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The effect of age-related macular degeneration on non-verbal neuropsychological test performance

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Abstract. Existing neuropsychological instruments used to clinically diagnose dementia, many of which are based upon visual image processing, do not take into account the different types of sensory loss presented by low vision patients. The purpose of the present study is therefore to assess the effects of low vision on non-verbal neuropsychological test performance. A retrospective chart review identified patients with age-related macular degeneration (ARMD), central vision loss, and an age-matched control group. All participants completed a depression inventory and a «blind» version of the mini-mental Status examination in order to "screen" for dementia. Each group was assessed with a pre-determined battery of non-verbal neuropsychological tests differing in their visual image characteristics (size of test items, contrast, chromaticity, glare, etc.). As expected, preliminary results show a decrease in performance across non-verbal tests for the ARMD group, particularly for tests characterized by visual scanning strategies (Trail Making Test (D-KEFS)) and small item sizes (i.e. Digit Symbol and Symbol Search WAIS subtests). Results demonstrate that ARMD affects performance on certain non-verbal test more than others. All participants will be re-assessed within a 6-week period using the same battery of tests in modified versions (i.e. magnified and polarity reversed). If the implemented visual-test modifications control for decrease in performance due to sensory loss, these adapted tests may be used to compliment existing «blind» cognitive screening presently used to assess low-vision patients, resulting in a more precise assessment of cognitive functioning for this low-vision group. © 2005 Published by Elsevier B.V.

Keywords: Age-related macular degeneration (ARMD); Neuropsychology; Cognitive assessment

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1. Introduction

With an increasingly aging population, age-related vision impairments are becoming prevalent and pose an increasingly significant social and economical impact on our society. Conditions such as age-related macular degeneration (ARMD) cause vision loss that cannot be adequately corrected with medical and/or surgical treatment, therapy, conventional eyewear or contact lenses. Age is not only a primary risk factor for low vision, but also for dementia. Using standardized neuropsychological assessment techniques, cognitive deficits can be detected several years before a clinical diagnosis of dementia can be established (overt behavioral changes and subjective memory complaints) by objectively measuring memory loss and other types of cognitive functioning [1].

A decade ago, The Canadian Study of Health and Aging Working Group estimated that about 35% of Canadians over 85 years old suffers from dementia [2]. Given their similar demographics and symtomology (depression, social withdrawal and isolation, decreased ability to use non-verbal cues during conversation, etc.), it is quite possible that persons with low vision are also suffering from dementia. If this is the case, the implementation of the most advantageous rehabilitation strategy for patients with low vision should take into account their cognitive status. The problem with this is the following: existing neuropsychological instruments used to clinically diagnose dementia, most of which are based upon visual image processing, do not take into account the different types of sensory loss presented by low vision patients (i.e., decreased visual acuity and contrast sensitivity). For this reason, it is currently not possible to differentially diagnose low vision patients with and without dementia [3]. This is a potentially important problem given that, in order to implement of the most effective rehabilitation strategy, one must first define and evaluate the disabling problem, including whether it is of its ocular or neural origin.

The motivation behind this research project originates from the fact that there is presently no adequate health service available for persons with low vision requiring an evaluation of cognitive status [4]. Not surprisingly, the problem of visual impairment in the detection of dementia is rarely discussed in the literature [4] and remains a public health issue that has been ignored. Epidemiological studies evaluating the prevalence of dementia rarely mention age-related vision impairment, even after taking into account the fact that there may be a higher incidence of dementia in the low vision population, given their shared demographics [5,6]. Large-scale studies investigating the progression of cognitive status in the elderly have failed to address sensory impairments in this population. For example, a prospective study by Korten et al. [7], the Mini-Mental State Examination (MMSE) [8] was used to assess the change in cognitive function in an elderly population over a 3-year period. Instead of addressing the problem of low vision with regard to the detection of dementia, recent studies have chosen to *circumvent* visual impairment problems by developing «blind» versions of the MMSE from which the eight items involving image processing are eliminated [3]. Although this may seem like the most logical and practical thing to do, it may have important implications regarding the sensitivity of such «blind» techniques when characterizing cognitive status. It is much more likely that the sensitivity and accuracy of the screening is compromised by simply choosing to not assess visually-related cognitive functioning when assessing overall cognitive status. The purpose of the present study is therefore to assess the effects of low

vision on non-verbal neuropsychological tests differing in visual characteristics (i.e., spatial frequency of test items) in order to evaluate which non-verbal tests are preferentially affected by low-vision (defined by reduced reading acuity).

2. Methods

A retrospective chart review identified patients with ARMD (acuity loss of varying degree) and an age-matched control group (no ocular pathology). ARMD patients had reading acuities (binocular) that ranged from 20/200 to 20/20 (one eye affected). All participants completed a depression inventory (Geriatric Depression Scale—GDS) and a «blind» version of the MMSE in order screen for depression and dementia [7], respectively. Each group was then assessed with a pre-determined battery of non-verbal neuropsychological tests differing in the size of their test items, defined by their respective spatial frequency (SF) characteristics ; either low spatial frequency (low SF or large item size) or high spatial frequency (high SF or small item size) characteristics (see Table 1). Raw scores for each participant were collected and converted to standardized scores based on age and education, when applicable.

