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Aphasia Screening Test (TeRAp): Construction and Validation for European Portuguese

Teste de Rastreio de Afasia (TeRAp): Construção e Validação para o Português Europeu

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ABSTRACT

Introduction: Aphasia is a common acquired language disorder following stroke or other brain injuries. However, it is not always easy to make a differential diagnosis with another communication disorder. Communication assessment in acute phases of the stroke, when the patient is bedridden or when there is no time for a more in-depth assessment, needs to be done with a formal screening test that has normative data. The aim of this study was to develop the Aphasia Screening Test (TeRAp) in digital format (appWeb) and present its clinimetric values.

Methods: A screening test (TeRAp) was built in appWeb format that assesses the main areas of language processing and automatically provides a diagnostic hypothesis. A group of people with aphasia was evaluated and their performance was compared with three control groups, one of healthy people and two groups of people with neurological conditions, one with dysarthria and the other with mild cognitive impairment.

Results: Ceiling values were obtained in all the tests. Sensitivity values of 1 and specificity values of 0.99 were obtained for the presence of aphasia.

Conclusion: An online aphasia screening test was developed, with excellent sensitivity and specificity results, which can be used by any health professional.

Keywords: Aphasia/diagnosis; Portugal; Psychometrics; Reproducibility of Results; Surveys and Questionnaires

RESUMO

Introdução: A afasia é uma perturbação adquirida da linguagem muito frequente após uma lesão cerebral, mas nem sempre é fácil fazer o diagnóstico diferencial com outra perturbação da comunicação. A avaliação da comunicação nas fases agudas do AVC, quando o doente está acamado ou quando não há tempo para uma avaliação mais aprofundada, deverá ser feita com um teste de rastreio formal do qual se tenha dados normativos. O objetivo deste estudo foi desenvolver o Teste de Rastreio de Afasia (TeRAp) em formato digital (appWeb) e apresentar os seus valores clinimétricos.

Métodos: Foi construído um teste de rastreio (TeRAp), em formato appWeb, que avalia as principais áreas do processamento da linguagem e fornece automaticamente uma hipótese de diagnóstico. Foi avaliado um grupo de pessoas com afasia e o seu desempenho foi comparado com três grupos de controlo, um de pessoas saudáveis e dois grupos de pessoas com patologias neurológicas, um com disartria e outro com défice cognitivo ligeiro.

Resultados: Foram obtidos valores de tecto em todos os testes. Foram obtidos valores de sensibilidade de 1 e de especificidade de 0,99 para a presença de afasia.

Conclusão: Desenvolveu-se um teste de rastreio da afasia, em formato *online*, com excelentes resultados de sensibilidade e especificidade, que poderá ser utilizado por qualquer profissional de saúde.

Palavras-chave: Afasia/diagnóstico; Inquéritos e Questionários; Portugal; Psicometria; Reprodutibilidade dos Resultados

KEY MESSAGES

- An aphasia screening test has been developed in an online format that quickly and concisely assesses speech, naming, auditory comprehension, repetition, reading, and writing.
- Clinimetric data on the sensitivity and specificity of the test are presented, based on the assessment of four groups of individuals: healthy, with stroke aphasia, dysarthria, and mild cognitive impairment.

INTRODUCTION

Aphasia is a communication disorder that affects a person's ability to speak, understand speech, read, and write and, consequently, their quality of life. It is typically caused by damage to the language centers of the brain, often as a result of stroke, traumatic brain injury, or other neurological conditions.[1]

Prevalence studies indicate that aphasia affects approximately one in every 250 people worldwide. The likelihood of developing aphasia increases with age, particularly in individuals over 65 years old. However, it can also occur in younger populations due to factors such as head trauma or neurological diseases.[2,3]

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Aphasia significantly increases the cost of post-stroke patient care due to extended hospital stays[4] and higher rates of discharge to rehabilitation centers compared to patients without aphasia.[5]

