated findings already documented in the literature on cerebral hemisphere specialization (Rapp, 2011; Rodrigues et al., 2013; Tynterova, Perepelitsa, & Golubev, 2022). Furthermore, the instrument was able to help understand the neuropsychological profile of patients with LHD, RHD, and neurologically healthy adults. Therefore, it can be said that the NEUPSILIN-L presents evidence of criterion-related validity by demonstrating differences in performance according to the participants' neurological clinical status. However, the study limitations include the small number of participants and the heterogeneity of cerebrovascular lesions, which may not have shown statistically significant differences. Analyses with larger and more homogeneous groups are recommended for future studies.

b) Comparisons between groups with and without aphasia

The hypothesis that participants with LHD and aphasia would have lower scores on the NEUPSILIN-L was also corroborated, again demonstrating criterion-related validity evidence. Differences in oral language skills between groups with and without expressive aphasia are expected, as these tasks involve naming, comprehension, automatic speech, and repetition, which may be impaired in these cases (Fontoura et al., 2014). The task of processing inferences is also speech-dependent, which may have hindered the performance of patients with aphasia. On the other hand, reflexive praxis is not a language-dependent task for execution, although participants must understand its instructions. Therefore, difficulties in attention and comprehension of what should be done may have highlighted these differences in this task.

It is important to note that participants in the groups with and without aphasia, despite having left hemisphere lesions, are heterogeneous in terms of the extent of the lesion, affected lobes, and time post-stroke, which are variables that influence neuropsychological deficits

(Rodrigues et al., 2011; 2018). This constitutes a further limitation of the present study. Patients with aphasia may have a greater number of neuropsychological deficits associated with extensive brain lesions, affecting various cognitive abilities such as working memory and attention (Crivelli et al., 2023; Lee & Pyun, 2014). Furthermore, even if patients have lesions in the same specific brain areas, they may manifest different impairments. It is suggested that case series studies with the same type of brain lesion or studies with homogeneous groups, using the NEUPSILIN-L, could contribute to research in the field.

c) Comparisons between oral and motor responses in post-stroke patients with LHD

Participants in the clinical groups showed better performance in the NEUPSILIN-L in tasks with motor response options compared to oral responses in the orientation, memory, and inferential processing subtests. It is possible that having response options facilitates neuropsychological assessment, as participants can recognize the correct alternative instead of recalling it. In the application of the NEUPSILIN-L, to standardize the instrument, all participants initially provided oral responses, followed by motor responses. This inclusion of motor responses has proven valuable in clinical practice, offering greater sensitivity when compared to tests relying solely on oral responses, especially for patients with aphasia (Crivelli et al., 2023). Furthermore, having visual options to point to for the answer may provide a more reliable assessment of the specific neuropsychological function in question. This result suggests that the motor modality, an innovation in the NEUPSILIN-L, allows the patient to respond to the subtest without the effect of expressive or oral language impairments affecting their score.

On the other hand, having alternatives for the participant to point to may make the assessment easier, and the participant may "guess" the answer, leading to a false-negative result (not demonstrating a deficit in the neuropsychological function). Therefore, it is recommended that the evaluator pays attention to the accuracy of the responses, hesitations, and test duration, and analyzes the patient's results in the NEUPSILIN-L to assess their neuropsychological profile. Despite these limitations, the use of the instrument is recommended for patients with expressive language difficulties, such as aphasia, mutism, and communication disorders, aiming to circumvent the language deficit and assess the target neuropsychological construct in clinical contexts.

d) Analysis of internal consistency

Finally, internal consistency analyses demonstrated results above 0.90, with alphas between 0.60 to 0.70 being considered borderline for an acceptable result (Hair, Black, Babin, Anderson, & Tatham, 2009). Therefore, the results of the NEUPSILIN-L demonstrate high internal consistency. Additionally, in general, the neuropsychological tasks showed statistically significant weak, moderate, and strong correlations in both groups, indicating that they assess related functions and demonstrate interdependence (Rodrigues et al., 2019). Moreover, many tasks are language-dependent, which supports the correlations found between the subtests.

From the correlations, it can be observed that the motor response alternatives continue to assess the main neuropsychological functions. Therefore, the results of the NEUPSILIN-L demonstrate high reliability. The weakness of the correlations among healthy individuals may have been due to this group exhibiting a ceiling effect in many of the tasks of this instrument, compromising the significance between them. In contrast, in the group of adults with stroke, there were weak, moderate, and strong correlations between all the NEUPSILIN-L tasks. The greater variability in scores in this group, compared to the healthy individuals, may have favored the stronger and more significant correlations.

