# Working memory screening, school context, and socioeconomic status - An analysis of the effectiveness of the Working Memory Rating Scale in Brazil

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## Abstract

**Objective:** The study explores the psychometric properties of the Brazilian-Portuguese version of the Working Memory Rating Scale (WMRS-Br) in a population of 355 young children from diverse socioeconomic status and schooling backgrounds.

**Method:** Public and private school teachers completed the WMRS-Br and children were assessed on a range of objective cognitive measures of fluid intelligence, working memory, and attention.

**Results:** Reliability and validity of the WMRS-Br were excellent across the public and private school sample. The WMRS-Br manifested substantial links with objective measures of working memory and medium links with selective attention, switching, and interference suppression. Confirmatory factor analyses suggest that a shorter version of the scale provides an adequate fit to the data.

**Conclusion:** The WMRS-Br represents a valid screening tool in a Latin American context that has the potential to improve the early detection of working memory deficits in children growing up in poverty.

## 1. Introduction

Working memory (WM) is a capacity limited cognitive system that temporarily holds and manipulates information over brief periods of time in the course of ongoing cognitive activities (Baddeley, 2000). It has been closely linked with children's learning progress in key academic domains such as language, reading and math, and low WM performance has been identified as a high risk factor for learning disorders (Engel de Abreu & Gathercole, 2012; Gathercole, Pickering, Knight, & Stegman, 2004; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Willcutt, Pennington, Olson, Chhabildas, & Hulslander, 2005). To date not many instruments have been designed to assess WM behavior in the classroom. The present paper focuses on one commercially available screening tool that has been developed in the UK – the Working Memory Rating Scale (WMRS; Alloway, Gathercole, & Kirkwood, 2008). The study addresses the psychometric properties of the WMRS in a population of young children from a range of socioeconomic status backgrounds in Brazil. A key question is whether a screening tool that was developed in England can provide an accurate indication of WM behavior in another linguistic, cultural, and educational setting that is marked by large degrees of social inequalities.

The WMRS is a behavioral rating scale designed to provide educators with an instrument to identify students who struggle with limited WM capacity. Teachers are often not familiar with the concept of WM and few have received explicit training on how to recognize and support WM problems in the classroom. WM deficits are therefore often undiagnosed or confused with problems of motivation or intelligence (Gathercole & Alloway, 2008). Traditionally, WM is assessed using cumbersome testing batteries that are generally expensive and have to be administered by a specialist with training in psychometric assessment, putting significant strains on public resources. Furthermore, assessments are generally conducted in highly controlled environments which do not necessarily reflect the WM demands of naturalistic setting.

The WMRS is currently the only available instrument for measuring WM behavior that can be administered by a teacher. It was developed on the basis of teacher interviews and classroom observations in the UK and consists of 20 descriptions of behaviors that characterize children with WM deficits. In contrast to other behavior rating scales that include features of WM (e.g. BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000), the main attributes of the WMRS are its exclusive focus on WM and its fast administration and scoring that can be done by a non-expert. Studies conducted in English-speaking countries have shown that scores on the WMRS correlate with objective measures of verbal and visuo-spatial WM, indicating good criterion-related validity (Alloway, Gathercole, Kirkwood, & Elliott, 2009a; Normand & Tannock, 2012).

One of the shortcomings of the WMRS is that its psychometric properties are not yet extensively researched. In their original study with 417 children in England, Alloway and colleagues (2009a) report that the scale manifests good internal reliability and exploratory factor analyses revealed that the 20 items measured the same underlying ability. In an independent study with 524 English-speaking children from Canada, Normand and Tannock (2012) confirmed high internal consistency of the scale; however, when verifying its one-factor structure with confirmatory factor analyses the model poorly fitted the data. Item-total correlations were high, leading to the conclusion that some of the 20 items were redundant. Additional analyses showed that the factor structure of a more parsimonious 5-item model was superior to the original model. The short version of the WMRS manifested satisfactory internal consistency and criterion validity that were similar to the ones obtained with the complete scale. Further studies are clearly needed to replicate these findings and to explore the validity of the short WMRS in an independent sample. Another limitation of the WMRS is that it is currently only available in English and has exclusively been studied in Anglo-Saxon teaching contexts. It is therefore at present unclear whether the WMRS provides an accurate indication of WM behavior in another linguistic and cultural setting. A related question is whether the WMRS represents a valid measurement tool if administered in challenging educational circumstances. The studies of Alloway and colleagues (2009a) and Normand and Tannock (2012) were conducted in first world countries with high Human Development Indices indicating high standards of living and of public school education. Whether teachers that work in less privileged circumstances are able to recognize signs of problematic WM behavior remains to be seen.

