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Lifelong Reading Disorder and Mild Cognitive Impairment: Implications for Diagnosis

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Abstract

Although neuropsychological tests are commonly used in the evaluation of possible mild cognitive impairment (MCI), poor test scores may be indicative of factors other than neurological compromise. The current study assessed the role of lifelong reading disorder on MCI classification. Community dwelling older adults with a suspected developmental reading disorder were identified by inference based on reading test performance. Individuals with a suspected reading disorder were significantly more likely to perform at a level consistent with MCI on several commonly used neuropsychological tests. The findings suggest a relationship between a history of reading disorder and MCI classification.

Keywords

Alzheimer's disease; cognition; dyslexia; learning disorders; memory disorders; mild cognitive impairment; neuropsychological tests

INTRODUCTION

The accurate and early identification of individuals at risk for Alzheimer's disease (AD) is a critical challenge for medical professionals treating older adults. In 2011 the National Institute on Aging established new criteria and guidelines for the classification of mild cognitive impairment due to AD (MCI) [1]. The core criteria for MCI entail a report of subjective decline, objective evidence of change in cognition from baseline, impairment in

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one or more cognitive domains, preservation of independence in functional abilities, and no indication of dementia.

Although report of decline in cognitive functions makes up a critical component of the MCI diagnosis, reliance on an individual's subjective experience is problematic. For example, one study found objective cognitive dysfunction to be present in only half of older adults with cognitive complaints [2]. Further cognitive complaints have been associated with nonneurological factors, such as medical disorders [3] and mood disorders.

While the use of neuropsychological measures provides an objective method of identifying neurologically based cognitive dysfunction (MCI), accurate interpretation of test performance requires a broad understanding of the factors contributing to an individual's test scores. Pre-morbid IQ, for example, can lead to MCI misclassification. Individuals with high IQ may be judged "normal for aging" when compared to available norms, but this may represent a decline from a higher prior level of ability [4]. Level of education and literacy, race, and socioeconomic status can influence test performance, and reading level may attenuate differences in neuropsychological test performance between African American and white elders [5, 6]. Bilingualism and cultural differences may also influence test performance particularly if the assessment is in English, the individual's second language. While much has been written about the bilingual advantage for executive functions [7], there is evidence for a bilingual disadvantage that includes inefficiency in word retrieval that can lead to data misinterpretation when the assessment is in the second language [8].

Notably there is little research exploring the influence of developmental history on MCI classification. It is known that many individuals with learning disorders have cognitive difficulties that persist throughout adulthood [9]. While learning disorders may be identified in terms of academic difficulty (e.g., poor reading), the underlying cognitive dysfunction is more complex. In the case of reading disorders, associated cognitive difficulties are seen in the areas of naming speed, verbal memory, and math achievement [10] as well as visual processing, attention/executive functions, and general language processing [11]. In addition, there is some evidence that memory tests that place a greater emphasis on complex language processing are associated with poorer test performance in individuals with dyslexia [12]. Further, the process of word decoding and encoding contribute to working memory burden, potentially leading to text-structure difficulties on language processing (reading) tasks [13]. Finally, the high comorbidity between reading and attention disorders suggests a potential additive contribution of multiple vulnerabilities on cognitive test performance [14].

Given that weaknesses in verbal memory, visual-spatial functions, and language functions are observed in learning disabled individuals, we question whether lifelong stable cognitive weaknesses in individuals with suspected reading disorders (SRD) may influence performance on measures commonly used to assess memory decline.

The goal of the current study was to assess the relationship between SRD and MCI classification. Because an emphasis on learning disorder identification is a relatively new component of the American educational system, assessing learning disorder history in older adults can be a challenge. In the current study, poorer word reading was used as a surrogate

measure to identify lifelong reading difficulty. We compared the likelihood of meeting psychometric criteria for MCI among those with and without poor word reading. Our hypothesis was that those with evidence of reading difficulty were more likely to be classified as MCI in comparison to those without any evidence of reading difficulty.

METHODS

Study population

The sample was comprised of participants of the community based Framingham Heart Study Offspring cohort [15] who had been administered a neuropsychological test battery as part of a larger study on brain imaging and cognition initially from 1999–2005 and a repeat examination an average of six years later, between 2002–2009. Participants with prevalent dementia, stroke, and other neurological disorders were excluded. Informed consent, approved by the Boston University Institutional Review Board, was obtained from all participants.