Several prognostic factors can influence the outcome of aphasia. These factors include the size and location of the brain lesion, the individual's overall health and cognitive status, the presence of additional neurological deficits, the initial severity of aphasia,[6-8] the timeliness of intervention,[9] and the presence and quality of speech and language therapy. Research indicates that intensive therapy, as well as ongoing support, can significantly improve long-term communication outcomes for individuals with aphasia.[10]

Post-stroke language intervention has been found to help optimize patient outcomes; consequently, an accurate aphasia diagnosis is crucial to ensure patients receive the rehabilitation they require.[11]

Early assessment and intervention during the acute phase of aphasia are crucial for optimal language recovery.[9] After the initial screening assessment carried out by the neurology, internal medicine, or neurosurgery clinician during the acute phase of a neurological event, it is essential to be referred for a formal and extensive assessment by a speech therapist to characterize the diagnosis, the severity of the aphasia, and develop a personalized therapeutic plan.

Understanding the definition, prevalence, need for acute evaluation, and prognostic factors of aphasia is vital for providing effective care and support to individuals affected by this challenging communication disorder, increasing their quality of life.[12]

A wide range of language tests are currently used in post-stroke care.[13] Stroke scales, such as the European Stroke Scale (ESS)[14] and the National Institutes of Health Stroke Scale (NIHSS),[15] quantify acute stroke severity and include subtest items that evaluate acute language functioning. These measures are used to provide information for decision-making on the treatment of hyperacute stroke, and also to identify patients with aphasia. However, they have not been specifically validated for this purpose and do not allow differentiating diagnoses between aphasic and non-aphasic stroke populations. Aphasia screening tests have been developed in order to overcome the difficulties experienced by doctors and speech therapists when carrying out a detailed language assessment in bedridden patients or when time is limited.

The development of new technologies allows for continuous access to validated assessment tools through a smartphone, which provides a significant added value compared to traditional clinical assessment using small tests with objects that have not been validated for this purpose and, as such, are highly dependent on the clinician's experience and subject to a much higher error rate.

Brief screening tests such as the Frenchay Aphasia Screening Test[16] and the Language Screening Test[17] have been specifically designed to assess post-stroke language performance. Such language assessments typically evaluate a narrow range of language abilities, frequently omitting reading and writing tasks. Consequently, they are not considered suitable for use in isolation for diagnostic purposes.

In Portugal, the two validated brief aphasia assessment tests – the Bedside Language Aphasia Screening Test[18,19] and the Aphasia Rapid Test[20,21] – have some limitations, such as a reduced assessment of discourse and no assessment of naming in the first test, and no assessment of spontaneous or induced speech and writing in the latter.

This study aimed to develop the Aphasia Screening Test (TeRAp) in digital format (appWeb) and present its clinimetric (statistical measures that ensure that the instrument is valid and reliable and prove the quality of the study) values.

Description of the appWeb TeRAp

After individual registration on the TeRAp website (https://app.terap-e.pt/), clinicians must create a patient record to save assessment data for future comparison with later reassessments. If the user does not want to save this data, they only need to create a patient record once. Saved data is only visible to the clinician who entered it.

The test begins with a speech assessment by describing a picture (Fig. 1). After the description, the evaluator determines whether the speech is aphasic, dysarthric/apraxic or normal. This decision should be based on the attached table with the most common characteristics in the three types of pathological speech, in the following parameters: rate, articulation, prosody (rhythm and melody of the speech), type and number of words used, type of impairment in syntactic structure, and types of paraphasias, which is the replacement of a correct word with an incorrect word (literal or phonemic paraphasia is the alteration of one or more phonemes in the word produced; when the number of phonemes altered is such that it is impossible to understand what is being said, we are dealing with neologistic paraphasia; verbal or semantic paraphasia results when the correct word is replaced by another word in the language's lexicon).

Next, naming capacity is assessed based on five photographic images of common objects (fork/*garfo*, scissors/*tesoura*, clothes peg/*mola*, key/*chave*, and watch/*relógio*), made up of three disyllabic words and two trisyllabic words.

