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The Semantic Object Retrieval Test (SORT) in Normal Aging and Alzheimer Disease

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Objective: To characterize performance on a test of semantic object retrieval (Semantic Object Retrieval Test-SORT) in healthy, elderly subjects and patients with Alzheimer disease (AD).

Background: Although the initial presentation of patients with AD often reflects impairment in delayed recall for verbally encoded memory, common complaints of patients with early AD are actually related to semantic memory impairment.

Design: Thirty-eight AD patients and 121 healthy aging controls enrolled in an Alzheimer's Disease Center received a battery of standard neuropsychologic tests including the SORT.

Results: Compared with normal controls, AD patients had SORT memory impairments with significantly more false positive memory errors, fewer correctly produced names, and more substitutions in the name production aspect of the test. SORT had robust test-retest reliability in normals.

Conclusions: The SORT task provides a direct, specific assessment of semantic memory, and has now been administered to 121 healthy, aging controls for normative ranges of performance and AD patients. The task detected semantic memory deficits in approximately half of patients with mild-moderate AD, which is comparable to other studies assessing semantic deficits in AD with less specific measures.

Key Words: semantic, memory, Alzheimer disease, naming, fluency

(*Cog Behav Neurol* 2006;00:000–000)

Received for publication May 24, 2006; accepted August 31, 2006.

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Supported by the Alzheimer's Disease Center at the University of Arkansas for Medical Sciences (C. Beck, PI, NIA NIH, AG-19606).

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The initial clinical presentation of patients with Alzheimer disease (AD) typically consists of impairment in delayed recall for verbally encoded memory. However, the impairments that follow this initial deficit can vary considerably across patients. Although development of these additional impairments represents an early marker of disease progression, recent investigations have focused on detection of the earliest onset of this degenerative disease. For example, mild cognitive impairment (MCI) has been described as a transitional state between cognitive performance typical of normal aging and AD. When the cognitive impairment of MCI includes episodic memory (aMCI) the conversion rate to AD is approximately 10% to 15% per year.[1,2]

With the focus on memory performance in both AD and MCI being the primary and/or initial deficit, there is considerable interest as to which is the next cognitive domain to be impaired and thus to signify further disease progression in these conditions. A common complaint of patients in the early stages of AD, and in patients with the subtypes of MCI that are not predominated by complaints of new learning difficulties,[3,4] is difficulty remembering what items are called; that is, in retrieving an item that they already have stored in memory and finding the word for that item. These difficulties fall within the domain of semantic memory impairment and/or word finding deficits if the memory is retrieved but the name cannot be accessed lexically. There are few standardized neuropsychologic measures of either of these factors. For example, while performance on the Boston Naming Test (BNT) has been promoted as an assessment of semantic memory in dementia (for usage list of putative tests of semantic memory used in AD studies),[5] the task clearly engages multiple cognitive components including visual object recognition, lexical-semantic processing, semantic-to-phonological transfer, access to the output phonological lexicon, as well as peripheral visual and speech functions.[6] Thus, impaired performance on this task could be due to disruption of cognitive components other than semantic. The Controlled Oral Word Association Test (COWAT) is a measure of verbal fluency and hence has been proposed as a measure of word finding.[7] This test requires a subject to name as many words as they can in 1 minute that begin with a specific letter. The difficulty with using this test as a measure of the word finding difficulty commonly described by dementia patients is that the task allows for the subjects to choose the words they wish to say, within a given framework, and they can skip over words they have difficulty producing. The COWAT thus provides a good marker of a frontal lobe search strategy for words within a specific category or framework rather than a test of accessing and producing a word for a specific target.

