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Cognitive Screening (TRIACOG) for Adults With Cerebrovascular Diseases: Construction Process and Validity Evidence

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This study presents the construction process of the Cognitive Screening Instrument (TRIACOG) for evaluating poststroke adults. The TRIACOG has undergone a rigorous developmental process: (a) literature review; (b) analysis of the most sensitive items on a brief neuropsychological evaluation to differentiate between clinical and healthy cases; (c) addition of items; (d) content analysis by expert judges; (e) reformulation of the instrument; (f) pilot study; (g) reformulation of the instrument; (h) a second pilot study in a clinical sample; and (i) analysis of evidence of criterion validity. The TRIACOG evaluates 8 functions: orientation, verbal and visual episodic-semantic memory, praxis, attention/working memory, executive functions, language, and numerical processing. The TRIACOG provides evidence of content and criterion validity. This article may guide the construction of items of other neuropsychological instruments. It is hoped that the TRIACOG may contribute to studies and neuropsychological clinical trials that evaluate poststroke patients.

Keywords: neuropsychological assessment, validity evidence, cerebrovascular diseases, cognitive screening

The aim of neuropsychological evaluation is to investigate the cognitive, behavioral, and emotional disorders of individuals with neurological dysfunction or injury (Harvey, 2012; Lezak, Howieson, Bigler, & Tranel, 2012). When selecting assessment tools, the examiner may choose screening instruments, brief instruments, or batteries, which provide information about the potentialities and difficulties of patients (Larner, 2013; Lezak et al., 2012).

Cognitive screenings are defined as techniques used to identify patients that may present indicators of a clinical condition, that is, these techniques can classify those who do and do not present evidence of a certain disease (Larner, 2013; Malloy, Cummings, & Edward, 1997). Patients with positive or suspected results should be referred to health care professionals trained to perform a more thorough evaluation to establish a diagnosis and administer the re-

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quired treatment (Wilson, Jungner, & WHO, 1968).

Screening instruments are quite useful in the hospital setting to evaluate patients with diseases that cause neuropsychological deficits, for example, those who have had a stroke. In the context of cognitive rehabilitation, the earlier deficits are detected, the more likely effective intervention measures can be implemented in time to improve the patient's prognosis and guide family members regarding problems that may arise in daily life (Nøkleby et al., 2008).

To construct an appropriate cognitive screening measure, it is recommended that instruments to be used by health professionals be able to be administered to most patients in 5–20 min, include a large number of cognitive domains, and be sensitive to the clinical conditions under which it will be applied (Malloy et al., 1997). Furthermore, the construction of neuropsychological instruments must follow specific steps and provide ample evidence of validity and reliability (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education [AERA, APA, & NCME], 2014; Pawlowski, Segabinazi, Wagner, & Bandeira, 2013).

There is no gold-standard cognitive screening instrument specifically for assessing cognitive impairment after stroke (Burton & Tyson, 2015; Dong et al., 2012; Nøkleby et al., 2008; Rodrigues, Becker, et al., 2019; Stolwyk, O'Neill, McKay, & Wong, 2014). In Brazil, studies often use instruments developed for patients with suspected nonvascular dementia, such as the Mini Mental State Examination (MMSE) (Burton et al., 2015; Dantas, Torres, Farias, Sant'Ana, & Campos, 2014; Ferreira, Moro, & Franco, 2015; Reis-Yamauti, Neme, Lima, & Belancieri, 2014). However, the MMSE is widely criticized because its items do not measure abilities that may be compromised in poststroke patients; thus, many cases are underdiagnosed (Lees et al., 2017; Lees et al., 2014; Mai, Sposato, Rothwell, Hachinski, & Pendlebury, 2016).

The Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005) is often used to evaluate vascular cognitive impairment as an alternative to MMSE (Rodrigues, Becker, et al., 2019). On the one hand, ceiling effects are less evident in stroke patients with the MoCA than with the MMSE (Cumming, Bernhardt, & Linden, 2011; Pendlebury, Mariz, Bull, Mehta, & Rothwell, 2012; Wong et al., 2014). On the other hand, the MMSE is more specific than the MoCA, but it is less sensitive for stroke patients (Pendlebury, Cuthbertson, Welch, Mehta, & Rothwell, 2010; Schweizer, Al-Khindi, & MacDonald, 2012; Wong et al., 2013). However, neither instrument evaluates specific skills that may be impaired after stroke, such as reading, spelling, arithmetic, and executive function (Rodrigues, Becker, et al., 2019; Stolwyk et al., 2014). Therefore, the use of both instruments in patients with vascular cognitive impairment is widely criticized (Chan et al., 2014; Pendlebury et al., 2010, 2012; Shen et al., 2016; Wong et al., 2013).