Auditory verbal comprehension is assessed by executing three orders directed at the body ("Close your eyes"/"*Feche os olhos"*, "Open your mouth"/ *"Abra a boca"*, "Raise your arm"/ "*Levante o braço"*) and three commands directed at the same five photographs of objects presented in Fig. 2, two of which are simple sentences ("Point to

Figure 1 – Image for speech evaluation

what's below the fork"/"*Aponte para o que está abaixo do garfo"*, "Point to what's in the middle"/ *"Aponte para o que está ao meio"*) and one that is a complex sentence ("Point to what's above the clock after touching the fork"/"*Aponte para o que está acima do relógio depois de tocar no garfo"*).

This is followed by the repetition of five words with three disyllables and two trisyllables (ball/*bola*, house/*casa*, briefcase/*pasta*, jacket/*casaco*, window/*janela*) and two simple sentences ("It's sunny today"/"*Hoje está sol*", "I really like eating soup"/"*Gosto muito de comer sopa*").

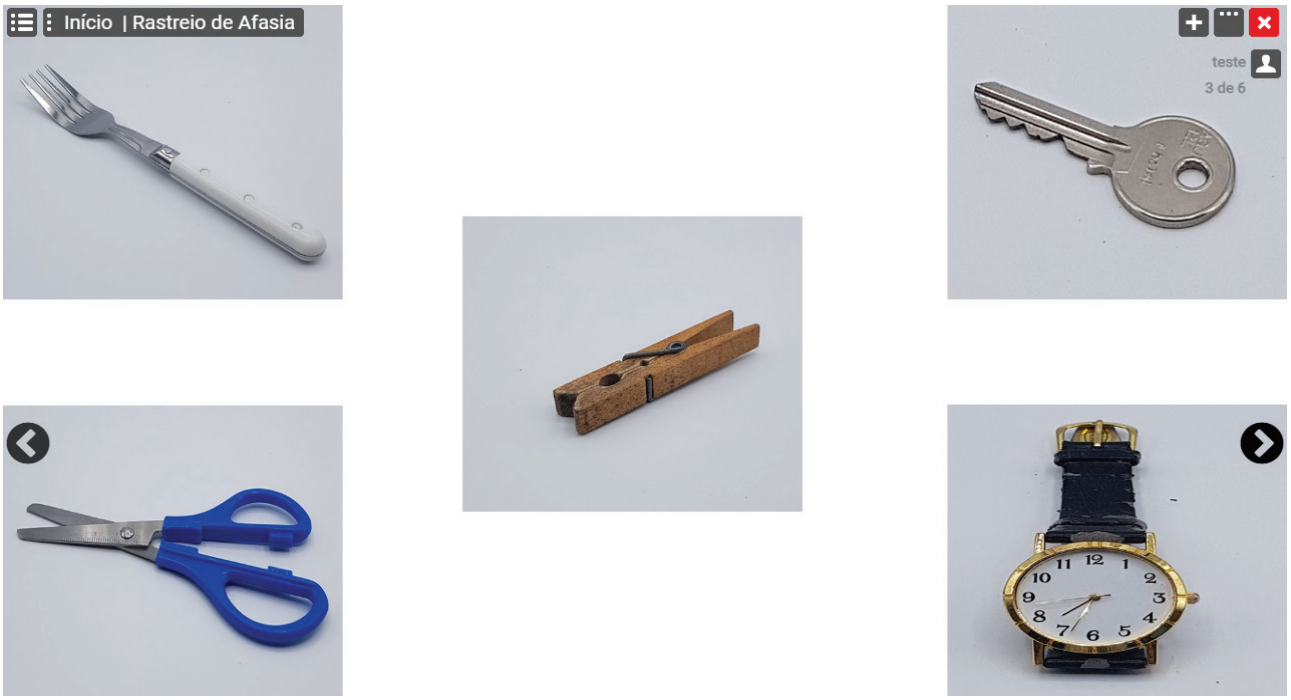

Figure 2 – Images used in naming and listening comprehension

Reading ability is assessed by reading aloud five words, three disyllables and two trisyllables (cat/*gato*, bed/*cama*, letter/*carta*, pan/*panela*, chair/*cadeira*) and then identifying them. Reading comprehension of two simple sentences is also assessed by choosing whether they are true sentences ("Do you live in Portugal?"/"*Vive em Portugal?*", "Is the Tagus river in Porto?"/"*O rio Tejo é no Porto?*").

