The Impact of Blurred Vision on Cognitive Assessment.

Submitted to

Journal of the International Neuropsychological Society

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Abstract
The purpose of this study was to systematic assess the effect of blurred vision on several non-verbal neuropsychological measures commonly used as part of test batteries to assess the cognitive status of different patient populations. Thirty highly educated and healthy participants aged between 21 and 33 were placed in either one of three blurred vision groups, defined by their maximal visual acuity (20/20 or control group, 20/40 and 20/60). Blurred vision was simulated using positive dioptries at a distance of 40 cm, the same distance at which tests were administered. Each participant was then assessed on a pre-determined battery of non-verbal and verbal neuropsychological tests demanding different levels of acuity for optimal performance (i.e., tests whose items varied in terms of size and spatial frequency characteristics). As expected, blurred vision did not affect verbal test performance (Similarities, Information and Arithmetic WAIS subtests). In general, the effect of blurred vision on non-verbal tests varied as a function of item size and spatial frequency characteristics defining each test. Performance on test defined by small-sized / high-spatial frequency items (i.e., WAIS Coding, Symbol Search, Picture Arrangement subtests; Conditions 1 through 4 of the D-KEFS Trial Making Test; All conditions of the Mesulam and Weintraub Cancellation Task) was significantly affected for both 20/40 and 20/60 acuity conditions. Performance on larger-sized / low-spatial frequency tests was less affected by blurred vision (i.e., WAIS Picture Completion and Matrix Reasoning subtests). Our results are a clear indication of how even a « minimal » loss of visual acuity (20/40) can have a significant effect on the performance for certain non-verbal tests, resulting in scores hypothetically interpretable as reflecting impaired cognitive status. Our findings suggest that the precision of the cognitive assessment and subsequent diagnosis are significantly affected when visuo-sensory abilities are not optimal, particularly for older patient populations where blurred vision resulting from correctable visual impairment is quite common. It is strongly recommended that if the visual acuity of a patient is unknown or believed to be even mildly impaired, the neuropsychologist should either communicate with the patient’s ocular health professional before assessment or adapt their test battery to the visual status.

Keywords: neuropsychology, visual acuity, blurred vision, aging.
INTRODUCTION

An effective and comprehensive cognitive assessment entails the use of verbal and non-verbal neuropsychological tests that are administered and scored on the presupposition that the patient being assessed has intact sensory abilities (Weschler, 1997). However, an assessment is often carried out without knowledge of the patient’s visual acuity and/or contrast sensitivity at the time of evaluation. Although is both common practice and common sense to instruct the patient to wear their corrective lenses before the assessment, information regarding whether or not the patient’s corrected acuity at the time of evaluation is optimal is often overlooked or not known. In addition, it has also been documented that a precise self-assessment of visual acuity is sometimes not possible for both younger (Skeel et al., 2003) and older (Klein et al., 1999) persons. Without knowledge of the patient’s visual capabilities before assessment, a poor score obtained on a non-verbal test may at least in part attributable to non-optimal visual acuity during assessment, and not a precise measure of the cognitive capacities targeted by that particular non-verbal test.

We suggest that this argument is most applicable to elderly patients evaluated for cognitive status. Large-scale epidemiological studies investigating the prevalence of correctable visual impairment in the elderly have demonstrated that approximately 20% of the elderly participants aged 75 years and over had acuities of worse than 20/40, an estimate considered to be conservative by the authors (Evans et al., 2002). As summarized by Evans & Rowlands (2004), most epidemiological studies suggest that between 10 and 50% of the elderly (65 years and over) participants sampled in each study presented visual acuity of 20/40 or worse. Although the percentages proposed by each study vary, it can be argued that an important percentage of older patients (1 out of 5) necessitating cognitive assessment probably present of visual impairment that may impact their performance on non-verbal tests.