3. Results

MMSE scores for all participants was greater than 20 (out of 24 visual items on the MMSE), suggesting normal cognitive status. One participant in each group presented possible mild depression,

Table 1
Standardized scores for ARMD and control participants having different near-reading acuities

Group	Reading acuity	Low SF		High SF				
		WAIS-III	VOT	D-KEFS			WAIS-III	
ARMD		PC	Hooper	VS	NS	MS	DS	SS
1	20/200	9	15	1	1	7	1*	1*
2	20/100	6	10.5	1	1	1	7	5
3	20/73	8	28	1	9	3	10	12
4	20/40	10	21.5	10	11	13	14	11
5	20/38	8	11	4	10	13	9	8
6	20/20	13	21	8	5	7	15	14
Control								
1	20/20	13	30	12	13	11	16	17
2	20/23	13	28	12	11	9	13	14
3	20/23	9	23	10	5	12	11	9
4	20/25	9	19	11	12	12	11	8
5	20/25	9	22	13	10	12	7	12
6	20/23	9	17	9	8	11	10	10
7	20/20	12	28	14	12	13	12	12

Low SF tests : Picture Completion (PC) subtest of the Weschler Adult Intelligence Scale (WAIS-III) and the Hooper Visual Organization test (VOT). High SF tests : Visual Scanning (VS), Number Sequencing (NS) and Motor Speed (MS) subtests of the Delis Kaplan Executive Function System (D-KEFS) in addition to the Digit Symbol (DS) and Symbol Substitution (SS) subtests of the WAIS-III. Asterisks (*) denote inability to complete test. A standardized score of 7 or less can be interpreted as being abnormal for WAIS and D-KEFS subtests. Scores of 16 or less on the Hooper can be considered as «pathological».

as reflected by a score of more than 9 on the GDS. Again, both the MMSE and GDS batteries are screening tools, and not used for diagnosing either cognitive or affective status. As shown in Table 1, the performance of ARMD patients on the non-verbal neuropsychological test was inferior to that of control group for both low SF and high SF tests. For the ARMD group, performance was directly related to reading acuity for the high SF tests, and importantly, was most evident for the tests defined by high SF items.

3.1. Reverse polarity condition

In order to assess the impact of glare-reduction on test performance, the performance of two ARMD participants was measured on high SF tests whose items were reversed in polarity (i.e., white test items on black background). Results showed that performance was not affected by reversing the polarity to the test items. Therefore, although these patients reported augmented comfort while completed the reversed-polarity test, no objective difference in performance was obtained.

3.2. Large print condition

In an attempt to correct for sensory loss, the performance of two ARMD patients (ARMD1 and ARMD2) was assessed using tests that were magnified by 150% (see Table 2). Although preliminary, results demonstrate that magnifying the print size of the tests may compensate for sensory loss, particularly for high SF tests. This was most evident for low-vision patients with severe vision loss (i.e., 20/200), as demonstrated by the «near normal» performance of patient ARMD 1 on the magnified version of the WAIS-III tests (was unable to complete the non-adapted test version). The finding that magnifying the tests did not significantly increase the performance for either patient on the low SF tests suggests that magnifying the tests by 150% enables clinicians to compensate for sensory loss only for the tests that are most affected by such loss (i.e., high SF tests), thus not affecting the clinical integrity of the low SF tests.

4. Conclusions and discussion

The findings of the present study demonstrate that ARMD affects performance on non-verbal neuropsychological tests to different extents, depending on (1) whether they are defined by high or low SF characteristics and (2) the acuity of the low-vision patient. It

Table 2
Standardized scores for two ARMD participants on both low SF (PC subset of WAIS-III and Hooper) and high SF (VS, NS and MS subtest of D-KEFS and DS and SS subtests of WAIS-III) tests for both small and large print (magnified by 150%) conditions

Group	Reading acuity	Low SF		High SF				
		WAISIII	VOT	D-KEFS			WAIS-III	
		PC	Hooper	VS	NS	MS	DS	SS
ARMD 1								
Small	20/200	9	15	1	1	7	1*	1*
Large	20/200	8	14	1	4	10	7	6
ARMD 2								
Small	20/73	8	28	4	9	3	9	12
Large	20/80	12	28	9	8	7	13	11

can, therefore, be proposed that certain non-verbal tests, particularly those characterized by low SF items, may be included when assessing low-vision patients for cognitive status instead of simply omitting them from a pre-determined test battery (i.e., «blind» cognitive assessments). Although reversing the polarity of non-verbal tests increased the patients' «comfort» during task completion, it did not however, significantly increase performance. Conversely, adapting non-verbal tests by increasing their size by 150% seemed to control for the sensory loss presented by the patients. Specifically, performance on the magnified tests was increased to «near normal» levels for the high SF tests, but not for low SF tests. These findings suggest that neuropsychological test magnification is a viable method for correcting for the sensory loss presented by low-vision patients without compromising the clinical integrity (i.e., standards) of these tests. In conclusion, these adapted tests may be used to complement (or replace) existing «blind» cognitive screening presently used to assess low-vision patients, resulting in a more precise assessment of cognitive status in ARMD and other low-vision conditions. This study represents a first attempt to adapt a health service to the specific needs of the low-vision patient. This undoubtedly has important repercussions regarding the optimal rehabilitation strategy for the low-vision patient since the origin of their disability, may depend on whether or not they are suffering from a dementing process.

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