For the writing assessment, the subject is asked to spontaneously write their first name, and after that five words (three disyllables and two trisyllables) are dictated (car/*carro*, table/*mesa*, door/*porta*, pen/*caneta*, baker/*padeiro*).

The words used in the test have a high and low frequency in the European-Portuguese language.[22]

At the end of these six tests, the TeRAp automatically provides a diagnostic hypothesis with a decision tree based on the patient's performance: aphasia, probable aphasia, dysarthria/apraxia or no impairment.

METHODS

We assessed 257 subjects with no neurological and/or psychiatric disease, 218 individuals with suspected acquired language disorders, 47 with speech disorders and 30 individuals with mild cognitive impairment (MCI) at various hospitals in the Lisbon metropolitan area.

The diagnosis and severity of aphasia were obtained using the Lisbon Aphasia Assessment Battery (BAAL).[23-25] The MCI diagnosis was based on the proposed criteria by the European Consortium on Alzheimer's Disease[26]: (a) cognitive complaints coming from the patients or their families; (b) the reporting of a decline in cognitive functioning relative to previous abilities during the past year by the patient or informant; (c) the presence of cognitive impairment evidenced by clinical/cognitive evaluation; and (d) the absence of major repercussions on daily life (patients may report difficulties concerning complex day-to-day activities).

Subjects with cognitive complaints were assessed using a detailed neuropsychological assessment protocol tackling attention, memory, and executive and visuospatial functioning, normally used at the Language Studies Laboratory of the Faculty of Medicine of the University of Lisbon. Sociodemographic data such as age, sex and education were collected from all subjects. Written informed consents were obtained from all subjects or a family member and in an aphasia-friendly format for people with aphasia.

The project was approved by the Ethics Committee of the Lisbon Academic Medical Center.

Statistics

Statistical analyses were performed using the software Statistical Package for Social Sciences (version 28.0).

A descriptive analysis of categorial variables was presented and the chi-squared test was used to test significant differences between sex and type of discourse. For the continuous variables, summary metrics (mean and standard deviation, median and interquartile range) were performed, and one-way ANOVA test was used to test significant differences.

Pearson correlations were used to compare the relationship between variables.

Results were considered significant when $p < 0.05$.

RESULTS

There were no statistically significant differences between the four groups regarding variables age, education and gender (Table 1).

In the group of healthy subjects, there was a ceiling effect on performance in all the tests (Table 2), with no influence from either age or education [Z = 0.632 (gl = 72) p = ns].

The language assessment with TeRAp took place on average around eight days after stroke occurrence in the group of individuals with aphasia and three days in the group of individuals with dysarthria (Table 3). The assessment with the BAAL and TeRAp took place with an average difference of 0.3 days in the group of individuals with aphasia

There were significant differences between the group of patients with aphasia and the three other groups (see Table 2), but no differences were found between the group of healthy subjects and the groups with dysarthria and mild cognitive impairment (Table 4).