When a patient does not present an ocular pathology (i.e., glaucoma, age-related macular degeneration, etc.), loss of visual acuity is most often the result of either refractive error
(lack of proper optical correction) or cataracts (clouding of the lens). Such visual loss, referred to as correctable visual impairment (CVI), leads to blurred vision that affects the efficiency with which visual information is processed. Blurred vision caused by refractive error has been demonstrated to effect performance on certain neuropsychological tests. For example, Kempen et al. (1994) demonstrated that blurred vision resulting from non-corrected near vision (Snellen acuity of 20/50) decreased performance on Benton’s Facial Recognition (FR) and Visual Form Discrimination (VFD, but not for Judgment of Line Orientation (JLO) (see Benton et al., 1983 for descriptions). These results were interpreted as evidence that reduced acuity significantly affects performance on neuropsychological tests whose items are defined by both detailed and low contrast information (i.e., FR and VDS tests). van Boxtel et al., (2001) demonstrated that normal age-related loss in visual acuity, contrast sensitivity and color weakness differentially effected performance on certain conditions of the classic Stroop color-word test, suggesting that decreased performance of elderly patients on the Stroop test may at least in part be related to a normal decline in age-related visual function. Most recently, Skeel et al., (2003) assessed the effect of decreased visual acuity on a battery of non-verbal neuropsychological measures where participants were grouped in non-corrected near vision acuity categories defined perfect (Snellen 20/20), mildly impaired (Snellen 20/25), moderately impaired vision (20/30 - 20/50, or severely impaired (< 20/70). Results demonstrated that performance was significantly impaired for certain tests necessitating higher-levels of acuity to be completed (i.e., Digit Symbol-Coding subtest of WAIS-III (Weschler, 1997) and Trail B subtest of Trial Making test (Reitan, 1992), even when the decrease in acuity was minimally affected (i.e., between 20/30 and 20/50). However, other tests hypothesized by the authors to be affected by reduced acuity were not (i.e., the d2 Test of Attention; Zillmer, 1998).

Whereas previous studies assessed the impact of naturally-occurring blurred vision on neuropsychological test performance, the present study is the first to systematic assess the impact of different levels of acuity loss on non-verbal test performance by simulating blurred vision. In doing so, two important questions can be addressed; (1) which non-verbal neuropsychological measures are affected by correctable VI and (2) at what level of
refractive blur does subsequent task performance mimic impaired cognitive functioning targeted by the task used. In addition, the present study differs from previous ones in that the effect of blur was assessed for a larger sample of non-verbal tests, including those currently used as part of batteries assessing different aspects of cognitive functioning (i.e., Wechsler Adult Intelligence Scale-3rd edition (WAIS-III) and the Delis Kaplan Executive Function System (D-KEFS)).
Methods

Participants
Thirty observers (18 male, 12 female) aged between 20 and 33 years (mean age = 23.6 years; SD = 2.93) were recruited within the University of Montreal, École d’optométrie (School of Optometry). All participants were either emmetropes or had corrected-to-normal vision (20/20) or better when tested. None of the participants reported having any systemic or ocular pathology affecting visual field and/or acuity or any known neurological condition. Twenty-eight of the participants had either a Bachelor’s level degree or were enrolled in a university level program. French was the mother tongue of all except one of the participants and therefore, assessments were for the most part carried out in French using the WAIS-III version for Canadian francophones. Participation was voluntary and lasted approximately 3 hours.

Acuity measures and manipulations
A licensed optometrist (LB) carried out acuity measures and dioptic refraction in a well-illuminated room. Binocular far visual acuity was assessed using a standard Snellen Acuity chart at a distance of 10 feet. Binocular near visual acuity was measured with a near Snellen equivalent visual acuity chart (Inami & Co., Ltd) at a distance of 40 cm. Participants were randomly placed in one of three experimental blur groups differing in best visual acuity: 20/20 (controls), 20/40 and 20/60. Positive (plus) lenses of different diopter strengths were used to blur the binocular near visual acuity of each participant to the target acuity (plano dioplers were worn for participants in the 20/20 or control group). In order to ensure that the participant did not see or memorize the letters contained in subsequent acuity chart lines during the blurring procedure, initial elevated diopter strength was used (resulting in ≈ 20/200 near acuity) and decreased until the target acuity level (either 20/40 or 20/60) was met for each participant. Trial lenses were worn directly over the habitual corrections in trial lens clips or in trial lens frames if the participants did not were eyeglasses (i.e., were emmetropes or wore contact lenses). For some participants, particularly those in the 20/40 or 20/60 blur groups, an amelioration in acuity is presented over time due to accommodation, a common occurrence in younger observers. For this reason, acuity was assesses every 30 minutes in order to ensure
constant target visual acuity throughout each testing session. If necessary, target visual acuity was maintained constant during each assessment by increasing diopter strength.

