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RESEARCH ARTICLE

Categorization Working Memory Span Task: Validation study of two Brazilian alternate versions

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Background: The Categorization Working Memory Span Task (CWMS task) is a complex working memory (WM) span test that has been used previously to assess age and individual differences in WM as well as the relationship between WM and complex aspects of cognition such as listening comprehension. Two alternate versions of the task have been developed to be used as outcome variables in WM training protocol, which mirrors the task involved in the CWMS task.

Objectives: (1) To translate and adapt the CWMS task for Brazilian Portuguese; (2) to test the equivalence of its 2 alternate versions; (3) to examine temporal stability; (4) to examine the influence of age and schooling on CWMS task; (5) to establish its relationship with other tests of WM.

Methods: Eighty-one older adults completed version A, and 86 completed version B of the CWMS task. After 6 months, a subsample (n = 85) completed the same version of the task.

Results: Versions A and B of the task generated comparable scores. Both versions had adequate temporal stability, which was higher for the CWMS total recall, which is the classical variable in this task to represent WM performance, when compared to the other variables generated by the test. The CWMS task variables were moderately correlated with schooling and other cognitive tests (Mini Mental State Examination, Letter-Number Sequencing, Spatial Span Backward, Digit Span Forward).

Conclusions: The 2 versions of the CWMS task were equivalent and stable temporally. The task was influenced by schooling and global cognition.

KEYWORDS

aging, cognitive testing, older adults, validation, working memory

1 | INTRODUCTION

Instruments that assess different aspects of cognition in seniors are important for understanding the transition between the expected cognitive aging and that related to some pathological condition.[1-3] Among cognitive functions that significantly change in the aging process, one could cite working memory (WM), which refers to the ability to temporarily maintain information for use in ongoing mental operations.[4] Scores in WM tend to be lower in older adults compared to younger individuals,[5-7] and it is further impaired in patients with neurocognitive disorders.[8,9]

Daneman and Carpenter[10] devised 2 working memory tests—the reading span and the listening/reading span test. In these tasks, the participant is required to read or listen to a number of sentences and remember the last word contained in each sentence. These tests have been extensively used in the aging literature to assess auditory WM and the phonological loop.[11,12] However, a limitation of the listening/reading span test is the fact that, in the context of a sentence, an individual could use linguistic cues to aid performance.

To overcome such limitation, other WM tasks, for instance, De Beni et al[12] created a new auditory WM test, the Categorization Working Memory Span Task (CWMS task), based on the presentation of lists of nouns rather than sentences. In the test, participants listen to sequences of 5 words and their task is to remember target words and tap their hand when they listen to an animal name (processing phase). In addition, this paradigm can be used to assess the rate of memory errors (intrusion errors) that represent failure of inhibitory mechanisms.[7,13] In the article where the test was presented, researchers aimed to investigate the relationship between WM, inhibitory control, and reading comprehension.[12] The researchers tested 44

psychology students aged between 18 and 20 years divided into good (22 subjects) and poor "comprehenders" (22 subjects) according to tests of logical reasoning and reading comprehension. Participants were tested with the Forward and Backward Digit Span (WAIS) and the Listening Span test from Daneman and Carpenter.[10] While there was no difference in the Digit Span tests, the poor "comprehenders" had more intrusions and recalled fewer words than the good "comprehenders." Secondly, a subsample of 30 participants (15 good and 15 poor "comprehenders") was tested by the CWMS test, and the results showed a lower recall of words in the correct order along with more intrusion errors in the poor "comprehenders" than the good ones. In a third study, the researchers tested 14 good "comprehenders" and 16 poor "comprehenders" in the CWMS test, but in this case, the participants should try to remember all the words. There was no difference between the groups when remembering the words in the correct order or any order, as the test in this modality proved to be very challenging. Overall, the results of De Beni et al's[12] study suggested that poor "comprehenders" seem to maintain irrelevant information in WM leading to overload in the phonological loop and commit a larger number of intrusion errors.