The National Institute for Neurological Disorders and Stroke and the Canadian Stroke Network (Hachinski et al., 2006) emphasize the need to develop sensitive protocols that assess a wide range of cognitive abilities. Researchers have emphasized that currently there are several limitations in the available tests for use with poststroke patients because many instruments used in studies do not include information about standardization, prior use in samples of poststroke patients, psychometric qualities, and applicability in different cultural contexts. Additionally, for cognitive screening, researchers emphasize the need for instruments to be brief and low in cost, show specificity of the measured domain, and not show any ceiling or floor effect on tasks.

In other countries, there has been an attempt to develop screening tools specific for poststroke patients; however, their psychometric properties are still being tested (Rodrigues, Becker, et al., 2019). The main objective of this study is to present the construction process and evidence of validity of the Cognitive Screening (TRIACOG) instrument for assessing adults after stroke. The developed instrument considers theoretical models suggesting that widespread brain networks may be involved in cognitive functioning; therefore, it includes tasks that assess a great number of neuropsychological functions in a few items. The TRIACOG also considers theoretical aspects of cognitive neuropsychology, linguistically controlling the words in verbal tasks (in terms of length, frequency, and imageability), and it includes both qualitative and quantitative scores, which can better differentiate clinical cases from neurologically healthy adults. It is expected that a detailed description of the TRIACOG's construction may help professionals who intend to develop neuropsychological instruments.

Method

The TRIACOG was constructed through the following steps: (a) literature review to identify the cognitive dimensions that should be included in the instrument; (b) analysis of the most sensitive items and cognitive dimensions of a brief neuropsychological evaluation to differentiate clinical patients with stroke from healthy adults; (c) inclusion of items in the TRIACOG (first version); (d) analysis by expert judges (evidence of validity based on the content of the instrument); (e) revisions of the instrument considering the judges' observations (second version); (f) pilot study in a sample of patients with stroke; (g) revision of the instrument considering the inadequacies found in the pilot study (third version of the TRIACOG); (h) a second pilot study in a sample of patients with stroke (fourth and final version of the TRIACOG); and (i) analysis of evidence of criterion validity. Each stage involved sample sizes and specific procedures that will be described separately.

Procedures for Constructing the TRIACOG

Literature review: Definition of the cognitive dimensions selected for the TRIACOG. A systematic review of neuropsychological instruments administered to adults who have suffered stroke was conducted (Rodrigues, Becker, et al., 2019), and other studies of cognitive screenings were analyzed (Bickerton et al., 2015; Burton et al., 2015; Lees et al., 2013; Nys et al., 2007; Stolwyk et al., 2014; Williams et al., 2016; Zhou & Jia, 2009). This review sought to find screening instruments with adequate psychometric properties and to identify neuropsychological functions that are often deficient in poststroke patients.

Analysis of the performance of adults after stroke with a brief neuropsychological instrument. Using a database (Fontoura, Rodrigues, Mansur, Monção, & Salles, 2013), items and cognitive dimensions that best discriminate between groups of poststroke patients and neurologically healthy adults were identified (Rodrigues, Machado, et al., 2019). Item response theory analysis, receiver operation characteristic curves, and network analysis (Hajian-Tilaki, 2013) were performed using the Brief Neuropsychological Assessment Battery NEUPSILIN for patients with expressive aphasia (NEUPSILIN-Af; Fontoura, Rodrigues, Fonseca, Parente, & Salles, 2011).

Inclusion of items in the TRIACOG (first version of the instrument). It was decided to alternate between items requiring verbal responses and pencil-and-paper tasks to allow the evaluation of patients with motor and oral expression disorders. Furthermore, tasks were developed to evaluate functions that may be compromised because of injuries to the right and left hemispheres based on the literature review.

Content analysis by expert judges (second version of the instrument). The TRIACOG was analyzed by eight judges trained in psychology or speech therapy who had master's and doctoral degrees in neuropsychology and had clinical and/or research experience in neuropsychology evaluating poststroke patients. In addition to adjusting the instrument, this step sought to collect evidence based on the content of the TRIACOG.

