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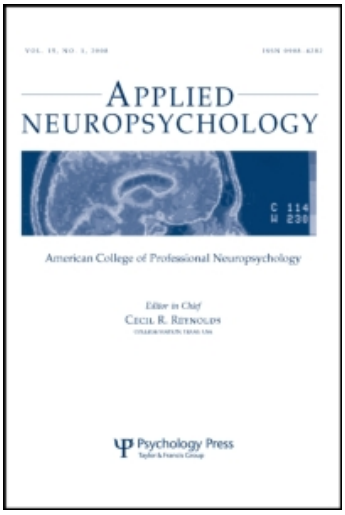

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High Specificity of the Word Memory Test and Medical Symptom Validity Test in Groups with Severe Verbal Memory Impairment

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By definition, false positives occur when an otherwise very easy symptom validity test (SVT) or effort test is failed because of cognitive impairment and not because of poor effort. Therefore, the highest rate of false positives will be found in those groups with the most severe cognitive impairment. For that reason, it is important to study people with severe impairment when evaluating the specificity of SVTs. Some people with various types of dementia, notably those with Alzheimer's disease, suffer from severe impairment of memory and other cognitive abilities. In this study, patients with possible or probable dementia were tested with the Word Memory Test (WMT; Green, 2003; Green & Astner, 1995) and the Medical Symptom Validity Test (MSVT; Green, 2004). While some dementia patients failed the easy subtests of these instruments and had severe verbal memory impairment, they showed distinctive profiles of scores that have been reported to be characteristic of people with severe impairment. Using profile analysis, the WMT and MSVT achieved a specificity of 98.4% or higher in the patients of the current study. This suggests that there will be extremely low false positive rates using the same methods in people with relatively minor impairment of the type found in, for example, mild traumatic brain injury or depression.

Key words: *dementia, effort, malingering, specificity, SVT*

INTRODUCTION

Poor effort when taking a neuropsychological test can invalidate the test results, and so it is necessary to employ symptom validity tests (SVT) to assess the validity of test results (Bush et al., 2005). However, a serious limitation to all SVTs is that some people with very severe cognitive impairment will fail them, even if they make a full effort (Merten, Bossink, & Schmand, 2007). For example, Reliable Digit Span is very rarely failed by people with mild head injuries if they make an effort to pass (Greiffenstein, Baker, & Gola, 1994), but it was failed by 44% of patients with stroke (Heinly, Greve, Bianchini, Love, & Brennan, 2005). In a study by Singhal, Green, Ashaye, Shankar, and Gill (2009), all of the advanced Alzheimer's dementia patients failed the easy forced-choice recognition memory subtests of both the Medical Symptom Validity Test (MSVT; Green, 2004) and the Nonverbal Medical Symptom Validity

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Test (NV-MSVT, Green, 2008). The usual adult criterion for Warrington's Recognition Memory Test was deemed unsuitable for use with people with dementia or mental retardation because of too many false positives for poor effort (Kim et al., 2009). Similarly, the Test of Memory Malingering was failed by 27% of dementia patients in the test manual (Tombaugh, 1996).

By definition, false positives occur when an otherwise very easy SVT or effort test is failed not because of suboptimal effort but *because of cognitive impairment*. Because cognitive impairment underlies false positives on SVTs, it follows that the highest rate of false positives will be found in those groups with the most severe cognitive impairment. For example, we expect more false positives in people with severe brain injuries than in those with mild head injuries. People with dementia and mentally retarded adults or children are likely to have the most severe impairment on nearly all cognitive tests, and so they are the groups at the highest risk for being misclassified by an SVT as making a poor effort. For that reason, these groups represent the best opportunity for us to assess the relative specificity of different SVTs, or to explore what Merten et al. (2007) called the "limits to effort testing." The gold standard for specificity in an SVT would be a test that has zero false positives in those with very severe cognitive impairment. Such a test would automatically have zero false positives in those with very mild or no cognitive impairment.