Finally, an unresolved issue concerns the extent to which scores on the WMRS relate to objective measures of attention. Increasing evidence suggests that WM and attention are closely intertwined processes. Individual differences studies reveal strong links between WM capacity and controlled attention (Engel de Abreu, Conway, & Gathercole, 2010; Engle, Tuholski, Laughlin, & Conway, 1999). Studies with atypical groups have shown that symptoms of inattention generally accompany low WM scores (Alloway, Gathercole, Kirkwood, & Elliott, 2009b, Gathercole, et al. 2008) and there is increasing evidence of WM impairments in children with attention-deficit hyperactivity disorder (ADHD; Alloway, Gathercole, & Elliott, 2010; Martinussen et al., 2005; Martinussen & Tannock, 2006). The exact nature of the relationship between attention and WM is not yet fully understood. Some theorists argue that attention increases the encoding of relevant over irrelevant information into WM, contributes to the active maintenance of information within the WM system, and participates in the manipulation and updating of the contents of WM (see Awh, Vogel, & Oh, 2006 for a review). There are indications that neither attention nor WM represent a uniform set of processes (Miyake et al., 2000); their relationship may therefore depend on the type of processes involved.

The presented study is the first to adapt the WMRS into Brazilian-Portuguese and explore its psychometric properties in a large sample of children from a wide range of socioeconomic status groups and different schooling contexts. The major objective was to complement earlier research with English-speaking children (Alloway et al., 2009a; Normand & Tannock, 2012) and examine the internal consistency, factor structure, validity, and diagnostic utility of the WMRS in a population of Brazilian children from different backgrounds in the early elementary school years. The study was designed to replicate the findings of Normand and Tannock (2012) and contrasts the original WMRS factor structure with the short 5-item version of the scale using confirmatory factor analyses. It extends previous works by exploring the relationship between WMRS scores and objective measures of attention. This is particularly relevant in the light of the consistent finding that WM deficits are associated with symptoms of inattention and mind-wandering (Alloway et al., 2009b; Martinussen et al., 2005). A particular interest was to explore the psychometric properties of the WMRS in Brazilian private and public schools in order to determine whether the scale can provide a valid instrument for assessing WM behavior in challenging educational contexts and in socially vulnerable populations.

Although Brazil is one of the fastest-growing major economies in the world, the country's educational system continues to be extremely unequal. Despite governmental efforts, the quality of public school education remains poor. According to the Brazilian education quality index IDEB, public schools have an average educational quality grade of 4 whereas private schools have a quality grade of 6 which corresponds to the average level of public schools in OECD countries (INEP, 2009; OECD, 2010). Private institutions operate in circumstances that resemble those of schools in developed countries. They offer higher teacher salaries and better facilities than public schools that must generally cope with tight budgets. Public school teachers are often not educated past high school and many have to work several shifts a day in order to make a decent living (for a review see Evans & Kosec, 2012 and IDB, 2008). The presented data was collected in public and private schools across two Brazilian states. Children completed a range of cognitive measures of fluid intelligence, WM, and attention. The majority of the tasks form part of standardized test batteries and are widely used in research and clinical settings to measures processes relate to WM and attention in children. The Brazilian Portuguese version of the WMRS (WMRS-Br) was adapted for the purpose of this study. It was predicted that the WMRS-Br would manifest satisfactory internal reliability and correlate with objective measures of WM and attention in the private school sample. Based on Normand and Tannock (2012), it was expected that the short WMRS would provide a better account of the data than the complete scale. It was anticipated that the WMRS-Br might be less effective in detecting WM problems in Brazilian public than private school settings. Firstly, public school teachers who struggle with heavy workloads, low salaries, and inadequate training might lack the motivation, time, or diagnostic competence to judge signs of problematic WM behavior in the classroom. Secondly, the climate in Brazilian public schools is likely to be emotionally charged as low socioeconomic status is associated with stressful life conditions. Public school children might therefore exhibit more disruptive classroom behaviors in contrast to private school children which might be inaccurately identified as WM problems.

## 2. Method

### 2.1. Participants

The data from 355 Brazilian children (182 girls, 173 boys) from the cities of São Paulo

/ state of São Paulo (48%) and Salvador/ state of Bahia (52%) was analyzed. Caregivers completed a social background questionnaire containing information related to the development of the child and the socio-demographic characteristics of the household. The data was collected as part of a larger study on the effects of poverty on children's cognitive development. Children with severe malnutrition and suspicion of developmental delays, intellectual, sensory, or neurological impairments were excluded from the study.