A first version of the TRIACOG was created and discussed in a brainstorming session with three neuropsychology specialists to analyze the number of items on the instrument, the appropriateness of the instructions, and the order of application of the tasks. After the brainstorming session, a second version of the TRIACOG was sent to five expert judges, who were asked to analyze which main neuropsychological function was being measured in each task, whether the instructions were understandable, and whether the item was suitable for use with inpatients. Furthermore, the judges were asked whether the tasks included in the TRIACOG evaluated specialized neuropsychological functions in both hemispheres and whether the number of tasks should be reduced. The judges received a structured questionnaire with these questions and the TRIACOG tasks.

Instrument revision considering the judges' observations (third version of the TRIACOG). The third version of the TRIACOG was created based on the changes suggested by the five judges. Because changes were made in the third version of the instrument, we considered it important to have two new judges review this version of the TRIACOG, which was then tested in a pilot study.

Pilot study in a clinical sample. A pilot study was conducted in which the instrument was administered individually at bedside to seven adults (49–73 years of age) hospitalized in a public hospital in the capital of the state of Rio Grande do Sul because of stroke. The participants were five men and two women with different education levels (5–15 years of schooling) who were evaluated between 5 and 22 days after a stroke. After signing an informed consent form, the participants answered a questionnaire about their sociodemographic data and health condition. At the end of testing, the participants were asked to report their impressions about the instrument (instructions, application time, and ability to complete the tasks). The sample was contacted for convenience and had no aphasia and no difficulty answering pencil and paper tasks.

Instrument revision after the pilot study (fourth and final version). Based on the pilot study, it was considered important to remove some tasks from the TRIACOG to reduce its time of application while maintaining the same cognitive dimensions of the instrument. The reduction in item number was based on a theoretical review (Bickerton et al., 2015; Burton et al., 2015; Lees et al., 2013; Nys et al., 2007; Rodrigues, Becker, et al., 2019; Stolwyk et al., 2014; Williams et al., 2016; Zhou et al., 2009) and analyses of the NEUPSILIN-Af (Rodrigues, Machado, et al., 2019).

Second pilot study in a clinical sample. A second pilot study was conducted with five poststroke inpatients (three women and two men) following the same procedures that were used in the first pilot study. The participants were 45–51 years old, had between 7 and 17 years of schooling, and were evaluated 5–16 days after the stroke. At this stage, the patients were again asked to report their impressions of the instrument (instructions, application time, and ability to complete the tasks).

Analysis of evidence of criterion validity. A total of 100 poststroke adults and 100 neurologically healthy adults participated in this stage of the study. The groups varied in terms of age and sex because a larger number of women and younger participants were found in the healthy sample (see Table 1). The sample size needed to identify a difference of $dz = 0.25$ considering a probability of $\alpha = .05$ and a statistical power $1 - \beta = 0.80$ was 100 individuals. The software used for the sampling calculation was G*Power (Faul, Erdfelder, Lang, & Buchner, 2007).

Results

Literature Review: Definition of the Cognitive Dimensions Selected for the TRIACOG

Based on the neuropsychological impairments frequently observed in adults after a stroke, it was considered especially important to include in the TRIACOG tasks that assess episodic memory (visual and verbal), attention, visuoconstruction, language, arithmetic, and executive function (Fontoura et al., 2013; Lees, Fearon, Harrison, Broomfield, & Quinn, 2012; Nys et al., 2007; Pawlowski et al., 2013; Rodrigues, Machado, et al., 2019; Rodrigues, Becker, et al., 2019; Stolwyk et al., 2014; Zhou et al., 2009).

Analysis of the Performance of Adults After a Stroke With a Brief Neuropsychological Instrument

As shown in a study by Rodrigues, Machado, et al. (2019), the orientation, oral language, academic skills (reading, writing, and arithmetic), and executive function dimensions of the NEUPSILIN-Af (Fontoura et al., 2011) best discriminated deficits in adults after a stroke. Furthermore, based on the analyses, items such as orientation to time, digit span, verbal fluency, spelling, reading, arithmetic, inference processing, and constructive praxis were important to include in a screening instrument.