MCI case identification

The study analyzed delayed recall scores on three memory measures: Logical Memory-delayed recall (LM-DR); Paired Associates-delayed recall (PA-DR); Visual Reproduction-delayed recall (VR-DR) [16]. In addition, one executive functioning measure was analyzed (Trail Making Test Part B) [17]. Performance >1.5 standard deviations (SD) below age-adjusted mean on a given measure was defined as meeting the psychometric criteria for MCI.

Suspected reading disorder definition

The presence of a SRD was defined by performance on an objective measure of single word reading ability. Because general intellect was a potential confound (i.e., individuals perform poorly because of generally reduced intelligence as opposed to circumscribed reading weakness), SRD was defined as performance falling in the lowest education-specific decile on the Word Reading component of the Wide Range Achievement Test: Word Reading subtest, 3rd Edition (WRAT-III) [18]. We used a three level education variable (i.e., No High School Degree, High School Degree, or College Degree). For example, individuals with no high school degree classified with SRD were in the lowest decile of WRAT-III performance among those with no high school degree, not necessarily in the lowest decile overall.

Statistical methods

Logistic regression was used to evaluate the association between SRD and neuropsychological test performance. Results are given as odds ratios (OR) comparing the odds of meeting MCI criteria in the SRD group to the odds of meeting MCI criteria in the control group. All analyses were adjusted for age. A second model additionally adjusted for education and a third set of analyses were stratified by the three level education variable.

RESULTS

MCI and SRD

The SRD group did not differ significantly from the Normal Readers (NR) group in age, gender, or educational attainment. Demographic information for the study sample is presented in Table 1. Obtained raw scores for the neuropsychological measures are presented in Table 2. In models adjusted for age alone (see Table 3), individuals who met criteria for SRD were significantly more likely to meet the psychometric definition of MCI on PA-DR (OR = 3.36, $p < 0.001$) and VR-DR (OR = 1.93, $p < 0.05$). Additional adjustment for educational attainment did not alter the results.

To better understand the relationship between education and MCI-level cognitive test performance in individuals with SRD, the sample was stratified by educational attainment (No High School, High School, College). No relationship between SRD and MCI level performance was revealed for individuals who did not complete high school (OR ranged from 0.44 to 2.45). For individuals with a High School degree, those with SRD were more than three times as likely to be classified as MCI on PA-DR (OR = 3.72). For individuals with a college degree, the presence of SRD was associated with elevated risk of MCI for all subtypes and significantly for VR-DR and PA-DR (OR = 5.64, 3.21 respectively; See Table 4).

DISCUSSION

Neuropsychological tests allow for the objective measurement of cognitive skills. These tests are particularly useful when evaluating older adults with subjective memory complaints. However, interpretation of obtained scores requires a full understanding of all factors that may give rise to poor test performance. While reading difficulties in individuals with MCI has been reported [19] and poorer linguistic ability in nuns in early life has been associated with later AD and cerebrovascular disease [20], we are unaware of any research that has attempted to assess the relationship between SRD and performance on neuropsychological measures commonly used to identify MCI.

The main finding of the current study is that older adults with SRD are significantly more likely to perform at a level consistent with MCI on measures commonly used in the assessment of memory concerns.

Although a relationship between SRD and MCI level neuropsychological test performance was found, the nature of this relationship remains unclear. The WMS-III Paired Associates and Visual Reproduction subtests are both complex measures that involve a range of cognitive processes. Paired Associates is particularly difficult at the acquisition level because some of the word-pairs lack semantic context in which to anchor information. As a result, poor initial acquisition will adversely influence the efficiency of encoding, decoding, and retrieval of words. Visual reproductions also require facile verbal abilities to quickly label and “encode” verbal details (e.g., two flags crossed, four boxes with dots in them, two rectangles one inside the other, etc.). Thus, working memory capacity to process visual information may be susceptible to becoming overloaded in individuals with reduced

language processing ability. Notably, in the current study, no relationship was found between SRD and recall performance on a memory test for short stories (i.e., a test in which language processing demands are reduced due to the organized meaningful nature of the information to-be learned).