All children were monolingual in Portuguese and had a mean chronological age of 7 years and 5 months (*SD* = 7.8 months; range 6 years 1 month – 8 years 11 months). Participants were recruited from Year 1 and Year 2 of nine private and eight public schools. In total 52 teachers took part in the study (30 from private and 22 from public schools). With one exception all of the teachers were woman. Teachers and school principals completed a questionnaire providing information on their schools characteristics and resources. All of the private schools were charging monthly fees of between 345 BRL (~170.09 USD) and 830 BRL (~409.36 USD). They were located in advantaged neighborhoods, and did not struggle with educational resources. The public schools were free of charge. They had a low average education quality index (IDEP = 3.9, INEP, 2009) and 86% of the schools indicated facing severe financial constraints. Main demographic characteristics of the sample are reported in Table 1. Notably, private and public school children differed significantly on the socioeconomic status indexes. Public school caregivers were low-skilled professionals (e.g. cleaners, street service workers) and 25% of the households were living on less than 2.50 USD a day. In contrast, none of the private school children were living in poverty and their caregivers were highly skilled (e.g. engineering professionals, medical doctors). Schools did also differ significantly in terms of classroom size: the average child-teacher ratio was 1:18 in private and 1:25 in public schools.

Table 1 about here

## 2.2. Procedure

The WMRS-Br was adapted from English into Brazilian Portuguese by a team of eight researchers. Emphasis in the adaption process was on conceptual and cross-cultural rather than on linguistic equivalence. In a first phase all of the items were translated from English into Brazilian Portuguese by a native Brazilian who lived in an English speaking country for over five years. The translation together with the English original was then revised by an expert panel of five independent assessors fluent in both Portuguese and English and the best features of each revision were retained. The scale was pre-tested and discussed with a group of teachers and problematic items were further modified by the expert panel including the original translator. The final scale was independently back-translated into English by two native speakers of Portuguese who are fluent in English. Teachers were asked to complete the WMRS-Br for each child participating in the study.

Children were individually assessed on a battery of objective measures of verbal and visuo-spatial WM, fluid intelligence and different attentional capacities. All of the assessments were adapted from English originals following forward- and back-translation procedures. Reliability of instruments was established for the scores produced by the measures in this study and are presented in the results section. Informed written consent procedures were followed for all participants and the study was approved by the national Brazilian ethics committee CONEP. The behavioral measures were administered in a quiet area of the school by qualified research assistants who were all trained by the first author. For all the measures, raw scores were used as dependent variables as no data were available regarding measures of standardized norms in a population of Brazilian children. Unless otherwise specified, tests that form part of published batteries were administered according to standard procedures and are not described in detail.

**2.3. Measures**

**Working memory rating scale** (Alloway et al., 2008). The WMRS consists of 20 descriptions of behaviors that characterize children with WM problems (see Alloway et al., 2009 for a description of the sample items). Teachers rate how typical each behavior was of a particular child during the school year, using a four-point Likert-type scale ranging from (0) not typical at all to (3) very typical. The dependant measure used for analyses was the sum of the responses.

**Objective measures of verbal and visuo-spatial WM.** Two verbal (digit recall and counting recall) and two visuo-spatial (dot matrix and odd-one out) WM measures from the computer-based Automated Working Memory Assessment (AWMA, Alloway, 2007) were administered. In the *Digit Recall* task the child has to immediately repeat sequences of spoken digits in the order that they were presented. In the *Counting Recall* task the child is presented with pictures containing circles and triangles and is asked to count and memorize the number of circles in each picture. At the end of each trial the child has to recall the number of circles of each picture in the right order. The *Dot Matrix* task consists of a 4X4 matrix and a red dot that appears in different locations of the matrix. Children have to remember the sequence of locations and recall them by tapping the squares of the empty matrix in the right order at the end of each trial. In the *Odd-One-Out* task children are presented with arrays of three boxes with one shape in each. They have to identify the shape that does not match with the two others, remember its location in each array, and recall the localization of the odd shape when presented with an array of empty boxes at the end of the trial.

**Fluid intelligence.** Children completed the Raven's Coloured Progressive Matrices (Raven, Court, & Raven, 1986), a nonverbal task in which geometrical figures need to be completed by choosing the missing piece among six alternatives.

**Attentional capacities.** Two measures from the Test of Everyday Attention for Children (TEA-Ch, Manly, Robertson, Anderson, & Nimmo-Smith, 1998) tapping into selective/focused attention (sky search) and switching/attentional control (opposite worlds) were administered. In the *Sky Search* task children are presented with an A3-sheet depicting 128 paired spacecrafts of which 20 pairs are identical. Children have to circle the identical pairs as fast as possible. Subsequently children are administered a motor control version of the task containing only the 20 target items without the distracters. The sky search time-per-target score is calculated adjusted for motor speed. In the *Opposite Worlds* task children are presented with four pictures containing each a path of digits 1 and 2. In the same world condition children have to follow the path and name the digits as fast as possible. In the opposite world condition children are instructed to follow the path and say "two" when they see a 1 and "one" when they see a 2. The dependant measure was the sum of correct responses on both task conditions.