Since its development, the CWMS task has been used in different studies to evaluate age and individual differences across the adult life span in auditory WM[7,14-17]; to observe the relationship between WM and inhibition[14,18]; to aid in the differentiation of normal and pathological aging[19]; and to evaluate seniors with Mild Cognitive Impairment.[20] This instrument was also used as an outcome measure in memory training studies involving participants with different cognitive profiles and ages.[17,18,21-26]

In Brazil, there are few verbal WM paradigms validated for use among older adults in the clinical and research context. Two alternate versions of the task have been developed to be used as outcome variables in a WM training protocol, which was based on the task involved in the CWMS task. The verbal stimuli are recorded, and the examples can be repeated as often as necessary to ensure that instructions were understood. The test can be applied in average in 10 minutes. Most importantly, the test allows the measurement of WM performance per se with the number of words correctly recalled, and of inhibitory mechanisms, with the intrusion errors measure (that is the stimuli/words that are recalled but should have been inhibited).

Although the CWMS task has been used in several studies, there is a paucity of data regarding its psychometric characteristics. Therefore, the objectives of this study were (1) to translate and adapt the CWMS task for Brazilian Portuguese; (2) to test the equivalence of the 2 different versions of the task; (3) to examine temporal stability; (4) to examine the influence of age and schooling on the CWMS task; and (5) to establish its relationship with other tests of WM.

Key points

- The 2 versions of the CWMS task were equivalent and stable temporally.
- The CWMS variables significatly correlated with schooling, working memory and general cognition tests.

2 | METHODS

2.1 | Participants

The participants were recruited at a public third age university program and at a public outpatient service for seniors. They were invited to participate in a study about cognition involving different activities. Potential participants were invited during a phone call when a general description of the study was offered. After the first assessment session, participants were included or excluded according to the following criteria. Exclusion criteria were age younger than 60 years, sensory difficulties hindering cognitive performance, Geriatric Depression Scale (GDS) scores higher than 5,[27,28] Geriatric Anxiety Inventory (GAI) scores higher than 13,[29,30] or Functional Activities Questionnaire (FAQ) scores higher than 1.[31,32] Inclusion criteria were intact cognitive performance according to the Mini Mental State Examination (MMSE) (cutoff scores were 25 for 4 years in school and 27 for 8 schooling)[33,34] and delayed recall of the CERAD Word List (recall lower than 3 words),[35,36] schooling higher than 4 years.

The data for the present analyses were extracted from the baseline assessment of a training study. For participants who did not receive the training, the second posttest data were used to examine the temporal stability of the 2 versions of the CWMS task, after 6 months (6-month follow-up for the no-intervention control group). In the baseline assessment, the study included 167 healthy older adults and 81 completed version A and 86 completed version B of the instrument. From the total sample, 85 seniors were randomized into the no-training control condition and they completed the same version of the CWMS task in the 6-month follow-up. The pretest and follow-up data were used to calculate the test-retest reliability. In the test-retest subsample, 38 seniors responded to version A and 47 to version B.

2.2 | Instruments

2.2.1 | The protocol

Participants completed a questionnaire, which required to indicate age, education, and number of self-reported diseases. The cognitive protocol comprised a battery of WM tests including the CWMS task,[12] which assesses verbal WM; Spatial Span Test (Wechsler Memory Scale III)[37,38], which evaluates visual WM; Forward and Backward Digit Span tests (Wechsler Adult Intelligence Scale, WAIS-III)[37,39] that assesses auditory attention and WM, respectively; and Letter-Number Sequencing (WAIS-III)[37,39] that assess verbal WM.

2.2.2 | The CWMS task

In the CWMS task, the participant listens to sequences of 5 words, composed of animals and common words. They are instructed to memorize the last word of the list—which is followed by a beep sound—(maintenance phase) and, at the same time, to raise the hand (in the Brazilian version, hand tapping was substituted by hand raising) (processing phase) when an animal name is heard. At the end of each set, they have to recall the target words in the order that they were presented.

Each 5-word sequence can have from 0 to 2 animals, which may occupy any positions. See Figure 1, for an example, of the test stimuli.

After the instructions, the participant is given 2 examples to practice and these may be repeated until he/she understands how the test works. The test begins with 2 sequences of 5 words, when the participant has to memorize 2 target words and raise the hand for 2 animals. The test comprises 5 blocks of 5-word sentences, ranging from 2 to 6 sequences in each block. Therefore, the last block contains 6 words to be memorized and 10 animals, as the test has an ascending difficulty level. The highest possible score is 20 recalled words and 27 hand raises for animals.