Less commonly used tasks in dementia evaluations for semantics include the Vocabulary, Comprehension, and Similarities subtests of the Wechsler Adult Intelligence Scale (WAIS), but each has limitations as a clinical assessment tool for primarily semantic deficits. The Vocabulary subtest, which requires the subject to describe what a word means, suffers from an educational bias. The Comprehension subtest, requiring a subject to answer open ended questions, and the Similarities subtest, where the subject must explain what each word in a word pair share in common, both require generating a word and the subject's educational background can have substantial impact on the test results.[8]

The Palm Trees and Pyramids Test provides a good measure of semantics without a word finding component.[9] The Palm Tress and Pyramids Test does represent a much more pure assessment of semantic operations than other tests noted above that rely extensively on other nonsemantic cognitive operations. However, while the Palm Trees and Pyramids Test would be an excellent addition to assessments of dementia, the amount of time it takes to administer the task has been considered detrimental to its inclusion in dementia evaluations that have become increasingly restricted in the time allowed for neuropsychologic evaluation.

We have developed a measure of semantic memory, the Semantic Object Retrieval Test (SORT), which assesses a specific form of semantic association. The task requires a subject to evaluate 2 stimuli that are features of objects, and to determine whether the stimuli are related to one another through a specific object (eg, "desert" and "humps" would retrieve the object "camel"). Successful task performance during functional magnetic resonance imaging (fMRI) was found to engage medial Brodmann area 6, bilateral ventral temporal lobe, and the dorsomedial and pulvinar nuclei of the left thalamus.[10,11] The task also has the added advantages of being brief and that it can be administered without specialized training.

In a patient with implanted bilateral thalamic electrodes and limited surface scalp electrodes, we recorded EEG during performance of the SORT.[12] The findings demonstrated that during all trials of the SORT there was a global decrease in α band EEG power, which was followed by an increase in spatially specific γ band EEG power in the thalamus and occipital scalp electrodes for only those trials which resulted in correct semantic object retrieval. The BA6 region is connected to the dorsomedial nucleus of the thalamus[13,14] and these regions have been postulated to mediate semantic search mechanisms or generate an object framework from featural input via spatially widespread reduction in α-band EEG power. We have posited that via this mechanism, multiple cortical regions that encode semantic memory of features in different sensorimotor/cognitive modalities are engaged, or at least readied to participate in the object retrieval task. The pulvinar nucleus activation in successful object retrieval is proposed to modulate spatially specific fast rhythm burst (γ) to facilitate feature binding during retrieval via the synchronization of neural regions associated with feature representations in semantic memory systems of the object to be retrieved.[15–19]

This test, having initially been used as a tool for investigating the anatomic substrates and possible physiologic mechanisms underlying its performance, was then applied as a neuropsychologic evaluation tool for semantic memory. In addition to the administration of the test as performed in the functional MRI and electrophysiology study as a measure of semantic memory, an additional component was added to each trial to assess word finding/lexical access abilities. After reporting that a feature pair resulted in semantic object retrieval, the subject was asked to say the name of the object. The task was also administered auditorily to eliminate any possible reading difficulties in aging subjects with visual impairments or illiteracy. We report here a cross-sectional analysis of SORT results administered to a group of healthy older adults and to a group of AD patients, identified using the DSM-IV and McKhann et al[20] criteria, in an Alzheimer's Disease Center (National Institute on Aging, NIH). In this analysis, we administered the SORT task as described above along with an extensive neuropsychologic battery to obtain normative performance data and to evaluate the performance profile in our AD patient group. Neuropsychologic tests included tests relevant to the detection of dementia, other putative measures of semantic memory and word finding, and measures to assess cognitive aspects that may be engaged in performance of the SORT task (measures of attention, working memory, and comprehension of instructions).