Conclusion

In summary, the NEUPSILIN-L demonstrated evidence of criterion-related validity and evidence of reliability (internal consistency and reliability). This instrument has shown its ability to differentiate between two clinical groups (LHD and RHD) and healthy adults, as well as between two groups with different clinical conditions (with and without aphasia). These findings are important in the field of neuropsychology to ensure that the instrument is capable of identifying different cognitive profiles (AERA, APA, & NCME, 2014). It is important to note that this is not a diagnostic tool but rather a tool for assessing the neuropsychological profile of adults, especially those with difficulties in verbalizing responses. It can assist healthcare providers in identifying deficits in patients and referring them for the appropriate treatment.

This study was conducted with preliminary data and has limitations, including a small number of participants and variability in the types and locations of the cerebrovascular lesions. Therefore, future studies will be carried out with larger samples and patients with other clinical conditions that affect expressive language. Normative data for the Brazilian population will also be provided, allowing clinicians and researchers to use this instrument in their neuropsychological assessments.

References

AERA, American Educational Research Association, APA, American Psychological Association, & NCME, National Council on Measurement in Education (2014). Standards for educational and psychological testing. Washington, DC: American Educational Association.

Almeida, O. P, & Almeida, S. A. (1999). Confiabilidade da versão brasileira da Escala de Depressão Geriátrica (GDS) versão reduzida. Arquivos de Neuro-Psiquiatria. São Paulo, 57(2)-B, 421–426.

Basilakos, A., Rorden, C., Bonilha, L., Moser, D., & Fridriksson, J. (2015). Patterns of post-stroke brain damage that predict speech production errors in apraxia of speech and aphasia dissociate. Stroke, 46(6), 1561–1566. https://doi.org/10.1161/STROKEAHA.115.009211

Boukrina, O., Barrett, A., Alexander, E., Yao, B., & Graves, W. (2015). Neurally dissociable cognitive components of reading deficits in subacute stroke. Frontiers in Human Neuroscience, 9–298. https://doi.org/10.3389/fnhum.2015.00298

Crivelli, D., Spinosa, C., Angelillo, M. T., & Balconi, M. (2023). The influence of language comprehension proficiency on assessment of global cognitive impairment following Acquired Brain Injury: A comparison between MMSE, MoCA and CASP batteries, Applied Neuropsychology: Adult, 30(5), 546–551. https://doi.org/10.1080/23279095.2021.1966430

Cunha, J. A. (2001). Escalas Beck. São Paulo: Casa do Psicólogo.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). Mini-mental state. Journal of Psychiatry Resources, 12, 189–198. https://doi.org/10.1016/0022-3956(75)90026-6

Fonseca, R. P., Salles, J. F., & Parente, M. A. M. P. (2009). Instrumento de Avaliação Neuropsicológica Breve NEUPSILIN. São Paulo: Vetor Editora.

Fontoura, D. R., Rodrigues, J. C., Fonseca, R. P., Parente, M. A. M. P., & Salles, J. F. (2011). Adaptação do Instrumento de Avaliação Neuropsicológica Breve NEUPSILIN para avaliar pacientes com afasia expressiva: NEUPSILIN-Af. Ciências & Cognição, 16(3), 78–94. http://pepsic.bvsalud.org/scielo.php?script=sci_arttext&pid=S1806-58212011000300008&lng=pt&tlng=pt

Fontoura, D. R., Rodrigues, J. C., Mansur, L. L., Monção, A. M., & Salles, J. F. (2013). Neuropsycholinguistic profile of patients post-stroke in the left hemisphere with expressive aphasia. Revista Neuropsicologia, Neuropsiquiatria y Neurociencias, 13, 91–110.

Goodglass, H., Kaplan, E., & Barresi, B. (2001). Boston Diagnostic Aphasia Examination Short Form. Philadelphia, USA: Lippincott Williams & Wilkins.

Kochhann, R., Varela, J. S., Lisboa, C. S. M., & Chaves, M. L. F. (2010). The Mini Mental State Examination: Review of cutoff points adjusted for schooling in a large Southern Brazilian sample. Dementia & Neuropsychology, 4(1), 35–41.