It has been shown that one way of reducing false positives on the MSVT in severely impaired people is to examine profiles of scores across subtests of different difficulty levels (Howe, Anderson, Kaufman, Sachs, & Loring, 2007; Howe & Loring, 2009; Singhal et al., 2009). If the easy MSVT subtest scores are below a certain cutoff, there are two possible explanations: (1) The person is actually so severely cognitively impaired that they cannot pass extremely easy recognition memory tests, or (2) there is poor effort and the test results are not reliable. To discriminate between these two possibilities, the difference between the mean scores on the easy and hard MSVT subtests is calculated. In the latter studies, dementia patients invariably displayed easy–hard differences of 20 points or more on the MSVT, whereas such large differences were often absent in people who were asked to feign impairment. The use of such profile analysis led to no more than 5% false positives in dementia patients (Howe et al., 2007; Howe & Loring, 2009). This work independently validated the specificity of the 20-point cutoff for the easy–hard difference, derived from testing by the third author and described in the MSVT test manual (Green, 2004). In contrast, out of 193 consecutive children with mild traumatic brain injury (TBI) tested by Kirkwood and Kirk (2010), only 7 cases, or 3.6% of the sample, displayed a profile similar to that reported in patients with dementia, also known as a genuine memory impairment profile (GMIP).

Singhal et al. (2009) studied institutionalized dementia patients, mainly with Alzheimer's disease, who were so impaired that they scored in the chance range on the extremely easy forced-choice recognition tasks of both the MSVT and the NV-MSVT. This means that in daily life, they would effectively have no useful verbal or visual-spatial memory, because recognition tasks are easier than almost any other form of memory test. Despite their very severe impairment, there were no false positives on the MSVT or NV-MSVT using profile analysis. Similar conclusions were reached by Henry, Merten, Wolf, and Harth (2009) when applying profile analysis to the NV-MSVT results from 65 neurological patients, including 21 cases with dementia. No false positives were evident in the group with dementia, and the specificity in the whole neurological group was 97.5%. Singhal et al. (2009) showed that the sensitivity of profile analysis to poor effort in the simulator group was only 60% with the MSVT and 70% with the NV-MSVT, but when both were used in combination, their sensitivity to poor effort was 80%. In clinical practice, a test method with close to 100% specificity in severely impaired people and a sensitivity of 80% in cases of poor effort would be very useful.

In this article, we will focus on the specificity of the MSVT and the Word Memory Test (WMT) in people with severe impairment. The original testing of people with dementia using the WMT was done by the third author using the German WMT, and data from these groups were included in the reporting sections of the WMT computer program (Green, 2003). These data showed that 95% of German dementia patients who failed the easy recognition memory subtests produced a difference of at least 30 points between the mean of the easy and hard WMT subtests (Immediate Recognition [IR], Delayed Recognition [DR], and Consistency [CNS], vs. Multiple Choice [MC], Paired Associates [PA], and Free Recall [FR]).

In the current study, we attempted to cross-validate the proposed easy–hard difference cutoffs in a different country and in a different language. We examined the computerized WMT profiles in a sample of patients with probable dementia tested in Spanish by the second author in Puerto Rico. We chose to focus on samples of patients with probable dementia because they tend to have as much cognitive impairment or more impairment than almost any other category of patient. The main goal was to find how many false positives there would be in people with impaired memory using previously established rules to analyze the profiles of results.

METHOD

Participants

A series of patients whose first language was Spanish was referred to a memory clinic by physicians, primarily neurologists, as part of a consecutive series for evaluation of cognitive functioning relevant to the possibility of dementia between 2006 and 2009. All cases were classified using the Clinical Dementia Rating (CDR) scale, according to clinical, nonpsychometric criteria described by Morris (1993) and Morris et al. (2001). Participants were included in the current analysis if they gave informed consent, which they all did, and if they were tested with the WMT. Later in the series, when the MSVT was obtained by the clinic where the study was carried out, both the WMT and MSVT were administered. Participants were not screened or excluded for potential financial incentives (e.g., disability claims or benefits) or for any other medical conditions.

The possible mild cognitive impairment group (MCI, $n = 60$) included: (1) 29 participants with a CDR rating of 0.5 and "uncertain dementia" in which only one domain, usually memory, was impaired or the impairment was doubtful, and (2) 31 cases with a CDR rating of 0.5 and "incipient dementia of an Alzheimer type (DAT)," involving impairment of memory and either one or two other domains (Morris, 1993).