METHODS

Subjects

Between November 2001 and October 2004, we studied 38 consecutive AD patients and 121 healthy aging controls, who were community dwelling volunteers for research programs of the Alzheimer's Disease Center at University of Arkansas for Medical Sciences. As part of the initial Alzheimer's Disease Center visit, patients were examined by a behavioral neurologist, received neuropsychologic testing, and were assessed by a social worker and by an intake nurse. After these evaluations were all completed, a conference of the evaluators occurred and a consensus diagnosis was formulated: healthy aging controls were without behavioral or cognitive complaints, had no impairment of daily functions, and had Clinical Dementia Rating (CDR) of 0.[21] AD patients met DSM-IV criteria for dementia and criteria of McKhann et al[20] for probable AD; CDRs ranged from 1 to 3 (a score of 1 indicates a mild impairment, 2 a moderate one, and 3 a severe deficit). Of the 35 with a CDR of 1, 27 were tested; the other 8 were not tested due to lack of time to complete the battery. There were 15 with a CDR of 2. Of these, 8 were tested, 1 was unable to comprehend the instructions and thus not tested, and 6 were not tested for a variety of logistical and scheduling reasons. Thirteen subjects had a CDR of 3. Of this group, 2 were tested.

This study was conducted according to the Good Clinical Practice Guidelines, The Declaration of Helsinki, and the US Code of Federal Regulations. Written informed consent was obtained from all participants or their caregivers according to the rules of the Institutional Review Board of University of Arkansas for Medical Sciences.

Healthy control subjects were between 61 and 91 years old (the 38 matched controls were of age 61 to 85 y) (Table 1). Patients were between 57 and 91 years of age, in good health, with no evidence of focal neurologic findings or a recent imaging study demonstrating no significant signs of cerebral infarction. The neuropsychologic battery was administered over several sessions.

Neuropsychologic battery:

1. Mini Mental State Exam
2. North American Adult Reading Test (NAART) (used to estimate full-scale intelligence quotient, FSIQ).
3. WAIS III subtests (Digit Span, Vocabulary, Similarities, Block Design, Matrix Reasoning and Letter Number Sequencing).
4. Symbol Digit Modalities Test.
5. Fluency: category (animals) and phonemic COWAT.
6. Boston Diagnostic Aphasia Examination subtests (Phrase Repetition, oral and written descriptions of the Cookie Theft Picture, Praxis)
7. BNT.
8. Token Test (Multilingual Aphasia Examination).
9. Judgment of Line Orientation.
10. Drawings: Clock (spontaneous drawing and copy), Necker Cube (copy), RBANS figure (copy).
11. Trail Making Test, Parts A and B.
12. Stroop Color Word Interference Test.
13. Wechsler Memory Scale III word list.
14. East Boston Memory Test.
15. SORT.
16. Geriatric Depression Scale.

Semantic Memory (and name production).

SORT Procedures

Neuropsychologic testing was performed by trained technicians; administration of the SORT took approximately 10 to 15 minutes. The technician recorded all subject responses, and scored the tests after the testing session. SORT stimuli consist of verbally presented word pairs. The words for this task are all features of objects. There are 2 types of word pairs: (a) 16 pairs, where the 2 words describing features of an object combine to elicit an object that was not presented (eg, the words "desert" and "humps," which produce the object "camel"), and (b) 16 word pairs that do not combine to retrieve an object not presented and are semantically unrelated (eg, "humps" and "alarm"). The same feature words used in the object retrieval pairs comprise the stimuli in the unrelated pairs, but are repaired with a semantically unrelated word (eg, humps and alarm).

The participants in the study were instructed immediately before SORT testing as to the meaning of "the two words combine together to make you think of a particular object." For each trial, participants were instructed to say or signal yes or no if the 2 words combine together to retrieve an object. They were further instructed that for the word pairs resulting in object retrieval, to provide the name of the object. They also received 2 to 4 standardized practice items to ensure that they understood the task. If it was evident from their responses in the practice test that they did not understand the nature of the task, the test was not administered. If the participant appeared to understand the SORT task, then entire test was administered.

SORT scoring reflects total correct answers, and semantic memory errors on the object retrieval aspect of the test—false positives ("overbinds") and false negatives ("underbinds"). On the name production aspect of the task, true positive responses were scored as "correct name."