**Neuropsychological testing**

Each participant was administered a pre-determined neuropsychological test battery that included the following measures:

1. **Wechsler Adult Intelligence Scale-3rd edition (WAIS-III)** (Wechsler, 1997): Picture Completion (PC), Digit Symbol-Coding (CD), Matrix Reasoning (MR), Picture Arrangement (PA) and Symbol Search (SS) subsets (Performance scale); Information (I), Similarities (S) and Arithmetic (A) subtests (Verbal scale). Verbal subtest performance was measured to control for the possible effect of blurred vision on general cognitive functioning and to provide a partial measure of the overall cognitive functioning of the participants. In addition, Canadian WAIS-III norms were used to obtain scaled score equivalents of raw scores for each WAIS-III subtest.

2. **Delis Kaplan Executive Function System (D-KEFS)** (D-KEFS; Delis et al., 2001): Complete Trail Making Test subtest; Visual Scanning (VS), Number Sequencing (NS), Letter Sequencing (LS), Number-Letter Switching (N-LS) and Motor Speed (MS).

3. **The Mesulam and Weintraub Cancellation Tasks (MWCT)** (Mesulam, 1985): Letters-Structured (L-S), Letters-Unstructured (L-U), Forms-Structured (F-S) and Forms-Unstructured conditions.

The aforementioned tests were chosen based on (1) the frequency of inclusion in neuropsychological test batteries for assessing the cognitive functioning of different patient populations and (2) the varying visual characteristics defining each test (i.e., size and spatial frequency of test items). After being blurred to target acuity, participants were seated comfortably at a table where they were presented each test on a support inclined at approximately 35 deg. This was done to ensure that the «target blur» was constant throughout the testing session and across the testing material (test surface always perpendicular to fixation). It also aided participants maintain a constant viewing distance of 40 cm from the test material. All assessments were carried out in the same environment and were supervised by a licensed neuropsychologist (AB). The raw scores
for each participant were then converted into their respective standardized score (when possible) for each measure and used for statistical analysis.

**Intra-subject testing: Digit symbol-Coding / Symbol Search WAIS subtests**

After participants completed the pre-determined test battery with their target acuity (i.e., 20/40), performance was assessed on modified versions of the Digit symbol-Coding and Symbol Search WAIS subtests under the other or non-target blur conditions (i.e., 20/20 and 20/60). The modified Digit symbol-Coding version was like the original except that the legend was modified to create new symbol-number pairings (i.e., the circle symbol paired with « 1 »), and the numbers above each empty response box were re-arranged across each line in random order. The frequency with which a certain number appeared within each line was controlled for in the modified versions (i.e., the number « 2 » always appeared 4 times in the first response line, twice in the second, three times in the third, etc.). As for the modified Symbol Search subtest, symbols in the target (two-item) and search (four-item) group for each line were rearranged in such a way that the same number of lines in each page contained target symbols in the search symbol group. Therefore, 7 out of the 15 lines presented on the first of the page of the modified Symbol Search subtests were « yes » responses.

Therefore, the performance of each participant was measured on the modified versions of the Digit Symbol-Coding and Symbol Search WAIS subtests at all blur conditions (20/20, 20/40 and 20/60). These subtests were chosen for the following reasons; (1) performance is minimally affected by learning for these measures (i.e., prior knowledge or strategy should not affect re-test performance) and (2) each subtest is defined by small size, high-spatial frequency items whose perception should be affected by blurred vision. In addition to the inter-subject performances acquired by the pre-determined test battery, intra-subject performance on these two tests allowed us to evaluate the effect of increasing blurred vision on the same measure for the same participant.
Results