Inclusion of Items in the TRIACOG (First Version of the Instrument)

Episodic-semantic verbal memory (immediate and delayed). The evaluation of episodic-semantic verbal memory, which may be compromised in poststroke patients (Ferreira et al., 2015; Pawlowski et al., 2013), is typically performed with (immediate and delayed) evocation tasks using word lists (Lezak et al., 2012). Eight short words of up to two syllables (or five letters) were included, and there were no semantic relationship among the words to avoid false memories (Stein, Feix, & Rohenkohl,

Table 1
Sociodemographic Data of the Participants

Variables	Healthy participants (n = 100)	Patients (n = 100)	F/χ^2	p
Sex (male/female)	31/69	53/47	8.480	.002
Age, *M* (*SD*)	55.59 (16.67)	63.16 (12.40)	13.281	<.001
Schooling *M* (*SD*)	8.48 (3.48)	7.52 (3.70)	3.567	.060
Dominant hand (R/L)	97/3	92/8	4.743	.121
Reading/writing habits, *M* (*SD*)	9.55 (5.32)	8.07 (6.09)	3.335	.069
Days after stroke, *M* (*SD*)	—	8.32 (4.59)	—	—
NIHSS *M* (*SD*)	—	3.70 (4.19)	—	—
Rankin scale, *M* (*SD*)	—	1.14 (1.55)	—	—
Number of stroke episodes (1/2/3/4)		(66/30/2/2)	—	—
Type of stroke (I/H/TIA/HT/AVM/SAH)		(79/6/3/9/1/1)	—	—
Hemisphere of injury (R/L/B/*ND*)	—	(34/47/12/7)	—	—
Region of injury (C/S/CS/Ce/Po/Bu)	—	(10/41/24/9/6/2)	—	—
TOAST				
Atherosclerosisof large arteries	—	22	—	—
Cardioembolic	—	24	—	—
Occlusion of small arteries	—	18	—	—
Infarctions due to other etiologies	—	2	—	—
Infarctions of undetermined origin	—	22	—	—
Not reported	—	3	—	—
Does not apply	—	9	—	—

Note. R = right; L = left; B = bilateral; ND = not determined; I = ischemic; H = hemorrhagic; TIA = transient ischemic attack; HT = hemorrhagic transformation; AVM = arteriovenous malformation; SAH = subarachnoid hemorrhage; C = cortical; S = subcortical; CS = corticosubcortical; Ce = cerebellum; Po = pons; Bu = bulb; NIHSS = National Institute of Health Stroke Scale; TOAST = Trial of Org 10,172 in Acute Stroke Treatment.

2006). Additionally, the frequency of the words was controlled according to a list extracted from Internet texts published by Nilc's Corpora (http://www.nilc.icmc.usp.br/nilc/tools/corpora.htm), and imageability of the words was controlled according to concreteness norms for Brazilian words (Janczura, Castilho, Rocha, van Erven, & Huang, 2007).

Auditory attention and working memory. Auditory attention and working memory are usually assessed using span tasks (Diamond, 2013). A forward digit span task was included, followed by a backward digit span task, each of which used six-digit sequences. In the instructions for the backward digit span task, an example was added to facilitate the participants' understanding.

Executive function: verbal fluency (phonological) and rapid serial naming of shapes. The verbal fluency task with phonological criteria is considered to provide information on language, executive function, and memory abilities (Lezak et al., 2012). This task was included in the TRIACOG because it can differentiate between poststroke and neurologically healthy adults (Ferreira et al., 2015; Pawlowski et al., 2013). It was decided to ask the participants to name words containing the letter P for 1 min because this phoneme is present in the most frequently occurring evoked words among Brazilian adults according to Senhorini, Amaro Júnior, de Mello Ayres, de Simone, and Busatto (2006).

The rapid serial naming of shapes task was based on the rapid naming of objects, digits, letters, or quantities with or without additional tasks (van der Sluis, de Jong, & van der Leij, 2004) and the Five-digit Test (Sedó, de Paula, & Malloy-Diniz, 2015) and had adequate psychometric properties for patients with stroke. This task measures processing speed, visual attention, inhibition, and flexibility (components of executive function). The TRIACOG included a task divided into three parts with 12 stimuli in each (square, star, circle, and triangle). In the first part, the participant was asked to name, as quickly as possible, a series of simple geometric shapes presented on a printed sheet. In the second part, which used another sheet, the participant was tasked to quickly name small geometric figures printed within larger geometric figures. In the third part, the participant was tasked to alternately name the larger and smaller geometric figures shown on another sheet according to the thickness of the edge of the larger figure. Before starting each part, the participant received training, and the task was performed only when he or she understood what should be done. The number of hits and misses and the time required for each part were recorded.