Patients were classified as having probable dementia if they met the criteria for "CDR 0.5, DAT," involving impairment in memory and at least three out of five CDR domains, or "CDR 1, Mild Dementia" or "CDR 2, Moderate Dementia." Forty-two of these dementia patients were tested with the WMT (Dementia Group 1; mean CDR = 1.05, $SD = 0.6$) before the MSVT was available in the clinic where the study was done. Twenty-three subsequently referred dementia cases were given both the WMT and the MSVT (Dementia Group 2; mean CDR = 0.83, $SD = 0.35$). Those patients given both tests were not selected in any other way, apart from the fact that they were consecutively referred after the MSVT was obtained by the memory clinic.

A CDR of 0 means that after neuropsychological assessment, it was determined that there was no impairment. There were 19 such cases, and this group will be called the "unimpaired group." In the clinical setting in which this study was performed, it was originally decided that the "unimpaired" cases would only be given the WMT. Their WMT results will be reported below.

Procedure

The computerized WMT (Green, 2003) was given in Spanish to all participants. When the first 42 dementia patients had been tested with the WMT, the clinic purchased the MSVT (Green, 2004) and all subsequent cases were given the Spanish versions of the WMT and the MSVT. Following the procedures used by Singhal et al. (2009) and Howe and Loring (2009), the examiner stayed in the room and controlled the mouse for all participants, except for those who asked to enter their own responses. If participants had reading difficulties, the examiner read the words aloud on initial presentation and recognition trials. To reduce time demands on these patients, the interval between IR and DR administration was halved, from 30 to 15 minutes for the WMT, but it was the standard 10 minutes on the MSVT.

RESULTS

Table 1 shows the mean scores on all WMT subtests in the groups from the current study and a group of healthy controls from Iverson, Green, and Gervais (1999). There were significant differences between groups on all subtests, as shown in the table ($F = 2.9$, $p < .03$ for IR; $F = 4.5$, $p < .004$ for DR; $F = 4.0$, $p < .009$ for CNS; $F = 10.8$, $p < .001$ for MC; $F = 3.8$, $p < .01$ for PA; and $F = 18.5$, $p < .001$ for FR; df 3, 143 in each case). There were too many post-hoc comparisons to report in detail (four groups by six WMT scores). However, it is notable that on Bonferroni comparisons, the unimpaired group in Table 1 scored significantly higher than all other groups on the hardest WMT memory subtest, FR ($p < .002$ in all cases). However, there were no statistically significant post-hoc differences between any pair of groups on the easiest WMT subtest, IR.

T-scores were calculated for the most difficult memory subtest, FR, while correcting for age. In the bottom line of Table 1, we can see the mean WMT FR score from each group expressed as a T-score relative to healthy adults of the same age and with 12 years of education, based on the normative data from the study by Rienstra, Spaan, and Schmand (2009). As we might expect, the unimpaired group had a T-score of 57, which is close to the normal mean for age, but the two dementia groups displayed impairment of verbal memory, with T-scores of 24 and 23, respectively. The average FR subtest scores for the probable dementia patients were more than two standard deviations below the normal mean for their age, which provides strong evidence that they suffered from impairment of verbal memory. The T-score of 37 in the possible MCI group was intermediate between the T-scores from the unimpaired and the dementia groups.

In Table 2, we can see that even among those in the dementia groups who passed the easy WMT subtests, the scores on the memory subtests (MC, PA, and FR)

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TABLE 1
Mean Scores on the Word Memory Test (WMT) in the Unimpaired Group, the MCI Group, and Two Dementia Groups

	Unimpaired Group (N = 19)		*Possible MCI (N = 60)*		*Dementia Group 1 (N = 42)*		*Dementia Group 2 (N = 23)*		
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Sig.*
WMT IR	98.6%	2.3	94.3%	8	82.1%	13	85.8%	15	$p < .04$
WMT DR	98.6%	2.1	91.5%	9	78.9%	13	81.6%	15	$p < .005$
Consistency	97.5%	2.3	90.2%	9	77.6%	11	83.1%	13	$p < .01$
Multiple Choice	95.7%	3.7	67.4%	21	38.9%	16	49.1%	21	$p < .001$
Paired Associates	90.7%	6.8	59.0%	24	26.4%	18	35.9%	19	$p < .01$
Free Recall % correct	67.9%	15.4	37.1%	17	17.6%	13	19.2%	13	$p < .001$
Free Recall T-score*	T57	—	T37	—	T24	—	T23	—	—