The application time for the CWMS task is between 10 and 15 minutes, depending on how many times the instructions are repeated. An example of a block with 2 sequences of 5 words is provided bellow (Figure 1). The Brazilian version of the task is variable upon request to the corresponding author.

Two versions of the task (A and B) are available; they should be equivalent in terms of difficulty level. The alternative versions are important for intervention and longitudinal studies as these may be used interchangeably in first and follow-up assessments.

The correction system takes into account the total number of recalled words, independently of the order in which they were recalled (CWMS total recall word), the number of times the person raised the hand (CWMS animal), and the number of times the person raised the hand incorrectly (CWMS hand raising error). Further, an additional score can be calculated—the proportion between the number of times the person raised the hand incorrectly and the number of words correctly recalled. The CWMS error in terms of hand raising is divided by the CWMS total word recall. This is a measure of the extent that participants are performing a WM task (CWMS tapping errors/correct recall).[40]

2.3 | The adaptation of the CWMS task to Brazilian Portuguese

2.3.1 | Translation and adaptation

To produce the Brazilian Portuguese version of the CWMS task, first, the test was translated by a bilingual speaker of Italian and Portuguese. Next, a Brazilian linguist, who lived in Italy, analyzed the translation and suggested some changes in a few words aiming to keep the words as close as possible to the original version of the test. In addition, final adaptations were performed: (1) Words in Portuguese with more than 3 syllables were replaced by words with similar meaning with 3 syllables or less (for example, ufficio, escritório, and oficina); (2) animal names that were uncommon in Brazil (which could not be recognized as animals in pilot testing) were replaced by names of common animals (for example, riccio, ouriço, and peixe); (3) infrequent words were replaced by frequent synonyms (for example, frade, padre or geranium, and violeta). These changes were suggested by a panel of neuropsychologists and a linguist.

The final version of the task in Brazilian Portuguese was recorded by a speech therapist in audio files using a computer and a microphone, using the same speed between one word and the next (1 s), and between one sequence and the next (2 s) as in the Italian version of the test. In the CWMS task, the words to be memorized are followed by a beep sound. The same beep was used in the Brazilian CWMS task as in the Italian version.

Pilot testing was performed with 25 community seniors who had unimpaired MMSE performance, with mean age of 69.25 (±10.23) and mean schooling of 6.45 (±2.80). In general, the test was well understood by participants. However, one word was misunderstood by some participants, and this word was substituted (odor, cheiro).

2.3.2 | CWMS task word frequency analysis

In total, each version of the CWMS task comprises 100 words, including 27 animals. To verify if the words included in the Brazilian version of the test were common words in Brazil, we conducted an additional study. A new group of 36 seniors who participated in a private third age university program, with mean age of 67.44 (7.59) years and mean schooling of 9.52 (3.90) years, was asked to evaluate the 200 words included in versions A and B of the CWMS task. Each participant received a list containing all the words, and they had to indicate if the word was *rare*, *little frequent*, *frequent*, and *very frequent* in a Likert scale, which varied from 1 to 4 points. Results indicated that in version A, 52 words, and in version B, 56 words were regarded as frequent or very frequent by more than 18 participants (50%) of the sample. In version A, 16 words and in version B, 18 words were regarded as rare.

2.4 | Procedures

During the assessment session, participants were invited to fill out the informed consent form, approved by the Ethics Committee of the university involved (034412/2013). The evaluation was performed individually and lasted around 90 minutes. The CWMS task was the first test to be applied after the inclusion criteria were verified.

2.5 | Statistical analyses

To investigate whether the variables followed a normal distribution, the Kolmogorov Smirnov test was used. To verify if the 2 versions of the test were equivalent, the groups that completed each version were compared with the independent sample Student *t* test. The Intra Class Correlation Coefficient[41] was used to verify temporal stability, and the adopted values for the interpretation of results were $r < .40$ poor

1	palco	prédio	costume	parto	***lagarta***
2	trabalho	pedra	ponto	*pavão*	**língua**

FIGURE 1 Example of word sequences in the Categorization Working Memory Span Task (CWMS task). The participant listens to these words and raises his/her hand when he listens to *lagarta* and *pavão* (animal names in Portuguese). At the end of these 2 sequences, the participant must say *lagarta* and *lingua* (target words followed by a beep sound)

agreement, .41 < *r* < .75 good agreement, and *r* > .75 excellent agreement. Correlation analyses were performed with Pearson bivariate correlations and interpreted with the criteria suggested by Cohen[42]: 0.1 a 0.29 small, 0.30 a 0.49 medium, 0.50 a 1 large correlation. The data were analyzed using the SPSS statistical program for Windows, version 20, and the level of significance adopted for was 5%, *P* < .05.