**WAIS-III**

Figure 1 shows the mean scaled scores for each WAIS subtest as a function visual acuity group (20/20/, 20/40 and 20/60). Each bar in Figure 1 (and in all subsequent figures) represents the mean scaled score for 10 participants; standard error bars are also shown for each group. As mean differences between WAIS subset performance is not informative in the context of the present study, separate single-factor between-subject ANOVAs were carried out to assess the effect of decreased visual acuity on performance for each WAIS subset. Analysis revealed that blurring vision (decreasing near visual acuity) significantly impaired performance on all the non-verbal subtests tested except for Matrix Reasoning (PC: $F_{(2,27)} = 4.588$, $p = 0.0193$; CD: $F_{(2,27)} = 11.191$, $p = 0.0003$; MR: $F_{(2,27)} = 0.270$, $p = 0.7654$; PA: $F_{(2,27)} = 5.809$, $p = 0.008$; SS: $F_{(2,27)} = 6.331$, $p = 0.0056$). Pairwise comparisons revealed that performance on the CD and SS subtests was decreased even when a « minimal » loss of acuity (20/40) was simulated (CD: $p = 0.0034$; SS: $p = 0.0116$; Bonferroni correction at alpha level of 0.0167). For the other subtests, performance was significantly affected at the 20/60 level of acuity. As expected, blurring did not significantly affect performance on the verbal measures tested (S, I & A subtests; $p > 0.05$).

**Digit symbol- Coding / Symbol Search subtest : Intra-subject results**

Each bar in Figure 2 represents the mean scaled score for 30 participants as a function of blur condition for both Digit Symbol-Coding and Symbol Search WAIS subtests. A repeated-measures ANOVA revealed that on average, the performance of each participant decreased significantly as a function of visual acuity on both subtests (CD: $F_{(2,58)} = 54.01$, $p = 0.0001$; SS : $F_{(2,58)} = 22.05$, $p = 0.0001$, respectively ).
D-KEFS Trail Making Test

The normative scaled scores for each D-KEFS test condition as a function of visual acuity group is shown in Figure 3. Analyses demonstrated that decreased visual acuity affected performance on the VS (F(2,27) = 6.264, p = 0.0058), NS (F(2,27) = 8.945, p = 0.010) and LS (F(2,27) = 5.15, p = 0.0128) D-KEFS test conditions at an acuity level of 20/40 (VS: p = 0.0034; NS: p = 0.0116; LS: p = 0.0116; Bonferroni correction at alpha level of 0.0167). N-L S and MS conditions were not affected by blurred vision (F(2,27) = 0.960, p = 0.3938; F(2,27) = 0.54, p = 0.9475, respectively).

[ INSERT FIGURE 3 APPROXIMATELY HERE ]

MWCT

Time to completion (seconds) and total errors committed (omissions + false positives) for each MWCT condition are shown as a function of visual acuity group in Figure 4. Separate single-factor between-subject ANOVAs demonstrated that decreased visual acuity affected time to completion performance for the all conditions (L-S (F(2,27) = 4.352, p = 0.0230), L-U (F(2,27) = 7.661, p = 0.0023), F-S (F(2,27) = 6.810, p = 0.0040), F-U (F(2,27) = 6.296, p = 0.0057) at an acuity level 20/40 (L-S: p = 0.0075; L-U: p = 0.0014; F-S: p = 0.0029; F-U: p = .0130; Bonferroni correction at alpha level of 0.0167). In addition, blurred vision also significantly increased the total errors committed for all the MWCT except the F-S condition (L-S (F(2,27) = 5.179, p = 0.0125), L-U (F(2,27) = 5.360, p = 0.0110), F-S (F(2,27) = 2.532, p = 0.0982), F-U (F(2,27) = 3.652, p = 0.0395 ; p < 0.0167).
DISCUSSION