Language: naming, vocabulary, spontaneous writing, repetition, inference processing, reading, and spelling. Many studies emphasize that adults usually exhibit changes in language after a stroke (Nøkleby et al., 2008; Oh, Kim, Shim, & Seo, 2015; Pawlowski et al., 2013; Weiss et al., 2016). For the naming task, an object typically known by adults (a comb) was selected. For the vocabulary task, the participant was asked to explain the meaning of the word blender. For the reading of words task, two pseudowords, two short words, and two long words were present; they were divided into concrete and abstract nouns of high and low frequency in Brazilian Portuguese according to the criteria described for the selection of items in the episodic-semantic verbal memory task. Similar to the reading task, the spelling task contained short and long stimuli divided into high- and low-frequency concrete and abstract nouns as well as two pseudowords. Last, a repetition task was constructed using a proverb, which the participant was asked to explain (for the evaluation of inference processing).

Numerical processing (transcoding and arithmetic skills). Arithmetic skills are often deficient in poststroke patients but are rarely included in cognitive screening instruments (Stolwyk et al., 2014). Four calculations of each of the mathematical operations were included in the first version of the TRIACOG. The participant wrote the numbers, set up the operation after dictation by the examiner (transcoding), and solved the calculations (arithmetic skills). The other two calculations were written by the examiner and were read (transcoding) and then solved (arithmetic skills) by the participant.

Praxis: ideomotor and constructive. Praxis is a skill that may be compromised after a stroke and may affect the performance of daily living tasks (Rodrigues, Pawlowski, Zibetti, Fonseca, & Parente, 2011). In the evaluation of ideomotor praxis, the participant was tasked with demonstrating how to use the named object (comb). Constructive praxis was measured with the clock drawing task, in which the participant, with pencil and paper, drew a clock and marked the time of 13 h 40 min.

Content Analysis by Expert Judges (Second Version of the Instrument)

In the brainstorming stage for the first version of the TRIACOG, it was decided to reduce the number of items on the episodic-semantic verbal memory task (from eight to six), include two shorter digit sequences in the working memory and attention tasks, replace the inference processing sentence with a shorter phrase, and remove a word and a pseudoword from the reading and spelling tasks. All suggestions were followed to reduce the administration time and maintain the quality of the instrument.

In the analysis by the five expert judges of the investigated neuropsychological functions, all the judges agreed on all items of the tasks included in the TRIACOG in their responses to the structured questionnaire. The judges suggested not removing any task and instead removing only items that evaluated the same cognitive functions. They also suggested the addition of new tasks, which were added when they were important for the assessment of poststroke patients.

Instrument Revision Considering the Judges' Observations (Third Version of the TRIACOG)

All the judges suggested including questions on orientation to time (age and year) and space (location and city), and thus, an initial task was included in the TRIACOG. The episodic-semantic verbal memory task was not changed; the same stimuli and instructions were maintained. Judges 1 and 4 suggested adding a visuoconstruction task (in addition to the clock drawing task) and a visual memory task to address functions that are usually associated with the right cerebral hemisphere. Thus, a semicomplex figure with no meaning and with external stimuli to the right and left was constructed based on classical visuoconstructive tasks such as Rey's complex figure test (Oliveira & Rigoni, 2014) and the Benton Visual Retention Test (Salles, Bandeira, Trentini, Segabinazi, & Hutz, 2016).

Judge 5 emphasized that it was important for the TRIACOG to be sensitive; thus, it was essential to increase the difficulty level of the items so that patients with even mild neuropsychological impairment could demonstrate their difficulty with this brief evaluation and be referred for a more complete neuropsychological assessment. With this goal, the letter used for the verbal fluency task was modified; the letter P was replaced with the letter V, which increased the difficulty of the task according to a study by Senhorini et al. (2006).

In the forward and backward digit span task, as judge 1 suggested, we added a sequence of three digits to avoid initially overloading the patient's memory. For the naming task, the object comb was replaced with blender, and the action running was used to evaluate articulatory aspects (with long words in Portuguese), thus increasing the difficulty level of the items (according to judge 5) and facilitating bedside application, as suggested by judges 3 and 4. The vocabulary task was retained. For the ideomotor apraxia task, the participant was required to demonstrate how to use a fork without actually using the object.

