Abstract

Previous work has demonstrated that illiterate individuals exhibit reduced performance on measures of working memory, relative to a literate cohort. Given the relationship of working memory to phonological processing, which is enhanced by literacy, we sought to examine working memory in illiterate individuals and whether differences can be attributed to artifacts of the test typically used. To the extent that differences actually exist, we also examined whether they can be attributed to the effects of literacy per se or whether they reflect the effects of formal schooling. To accomplish this, we explored the performance of four groups of participants (illiterate, functionally illiterate, self-educated literate, school-educated literate), on five tests of working memory. Illiterate groups performed more poorly than the literate groups on all measures except the “Spatial Span” forward condition and “Remembering a New Route.” Our results suggest that differences in working memory performance among literate and illiterate individuals can be attributed to literacy per se. Formal schooling, however, appears to enhance working memory skills. Finally, we stress the need to use tools that are not influenced by literacy and schooling effects in the clinical assessment of illiterate individuals.

Keywords: Illiteracy; Neuropsychology; Cognitive; Functional illiteracy; Self-educated; Attention span

Introduction

Illiterate individuals represent a substantial proportion of the world population (UNESCO, 2008), and in industrialized countries, they are clearly over-represented among the elderly. Data published by the National Statistical Service of Greece (2000) showed that 13.6% of the population of ≥65 years of age had never attended school, while the rates in other age groups ranged from 0.003 to 0.007 for those 15–44 years old and 0.03 among 45–64-year olds. Thus, they pose both a challenge and an opportunity for neuropsychologists. Traditional psychometric tests based on school-related activities may be biased for this group; therefore, identifying and developing appropriate methods for assessing their cognitive functioning is imperative. Moreover, investigating differences and similarities in cognitive functioning in literate and illiterate groups afford a unique opportunity to explore the ways in which brain functioning is influenced by the attainment of grapheme to phoneme correspondence.

Several studies have documented lower scores on neuropsychological tests among illiterate individuals relative to their literate counterparts (for a review, see Ardila et al., 2010). Low scores among illiterate individuals have been observed on most cognitive tasks, including naming, delayed repetition of words (long-term memory; Folia & Kosmidis, 2003; Nitrini et al., 2004), constructional abilities (Dansilio & Charamelo, 2005; Matute, Leal, Zarabozo, Robles, & Cedillo, 2000; Ostrosky, Ardila, Rosselli, Lopez-Arango, & Uriel-Mendoza, 1998), phonological verbal fluency, language comprehension, concept functions (Ostrosky et al., 1998), mental spatial organization, focused and divided attention, visual-organizational skills, and cognitive processing (Van Linden & Cremers, 2008). In a study evaluating memory and attention across the life span...
(Gomez-Perez & Ostrosky-Solis, 2006), the investigators found that attention-working memory was one of the functions most sensitive to educational level. The link between literacy and cognitive abilities was, perhaps, most clearly demonstrated in a study in which illiterate adults learned to read (e.g., through the Neuroalfa method), as they improved their scores on several cognitive measures (Ardila, Ostrosky-Solis, & Mendoza, 2000).

The significance of these findings is 2-fold. On the one hand, discrepancies between cognitive functioning in literate and illiterate individuals provide a means through which to explore the effects of literacy attainment on the brain. On the other hand, such discrepancies lead to concern regarding the appropriateness of the cognitive measures used in clinical and other assessments, given their potential for underestimating, and, thus, over-diagnosing illiterate individuals.

One of the many cognitive functions on which illiterate individuals exhibit decreased performance is that of working memory (Castro-Caldas, Peterson, Reis, Stone-Éländér, & Ingvar, 1998; Gomez-Perez & Ostrosky-Solis, 2006; Kosmidis, Tsapkini, & Folia, 2006; Reis & Castro-Caldas, 1997). This function is an essential precondition for the expression of many others and has been found to relate to fluid intelligence (Engle, Tuholski, Laughlin, & Conway, 1999). Working memory plays a role in a multitude of daily cognitive processes, such as decision-making and judgment, as it facilitates activities such as mental accounting, risk estimation, and perception of the effects of context on making judgments and comparisons. Moreover, there is growing evidence that working memory is involved in language and vocabulary acquisition as well as in language processing.