The present study is the first to assess the effect visual acuity loss on neuropsychological test performance by simulating blurred vision, a condition usually resulting from correctible visual impairment (CVI) such as refractive error or cataracts in the elderly. In general, our results demonstrate that blurred vision results in significantly lowered scores on most non-verbal tests assessed in the present study, particularly for those defined by small-sized / high-spatial frequency items. Results from the present study demonstrate that minimal to moderate visual acuity loss (i.e., 20/40 or 20/60) significantly affects performance on tests commonly used during neuropsychological assessment and include, but are not limited to (1) the Picture Completion, Coding, Picture Arrangement and Coding, subtests of the WAIS (2) conditions 1 through 3 of the D-KEFS Trial Making Test and (3) all conditions of the Mesulam and Weintraub Cancellation Task (MWCT). As expected, blurred vision (whether minimal or moderate) did not significantly affect performance on verbal tests (i.e., Similarities, Information and Arithmetic WAIS subtests), nor on tasks defined by larger-sized / lower-spatial frequency item characteristics (i.e., Matrix Reasoning WAIS subtests). Our results stress the importance knowing a patient’s visual acuity at the time of neuropsychological evaluation since even a « minimal » loss of visual acuity (20/40) significantly affects performance on a variety commonly used non-verbal tests, resulting in scores hypothetically interpretable as reflecting impaired cognitive status.

Neuropsychological test characteristics most affected by blurred vision

In agreement with previously studies (Kempen et al., 1994; Skeel, et al., 2003), our results suggest that blurred vision predominantly affects performance on neuropsychological tasks requiring efficient (1) visual scanning and/or (2) processing small-sized / high-spatial frequency items to be completed. For example, even a minimal loss of acuity (20/40) significantly affected performance for the Coding and Symbol Search WAIS subtests, all conditions of the MWCT as well as the Visual Scanning, Number-Sequencing and Letter Sequencing conditions of the D-KEFS. These results are consistent with those of Skeel et al. (2003), who demonstrated that persons with moderate
and severe (< 20/70) impairment of near visual acuity performed significantly worse on both the Coding subset of the WAIS and Trails B subtest of Trial Making test. However, they unexpectedly found no effect of blur on d2 Test of Attention performance, a task that necessitates both efficient visual scanning capabilities and intact visual acuity given the small-sized / high-spatial frequency items comprising the task. They argued that their negative result was due to the fact that scanning for relevant stimuli in this task is in an expected direction (i.e., from left to right), and therefore, participants did not have to adjust their focus on consecutively scanned items in unexpected directions during task completion, as is the case for other visual scanning tasks where performance was found to be affected by blurred vision (i.e., Trails B). This argument is not consistent with our results for the following reason. Participants performed significantly worse when blurred for all conditions of the MWCT test, regardless of whether the target letter (i.e., A) or symbol (bisected circle) to be circled was embedded within structured (arranged in rows and columns) or non-structured (arranged in pseudo-random fashion) distracters. When structured, all participants searched for the target in a systematic left-to-right manner, much like during d2 Test of Attention task completion or searching for a word within a written text. Therefore, visual scanning efficiency was not affected by expected scanning direction for the MWCT; reduced performance on this visual search task is entirely dependent on whether vision is blurred or not, particularly since the targets and distracters comprising these tasks are small and differ by high-spatial frequency characteristics.

*Naturally-occurring versus simulated blur*

Previous studies investigating the effect of reduced visual acuity on neuropsychological test performance used participants that had existing visual impairment i.e., uncorrected refractive error or naturally-occurring blurred vision. For example, the participants in the Kempen et al., (1994) study presented binocular Jaeger visual acuity of J5 (≈ Sellen equivalent 20/50) to worse than J14, with a median of J12 (≈ 20/130). Based on their uncorrected near visual acuity, Skeel et al., (2003) classified participants as belonging to perfect (20/20), mild impairment (20/25), moderate impairment (20/30-20/50) or severe impairment (< 20/70) categories. Skeel (2003) suggests that it is advantageous to assess
the impact of decreased visual acuity of test performance in patients who already have existing visual impairment since patients can incorporate natural compensation strategies to accommodate sensory loss, suggesting that such an approach offers a more ecological valid results (Boxtel et al., 2001). However, it can also be argued that the compensatory strategies developed by these patients in their natural environment are probably not applicable to the neuropsychological setting, where they are asked to complete unnatural tasks such as cancellation, line tracing, and visual search tasks under strict time restraints and a novel environment, where their strategies may not necessarily apply. For this reason, we consider the accuracy with which we systematically manipulated the degree of blur to be more important in the context of the present study than the potential of compensatory strategies not being used by the participants.