Two measures of response inhibition were administered. Children completed a Brazilian version of the *Simon Says* task ("o mestre mandou" meaning "the master ordered") modified after Carlson and Meltzoff (2008). In this task children are standing opposite the experimenter that is performing a series of physical actions accompanied by verbal commands (e.g. "touch your nose"). Children are instructed to imitate the action of the experimenter if the command is prefaced with the phrase "o mestre mandou" but stand still for commands without the beginning "o mestre mandou". The experimenter performs all the actions. In total 16 trials are administered of which 8 were non-imitation trials. The task is preceded by two practice trials with corrective feed-back and children are reminded of the task rules after the first half of test trials. The dependant measure used for analyses was the sum of responses on the non-imitation trials (coded as: 3 = no movement; 2 = wrong movement; 1 = partial imitation; 0 = complete imitation). Children also completed a Brazilian Portuguese version of the *Go/No-Go* task adapted from Cragg and Nation (2008). The task is presented on a laptop computer and consists of a background scene of a soccer goal and either a soccer ball (Go trials) or a football (No-Go trials) that appears for 200ms centrally near the bottom of the screen. Children are instructed to continuously press down the left mouse button (marked with a star) with the index finger of their dominant hand. When the soccer ball is presented they have to let go of the star key and press the response key (right mouse button) as fast as possible with the same finger. When a football appears they have to keep their finger pressed down on the star key (see Cragg & Nation, 2008 for a detailed description of the task). Children first complete two blocks of 10 Go trials each. Next two mixed blocks (containing Go and No-Go trials) of 32 trials each are presented. No-Go stimuli occur on 25% of the trials. The dependant measure used for analyses was the percentage of correct responses in the mixed blocks. Go trials were scored as correct if the child released the star key and pressed the adjacent response key. No-go trials were scored as correct if the child continued pressing the star key.

Children completed two computerized measures of interference suppression that were administered with response buttons on each side of the computer screen. In the *Flanker* task (described in detail in Engel de Abreu, Cruz-Santos, Tourinho, Martin, & Bialystok, 2012) children are asked to indicate as fast as possible the direction of a central fish in a row of five fish by pressing the corresponding left or right response button as quickly as possible. On congruent trials (50%), the flanking fish are pointing in the same direction as the target, and on incongruent trials, the distracter fish point in the opposite direction. In the *Simon* task (based on Bialystok, Craik, Klein, & Viswanathan, 2004) children have to press the green response button if a green teddy bear appears on the screen and the yellow button if a yellow teddy bear appears. Each trial starts with a 1,000-ms fixation cross in the middle of the screen, followed by a green or a yellow teddy bear that appears either left or right from fixation for 5,000 ms or until a response is made. Responses are followed by feedback (1,000 ms) and a 400-ms blank interval. Half the trials are incongruent, so the colored teddy bear appears on the side opposite to the appropriate response button. For both tasks, Flanker and Simon, children complete two blocks of 20 trials each in which presentation of congruent and incongruent trials was randomized. Eight practice trials precede the experimental trials. If more than two errors occur on these trials, the instructions and the practice are repeated until the child reaches the criterion level. The dependant measures used for analyses were the reaction times (RTs) on incongruent trials (excluding incorrect responses, RTs below 200 ms, and RTs above 3 *SD* of individual means).

## 3. Results

Cronbach's alpha's for the WMRS-Br across the total sample was .98, with coefficients of .97 and .98 for private and public school samples respectively. Intercorrelations between the 20-items were high (Pearson's correlation coefficients ranging from .50 to .87) and exploratory factor analysis with oblique rotation showed that a single factor accounted for 69.16% of the total variance (61.78% for private and 71.49% for public schools). This suggests that the WMRS-Br manifests satisfactory internal reliability and convergent validity across the Brazilian sample.

Next, confirmatory factor analyses were performed on the covariance structure to evaluate the relative fits of the complete 20-items WMRS model and of the short 5-item model as suggested by Normand and Tannock (2012). Maximum likelihood estimation was applied using AMOS 19 (Arbuckle, 2010) and model fit was assessed with the $\chi^2$ statistic (nonsignificant = good fit); the Comparative Fit Index (CFI; Bentler, 1990; above .90 = acceptable fit), and the Root Mean Square Error of Approximation (RMSEA; Browne & Cudeck, 1993; below .10 = acceptable fit). Fit statistics in Table 2 indicate that the complete 20-item Model 1 provided a bad account of the data for both public and private school samples: $\chi^2$ values were high, CFI indexes were below .90, and RMSEA values were above .10. The higher end of the interitem correlation range was above .86 suggesting redundancy of the items. In contrast to Model 1, the short 5-item Model 2 fitted the data better as indexed by CFI values above .98 and RMSEA indexes below .10. Internal consistency coefficients of Model 2 were high, with Cronbach's alphas ranging from .91 to .92.