Several studies have found a reciprocal relationship between working memory and both vocabulary and reading. They have reported a positive correlation between vocabulary and digit span (Gathercole, Service, Hitch, Adams, & Martin, 1999; Kormos & Safar, 2008), as well as between vocabulary and pseudo-word repetition (Gathercole, Briscoe, Thorn, & Tiffany, 2008; Gathercole, Willis, Emmslie, & Baddeley, 1992; Gathercole et al., 1999; Jarrold, Thorn, & Stephens, 2009)—the latter being a test used to evaluate the phonological loop component of the working memory model (Baddeley, 1999; Hoff, Core, & Bridges, 2008), which underlies verbal working memory. Several investigators have suggested that the phonological loop facilitates language acquisition mainly through vocabulary learning and appears to be enhanced by literacy (Baddeley, Gathercole, & Papagno, 1998). The phonological loop consists of two components, a temporary storage system which holds memory traces for several seconds, during which time they decay, unless they are constantly refreshed by the second component. The second component is a subvocal rehearsal system that serves to maintain the information in temporary store, but also to register visual information for namable items within the store (Baddeley, 1999).

Several studies have shown that there are differences in explicit phonological processing capacity between literate and illiterate individuals (Castro-Caldas et al., 1998; Kosmidis et al., 2006; Reis & Castro-Caldas, 1997). Indeed, these investigators have demonstrated that literacy influences the capacity of the phonological loop, as measured by pseudo-word repetition tasks, for example, language repetition in illiterate people is equivalent to that of literates for real words, but reduced for pseudo-words. Repetition of pseudo-words is a task that relies on phonological processing (Bowey, 1996), probably involving the implicit mechanism of semantic representations as well as explicit phonological awareness (Reis & Castro-Caldas, 1997). Some researchers have proposed that the absence of a reference system related to the phonology of words limits illiterate individuals to processing words mainly via semantic strategies (Kosmidis et al., 2006; Kosmidis, Tsapkini, Folia, Vlahou, & Kiosseoglou, 2004; Reis & Castro-Caldas, 1997; Reis, Faisca, Mendoca, Ingvar, & Petersson, 2007). In other words, for illiterate people, the act of repeating pseudo-words relies mainly on their semantic representations, whereas literate individuals develop secondary reference systems through formal education. Therefore, phonological awareness of written words constitutes an important subsidiary reference system for literate individuals (Reis & Castro-Caldas, 1997). Consequently, the difficulties observed among illiterate individuals on pseudo-word repetition may be due to their use of ineffective cognitive strategies while trying to compensate for their lack of explicit phonological awareness (Kosmidis et al., 2006).

Neuroimaging research has confirmed behavioral studies suggesting differential cognitive processing in illiterate relative to literate individuals. These investigations showed that learning how to read and write may change the functional connectivity of the human brain, perhaps by influencing areas related to memory. Such explorations have demonstrated functional differences between illiterate and literate individuals in brain regions activated during language-based tests and related to verbal working memory (Castro-Caldas et al., 1998; Petersson, Silva, Castro-Caldas, Ingvar, & Reis, 2007). In a brain activation study using PET, Castro-Caldas and colleagues (1998) compared word and pseudo-word repetition in literate and illiterate participants. The two groups performed similarly on the repetition of real words, activating similar areas of the brain. Conversely, the illiterate group showed greater difficulty in repeating pseudo-words correctly and did not activate the same brain structures as literates. Specifically, the illiterate group failed to activate the anterior cingulate cortex and basal ganglia during the repetition of pseudo-words, regions which were clearly activated in the literate group. This observation led the researchers to the conclusion that the literate group, probably through the acquisition of phoneme-grapheme correspondence, had a trained system for phonological attention/awareness (Castro-Caldas et al., 1998). Additionally, Petersson and colleagues (2007) found that illiterate participants consistently showed greater right hemisphere lateralization in the inferior parietal cortex than their literate controls. These
results provided evidence suggesting that literacy influences the functional hemispheric balance between the right and the left inferior parietal zone, brain regions related to reading and verbal working memory (Petersson et al., 2007).

Based on the aforementioned findings, we can make inferences regarding the relationship between reading and the phonological loop. It appears that reading activates the phonological loop, thus providing increased opportunities for training or practicing working memory skills. Presumably, illiterate individuals lack such opportunities for activating the phonological loop and improving their working memory.