In addition, grouping participants as a function of their visual acuity (within a predetermined range) may result in less precise associations between level of acuity and task performance. We found that increasing blur from 20/40 to 20/60 significantly affected performance for certain tasks (i.e., Picture completion and Picture arrangement WAIS subtests) but not for others. Therefore, by manipulating visual acuity to target blur levels, one can establish a “minimal” or “cut-off” acuity above which certain tests should not be administered since they significantly affect task performance. Categorizing participants results in a range of acceptable acuities rather than an exact cut-off acuity. Therefore, we argue that simulating blur is advantageous over measuring the effects of naturally-occurring blur in the context of the present and similar studies.

**Effect of ocular pathology on neuropsychological task performance**

In addition to CVI, ocular conditions such as glaucoma, ARMD, retinitis pigmentosa and diabetic retinopathy also result in reduced visual acuity (and contrast sensitivity and visual fields deficits) (REFS). As with the simulated blurred groups (i.e., 20/40 and 20/40) in the present study, we have recently demonstrated (Bertone et al., 2005) that the performance of patients with ARMD is significantly reduced on non-verbal neuropsychological tasks, particularly for tasks characterized by visual scanning strategies (Trail Making Test (D-KEFS)) and small-sized / high-spatial frequency items
(i.e., Digit Symbol and Symbol Search WAIS subtests). Performances on larger-sized / low high-spatial frequency defined tasks were less affected (i.e., Picture Completion subtest of the WAIS and the Hooper Visual Organization test (VOT)) by ARMD. However, when patients were re-assessed within a six-week period using the same battery of tests in magnified versions (tests size increasing by 150%), performance increased to « near normal » levels for tasks defined by small-sized / high-spatial frequency items, but not for larger-sized / low high-spatial frequency defined tasks (performance remained constant), particularly for ARMD patient with severe loss of acuity loss and central vision. These findings are important in that loss of visual acuity, whether the result of CVI or ocular pathology, significantly affects performance on neuropsychological testing and therefore, compromises the validity of cognitive status diagnosis derived in part for non-verbal neuropsychological test results if the visual acuity of the patient is not known. By correcting for the loss of visual input (by stimulus magnification), task performance was improved for the ARMD group. Taken together, the results of Bertone et al., (2005) and those of the present study demonstrate that non-verbal neuropsychological task performance can be significantly affected by either degrading (i.e., blurring) or enhancing (i.e., magnifying) visuo-sensory input, irrespective of cognitive status.

**Patient populations most affected by reduced visual acuity: the elderly**

Patient populations likely to present non-optimal visual acuity at the time of assessment include persons who have sustained traumatic brain injury (TBI) (Skeel et al., 2003) and of course, persons with ocular pathology (Kempen et al., 1994; Bertone et al., 2005). However, we argue that the patient population most relevant to the arguments presented in this study are elderly patients (van Boxtel et al., 2001), specifically, elderly patients being assessed for probable dementia.

The prevalence of CVI is increases with age and is often untreated. In fact, some epidemiological studies have demonstrated that approximately one out of four (or 25%) of participants over the age of 75 with “corrected vision” still had a visual capabilities considered to be impaired (Evans, 2002); the authors considered this figure to be a
conservative estimate. Some studies have found even higher prevalence of CVI for the same age group (i.e., Jack et al., 1995; Reinstein et al., 1993). New refractive corrections would likely improve the visual acuity in many older adults (Tielsch et al., 1990), and consequently, performance on non-verbal tasks. These statistics is of important concern for practitioners involved in the assessment of cognitive status for patients potentially suffering form dementia of the Alzheimer or Parkinson type, mild cognitive impairment, and other degenerative pathologies affecting the elderly. In theory, one out of every four patients assessed probably has non-optimal visual acuity when assessed, even when wearing his/her corrective lenses. As we have demonstrated, even minimal visual impairment (i.e., 20/40) has significant effects on performance on certain tasks often used as part of batteries to either diagnose a probable dementing process or differentially diagnose between different types of dementia. For this reason, knowledge of the *ocular status* of elderly patients is necessary in order to carry out an efficient and precise cognitive assessment. Based on the present results, we suggest that failure to take into account the patient’s visual capabilities may lead to performance hypothetically interpretable as reflecting impaired cognitive status.