While the findings of the current study are interesting, there are a number of weaknesses that must be considered when interpreting the results. First, identification of potential lifelong learning disorder in older adults is challenging. We relied upon performance on a single-word reading measure to infer the presence of learning difficulty. Because educational ability and single-word reading measures are both correlated with overall intellect, it is possible that our study is explained by the known association between low intellect and greater risk of AD [21]. However, low intellect alone is less likely to fully explain the findings given that controlling for education did not fully remove this relationship (as educational attainment and intelligence are strongly correlated). Further, if low intellect alone fully explained the findings, a relationship between all neuropsychological measures and membership in the SRD group would be expected. Instead, the relationship was only found in two of the four measures. Second, while the current study identified an increased likelihood of test scores falling within the range associated with MCI, the meaning of these low scores has not yet been determined. It is possible that lower test scores reflect lifelong lower verbal skills that may lead to more difficulty with cognitive strategies that draw upon verbal agility. Thus, learning disorder history may increase the likelihood of misdiagnosis of prodromal neurodegenerative disease. Alternatively, a neurodevelopmental reading disorder may represent a risk factor for the development of AD in later life.

Overall, given that lifelong neurodevelopmental learning disorders are associated with a range of cognitive weaknesses that for may persist across the individual's lifespan, the findings are not surprising. However, the current study finds evidence to suggest the need to carefully assess neurodevelopmental history when evaluating older adults with subjective memory complaints.

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REFERENCES

1. Albert MS, DeKosky ST, Dickson D, Dubois B, Feldman HH, Fox NC, Gamst A, Holtzman DM, Jaqust WJ, Peterson RC, Snyder PJ, Carrillo MC, Thies B, Phelps CH. The diagnosis of mild cognitive impairment due to Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. Alzheimers Dementia. 2011; 7:270–279.
2. Gallassi R, Bisulli A, Oppi F, Poda R, Di Felice C. Subjective cognitive complaints, neuropsychological performance, affective and behavioural symptoms in non-demented patients. Int J Geriatr Psychiatry. 2008; 23:95–101. [PubMed: 17879254]
3. Jefferson AL, Poppas A, Paul RH, Cohen RA. Systemic hypoperfusion is associated with executive dysfunction in geriatric cardiac patients. Neurobiol Aging. 2007; 28:477–483. [PubMed: 16469418]

4. Rentz DM, Huh TJ, Faust RR, Budson AE, Scinto LF, Sperling RA, Daffner KR. Use of IQ-adjusted norms to predict progressive cognitive decline in highly intelligent older individuals. Neuropsychology. 2004; 18:38–49. [PubMed: 14744186]
5. Manly JJ, Jacobs DM, Sano M, Bell K, Merchant CA, Small SA, Stern Y. Cognitive test performance among nondemented elderly African Americans and whites. Neurology. 1998; 50:1238–1245. [PubMed: 9595969]
6. Manly JJ, Jacobs DM, Touradji P, Small SA. Reading level attenuates differences in neuropsychological test performance between African American and White elders. J Int Neuropsychol Soc. 2002; 8:341–348. [PubMed: 11939693]
7. Bialystok E. Reshaping the mind: The benefits of bilingualism. Can J Exp Psychol. 2012; 65:229–235. [PubMed: 21910523]
8. Sadat J, Martin CD, Alario FX, Costa A. Characterizing the bilingual disadvantage in noun phrase production. J Psycholinguist Res. 2012; 41:159–179. [PubMed: 21997516]
9. Shaywitz SE, Shaywitz BA. Dyslexia (specific reading disability). Biol Psychiatry. 2005; 57:1301–1309. [PubMed: 15950002]
10. Swanson HL. Cognitive profile of adolescents with math disabilities: are the profiles different from those with reading disabilities? Child Neuropsychol. 2012; 18:125–143. [PubMed: 21967554]
11. Stothers M, Klein PD. Perceptual organization, phonological awareness, and reading comprehension in adults with and without learning disabilities. Ann Dyslexia. 2010; 60:209–237. [PubMed: 20838941]
12. Caravajal PJ, Altmann LJ, Lombardino LJ. Information recall in compensated adult dyslexics: Does repetition help? Abstracts of the Thirty-seventh Annual Meeting of the International Neuropsychology Society, February. 2009; 7:170.
13. Stanovich K. Toward an interactive compensatory model of individual differences in the development of reading fluency. Read Res Q. 1980; 16:32–71.
14. Willcutt EG, Pennington BF. Comorbidity of reading disability and attention deficit hyperactivity disorder: Differences by gender and subtype. J Learn Disabil. 2000; 33:179–191. [PubMed: 15505947]
15. Feinleib M, Kannel WB, Garrison RJ, McNamara PM, Castelli WP. The Framingham Offspring Study. Design and preliminary data. Prev Med. 1975; 4:518–525. [PubMed: 1208363]
16. Wechsler, DA. Wechsler Memory Scale Revised Manual. San Antonio, TX: Psychological Corporation; 1987.
17. Reynolds, CR. Comprehensive trail-making test: Examiner's manual. Austin, TX: Pro-Ed; 2002.
18. Wilkinson, GS. WRAT-3: The Wide Range Achievement Test Administration Manual, Third Edition. Wilmington, DE: Wide Range, Inc; 1993.
19. Lee E, Hermann BP, Rue AL, Chan E, Jones JE, Sager MA. Cognitive profiles of persons at risk for Alzheimer's disease. Abstracts of the Thirty-fifth Annual Meeting of the International Neuropsychology Society. 2007:86.
20. Snowdon DA, Greiner LH, Markesbery WR. Linguistic ability in early life and the neuropathology of Alzheimer's disease and cerebrovascular disease: findings from the Nun Study. Ann N Y Acad Sci. 2000; 903:34–38. [PubMed: 10818486]
21. Stern Y. Cognitive reserve and Alzheimer disease. Alzheimer Dis Assoc Disord. 2006; 20:69–74.