If illiterate individuals are less effective than literate individuals on measures of working memory, this raises a major concern: The potential effect of working memory on other cognitive abilities may lead to an underestimation of their cognitive functioning and, thus, to misdiagnosis. In fact, in our previous work (Folia & Kosmidis, 2003), we found that poor word list learning among illiterate individuals was an artifact of the nature of the test, as this same group performed as well as a literate cohort on an object learning analog. Therefore, the fact that past investigations have relied almost exclusively on one test, namely, “Digit Span” to assess working memory among illiterate individuals leads to questions regarding the generalizability of these findings to other measures of working memory. School-based skills are often inherent in psychometric tests such as “Digit Span.” Thus, the use of such tests with illiterate individuals might introduce a bias into the assessment, as most have never attended school. Therefore, any investigation of the effects of literacy on working memory would warrant inclusion of a way to separate the effects of literacy from those of formal schooling, in order to define more clearly which measures of working memory could lead to an underestimation of the capacities of illiterate individuals.

Despite the well-documented finding that literacy enhances cognitive skills, it is usually associated with schooling and only a few studies have attempted to separate these effects. One such investigation involved an ethnic group in Liberia, the Vai, who were literate despite never having attended school (Scribner & Cole, 1981; cf. Ardila et al., 2010). In this study, the researchers demonstrated that some cognitive skills are associated with literacy, but not necessarily with schooling. Similarly, in an attempt to disentangle the effect of education from literacy, Kosmidis and colleagues (2004, 2006) found a double dissociation of sorts, wherein literacy per se enhanced the capacity of the phonological loop component of working memory, but level of education influenced lexical decision-making and semantic processing.

In the present study, we sought to explore the differential effects of literacy versus formal schooling on working memory capacity. In our previous work, we separated the effect of formal education from literacy by comparing three groups on measures of semantic and phonological processing: Literate/high level of education (>9 years), semi-literate/low level of education (1–9 years), and illiterate (no formal schooling) individuals (Kosmidis et al., 2004). We were thus able to discern the effect of education on semantic processing, but literacy on phonological processing. In the present undertaking, we had access to four groups of literate and illiterate adults: Individuals who attained literacy through formal schooling, those who were self-taught and literate, despite lacking formal schooling, individuals who had attended school for a short period of time, but had forgotten (or never actually learned) how to read and write, consequently being functionally illiterate, and illiterate individuals with no schooling.

A second aim in undertaking the present study was to investigate the appropriateness of various neuropsychological tests for illiterate individuals. For this reason, we included “Spatial Span” (Wechsler Memory Scale-III; Wechsler, 1997) and “Remembering a New Route” (Rivermead Behavioural Memory Test, RBMT; Wilson, Cockburn, & Baddeley, 2003). We reasoned that due to their characteristics, they might not be affected by the attainment of literacy to the same degree as the other tests included in the present assessment (i.e., “Digit Span” and “Sentence Span”). Whereas Digit Span mainly relies on the capacity of the phonological loop (Gathercole, 2006; Gathercole et al., 1999), which is known to be enhanced with schooling, Spatial Span measures visual working memory, and presumably mostly relies on the capacity of the visuospatial sketchpad, another working memory component underlying the storage of visuospatial information. This function is considered to be involved in many daily activities, including orienting ourselves and navigating in our immediate environment, judging the position of other drivers while driving, or searching for our keys, reading glasses, and so forth, activities in which most people usually engage regardless of their level of literacy (or lack thereof; Baddeley, 1999). The “RBMT” has been found to be minimally affected by educational level, probably due to its simulation of everyday-type activities (Yassuda et al., 2009).

In sum, given the importance of working memory as a precondition for the execution of many cognitive processes, and given the relationship of working memory to explicit phonological processing, which is enhanced by literacy, we wondered about the source of the reported differences between literate and illiterate individuals on this cognitive function. More specifically, we sought to answer the following questions: (1) Do illiterate individuals actually have a shorter or less effective working memory/attention span, or might previous reports be attributable to artifacts of the test typically used (i.e., Digit Span)? (2) To the extent that differences do, in fact, exist between literate and illiterate individuals on a variety of tests of working memory, do they reflect skills acquired through formal education, or merely through the acquisition of reading and writing skills? (3) Finally, might other tests of working memory/attention span be more ecologically valid and, thus, fairer for illiterate individuals?
Method

Participants

We examined 65 healthy adults (59 women). Their ages ranged from 60 to 80. In addition to their self-report regarding their education, all participants were screened for reading ability using a first-grade reading test. The reading test comprised the recognition of letters, reading syllables and words aloud, as well as reading a short text with questions regarding comprehension of the passage.