Judges 3, 4, and 5 suggested adding oral and written comprehension tasks. Thus, a set of figures containing the target (fork), a semantic distractor (dish), a visual distractor (broom), and a phonological distractor (cat; in Portuguese fork is written as garfo and cat is gato; thus, they have the same initial phonemes) was developed to evaluate the patient's oral comprehension. The written comprehension task consisted of an image of a bicycle, in which the participant was asked to point to its name (target) among distractors that were semantically and visually related to the final portion of the word (motorcycle), had a visual relationship with the initial part of the word (binoculars) and had no relationship to the word (coffee maker). The naming and comprehension figures used presented high conceptual agreement according to the study of Zibetti, Bordignon, and Trentini (2015).

The word-reading task was replaced by the reading of a long sentence, as suggested by judge 5. The use of a sentence reading task could show greater sensitivity to hemineglect and language deficits related to different types of stimuli (nouns, verbs, and adverbs) in addition to providing a sentence that could be interpreted (inference processing). The spelling task was not changed, but new instructions that required the patient to repeat the word/pseudoword before writing it were added to analyze repetition and exclude errors caused by auditory processing deficits. Judges 1, 3, and 5 suggested replacing the term dictate with say in the instructions to facilitate the understanding of patients with low education levels.

Only two calculations were maintained in the numerical processing task: the multiplication of two 2-digit numbers (i.e., two numbers between 10 and 99) dictated by the examiner, as suggested by judge 5, and a subtraction problem that the participant was asked to read and solve using paper (transcoding and calculations). In the clock drawing task, 13 h 40 min was changed to 1 h 40 min to avoid interference of deficits because of low education levels, as suggested by judge 5. Judge 1 suggested reducing the serial naming task from 12 to eight items; this suggestion was followed because the aim was to make the TRIACOG as short as possible. Judge 2 suggested complementing the task's instructions by adding the statement, "Name these figures from left to right." The two judges who analyzed the third version of the TRIACOG did not suggest any modification to the instrument. There was 100% agreement among the judges regarding the cognitive dimensions involved in the tasks, according to the questionnaire they answered.

Pilot Study in a Clinical Sample

None of the participants had difficulty understanding the instructions except for the rapid serial naming of shapes task, for which extra explanations were provided. The TRIACOG was completed in 30–40 min by the participants, which was considered a long administration time. Finally, all patients reported having enjoyed completing the tasks.

Instrument Revision After the Pilot Study (Fourth and Final Version)

The orientation to space items were removed; only one five-digit sequence was maintained in the forward and backward digit span tasks; the time for the verbal fluency task was reduced from 1 min to 30 s, and the complexity of the figure to be copied and subsequently recalled in the visual memory task was reduced. The instructions for the rapid serial naming of shapes task were changed to facilitate understanding. The fourth version of the TRIACOG was then developed and subjected to a second pilot study.

Second Pilot Study in a Clinical Sample

The participants took an average of 20 min to complete the TRIACOG, had no complaints about the instructions, and reported enjoying performing the tasks. This was considered the final version of the instrument, and it was applied in clinical and nonclinical samples for subsequent analysis of its psychometric properties.

The TRIACOG contains 22 subtests and assesses eight main neuropsychological functions: orientation (to time, 2 points); episodic-semantic verbal memory (immediate and delayed, six words, 6 points); praxis (constructive, reproduction of a figure, 24 points, and drawing a clock, 9 points; ideomotor, use a fork, 1 point); visual memory (reproduction of a figure, 24 points); attention/working memory (digit span forward and backward, 10 points); executive function (verbal fluency, letter V, 4 points); speed processing, inhibition, and alternation, rapid serial naming of shapes (24 points); language (naming objects and actions, 2 points each); oral comprehension (1 point); written comprehension (1 point); vocabulary (2 points); phrase reading (14 points); inference processing (2 points); spelling (6 points) and repetition (3 points); and numerical processing (transcoding and arithmetic skills, 7 points). Future analysis will simplify the test scores for standardization (0 = *deficit*, 1 = *deficit alert*, 2 = *no deficit*). In addition to the number of hits, the duration of the test and the types of errors made by the sample were analyzed and recorded on a specific form. A TRIACOG application and scoring manual was developed to standardize the administration and attribution of scores among evaluators.