Not only is the *prevalence* of CVI increased with age, it is also *accelerated* with age (REF). As mentioned by Skeel (2003), it is quite possible that the visual acuity of an elderly patient evaluated on a yearly basis changes to a larger degree compared to younger patients. One would therefore expect that elderly patients would be less likely evaluated with their optimal correction. Hypothetically, it is possible that in addition to presenting continuing cognitive decline, elderly patients may also present increased CVI making it difficult to dissociate ocular-related loss form cognitive-related loss with time. Another scenario is that the *real* cognitive status of such patient remains relatively unchanged but due to changing visual status, their cognitive profile, based in part on non-verbal test results, will reflect deteriorating cognitive status. Such a scenario is evidenced by our intra-subject results where scores on the Digit Symbol-Coding / Symbol Search WAIS subtests were significantly decreased as blur was increased for the same participant, tested within the same session. In this case, participants presented the same cognitive status but their task performance was entirely dependant on their visual acuity.
It can be argued that the same pattern of results would be manifested for other non-verbal tasks, particularly for those defined by small-sized / high-spatial frequency items:

**Clinical implications: The need to establish protocol**

It is common practice, as well as common sense, to ask a patient to wear his/her corrective lenses before neuropsychological assessment. However, it is not known whether the intake interview of either private or public health practitioners include the following fundamental questions regarding the patient’s *ocular status* at the time of assessment; Is the patient’s corrected visual acuity is optimal? What is the patient’s present corrected acuity? When was patient’s last optometric assessment? Does the patient suffer from any ocular condition causing degraded visual capacities (i.e., cataracts, glaucoma, diabetic retinopathy, etc.)? Are the corrective lenses worn by the patient issued by a health professional or simply over the counter reading glasses? It is above and beyond the neuropsychological profession to be able to efficiently assess the ocular status of the patients being evaluated. However, it is possible to inform oneself *through communications with other professionals responsible for the ocular health of the patient*, and not by simply asking the patient about his/her own vision as precise self-assessment is sometimes not possible (Friedman et al., 1999; Klein et al., 1999; Skeel et al., 2003).

**IDEAS ABOUT HOW TO END …CONCLUSION**

**ACKNOWLEDGEMENTS**

This work was supported by a CIHR Research Group On Sensory and Cognitive Aging post-doc aging grant to AB and a Réseau de Recherche en Santé de la Vision (FRSQ) grant to AB & JF.
REFERENCES


Figure legends (INCOMPLETE)

Figure 1. mention abbreviations of each subtests … Picture Completion (PC), Digit Symbol-Coding (CD), Matrix Reasoning (MR), Picture Arrangement (PA) and Symbol Search (SS) subsets (Performance scale); Information (I), Similarities (S) and Arithmetic (A) subtests (Verbal scale).

Figure 3. mention abbreviations of subtests … (Visual Scanning (VS), Number Sequencing (NS), Letter Sequencing (LS), Number-Letter Switching (N-LS) and Motor Speed (MS).

Figure 4. Letters-Structured (L-S), Letters-Unstructured (L-U), Forms-Structured (F-S) and Forms-Unstructured conditions.

Figure Letters-Structured (L-S), Letters-Unstructured (L-U), Forms-Structured (F-S) and Forms-Unstructured conditions
Figure 2.
Figure 3.

D-KEFS Trail Making Test Condition

Normative Score

Condition 1 - Visual Scanning
Condition 2 - Number Sequencing
Condition 3 - Letter Sequencing
Condition 4 - Number-Letter Switching
Condition 5 - Motor Speed

Acuity
- 20/20
- 20/40
- 20/60
Figure 4.