Table 2 about here

Standardized factor loadings of the 5 items on the WMRS factor were significant and ranged homogeneously from .72 to .92 for private schools and from .76 to .92 for public schools (Table 3). Multiple group analyses were conducted in which factor loadings across private and public schools were constrained to be equal. Fit statistics were acceptable [$\chi 2$ (13) = 21.72, $p$ = .06; CFI = .99; RMSEA = .04] and the $\chi^2$ difference with the unconstrained model was non-significant [$\Delta\chi 2$ (3) = 4.82, $p > .10$] indicating that a model specifying an invariant factor pattern across public and private schools provided a good account of the data.

Table 3 about here

A next set of analyses explored the relationship between the WMRS-Br (complete and short version) and objective measures of verbal and visuo-spatial WM, general fluid intelligence, and attentional capacities. Zero-order correlation coefficients together with descriptive statistics are provided in Table 4. Skewed variables were transformed as necessary to comply with the assumption of normality. The data showed that children from public schools presented significantly more problematic WM classroom behaviors than children from private schools [short WMRS-Br: $t$ (353) = 2.73, $p < .05$; complete WMRS-Br: $t$ (353) = 3.05, $p < .05$]. The same pattern emerged for the objective cognitive measures of WM with private school children outperforming their public school peers on all four AWMA measures ($p$'s < .001 in each case). The data further showed that the short and the complete version of the WMRS-Br were strongly related ($r = .93$) and manifested similar patterns of association with the cognitive measures. The WMRS-Br was most strongly associated with the verbal WM measures and manifested medium links with visuo-spatial WM. Notably, the WMRS-Br scores correlated more strongly with the WM measures than with fluid intelligence indicating that teachers were not merely assessing children's general cognitive abilities when completing the rating scale. The WMRS-Br manifested medium links with selective attention, switching, and interference suppression and small associations with response inhibition.

Table 4 about here

The last part of the analyses explored the efficacy of the WMRS-Br to identify children with WM problems. From the total sample of 355 children, 22 children with low performance on the AWMA measures (scores of at least 1 *SD* below the mean on 3 out of 4 WM tasks) were assigned to the low WM group (45% of girls and 82% of children from public schools). The low WM children were matched on age and socioeconomic status with a sample of 22 children with average WM performance selected from the same schools and classrooms. Results in Table 5 indicate that the low WM children scored significantly higher on the WMRS-Br compared to the average WM children. Effect sizes were large (Cohen's $d$ of 1.47 and 1.14) and in a similar range to the effect sizes of the objective WM measures (Cohen's *d*s ranging from 1.31 to 2.18). Notably groups did not differ significantly on the Ravens measure of fluid intelligence.

Table 5 about here

## 4. Conclusion

The aim of this study was to adapt the WMRS into Brazilian Portuguese and explore its psychometric properties and links with objective measures of WM and attention in a population of Brazilian children from a range of socioeconomic status and schooling backgrounds. A particular interest was to examine whether WM screening can be achieved with a short version of the original scale as suggested by Normand and Tannock (2012), and whether the WMRS provides a valid instrument for assessing WM behavior in challenging educational settings and in socially vulnerable populations.

Results indicate that the WMRS-Br manifests good internal reliability and construct validity. Higher teacher ratings were associated with lower scores on objective measures of WM and children identified with very poor WM received significantly higher scores on the WMRS-Br than children with average WM skills despite comparable performance on a test of fluid intelligence. These findings establish convergence between the rating-based WMRS-Br and direct cognitive assessments of WM in a Brazilian sample. Importantly, the psychometric properties of the WMRS-Br were highly similar to the ones of the original English version (Alloway et al., 2009a), demonstrating firstly that the adaptation of the scale into Brazilian Portuguese was adequate and secondly that the WMRS represents a reliable and valid tool that can be used in cultural and educational settings that extend beyond the UK and Canada.