Since we were interested in separating the effects of formal education on literacy, we divided our participants into four groups based on their success on the reading screening test, as well as their self-reported school attendance. The four groups are described below:

1. **Illiterate** [n = 20 women; mean age = 69.55 (SD = 7.16)]. These participants failed to read letters, syllables, or words on the screening test and reported no formal schooling.
2. **Functionally illiterate** [n = 12, 10 women; mean age = 67.08 (SD = 5.96)]. These participants failed to read letters, syllables, or words on the screening test, despite their report that they had attended school (range = 1 month to 3 years).
3. **Self-educated literate** [n = 6 women; mean age = 67.00 (SD = 7.18)]. These participants read letters, syllables and words on the screening test successfully and reported that they had learned how to read and write while helping their children with their homework, but had never attended school themselves.
4. **Educated literate** [n = 27, 23 women; mean age = 65.26 (SD = 6.88)]. These participants read letters, syllables, and words on the screening test successfully and reported having attended school, where they learned how to read and write (range = 1–6 years).

All participants in the present study had a similar socio-cultural background. They were raised in a highly homogeneous rural community in the Greek province of Thessaly. The reasons they stated for not attending school or for early drop-out were mainly socio-economic. The participants were of school age during and after World War II and the Civil War in Greece. Therefore, poverty and social roles dictated whether or not they would attend school. Typically, in many homes, the eldest daughter took on the responsibility of child-rearing, while the parents worked outside the home. Additionally, the majority of the population of this town had immigrated to Germany, the Netherlands, Australia, and Canada in the 1960s. Therefore, many of the participants in the present study had traveled abroad, with some traveling frequently or even retaining two homes, spending half of the year in their village and the other half abroad. Interestingly, a few also spoke a foreign language (namely, that of the country to which they had immigrated in the past).

All participants provided written informed consent (the examiner read the form for those who could not read themselves) and were treated according to the ethical guidelines set forth by the Declaration of Helsinki.

Procedure

We administered the same battery of tests and in the same order to each participant. The duration of the battery, in total, did not exceed 1 h. Our battery included tests that are widely used as standardized measures of working memory and attention span, as well as measures we thought might approximate activities of daily life (see below).

Materials

1. **Hindi Mental State Examination** (Ganguli et al., 1995) (developed specifically for the assessment of illiterate individuals), for a brief cognitive screening. Variable: Total score.
2. **Geriatric Depression Scale** (short form) (Sheik & Yesavage, 1986), for measuring potential depression (as it might influence cognitive performance). (We should note that the examiner read the questions to all participants; participants then responded verbally.) Variable: Total score.
3. **Digit Span** from the Wechsler Adult Intelligence Scale-III (Wechsler, 1997), for measuring working memory. Variables: Maximum span (number of digits repeated) forward and backward.
4. **Spatial Span** from the Wechsler Memory Scale-III (Wechsler, 1997), for measuring short-term spatial memory. Variables: Maximum span (number of blocks tapped) forward and backward.
(5) *Sentence Span*, inspired by the “Listening Span” test of Daneman and Carpenter (1980). The examiner read a series of sentences, after having asked the participants to retain and repeat only the last word of each sentence. In an approach analogous to the aforementioned attention span tests, sentences were read first two at a time, then three at a time, then four at a time, and so forth. The examinee had to complete all three sets of sentences at each level of difficulty in order to proceed to the next level. Variable: Maximum number of last words repeated on a single trial.

(6) *Remembering a New Route*, a subtest of the RBMT (Wilson, Cockburn, & Baddeley, 2003). The examiner indicated a route in the room, while demonstrating and verbally identifying the landmarks: Chair–door–window–table–chair. When following this route, the examinee was also asked to carry an envelope containing a “message” and to leave it on the table.

Results

Given the small and unequal sample sizes, comparisons involving the four groups were carried out using Kruskal–Wallis non-parametric analyses of variance. The four groups did not differ significantly with respect to age, $\chi^2(3) = 3.393, p > .05$, general cognitive status (which was normal for all groups), $\chi^2(3) = 6.923, p > .05$, or depression (which was low for all groups), $\chi^2(3) = 3.747, p > .05$.

Further analyses yielded a significant group effect on Digit Span forward, $\chi^2(3) = 26.698, p < .001$, Digit Span backward, $\chi^2(3) = 16.902, p \leq .001$, *Sentence Span*, $\chi^2(3) = 28.082, p < .001$, and the backward condition of Spatial Span, $\chi^2(3) = 16.788, p \leq .001$. The forward condition of Spatial Span, as well as Remembering a New Route, did not yield a significant group effect.