Note. DR = Delayed Recognition; IR = Immediate Recognition; MCI = Mild Cognitive Impairment.
*Age-corrected T-scores are relative to healthy adult volunteers from the study by Rienstra et al. (2009).

were still impaired relative to the normal mean from adults in the WMT program (Green, 2003) and relative to healthy controls of the same age studied by Rienstra et al. (2009). For example, the mean FR score of 28.9% in members of Dementia Group 1 who passed the easy subtests (i.e., not meeting Criterion A) was 2.8 standard deviations lower than the healthy adult mean of 63.7% ($SD = 12.4$; Green, 2003), and this score is equivalent to a T-score of 33 for people of the same age from the study by Rienstra et al. (2009). Thus, those patients in Dementia Group 1 who passed the easy WMT subtests still showed impairment of verbal memory on the FR subtest. The mean FR score of 21.7% (T-27) of patients in Dementia Group 2 passing the easy WMT subtests was even lower. The mean FR score of 41.5% of patients in the possible MCI group passing the easy subtests was still 1.8 standard deviations lower than the healthy adult mean, which indicates probable verbal memory impairment in at least some group members. Their FR score of 41.5% converts to a T-score of 40 based on the data from Rienstra et al. (2009).

Among those patients who failed the easy subtests of the WMT, the scores on the more difficult memory subtests (MC, PA, and FR) were even lower than among those who passed the easy subtests. For example, the mean FR score of 13% correct ($SD = 10$) in Dementia Group 1, failing the easy subtests, was four standard deviations below the mean from the sample of healthy adults shown in the table. Their mean FR score would be a T-score of 21 relative to the Rienstra et al. (2009) healthy adult volunteers, and it was lower than the mean from three patients with bilateral hippocampal damage and amnesia in the study of Goodrich-Hunsaker and Hopkins (2009). The intention in selecting the current patients was that many of them would probably have severe verbal memory impairment as part of their dementing illness. It is clear from Tables 1 and 2 that many of these patients did have severe verbal memory impairment, and therefore, they represented a good sample for testing the specificity of the WMT and MSVT profile criteria.

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TABLE 2
Word Memory Test (WMT) Subtest Scores in Subgroups That Passed or Failed the Easy WMT Subtests, Contrasted With Means From Healthy Adult Volunteers

			WMT Scores as Percent Correct (Standard Deviations in Brackets)						
	Age	N	*IR*	*DR*	*CNS*	*MC*	*PA*	*FR*	*FR T-Score by Age*
GROUPS PASSING EASY WMT SUBTESTS									
Healthy adults*	39 (7.0)	40	98.0% (2.8)	98.6% (2.4)	96.8% (3.8)	95.4% (6.7)	92.6% (9.6)	63.7% (12.4)	T50
Unimpaired group	55.8 (7.5)	19	98.6% (2.3)	98.6% (2.1)	97.5% (2.3)	95.7% (3.7)	90.7% (6.8)	67.9% (15.40)	T54
Dementia Group 1	75.9 (6.7)	12	92.7% (4.5)	92.9% (4.1)	90.2% (2.9)	53.7% (16.6)	41.7% (18.9)	28.9% (11.0)	T33
Dementia Group 2	70.7 (5.4)	12	96.3% (2.9)	92.9% (4)	91.5% (4)	61.3% (19)	44.6% (18)	21.7% (14)	T27
Possible MCI	67.9 (8.6)	47	96.0% (3)	95.3% (4.3)	94.0% (5.3)	74.5% (16.5)	66.4% (19.0)	41.5% (15.7)	T40
GROUPS FAILING EASY WMT SUBTESTS									
Dementia Group 1	74.1 (8.0)	30	77.9% (12.8)	73.3% (12.1)	72.6% (8.8)	33.0% (12.3)	20.3% (14.0)	13% (10.1)	T21
Dementia Group 2	72.7 (9.5)	11	74.8% (14)	69.3% (13)	74.1% (14)	35.9% (14)	26.4% (17)	16.6% (14)	T23
Possible MCI	72.1 (9.2)	13	84.2% (9.5)	78.0% (9.4)	76.5% (5.1)	41.9% (16.6)	32.3% (19.7)	21.1% (9.9)	T26

Note. CNS = Consistency; IR = Immediate Recognition; DR = Delayed Recognition; FR = Free Recall; MC = Multiple Choice; MCI = Mild Cognitive Impairment; PA = Paired Associates.
*There were no failures in the healthy adults or in the unimpaired group. The healthy adult group means were taken from the WMT program (Green, 2003). Age-corrected T-scores for the Free Recall subtests are from Rienstra et al. (2009).