The study further showed that scores on the WMRS-Br were differentially associated with children's attentional capacities. Links emerged between the WMRS-Br and objective measures of selective attention, switching, and interference suppression but not with response inhibition. These results are consistent with other studies in which scores on the WMRS were associated with some aspects of attention but separable from others linked with inhibition and self-regulation (Alloway et al., 2009b; St Clair-Thompson, 2011). Our findings also fit well with evidence showing that children with WM deficits have a highly specific attentional profile that is distinguishable from children with a clinical diagnosis of ADHD. Whereas children with WM impairments generally present short attention spans and exhibit high levels of distractibility, they rarely manifest symptoms of impulsivity which are typically present in ADHD (Alloway et al., 2010; Gathercole et al., 2008; Martinussen & Tannock, 2006). Importantly, response inhibition has been linked to impulsivity and is suggested to play a key role in the manifestation of impulsivity in ADHD (Chamberlain & Sahakian, 2007). The present findings complement these studies with clinical populations. Whereas WM behaviors were associated with performance on attention measures that involve filtering distracting information, they were unrelated to measures of response inhibition which are typically linked to impulsivity.

The presented research replicates the findings of Normand and Tannock (2012), suggesting that a short WMRS can provide a valid screening tool for identifying WM problems in the classroom, and extends them to young children from different socioeconomic backgrounds in Brazil. Confirmatory factor analyses showed that the short 5-item WMRS model was superior to the original model in the Brazilian sample. The reduced scale manifested good internal consistency, item-total correlations, and validity that were similar to the ones obtained in the Canadian sample. Furthermore, the pattern of association of the short scale with objective measures of WM and attention was highly similar to the complete WMRS-Br, indicating that little information was lost in cutting out three quarter of the original item pool. It is worth noting that the five key items did not pose any problems in the adaption process, were clear to teachers, and do not dependant on the availability of school resources.

A key issue of the study was to determine whether the WMRS-Br represents a valid instrument for detecting problematic WM skills if administered in challenging teaching conditions in the context of poverty. Brazilian public school environments have been described as being characteristically different from those found in more advantaged settings (Evans & Kosec, 2012; IDB, 2008). In the present study, public schools presented a low educational quality index and public school children came from socio-economically disadvantaged backgrounds. There were two major concerns in using teacher rating scales to assess WM behavior in such school settings. Firstly, poor training, low salaries, and limited school resources might interfere with the motivation or diagnostic competence of public school teachers to reliably assess WM behaviors in the classroom. Secondly, teacher ratings in public schools might be more open to a negative halo effect where disruptive behavior associated with poverty are more likely to result in the child being rated as presenting low WM skills despite there being an absence of WM problems. These hypotheses were not confirmed by the study. Instead, results indicate that the WMRS-Br manifested excellent psychometric properties in the public school sample and signs of problematic WM behavior, as recognized by Brazilian public school teachers, were related to lower performance on objective tests of WM. These findings are promising and particularly relevant for developing countries where reliable and cost-effective screening tools are often lacking (Salles et al., 2011).

The findings have important practical implications for improving efficiency in detecting children at risk of educational underachievement. WM is associated with academic attainment and WM weaknesses are linked to clinical conditions like ADHD and other learning disorders

(Alloway et al., 2010; Gathercole et al., 2004; Martinussen et al., 2005; Willcutt et al., 2005). The early identification of poor WM skills is thus clearly desirable in order to prevent subsequent learning difficulties. As standard cognitive assessments are associated with high costs, WM impairments go often undetected in children growing up in poverty. A reliable and cost-effective measure like the WMRS-Br, that is quick to score and easy to interpret by a non-specialist, therefore represents a particularly valuable tool in countries like Brazil with a shortage of public health services, in order to determine whether referral for time-intensive and expensive cognitive assessment is warranted.

To our knowledge this is the first study that adapts the WMRS into another language and uses it in a large and diverse sample of students in an educational context that differs from previous studies conducted in Anglo-Saxon countries (Alloway et al., 2009a; Normand & Tannock, 2012). Taken together, the study indicates that the WMRS represents a suitable assessment tool with useful screening properties in a Latin American context and with children from a range of socioeconomic backgrounds. Furthermore, the study provides additional evidence that a short version of the scale has the potential to effectively identify children with poor WM skills in the classroom. A time-effective reduced WMRS might be particularly useful for teachers that are dealing with heavy teaching loads and large class sizes. Finally, the scale was found to have diagnostic utility for teachers in challenging educational settings with socially vulnerable populations. The WMRS-Br might therefore have the potential to improve the early detection of WM deficits in children growing up in poverty in Brazil, so that appropriate remediational support can be provided which might help to improve children's educational opportunity and future life chances.