Table 1

Demographic data for the study sample

		Age (y)	Gender	Education		
	n	**Mean [SD]**	**% women**	**No HS Degree %**	**HS Degree %**	**College Degree %**
Suspected Reading Disorder	163	62 [9]	37%	3%	58%	39%
Normal Readers *HS, high school*	1641	62 [9]	56%	3%	56%	41%

Table 2

Obtained raw scores for the neuropsychological measures

	WRAT-Reading	Logical Memory Delay	Visual Reproduction Delay	Paired Associates Delay	Trail Making Test Part B (min)
	Median [Q1,Q3]	Mean [SD]	Mean [SD]	Mean [SD]	Median [Q1,Q3]
Suspected Reading Disorder	41 [38, 44]	9.9 [3.3]	7.2 [3.3]	7.7 [1.5]	1.4 [1.1, 1.8]
Normal Readers	50 [47,53]	10.9 [3.6]	8.5 [3.3]	8.5 [1.4]	1.1 [0.9, 1.5]

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Table 3

Odds ratio for the likelihood of performing at MCI levels in a group of individuals with a history of suspected reading disorder

	Model 1[1] Cases/n OR [95% CI]	**Model 2[2] Cases/n OR [95% CI]**
Logical Memory	108/1804	108/1804
Delay	1.13 [0.59–2.15]	1.13 [0.58–2.20]
Visual	118/1803	118/1803
Reproduction Delay	1.93 * [1.14–3.28]	1.92 * [1.12–3.29]
Paired Associates	123/1798	123/1798
Delay	3.36 *** [2.13–5.31]	3.38 *** [2.13–5.35]
Trail Making Test	79/1794	79/1794
Part B	1.78 [0.94–3.39]	1.83 [0.96–3.51]

[1] Adjusted for age;

[2] Adjusted for age and education.

* $0.01 < p < 0.05$;

** $0.01 < p < 0.001$;

*** $p < 0.001$.

Table 4

Education stratified odds ratios for the likelihood of performing at MCI levels in a group of individuals with a history of suspected reading disorder

	No HS degree OR [95% CI]	HS degree only OR [95% CI]	College degree OR [95% CI]
Logical Memory	19/54	71/1010	18/740
Delay	0.44 [0.05–4.25]	1.06 [0.47–2.39]	2.32 [0.65–8.31]
Visual	12/54	81/1009	25/740
Reproduction Delay	2.45 [0.34–17.78]	1.22 [0.59–2.53]	5.64*** [2.20–14.49]
Paired Associates	9/53	81/1007	33/738
Delay	1.13 [0.10–12.32]	3.72*** [2.13–6.49]	3.21** [1.32–7.77]
Trail Making Test	10/52	53/1003	16/739
Part B	1.04 [0.10–10.47]	2.15 [1.01–4.60]	1.44 [0.32–6.54]

Adjusted for age; HS, high school

* $0.01 < p < 0.05$;

** $0.01 < p < 0.001$;

*** $p < 0.001$.