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Profile Analysis

In the possible MCI group, 13 cases (21.6% of the group) failed the easy WMT subtests, meeting Criterion A. This is significantly lower than the failure rate in the two dementia groups (chi-square = 29, $df = 2$, $p < .001$) and is consistent with the assumption that the possible MCI group had less severe verbal memory impairment than the dementia groups. In 11 of the possible MCI cases meeting Criterion A, there was a possible dementia profile (or GMIP) because they did not meet Criterion B. That is, the easy–hard difference was 30 or more in all such cases. In two cases, Criteria A and B were met, meaning that these two cases would be classified as having a "poor effort" profile. Assuming that they did actually put forth a full effort, this would represent a false positive rate of 3.3% or a specificity of 96.7% for profile analysis in the MCI group.

In Dementia Group 1, 30 out of 42 cases (71%) failed the easy subtests of the WMT and met Criterion A. However, none of the failures had an easy–hard difference less than 30 points (Criterion B) and so none produced a poor effort profile by meeting both Criteria A and B. They all had a possible dementia profile or GMIP (meeting Criterion A but not B).

The patterns of results in Dementia Group 2 on both the WMT and the MSVT are shown in Table 3. There were 23 cases of probable dementia given both the WMT and the MSVT, and 11 of these cases (48% of the group) failed the easy WMT subtests and met Criterion A. However, none of these cases had an easy–hard difference less than 30 on the WMT and so no case would be classified as poor effort because of meeting Criteria A and B on the WMT. Hence, the WMT results for all dementia patients in this sample failing the easy subtests would be classified as "possible dementia profiles" on the WMT. In cases with such profiles tested clinically, poor effort would only be concluded if dementia could be ruled out.

Failure on the easy MSVT subtests (meeting Criterion A) was present in 44% of Dementia Group 2 (10 out of 23 cases). However, none of these cases had an easy–hard difference less than 20 (Criterion B).

TABLE 3
Results of Word Memory Test (WMT) and Medical Symptom Validity Test (MSVT) in Patients From Dementia Group 2

	Criteria met on the WMT & MSVT					
	WMT		*MSVT*		*Both Tests*	
	A	*B*	*A*	*B*	*A & B on One or Both Tests*	*A without B*
Case No.	*Pass/Fail Easy Subtests*	*Easy–Hard Difference <30*	*Pass/Fail Easy Subtests*	*Easy–Hard Difference <20*	*Poor Effort Profile on One or Two Tests*	*Possible Dementia Profile on One or Two Tests*
1	Pass	—	Pass	—	No	None*
2	Fail	No	Fail	No	No	Both
3	Fail	No	Pass	—	No	One
4	Pass	—	Pass	—	No	None
5	Fail	No	Fail	No	No	Both
6	Fail	No	Fail	No	No	Both
7	Pass	—	Pass	—	No	None
8	Fail	No	Fail	No	No	Both
9	Fail	No	Pass	—	No	One
10	Pass	—	Pass	—	No	None
11	Pass	—	Pass	—	No	None
12	Fail	No	Fail	No	No	Both
13	Pass	—	Pass	—	No	None
14	Pass	—	Fail	No	No	One
15	Pass	—	Pass	—	No	None
16	Pass	—	Pass	—	No	None
17	Fail	No	Fail	No	No	Both
18	Pass	—	Pass	—	No	None
19	Pass	—	Pass	—	No	None
20	Fail	No	Fail	No	No	Both
21	Pass	—	Fail	No	No	One
22	Fail	No	Pass	—	No	One
23	Fail	No	Fail	No	No	Both
% that meet criteria	48% (11/23)	0%	43% (10/23)	0%	0%	56%

*"None" means that the person scored above the cutoffs on the easy subtests of both the WMT and MSVT, and in these cases, the easy–hard difference is not calculated.