The test's content validity was achieved by sending a questionnaire with 30 questions about content, interest, suitability, and usability to five neurologists and five speech therapists with experience in assessing individuals with

Table 1 – Baseline characteristics of the sample

	Healthy controls	Aphasia	Dysarthria	Mild cognitive impairment	Statistics	
	n = 257	n = 218	n = 47	n = 30	Z	*p*
Age	65.5 ± 14.0 (18 - 91)	67.2 ± 11.8 (31 - 93)	65.7 ± 14.1 (35 - 93)	69.0 ± 11.6 (30 - 85)	1.1	ns
Education	8.5 ± 4.4 (3 - 21)	8.2 ± 5.0 (0 - 21)	8.8 ± 5.3 (2 - 17)	8.5 ± 5.3 (0 - 17)	0.3	ns
Sex (M/F)	119/138	100/118	20/27	10/20	$\chi^2 = 0.572$	ns

Table 2 – Sample performance in the tests

Tests	Healthy controls (n = 257)	Aphasia (n = 218)	Mild cognitive impairment (n = 30)	Dysarthria (n = 47)	Statistics	
Speech Fluent/Nonfluent	257/0	148/70	30/0	47/0	χ^2 = 942.007	< 0.001
	Median/ interquartile range (Min. - Max.)	Median/ interquartile range (Min. - Max.)	Median interquartile range (Min. - Max.)	Median/ interquartile range (Min. - Max.)	Z	*p*
Naming Max. = 5	5/0 (0 - 5)	3/5 (0 - 5)	5/0 (3 - 5)	5/0 (5 - 5)	128.3	< 0.001
Orders comprehension Max. = 6	6/0 (5 - 6)	5/3 (0 - 6)	6/1 (3 - 6)	6/0 (4 - 6)	90.0	< 0.001
Repetition Max. = 7	7/0 (0 - 7)	7/5 (0 - 7)	7/0 (6 - 7)	7/0 (7 - 7)	68.8	< 0.001
Reading words Max. = 5	5/0 (0 - 5)	4/5 (0 - 5)	5/0 (4 - 5)	5/0 (0 - 5)	83.2	< 0.001
Word Identification Max. = 5	5/0 (0 - 5)	5/5 (0 - 5)	5/0 (4 - 5)	5/0 (0 - 5)	63.1	< 0.001
Sentence reading Max. = 2	2/0 (0 - 2)	1/2 (0 - 2)	2/0 (1 - 2)	2/0 (0 - 2)	100.0	< 0.001
Word writing Max. = 6	6/0 (0 - 6)	3/6 (0 - 6)	6/0 (6 - 6)	6/0 (0 - 6)	131.4	< 0.001
TeRAp total Max. = 36	36/0 (35 - 36)	26/23 (1 - 36.5)	36/1 (31 - 36)	36.5/0 (17.5 - 36.5)	137.7	< 0.001

acute and chronic aphasia, obtaining a universal content index of 1.0.

With the total sample of subjects with aphasia, convergent validity was obtained through performance on the TeRAp and the aphasia quotient (AQ) of the Lisbon Aphasia Assessment Battery, which is the gold standard instrument for assessing aphasia in Portugal. The AQ is obtained by adding up, in percentage, the values for the degree of speech (from 0 to 5), the naming of objects (from 0 to 16), the auditory comprehension of simple orders (from 0 to 8), and the repetition of words (from 0 to 30) and dividing the result by four. A strong correlation was obtained with a value of R = 0.876, $p < 0.001$.

Criterion validity was demonstrated through external validity by the performance of 40 subjects in the TeRAp and the Bedside Language Aphasia Screening Test.[18,19] A strong correlation was obtained when with values of R = 0.801, $p < 0.001$.

Table 3 – Evaluation time

Tests	Aphasia (n = 218)	Mild cognitive impairment (n = 30)	Dysarthria (n = 47)
	Mean ± SD (Min - Max)		Mean ± SD (Min - Max)
Stroke/TeRAp days	7.8 ± 7.4 (1 - 53)		3.2 ± 4.2 (0 - 27)
TeRAp/BAAL days	0.3 ± 0.8 (0 - 5)		0 ± 0 (0 - 0)
Same diagnosis (TeRAp/BAAL) n Yes/No (%)	214/4 (98.5%)	29/1 (96.6%)	47/0 (100%)

Table 4 – Comparison between healthy subjects and those with pathologies

Healthy controls	Aphasia	Mild cognitive impairment	Dysarthria
Mean difference	13.9251	0.6905	0.6274
Standard error	0.7172	1.5028	1.2357
p	< 0.001	1.000	1.000

To assess internal consistency, Cronbach's alpha was used with all the subjects in the four groups, and a value of 0.990 was obtained.