3 | RESULTS

Participants were divided into those who completed version A of the CWMS task in the first assessment and version B in the second (n = 81) and those who completed version B of the task first and version A in the second assessment (n = 86). The 2 groups were similar in age, schooling, sex, MMSE, Delayed CERAD Word List Recall, GDS, GAI, and FAQ scores in the first assessment (Table 1).

Table 1 shows the results for the variables generated by the CWMS task, when the 2 versions of the test were compared in the baseline assessment. There were no significant differences between versions A and B of the test. In addition, the correlation between versions A (first assessment) and B (second assessment) was satisfactory: .73 (*P* < .001). These findings suggest that the 2 versions of the test are equivalent.

To examine temporal stability, we compared CWMS task scores at the baseline and after 6 months, (for version A, n = 38 and version B, n = 47). Table 2 indicated that both versions have adequate temporal stability. Temporal stability was higher for the CWMS total recall than for the other variables generated by the test.

The CWMS task variables were correlated with schooling and the other cognitive tests. Table 3 showed that CWMS total recall was moderately correlated with the MMSE and the Letter-Number Sequencing. The CWMS hand raising error showed a negative moderate correlation with the MMSE and Spatial Span Backward. The CWMS variable animal (hand raising) was moderately correlated with schooling and Spatial Span Backward; there was a negative moderate correlation with Digit Span Forward.

4 | DISCUSSION

The purpose of this study was to document the process of translation and adaptation of 2 versions of the Brazilian CWMS task as an auditory complex verbal WM span test. In addition, we aimed to present validation data, specifically, temporal stability and convergent validity evidence. Present results suggested that the 2 versions of the CWMS task are equivalent. Also, the total recall score for the CWMS task is stable temporally, and it significantly correlated with other WM tests, although correlation values were weak to moderate.

Different studies[1-3] highlighted the importance of investigating instruments that assess WM in the context of aging, mainly because this is the memory subsystem that seems to change more significantly in aging. The CWMS task is a promising verbal WM instrument as it requires short-term memorization of words and simultaneous processing of semantic information. In addition, this paradigm does not offer the contextual support of sentences—as in the Reading or Listening span test—and, therefore, may be more sensitive to WM dysfunction. Previous studies[7,16] have shown that the paradigm is also useful to asses WM across the adult life span.[16]

The fact that the 2 alternate versions of the CWMS task were shown to be equivalent is a relevant finding as they make the test appropriate for use as outcome measures in nonpharmacological interventions and longitudinal studies. In addition, present results showed satisfactory temporal stability parameters for the CWMS task variables and even higher stability for the CWMS total words recalled. It is noteworthy that stability values may have been reduced in the present study because of the fact that retest was performed 6 months later and not earlier. These findings represent original contributions as these psychometric parameters for the CWMS task had not been reported previously.

Present results suggested that the CWMS task is influenced by education and general cognitive ability (MMSE), but not by age. However, Borella et al[23] reported age effects in a sample of seniors older than 75 years. Therefore, this incongruence regarding the influence of age may be associated with restriction in the age range of participants (60-79) in the present study or with the fact that the Brazilian sample was

TABLE 1 Sample characteristics of participants who completed versions A and B in the first assessment

Measure	Version A first (n = 81)	Version B first (n = 86)	*P* value
Age	63.5 (14.3)	64.3 (14.5)	0.72
Schooling	7.9 (4.7)	7.8 (4.8)	0.88
Sex	55 (68%)	54 (63%)	0.68*
MMSE	26.8 (2.0)	26.8 (2.1)	0.99
CERAD word list	6.1 (1.6)	5.9 (1.7)	0.26
GDS	3.3 (1.6)	3.0 (1.6)	0.25
GAI	5.7 (3.7)	5.7 (3.8)	0.95
FAQ	0.1 (0.3)	0.1 (0.2)	0.71
CWMS total words recalled	8.1 (2.5)	7.9 (2.5)	0.62
CWMS hand raising error	1.9 (2.3)	1.7 (2.2)	0.47
CWMS animal (hand raised correctly)	22.2 (3.8)	21.9 (3.9)	0.65
CWMS tapping errors/words recalled	0.3 (0.3)	0.2 (0.3)	0.43

Note. Means and standard deviations for measures; sex = absolute value and percentage in parenthesis; *P* values refer to the independent sample Student *t* test.