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Therefore, none were classified as poor effort (Table 3). All cases failing the easy MSVT subtests would be classified as having a "possible dementia profile," also known as a GMIP. No dementia case had a poor effort profile on either the WMT or the MSVT, representing 0% false positives or 100% specificity.

Twelve cases from Dementia Group 2 passed the easy subtests of the WMT, and their mean profiles on both the WMT and MSVT are shown in Table 4. Even though they scored above the cutoffs on the easy recognition memory subtests, their scores on the more difficult subtests of the WMT were clearly impaired relative to healthy adult controls (Rienstra et al., 2009). Similarly, their mean MSVT FR score of 30% was extremely low compared with, for example, the mean score of 92% correct ($SD = 7.5$) among nurses seeking license renewal, tested by Dr. Michael Chafetz and shown in the MSVT program (Green, 2008). This demonstrates that some patients diagnosed with probable dementia have impairment of verbal memory, but they are not sufficiently cognitively impaired to fail the extremely easy recognition memory subtests of the WMT or MSVT.

There are twice as many word pairs on the WMT than on the MSVT, and so we would expect the MSVT subtests to be easier than the equivalent WMT subtests. In fact, the scores on the IR, DR, PA, and FR subtests of the MSVT were all significantly higher than their equivalents on the WMT ($p < .01$ or lower, Wilcoxon signed ranks test).

There were significant age differences between groups ($F = 10.8$, df 3, 143, $p < .01$), and this was why the FR scores were converted to age-corrected T-scores. Post-hoc Bonferroni analysis showed that the unimpaired group, with a mean age of 55.8 years ($SD = 7.5$), was significantly younger than the MCI group (mean = 68.8 years, $SD = 8.9$, $p < .01$). The mean age of the MCI group was slightly but significantly lower than the mean of 70.9 years ($SD = 8$) in Dementia Group 1 ($p < .01$) and significantly higher than the mean in Dementia Group 2 (65.2 years, $SD = 8$, $p < .05$). In the dementia groups combined, there was no significant correlation between age and WMT IR ($r = -.18$) or DR ($r = -.1$), but age did correlate significantly with the scores on the MC ($r = -.29$), PA ($r = -.26$), and FR ($r = -.34$) subtests. In the possible MCI group, age correlated nonsignificantly with WMT IR ($r = -.16$) and DR ($r = -.07$) but correlated significantly with scores on the MC ($r = -.29$), PA ($r = -.28$), and FR ($r = -.33$) subtests.

DISCUSSION

The current study shows that using profile analysis, there were no false positives in Dementia Group 2, in which patients were given the MSVT. This finding supports previous reports of very high specificity for profile analysis with the MSVT in severely impaired people (Howe et al., 2007; Howe & Loring, 2009; Singhal et al., 2009). In Dementia Group 2, there were also no false positives on the WMT using profile analysis. In all groups, when Criterion A was met, there was nearly always a plausible profile of subtest scores within each test because Criterion B was not met. That is, the scores on objectively more difficult subtests were much lower than their scores on the easier subtests, as we expect from someone with valid test results. Using Criterion B, based on the magnitude of the mean difference between the easy and hard scores, it was possible to avoid false-positive classification of all members of the dementia groups on both the WMT and the MSVT (100% specificity).

Two people out of 60 in the possible MCI group failed the easy subtests of the WMT and/or the MSVT and had a "poor effort" profile (i.e., met Criteria A & B). Assuming that all cases were actually making a full effort, which is uncertain, there were only two false

TABLE 4
Word Memory Test (WMT) and Medical Symptom Validity Test (MSVT) Mean Scores in Dementia Group 2 Broken Into Those Passing and Failing the WMT Easy Subtests

	Cases Meeting Criterion A on the WMT (Failing)		*Cases Not Meeting Criterion A on the WMT (Passing)*	
Subtest	*WMT Scores Mean (SD)*	*MSVT Scores Mean (SD)*	*WMT Scores Mean (SD)*	*MSVT Scores Mean (SD)*
IR	74.8% (14)	82.3% (17)	96.0% (3)	97.9% (3)
DR	69.3% (13)	84.6% (10)	92.9% (4)	94.2% (4)
CNS	74.1% (14)	78.6% (18)	91.5% (4)	92.9% (5)
MC	35.9% (14)	—	61.3% (19)	—
PA	26.4% (17)	41.8% (28)	44.6% (18)	55.8% (27)
FR	16.6% (14)	24.1% (19)	21.7% (14)	30.0% (15)