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Table 1

Descriptive statistics (with *SD* in parenthesis) and significance tests for demographic data

| | Total (N = 355) | Private (N = 173) | Public (N = 182) | $F$ or $\chi^2$ (1, 353)[1] |
|---|---|---|---|---|
| Age (months) | 89.11 (7.84) | 88.77 (8.44) | 89.43 (7.22) | .63 |
| Sex (% female) | 51.30 | 49.70 | 52.70 | .33 |
| Grade (% in Year 1) | 50.40 | 48.60 | 52.20 | .47 |
| Ethnicity (%) | | | | |
| Caucasian | 44.80 | 72.80 | 18.10 | 107.32* |
| Afro-Brazillian | 11.80 | 1.20 | 22.00 | 36.86* |
| Multiracial | 43.40 | 26.00 | 59.90 | 41.45* |
| Poverty index[2] (% below the poverty line) | 12.70 | .00 | 24.70 | 48.98* |
| International Socio-Economic Index[3] | 52.57 (21.67) | 70.24 (14.31) | 35.77 (11.92) | 610.38* |
| Nutritional status (Body Mass Index-for-age) | .71 (1.29) | .80 (1.22) | .63 (1.34) | 1.46 |
| Class size (number of students) | 21.38 (6.69) | 17.56 (5.05) | 25.02 (6.00) | 159.47* |

Note: [1]one-way ANOVA for continuous variables and Pearson chi-square statistics for categorical variables. [2]USD 2.50-a-day poverty line. [3]Ganzeboom, 2010. **p* < .001.

Table 2

Fit indices of the confirmatory factor analyses models for the complete 20-item and the short 5-item WMRS-Br models

| Sample | N | $\chi^2$ | *df* | *p* | CFI | RMSEA | α | Interitem correlation range |
|---|---|---|---|---|---|---|---|---|
| | | | | Model 1: 20-item one-factor model | | | | |
| Total sample | 355 | 1002.7 | 170 | .00 | .89 | .12 | .98 | (.50, .87) |
| Private | 173 | 811.83 | 170 | .00 | .81 | .15 | .97 | (.25, .88) |
| Public | 182 | 651.63 | 170 | .00 | .89 | .13 | .98 | (.47, .90) |
| | | | | Model 2: 5-item one-factor model | | | | |
| Total sample | 355 | 8.73 | 5 | .12 | 1.00 | .05 | .92 | (.62, .77) |
| Private | 173 | 12.9 | 5 | .02 | .99 | .09 | .91 | (.59, .80) |
| Public | 182 | 4.01 | 5 | .55 | 1.00 | .00 | .92 | (.53, .82) |

Note: WMRS-Br = Working Memory Rating Scale Brazilian Version.

Table 3

Standardized factor loadings (with $R^2$ values in parenthesis) for the 5-item WMRS-Br model

| Item | | Total sample | Private | Public |
|---|---|---|---|---|
| 4 | Abandona atividades antes de completá-las<br>(*Abandons activities before completion*) | .76 (.58) | .72 (.52) | .76 (.58) |
| 10 | Se beneficia da ajuda contínua do professor(a) durante tarefas mais longas<br>(*Benefits from continued teacher support during lengthy activities*) | .84 (.71) | .78 (.61) | .86 (.74) |
| 14 | Não segue corretamente as instruções em sala de aula (ex: segue bem alguns, mas não todos, os passos de uma instrução)<br>(*Does not follow classroom instructions accurately, e.g. carries out some but not all steps in an instruction*) | .81 (.66) | .81 (.66) | .81 (.66) |
| 16 | Está tendo pouco progresso em leitura e matemática<br>(*Is making poor progress in literacy and math*) | .84 (.71) | .86 (.74) | .83 (.68) |
| 20 | Depende do colega sentado ao lado para lembrá-lo(a) da tarefa que está realizando<br>(*Depends on neighbor to remind them of the current task*) | .92 (.85) | .92 (.86) | .92 (.84) |

Note: WMRS-Br = Working Memory Rating Scale Brazilian Version. All estimates are significant at $p < .001$

Table 4

Descriptive statistics and Pearson's correlation coefficients (right hand side of the table) between the WMRS-Br and objective cognitive measures of working memory, fluid intelligence, and attention