Lee, B., & Pyun, S.-B. (2014). Characteristics of cognitive impairment inpatients with post-stroke aphasia. Annals of Rehabilitation Medicine, 38(6),759–765. https://doi.org/10.5535/arm.2014.38.6.759

Nurmi L., Kettunen, J., Laihosalo, M., Ruuskanen, E. I., Koivisto, A. M., & Jehkonen, M. (2010). Right hemisphere infarct patients and healthy controls: Evaluation of starting points in cancellation tasks. Journal of the International Neuropsychological Society, 16(5), 902–909. https://doi.org/10.1017/s1355617710000792

Pawlowski, J., Fonseca, R. P., Salles, J. F., Parente, M. A. M. P., & Bandeira, D. R. (2008). Evidências de validade do Instrumento de Avaliação Neuropsicológica Breve NEUPSILIN. Arquivos Brasileiros de Psicologia, 60(2), 101–116. http://pepsic.bvsalud.org/scielo.php?script=sci_arttext&pid=S1809-52672008000200011&lng=pt&tlng=pt

Pawlowski, J., Parente, M. A. M. P., & Bandeira, D. R. (2013a). Fiabilidad del Instrumento de Evaluación Neuropsicológica Breve Neupsilin. Avances en Psicologia Latinoamericana, 31(1), 62–70. http://dx.doi.org/10.12804/revistas.urosario.edu.co/apl/a.1859

Pawlowski, J., Remor, E., Salles, J. F., Parente, M. A. M. P., Fonseca, R. P., & Bandeira, D. R. (2014). Evidências de validade de construto do NEUPSILIN utilizando análise fatorial confirmatória. Actualidades en Psicología, 28, 37–52. https://psycnet.apa.org/doi/10.15517/ap.v28i117.14097

Pawlowski, J., Rodrigues, J. C., Martins, S. C. O., Brondani, R., Chaves, M. L. F., Fonseca, R. P., & Bandeira, D. R. (2013b). Avaliação neuropsicológica breve de adultos pós-acidente vascular cerebral em hemisfério esquerdo. Avances en Psicología Latinoamericana, 31(1), 33–45. http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S1794-47242013000100003&lng=en&tlng=pt

Radanovic, M., Mansur, L. L., & Scaff, M. (2004). Normative data for the Brazilian population in the Boston Diagnostic Aphasia Examination: Influence of schooling Brazilian. Journal of Medical and Biological Research, 37, 1731–1738. https://doi.org/10.1590/S0100-879X2004001100019

Rapp, B. & Lipka, K. (2011). The literate brain: The relationship between spelling and reading. Massachusetts Institute of Technology Journal of Cognitive Neuroscience, 23(5), 1180–1197. https://doi.org/10.1162/jocn.2010.21507

Rodrigues, J. C., Bandeira, D. R., & Salles, J. F. (2020). Cognitive Screening (TRIACOG) for adults with cerebrovascular diseases: Construction process and validity evidence. Psychology & Neuroscience, 13(2), 206–218. https://doi.org/10.1037/pne0000197

Rodrigues, J. C., Machado, W. L., Fontoura, D. R., Almeida, A. G., Brondani, R., Martins, S., Bandeira, D. R., & Salles, J. F. (2019). What neuropsychological functions best discriminate performance in adults post-stroke?, Applied Neuropsychology: Adult, 26(5), 452–464. https://doi.org/10.1080/23279095.2018.1442334

Rodrigues, J. C., Pawlowski, J., Zibetti M. R., Fonseca, R. P. & Parente, M. A. de M. P. (2011). Avaliação de apraxias em pacientes com lesão cerebrovascular no hemisfério esquerdo. Psicologia: Teoria e Prática,13(2), 209–220. http://pepsic.bvsalud.org/scielo.php?script=sci_arttext&pid=S1516-36872011000200016&lng=pt&tlng=pt

Rodrigues, J. C., Pawlowski, J., Müller, J. L., Bandeira, D. R., & Salles, J. F. (2013). Comparação dos erros na escrita de palavras entre adultos após AVC unilateral nos hemisférios cerebrais. Revista Neuropsicologia Latinoamericana, 5(4), 1–14. http://dx.doi.org/10.5579/rnl.2013.0154

Russell, C., Malhotra, P., Deidda, C., & Husain, M. (2013). Dynamic attentional modulation of vision across space and time after right hemisphere stroke and in aging. Cortex, 49, 1874–1883. https://doi.org/10.1016%2Fj.cortex.2012.10.005

Tynterova, A., Perepelitsa, S., & Golubev, A. (2022). Personalized neurophysiological and neuropsychological assessment of patients with left and right hemispheric damage in acute ischemic stroke. Brain Sciences, 12(554), 1–12. https://doi.org/10.3390/brainsci12050554

Vossel, S., Weiss, P., Eschenbeck, P., & Fink, G. (2013). Anosognosia, neglect, extinction and lesion site predict impairment of daily living after right-hemispheric stroke. Cortex, 49, 1782–1789. https://doi.org/10.1016/j.cortex.2012.12.011