**P* value refers to the chi-square test. MMSE, Mini Mental State Examination; GDS, Geriatric Depression Scale; GAI, Geriatric Anxiety Inventory; FAQ, Functional Activities Questionnaire; CWMS, Categorization Working Memory Span Task.

TABLE 2 Intra Class Correlation Coefficient for the first assessment and the 6-month retest

Measure	Version A (n = 38)			Version B (n = 47)		
	Baseline	6-month retest	ICC	Baseline	6-month retest	ICC
CWMS total words recalled	8.29 (2.86)	8.34 (3.52)	0.75	7.70 (2.24)	7.29 (2.55)	0.80
CWMS animal (hand raised)	21.92 (4.10)	24.21 (3.51)	0.66	22.23 (3.47)	22.40 (3.91)	0.65
CWMS animal error	1.37 (2.16)	1.57 (1.92)	0.66	1.26 (1.73)	1.48 (1.75)	0.31

Note. CWMS, Categorization Working Memory Span Task; *P* value refers to Intra Class Correlation Coefficient; ICC < 0.40 poor agreement, 0.41 < ICC <0.75 good agreement, and ICC > 0.75 excellent agreement.

TABLE 3 Correlations between the CWMS test variables and age, education and other cognitive tests (n = 167) in the first assessment

	CWMS Total Words Recalled	CWMS Animal (Hand Raised)	CWMS Hand Raised Error
Age	−0.13	−0.25**	0.04
Schooling	0.27**	0.31**	−0.07
MMSE	0.32**	0.28**	−0.00
Spatial span forward	0.19*	0.17*	−0.13
Spatial span backward	0.22**	0.37**	−0.07
Digit span forward	0.19*	0.01	−0.31**
Digit span backward	0.12	0.20**	−0.07
Letter-number sequencing	0.31**	0.25**	−0.03

Note. *P* value refers to Pearson coefficient; MMSE, Mini Mental State Examination.

Cohen (1988)[42]: 0.1 a 0.29 small, 0.30 a 0.49 medium, 0.50 a 1 large correlation.

*$P < .05$,

**$P < .001$.

younger. The CWMS may be superior to other WM tests as it is organized in an ascending difficulty level and have 2 versions.

The effect of schooling on the CWMS task had not been investigated previously. Most studies with the CWMS task involved younger and older adults with schooling higher than 8 years. The present study showed that schooling has a positive association (although modest) with the CWMS total words recalled and CWMS animal (more intrusions with lower schooling). This finding is relevant as test scores may need to be interpreted according to participants' level of schooling. In other words, future normative studies should stratify test scores at least according to age and education.

The present study reported a moderate positive correlation between the CWMS total words recalled and Letter-Number Sequencing. The latter involves processing of auditory information from 2 concurring systems (letters and numbers),[43] as is the case with the CWMS task, which may explain the moderate relationship between the 2 tests.

A negative correlation was observed between CWMS hand raising errors and Digit Span Forward test. In the original study of De Beni et al,[12] the authors aimed to create a test that could assess WM along with inhibitory control. This finding suggests that raising the hand inappropriately (when nonanimal words are heard) may be associated with measures of auditory attention.

5 | CONCLUSION

The CWMS task is an instrument with 2 alternate versions that can be used to assess verbal WM. The task can also be used as an outcome measure in intervention studies. The task was influenced by age, schooling, and global cognition, and it correlated moderately with other WM tests.

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CONFLICT OF INTEREST

None declared.

AUTHORSHIP

P.S.B. performed the acquisition of data, substantial contributions to conception of this study, and drafting of the article; E.B. did the substantial contributions to conception of this study and revised it critically for important intellectual content; B.C. analyzed and interpreted the data; M.S.Y. drafted the article, revised it critically for important intellectual content, and did the final approval of the version to be published.

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