The Mann–Whitney pair-wise group comparisons were conducted on those tests, which yielded a group effect. We found that overall, the illiterate groups performed worse than the literate groups on all tests. The uneducated and the functionally illiterate group on Digit Span forward ($Z = -2.593, p < .01$) and *Sentence Span* ($Z = -2.833, p < .01$). Similarly, in comparisons of the two groups with some schooling, the literate group outperformed the functionally illiterate group on Digit Span forward ($Z = -2.368, p < .05$), Spatial Span backward ($Z = -2.394, p < .05$), and *Sentence Span* ($Z = -3.377, p < .001$). This pattern of findings led to the conclusion that it is literacy *per se*—not formal schooling—that influences performance. Median performance (chosen instead of means as more relevant to the non-parametric analyses conducted) on each test by a group is shown in Table 1.

Discussion

The present findings suggest that literate individuals perform better than illiterate individuals on measures of working memory, regardless of any formal schooling. This difference appears to reflect the acquisition of literacy *per se*, and the

<table>
<thead>
<tr>
<th>Groups</th>
<th>DSpf (medians)</th>
<th>DSpb (medians)</th>
<th>SpSpf (medians)</th>
<th>SpSpb (medians)</th>
<th>SentSp (medians)</th>
<th>Route (medians)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illiterate versus literate</td>
<td>5 &lt; 6***</td>
<td>2 &lt; 3***</td>
<td>6 = 7</td>
<td>2 &lt; 6***</td>
<td>0 &lt; 2.3***</td>
<td>5 &lt; 5*</td>
</tr>
<tr>
<td>Illiterate versus self</td>
<td>5 &lt; 6.5*</td>
<td>2 = 2</td>
<td>6 = 7</td>
<td>2 = 3.5</td>
<td>0 &lt; 2**</td>
<td>5 = 5</td>
</tr>
<tr>
<td>Illiterate versus functionally illiterate</td>
<td>5 = 5</td>
<td>2 = 3</td>
<td>6 = 7.5</td>
<td>2 = 3</td>
<td>0 = 0</td>
<td>5 = 5</td>
</tr>
<tr>
<td>Functionally illiterate versus self</td>
<td>5 &lt; 6.5*</td>
<td>3 = 2</td>
<td>7.5 = 7</td>
<td>3 = 3.5</td>
<td>0 = 2</td>
<td>5 = 5</td>
</tr>
<tr>
<td>Functionally illiterate versus Literate</td>
<td>5 &lt; 6***</td>
<td>3 &lt; 3*</td>
<td>7.5 = 7</td>
<td>3 &lt; 6*</td>
<td>0 &lt; 2.3***</td>
<td>5 = 5</td>
</tr>
<tr>
<td>Self versus literate</td>
<td>6.5 = 6</td>
<td>2 &lt; 3*</td>
<td>7 = 7</td>
<td>3.5 = 6</td>
<td>2 = 2.33</td>
<td>5 = 5</td>
</tr>
</tbody>
</table>

Notes: DSpf = Digit Span forward, DSpb = Digit Span backward, SpSpf = Spatial Span forward, SpSpb = Spatial Span backward, SentSp = Sentence Span, sample size: illiterate group = 20, functionally illiterate group = 12, self-educated group = 6, and literate group = 27. Kruskal–Wallis comparisons for four independent groups were conducted to detect group differences. Paired comparisons were done with Mann–Whitney U-tests. The direction of significant differences is depicted with the “<” symbol.

*p < .05.

**p < .01.

***p < .001.
concomitant development of explicit phonological processing/awareness, rather than other cognitive skills typically trained in school. In the two literate groups, schooling gave an advantage only on the Digit Span backward condition; the fact that literacy conferred an advantage on this task was also demonstrated by the better performance of the self-educated compared with the functionally illiterate group. The illiterate and functionally illiterate groups were indistinguishable from each other. Consequently, we propose that improved cognitive performance with the acquisition of literacy—at least on working memory tasks, if not others, as well—can be attributed to the further development or training of phonological processing and working memory skills through the acquisition of literacy per se, rather than to the multitude of other skills and values typically learned in school.