Note. CNS = Consistency; DR = Delayed Recognition; FR = Free Recall; IR = Immediate Recognition; MC = Multiple Choice; PA = Paired Associates.

positives on the WMT in the MCI group (96.7% specificity). Combining all groups from the current study together, there would be, at the most, a 1.6% false positive rate on the WMT, which represents a specificity of 98.4% in possible MCI and probable dementia. This level of specificity is excellent for almost any clinical or forensic purpose. The current results show that it is possible to achieve very high specificity for poor effort in groups with dementia, mainly of a probable Alzheimer's type, who have severe impairment of verbal memory, as shown by their very low FR scores on both tests (Tables 1 and 2). Thus, even if someone suffers from severe verbal memory impairment, it is possible to determine from the test results on the WMT or MSVT whether failure on the easy subtests is likely to reflect actual impairment (in the case of a possible dementia profile) or unreliable test scores (in the case of a poor effort profile). The risk of drawing a false-positive conclusion of poor effort in the patients similar to those from the current study would be extremely low.

It follows logically that the specificity of these tests will be even higher in groups of patients who are less cognitively impaired and are therefore at much lower risk of false positives than people with probable dementia. This would include anyone with mild TBI and most people with moderate or severe TBI. This conclusion is relevant to previous studies, including that of Greve, Ord, Curtis, Bianchini, and Brennan (2007) who concluded that some people with mild TBI failed the easy WMT subtests and that their failure was a result of genuine impairment (i.e., that they were false positives for poor effort). If WMT profile analysis does not lead to false-positive classifications in people with sufficient impairment to be diagnosed as having probable dementia, then it is very unlikely indeed that it will lead to any false positives in people with much less severe impairment or no impairment as a result of mild TBI.

While the specificity of profile analysis with the WMT and MSVT is high, it is to be expected that the sensitivity of this method to poor effort will be lower than that which may be achieved using simple cutoffs on easy tasks (Green, Flaro, Brockhaus, & Montijo, in press). The main purpose of profile analysis is to achieve the lowest possible rate of false positives *among those in whom there is a reasonable possibility of very severe impairment*. It is important to note that the interpretation of a possible dementia profile on the WMT or MSVT occurs in a clinical context and that other information must be taken into account. If a person is truly severely impaired, as in the case of patients with dementia or mental handicap, there is invariably other evidence pointing to the probability of very severe impairment, which will assist the clinician in interpreting profiles of test scores. For example, the person may be in 24-hours-a-day care. Such evidence would be absent in a case with much less severe impairment, such as mild TBI, depression, or posttraumatic stress disorder. Someone with the latter diagnoses would be classified as making a poor effort, even if they produced a dementia profile on the WMT or MSVT, because such diagnoses are not known to cause impairment as great as that found in dementia or in people with bilateral hippocampal damage. On the other hand, a person who has clear clinical signs indicating severe impairment or a diagnosis implying such impairment (e.g., Huntington's disease, Korsakoff syndrome, or widespread brain tumor) would be regarded as putting forth a full effort if a dementia profile is observed.

For example, in the study of Green et al. (in press), adults with very mild TBI were selected, and 42% of these adults failed the easy MSVT subtests in the presence of disability payments or other compensation. In contrast, the failure rate on the same subtests was 0 among children with severe TBI in the study of Carone (2008), and non-French-speaking children who were tested in French still scored at almost perfect levels on the easy subtests (Richman et al., 2006). Of the adults with mild TBI, 13% had a "possible dementia profile," and 29% had a poor effort profile. In all such cases, poor effort would be concluded because it is not plausible that someone with a very mild TBI would score lower than children with severe TBI or as low as people with dementia on extremely easy MSVT subtests (Iverson, 2005). Although there were possible dementia profiles on the MSVT in 13% of adult mild TBI cases in the Green et al. (in press) study, there was no evidence of any other condition which could cause enough impairment to produce such low scores on very easy subtests. Dementia could be ruled out in these cases of mild TBI. Hence, failure on the easy MSVT recognition memory subtests in the latter adults with mild TBI would be attributed to suboptimal effort.