| | | Total (N = 355) | Private (N = 173) | Public (N = 182) | WMRS-Total | | WMRS-Private | | WMRS-Public | |
|---|---|---|---|---|---|---|---|---|---|---|
| Measures | α | Mean (SD) | Mean (SD) | Mean (SD) | short | complete | short | complete | short | complete |
| Working Memory Rating Scale-Br | | | | | | | | | | |
| Short | .92 | 2.42 (3.76) | 1.65 (2.84) | 3.16 (4.34) | -- | -- | -- | -- | -- | -- |
| Complete | .98 | 9.72 (13.93) | 6.76 (10.25) | 12.54 (16.23) | .93** | -- | .90** | -- | .95** | -- |
| Verbal working memory | | | | | | | | | | |
| Digit recall | .93 | 23.28 (4.74) | 24.85 (4.42) | 21.78 (4.56) | -.40** | -.41** | -.38** | -.40** | -.37** | -.37** |
| Counting recall | .92 | 13.86 (4.43) | 15.32 (4.58) | 12.47 (3.81) | -.45** | -.43** | -.40** | -.37** | -.48** | -.45** |
| Visuo-spatial working memory | | | | | | | | | | |
| Dot matrix | .91 | 17.57 (4.16) | 19.24 (4.14) | 15.99 (3.53) | -.29** | -.29** | -.28** | -.28** | -.24** | -.23** |
| Odd-One-Out | .91 | 14.10 (4.23) | 15.30 (4.43) | 12.96 (3.71) | -.33** | -.30** | -.29** | -.23** | -.32** | -.31** |
| Fluid intelligence | | | | | | | | | | |
| Raven CPM | .82 | 20.67 (5.21) | 23.06 (5.09) | 18.40 (4.21) | -.29** | -.29** | -.24** | -.21** | -.27** | -.29** |
| Selective/focused attention | | | | | | | | | | |
| Sky search (s) | -- | 7.78 (3.95) | 6.45 (2.28) | 9.04 (4.73) | -.28** | -.30** | -.34** | -.37** | -.18* | -.18* |
| Switching/Attentional control | | | | | | | | | | |
| Opposite worlds | .66 | 90.88 (3.69) | 92.30 (2.80) | 89.53 (3.93) | -.34** | -.35** | -.29** | -.26** | -.33** | -.35** |
| Response inhibition | | | | | | | | | | |
| Simon says | .59 | 18.43 (4.64) | 18.59 (4.60) | 18.27 (4.68) | -.16* | -.17* | -.17* | -.16* | -.14 | -.17* |
| Go/No-Go (%) | .73 | 67.06 (13.26) | 66.04 (13.00) | 68.03 (13.46) | -.11* | -.13* | -.06 | -.06 | -.17* | -.20** |
| Interference suppression | | | | | | | | | | |
| Flanker RT (ms) | .87 | 1030.39 (309.97) | 977.12 (267.96) | 1081.02 (338.23) | -.27** | -.27** | -.26** | -.26** | -.24** | -.25** |
| Simon RT (ms) | .83 | 879.50 (176.00) | 835.28 (166.54) | 921.53 (174.88) | -.29** | -.29** | -.26** | -.25** | -.27** | -.27** |

Note: WMRS-Br = Working Memory Rating Scale Brazilian Version; Raven CPM = Raven's Coloured Progressive Matrices; RT = reaction time; square root transformation of Dot Matrix, Raven, Opposite Worlds, and Simon Says; inverse transformation of the short WMRS-Br, Sky Search, Flanker and Simon tasks; log transformation of the complete WMRS-Br. For ease of interpretation means and *SD* of the untransformed variables are reported. $*p < .05$. $**p<.01$.

Table 5

Descriptive statistics and significance tests for objective measures of working memory, fluid intelligence and the WMRS-Br according to working memory skills

| | Low working memory *n* = 22 | Average working memory *n* = 22 | Significance | | |
|---|---|---|---|---|---|
| Measures | Mean (*SD*) | Mean (*SD*) | *t* (42) | *p* | effect size |
| Age (months) | 88.00 (7.76) | 89.32 (7.31) | .58 | .565 | .17 |
| International Socio-Economic Index[1] | 36.59 (16.86) | 37.14 (19.19) | .10 | .921 | .03 |
| Fluid intelligence | | | | | |
| Raven CPM | 16.18 (3.03) | 18.32 (3.93) | 2.00 | .052 | .61 |
| Verbal working memory | | | | | |
| Digit recall | 17.64 (2.12) | 23.82 (4.67) | 5.37 | .000 | 1.70 |
| Counting recall | 7.77 (2.14) | 13.86 (4.10) | 6.18 | .000 | 1.86 |
| Visuo-spatial working memory | | | | | |
| Dot matrix | 12.64 (2.57) | 16.82 (3.71) | 4.30 | .000 | 1.31 |
| Odd-One-Out | 8.27 (2.98) | 14.68 (2.90) | 7.23 | .000 | 2.18 |
| Working Memory Rating Scale-Br | | | | | |
| Short | 7.55 (5.19) | 1.68 (2.21) | 4.88 | .000 | 1.47 |
| Complete | 26.95 (19.82) | 8.77 (10.93) | 3.77 | .001 | 1.14 |

Note: WMRS-Br = Working Memory Rating Scale - Brazilian Version. effect sizes are Cohen's *d;*[1]Ganzeboom, 2010.