We examined a group of participants who were literate, but had never attended school (self-educated literate group), as well as a group that had attended school for a short period of time, but were actually illiterate (functionally illiterate group), in order to isolate the effect of formal schooling from the effect of literacy. We cannot, however, be sure—and this constitutes a limitation of the present study—that the functionally illiterate group was homogeneous with respect to the skills learned in school, since their reported duration of school attendance was minimal, varied, and, in some cases (i.e., during World War II), may not have been continuous. This means that within this group, some individuals might have acquired and retained some skills, others might have acquired some skills that were forgotten over time, while yet others might never have acquired any skills at all. Another potential limitation to the generalizability of the present findings pertains to the sex ratio within the sample, which was predominantly woman. Consequently, our findings may not necessarily be typical of a male cohort.

Given the aforementioned caveats, our conclusion concerning literacy versus formal schooling relies mostly on the results of the comparisons between the self-educated group and each of the other groups, since literacy and lack of formal schooling are factors clearly controlled in these cases. As noted earlier, the self-educated and the literate group performed equally well on all tasks with the exception of the Digit Span backward condition. On the other hand, the self-educated group performed significantly better than the illiterate individuals on the Digit Span forward condition and Sentence Span tasks specially designed to tap verbal working memory. Since both groups lacked formal schooling, the observed differences may be attributed to the acquired knowledge of literacy.

A closer look at the data, however, revealed additional information concerning the effects of literacy and schooling. Digit Span backward did not differentiate the self-educated from the illiterate groups. In other words, even though the acquisition of literacy differentiated the self-educated group from the illiterate groups with respect to several tasks of working memory, this group did not seem to reach the level of literate individuals on a more challenging task. The fact that Digit Span backward is a school-type task of advanced difficulty compared with the other measures used in the present study may provide a sufficient explanation of the aforementioned finding. This finding also raises questions about the extent to which literacy per se can exercise abilities that are usually associated with formal schooling. Therefore, the present findings suggest that literacy strengthens working memory, but that this skill may be reinforced and further cultivated through formal education, presumably as one develops learning strategies. If this is the case, the difference between school-educated and self-educated literates favoring the former group on Digit Span backward could be attributed to further training of this skill through formal education.

With respect to our question regarding whether illiterate individuals actually have a shorter or less effective working memory/attention span than literates, our findings replicate and extend previous reports of poor working memory in illiterate individuals (Ardila, Rosselli, & Rosas, 1989; Gomez-Perez & Ostrosky-Solis, 2006; Kosmidis et al., 2006; Ostrosky et al., 1998). Illiterate individuals in the present study performed worse than literate individuals on all tests with the exception of Spatial Span forward.

One of our additional goals in undertaking the present study was to investigate the ecological validity of tests assessing working memory in illiterate individuals. Therefore, we consider our finding that the Spatial Span forward condition did not differentiate the illiterate from the literate group particularly interesting. We speculate that the equivalence in the performance of all four groups on this task reflects the fact that it is based on cognitive processing that is not trained in school; thus, those with a school education had no advantage. Whereas the capacity of the phonological loop (as measured by Digit Span) is known to be enhanced through the acquisition of literacy, vocabulary, and formal education, visuospatial working memory (as measured by Spatial Span) is exercised in everyday life, as it is involved in many daily activities (Baddeley, 1999). The importance of using tasks that simulate everyday life when assessing the cognitive abilities of illiterate individuals has been highlighted in several studies (Folia & Kosmidis, 2003; Yassuda et al., 2009). In our findings and in accordance with our hypothesis, the Remembering a New Route task did not differentiate the self-educated literate group from the illiterate groups, and the literate from the functionally illiterate group, suggesting that, along with the Spatial Span forward condition, it might have greater ecological validity than Digit Span and Sentence Span. One caveat regarding this test, however, is the fact that in healthy individuals it yields a ceiling effect.

The present findings raise concerns relative to the applicability of traditional neuropsychological tests to illiterate populations. When assessing illiterate individuals in a clinical context, it is important to obtain reliable criteria that are not
subject to bias. Measures with ecological validity and empirical support should be preferred in general, but certainly specifically when testing illiterate individuals.

In conclusion, our findings suggest that poor performance of illiterate individuals on measures of working memory can be attributed to the absence of literacy and not to the absence of formal schooling. They also suggest, however, that working memory skills might be reinforced through formal schooling. Additionally, we stress the need to use ecologically valid tools in order to avoid bias when assessing illiterate individuals. The present findings suggest that Spatial Span is an appropriate test for assessing working memory in illiterate individuals, but that Digit Span and Sentence Span may not be.

Funding

None.

Conflict of Interest

None declared.

References