The same logic applies to failure on the WMT easy subtests, which were passed by 31 out of 32 mentally retarded adults in a German institution (Brockhaus & Merten, 2004) and by people with bilateral hippocampal damage and amnesia (Goodrich-Hunsaker & Hopkins, 2009). It would not be plausible that someone with a mild TBI would be more impaired than the latter cases, and so failing scores on the easy subtests of the WMT in someone with mild TBI would invariably suggest poor effort. However, if there were a question of profound cognitive impairment, similar to that seen in some people with dementia, the possibility of actual severe impairment would need to be taken into account using profile analysis (Criteria A and B). For example, if a 70-year-old suffered a mild head injury and then showed a possible dementia profile on the WMT or MSVT,

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serious attention would have to be given to the possibility of dementia unrelated to the head injury before poor effort could be concluded.

One limitation to the current study is that we did not examine the sensitivity of the WMT and MSVT to poor effort. That would require the use of a known group of poor effort cases or experimental simulators. A related limitation is that we had no information on whether there were external incentives to exaggerate impairment (e.g., disability benefits). It is known that such incentives affect WMT performance (Flaro, Green, & Robertson, 2007). We have assumed good effort in all cases, but we cannot determine to what extent external incentives might have been present or whether they led to incomplete effort on testing in some cases. Although this does not affect estimates of the specificity of the WMT or MSVT, it could have implications for sensitivity. Independent studies will be needed to establish the sensitivity of WMT and MSVT profile analysis in cases with and without external incentives and poor effort. Ideally, such studies would look at the use of profile analysis, combined with careful consideration of independent clinical data to determine whether very severe impairment is likely.

We did not analyze comprehensively the profiles of neuropsychological test results in the patients of the current study. A more detailed evaluation of the neuropsychological deficits in those with a dementia profile would be very interesting, but this was beyond the scope of this study.

It may be argued that a flaw of the CDR classification system used in this study is that it depends on subjective judgment of the person's day-to-day functioning. In the current context, however, diagnostic imprecision is not a major drawback because the study was not intended to contribute to the diagnosis of dementia subtypes. Instead, the goal was to isolate samples with severe cognitive impairment and to evaluate the specificity of profile analysis in these people. Dementia patients were chosen because they would include many cases with severe verbal memory impairment. The mean scores from the probable dementia groups in this study clearly showed impairment on the WMT and MSVT memory subtests, and in many cases, the impairment was very severe. For example, the dementia groups failing the easy subtests scored almost three standard deviations below the age-corrected normal means on FR (Table 2). The dementia groups scored in the same range on WMT MC, PA, and FR subtests as cases with bilateral hippocampal damage and profound amnesia in the study of Goodrich-Hunsaker and Hopkins (2009). In fact, the probable dementia patients in the current study were even more impaired than the latter cases of bilateral hippocampal damage. The hippocampal damage cases did not fail the extremely easy recognition memory subtests of the WMT, but many of the current dementia cases did fail these easy subtests. Despite their severe impairment, no member of the dementia groups in the current study was classified as a case of poor effort. The results, therefore, show that the specificity of the WMT and MSVT is high when profile analysis is used to interpret scores *from people with severe memory impairment* from probable or possible dementia. We would expect the same to be true of people with severe impairment from any disease because the underlying principle is that genuine impairment will lead to much higher scores on very easy tasks than on much harder tasks.

A flaw of the CDR system is that it does not discriminate well between various types of dementia (e.g., Huntington's versus Alzheimer's disease). If this study were intended to validate the WMT or MSVT as a diagnostic test for specific subtypes of dementia, a lack of diagnostic specificity in the CDR criteria would be important, but this study was not designed to meet that goal. It is also important to point out that the current study was not done because high rates of poor effort are suspected in people with dementia, nor was the main application of the current findings intended to be with dementia populations. People with probable or possible early dementia were selected only because this population is at very high risk for having severe verbal memory impairment. It is in people with such severe impairment that we may most effectively study the limits to the specificity of any memory-based SVT, as suggested by Merten et al. (2007) in their article on the limits to effort testing. The current findings suggest that profile analysis with the MSVT and WMT is clinically useful in achieving high specificity for these tests in people with very severe impairment and probable dementia. If so, then we would expect extremely low rates of false positives for poor effort in nondemented samples, such as those with mild TBI.

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