Analysis of Evidence of Criterion Validity

Analysis of variance (controlled for age, education and sex) was performed to compare the performance of poststroke patients and healthy individuals on the TRIACOG. The level of significance of the differences was reported in addition to effect size (partial eta squared). Effect sizes of 0.0099, 0.0588, and 0.1379 were considered small, medium, and large, respectively (Richardson, 2011).

Statistically significant differences were found on all the TRIACOG tasks. The patients scored lower, with medium and large effects in most cases (see Table 2). Larger effect sizes were found for the following tasks: constructive praxis (copying a figure and drawing a clock), executive function (verbal fluency and rapid serial naming of shapes), numerical processing, and visual memory.

Discussion

The construction of the TRIACOG in specific stages enabled the refinement of the tasks based on theoretical and empirical studies, discussions with experts, and pilot studies. The process used to develop the screening tool in stages was based on other neuropsychological instruments constructed in Brazil that highlight the importance of following the assumptions of experimental psychology, psycholinguistics, cognitive neuropsychology, and psychometry to obtain tools sensitive to clinical populations (Fonseca, Salles, & Parente, 2008; Fontoura et al., 2011; Rodrigues, Nobre, Gauer, & Salles, 2015; Rodrigues & Salles, 2013; Salles et al., 2011).

A detailed analysis of the literature (Bickerton et al., 2015; Burton et al., 2015; Lees et al., 2013; Nys et al., 2007; Rodrigues, Becker, et al., 2019; Stolwyk et al., 2014; Williams et al., 2016; Zhou et al., 2009) and the performance of poststroke adults on a brief instrument (Rodrigues, Machado, et al., 2019) informed the items that were initially included in the TRIACOG. According to Urbina (2007), one of the primary requirements for seeking evidence of the content validity of a test is the careful specification of the content domains and cognitive processes underlying the test items. Thus, evidence of the TRIACOG's content was sought because the systematic procedures used to ensure the relevance of the items, which measure neuropsychological functions that may be compromised in poststroke patients, were recommended by the AERA, APA, and NCME (2014) and Urbina (2014).

Table 2
Comparison of the Groups' Performance on the TRIACOG

TRIACOG	Healthy adults (n = 100)	Poststroke patients (n = 100)	F	p	η^2
Orientation	1.95 (0.22)	1.61 (0.65)	16.083	<.001	0.076
Verbal memory	6.02 (2.13)	4.30 (2.23)	14.383	<.001	0.068
Immediate verbal memory	4.33 (1.02)	3.54 (1.41)	10.169	.002	0.049
Delayed verbal memory	1.69 (1.45)	0.76 (1.22)	8.866	.003	0.043
Constructive praxis	28.76 (2.70)	19.39 (9.61)	67.712	<.001	0.257
Copying a figure	21.62 (1.61)	14.92 (7.39)	61.338	<.001	0.238
Drawing a clock	7.14 (1.67)	4.47 (2.85)	46.511	<.001	0.192
Attention/working memory	5.65 (2.34)	3.77 (2.44)	21.649	<.001	0.099
Digit span forward	3.83 (1.60)	2.75 (1.86)	15.339	<.001	0.073
Digit span backward	1.82 (1.38)	1.02 (1.25)	10.429	.001	0.051
Executive function	24.63 (2.16)	19.50 (6.75)	43.487	<.001	0.182
Verbal fluency	1.84 (0.88)	0.99 (1.02)	30.272	<.001	0.134
Rapid serial naming	22.79 (1.88)	18.51 (6.23)	36.358	<.001	0.156
Ideomotor praxis	0.99 (0.10)	0.87 (0.34)	9.101	.003	0.044
Language	33.64 (2.07)	28.78 (6.20)	39.928	<.001	0.169
Naming	3.86 (0.53)	3.36 (1.02)	10.512	.001	0.051
Oral comprehension	1.00 (0.00)	0.91 (0.29)	9.143	.003	0.045
Vocabulary	1.50 (0.56)	1.04 (0.60)	21.015	<.001	0.097
Reading	13.80 (0.47)	12.32 (3.31)	14.987	<.001	0.071
Inference processing	1.19 (0.76)	0.61 (0.80)	20.907	<.001	0.096
Spelling	3.29 (0.89)	2.28 (1.35)	28.153	<.001	0.126
Repetition	8.00 (0.00)	7.40 (1.94)	6.969	.009	0.034
Written comprehension	1.00 (0.00)	0.86 (0.35)	15.190	<.001	0.072
Numerical processing	6.04 (1.31)	4.34 (2.33)	33.520	<.001	0.146
Visual memory	16.07 (6.22)	7.73 (6.91)	68.695	<.001	0.260