Only one group of 20 individuals with aphasia compared the initial result and the result after three days and found a significant relationship in their performance in both periods ($R = 0.965$ $p < 0.001$).

In another sample of 20 individuals with aphasia, inter-observer reliability was assessed with evaluations on the same day, and no significant differences were found in the results obtained by the two evaluators ($R = 0.965$, $p < 0.001$).

Using all the subjects as a sample, the TeRAp was found to have a specificity of 0.99 and a sensitivity of 1 to diagnose someone with aphasia.

DISCUSSION

After a neurological event, assessing communication skills is fundamental for differential diagnosis. The correct diagnosis and characterization of language impairments are relevant variables for therapeutic referral and predictors of recovery.[27]

An effective screening assessment for an acquired language disorder (for example, in a hospital emergency room, with a bedridden patient, or during a medical appointment with time constraints) can only be carried out using a test that is easy and quick to use, that is always available, and that does not require detailed records.

There are several aphasia screening tests published around the world, either built from scratch or adapted from more extensive assessment batteries. Language screening tests validated for European Portuguese have several limitations, most notably the poor assessment of speech, which is a fundamental measure in language assessment and differential diagnosis with other acquired communication disorders.

A screening test (TeRAp) was developed to always be available to the observer with an internet connection (https://app.terap-e.pt/) and without requiring paper support for its implementation and scoring. The differential diagnosis between aphasia, motor speech disorder, and normality is presented automatically at the end of the test.

The fact that the test is permanently available via smartphone means that any clinician, under any circumstances, can have access to an aphasia screening test that has been validated for the Portuguese population and is simple, fast, and accurate.

We observed and compared the performance of healthy individuals and individuals who suffered from aphasia, motor speech disorders or mild cognitive impairment.

The TeRAp has ceiling values in all the tests, which makes it an instrument in which any score below the upper limit suggests a pathological change, being, therefore, very easy to interpret.

The clinimetric properties of the test proved to be very good in the various measures evaluated, of which the instrument's specificity and sensitivity for the differential diagnosis between aphasia, motor speech disorder, and normality stand out.

We hope that this test will be useful to all professionals who interact with people with acquired communication disorders; so that a correct and quick diagnosis can hasten the referral to an extensive language and communication assessment by a speech therapist thus exponentially increasing the patient's chance of improving their communication, quality of life, and reintegration into society.

Limitations

The main limitations of the study were the number of subjects in the various sample groups and the fact that the subjects were all assessed exclusively by speech therapists, which may be creating a bias in diagnostic quality/ease, especially in speech assessment.

CONCLUSION

An aphasia screening test – the TeRAp – has been developed in an online format – appWeb – which quickly and accurately assesses speech, naming, auditory comprehension, repetition and reading and writing, and which ultimately provides a diagnostic hypothesis based on a decision tree.

The test's clinimetric data is presented, based on the assessment of a sample of healthy participants, and three samples of participants with neurological conditions: stroke aphasia, dysarthria and mild cognitive impairment.

The TeRAp can be used as a screening tool for an acquired language disorder, in an acute or chronic phase, or as a measure of clinical evolution of patients.

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PREVIOUS AWARDS AND PRESENTATIONS

An oral communication of this work was presented in the *IX Congresso Nacional da APTF*.

AUTHOR CONTRIBUTIONS

JF: Conceptualization, methodology, data collection and analysis, writing of the manuscript.

FM, BS, CM: Data collection, writing of the manuscript.

All authors approved the final version to be published.

PROTECTION OF HUMANS AND ANIMALS

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and to the Helsinki Declaration of the World Medical Association updated in 2013.

DATA CONFIDENTIALITY

The authors declare having followed the protocols in use at their working center regarding patients' data publication.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

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