Evidence of content validity was achieved by the analysis of the TRIACOG by expert judges. All of the judges agreed with the cognitive dimensions (constructs) that were included to assess poststroke patients and confirmed that the tasks of this instrument measure the neuropsychological functions for which they were proposed, corroborating the face validity (Sartori & Pasini, 2007; Urbina, 2007, 2014). Because the TRIACOG was constructed based on classic neuropsychological tasks, no disagreement regarding the investigated neuropsychological functions was expected. Furthermore, the judges helped with the instructions and suggested increasing the degree of difficulty of the items to ensure the understanding of the tasks and the sensitivity of the TRIACOG for the poststroke population. All suggestions were important for increasing the evidence of the instrument's content validity (AERA, APA, & NCME, 2014), which was subsequently tested in two pilot studies.

The first pilot study indicated that the TRIACOG did not fulfill the criterion of a screening instrument because its administration time was long, relative to the time considered adequate for screening-type tools (Larner, 2013; Malloy et al., 1997). Additionally, some instructions were not understandable to all patients and required adjustments. Based on the pilot study, less sensitive items were excluded, and the length of the instrument was reduced while its quality was maintained. The second pilot study showed in a real context that the TRIACOG could be applied to poststroke inpatients and that it maintained the criteria of being a quick screening instrument that was inexpensive and easy to administer (Larner, 2013). Additionally, it is important to note that the patients reported that they enjoyed completing the test and showed interest in obtaining the results of the evaluation, given that their deficits could compromise their return to usual activities.

The TRIACOG presented evidence of criterion validity as statistically significant differences were found for all the tasks when comparing contrasting groups (healthy and poststroke individuals). This type of evidence is important in neuropsychological assessments to ensure that the instrument is capable of identifying participants who present indicators of cognitive impairment (Pawlowski et al., 2013; Urbina, 2007). Therefore, evidence of an instrument's criterion validity includes its ability to predict external variables (or criteria) to ensure that the tool is capable of identifying deficits that are consistent with certain conditions and diagnoses (AERA, APA, & NCME, 2014; Urbina, 2007), in this case, forms of impairment after a stroke.

In addition to the level of significance of comparison between groups, greater size effects were found for the tasks assessing constructive praxis (copying a figure and drawing a clock), executive function (verbal fluency and rapid serial naming of shapes), arithmetic, and visual memory. Studies highlight the importance of assessing these skills, which are generally deficient in poststroke patients (Nøkleby et al., 2008; Rodrigues et al., 2011; Stolwyk et al., 2014). Additionally, the TRIACOG's remaining tasks, which had a medium effect, also discriminate between clinical and healthy groups and are appropriate for assessing orientation, verbal memory, language, and attention, which may be deficient among adults after a stroke (Nøkleby et al., 2008; Nys et al., 2007; Pawlowski et al., 2013).

In summary, the TRIACOG construction process showed that this instrument presents evidence of content and criterion validity and has the characteristics of a cognitive screening tool. The feature that differentiates the TRIACOG from other screening instruments, such as the MMSE and the MoCA, is that it was designed on the basis of generally impaired poststroke neuropsychological functions. In addition, the quality and difficulty of the items for the Brazilian population were controlled. A detailed description of the tasks included in the TRIACOG may help researchers who intend to construct neuropsychological instruments by indicating which are the best items to include in an evaluation.

These were initial analyses, and for future studies, we intend to expand the evidence of the TRIACOG's validity to investigate its internal structure and dimensions and verify its predictive validity. We intend to establish cutoff points to identify cases with neuropsychologically compromised cerebrovascular diseases by cognitive dimension and to simplify the scoring of the instrument. It is expected that the TRIACOG can be used by health professionals with previous training in the instrument to identify patients at risk for vascular cognitive impairment and recommend more thorough neuropsychological evaluation.

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