Procedures

All testing was performed by trained neuropsychologic testing technicians over multiple testing sessions. Administration of the SORT took approximately 10 to 15 minutes. The technician recorded all responses the subject made and scored the tests after the testing sessions.

RESULTS

Normal Healthy Controls and SORT

Demographic information for 121 healthy aging controls is given in Table 1. Table 2 provides means and standard deviations (SD) for SORT variables. Memory Total represents the total number of correct "yes" and correct "no" responses to the question "do these two

TABLE 1. Means and SD for Demographic Variables for Normal Participants Overall

Variable	Normal (n = 121)
Age (y)	72.61 (6.06)
Education (y)	15.28 (2.52)
Sex (% female)	69%
Full scale IQ estimate	110.43 (11.74)
Geriatric depression scale	3.18 (3.56)

TABLE 2. Means and SD for SORT Variables for Normal Participants

Variable	Normal Participants (n = 121)
Memory total (max. 32)	29.36 (2.08)
False positive (max. 16)	2.05 (1.99)
False negative (max. 16)	0.60 (0.98)
Correct names (max. 16)	14.83 (1.24)

TABLE 3. Means and SD for Age and SORT Variables by Decade (60s, 70s, 80s) for Normal Participants

	Normal Participants by Decade			
Variable	**60s (n = 44)**	**70s (n = 56)**	**80s (n = 19)**	***P***
Age (y)	66.57 (1.87)	73.84 (2.88)	82.00 (1.83)	*
Memory total (max. 32)	29.09 (1.97)	29.38 (2.18)	29.68 (2.06)	ns
False positive (max. 16)	2.27 (1.72)	2.05 (2.19)	1.68 (2.03)	ns
False negative (max. 16)	0.64 (1.10)	0.57 (0.95)	0.63 (0.83)	ns
Correct names (max. 16)	14.82 (1.47)	15.04 (0.97)	14.21 (1.27)	†

*Age significantly different for all 3 decades, *P*s < 0.05.
†Correct Names significantly different for 80s compared with 70s, $P < 0.05$.

words combine together to make you think of a particular object.'' Incorrect responses are recorded as false positive and false negative responses. True positive responses are further delineated as to whether the correct name was also provided. Age, education, sex, FSIQ, and mood scores were not related to SORT scores, except for a sex difference in false negative performance, with males reporting significantly more false negatives than females, $t(119) = -2.04$, $P < 0.05$, (M males = 0.86 vs. M females = 0.48). Table 3 provides SORT results by decade (60s, 70s, and 80s); education, sex, FSIQ, and mood did not differ significantly among these groups.

Possible associations between the SORT and other neuropsychologic variables in normal participants were explored. Due to the number of comparisons, an α level of 0.01 was used to determine significance. Memory Total score and false positives were not correlated with any of the neuropsychologic variables. False negatives were negatively associated with Similarities ($r = -0.25$), Matrix Reasoning ($r = -0.29$), Logical Memory delayed recall ($r = -0.27$), and recognition ($r = -0.26$). Correct Names produced was positively associated with Similarities ($r = 0.24$), Matrix reasoning ($r = 0.27$), and Logical Memory 1 and 2-recall (rs = 0.26, 0.29, respectively).

AD Patients, Matched Healthy Normal Controls, and SORT

Data from 38 individuals with AD were available for both the SORT measures and the same neuropsychologic tasks. We first matched our AD participants for age, education, sex, and FSIQ (as assessed by the NAART) with 38 of our control participants, such that participant groups were not significantly different for any of these variables (Table 4). Independent t tests revealed significant differences in performance between AD participants and healthy matched controls for all SORT variables (Table 5).

TABLE 4. Means and SD for Demographic Variables for AD and Sex, Age, Education, and FSIQ-matched Normal Participants

	Group	
Variable	**AD (n = 38)**	**Normal (n = 38)**
Age (y)	76.13 (8.11)	73.16 (6.66)
Education (y)	13.71 (3.79)	15.05 (2.92)
Sex (% female)	37%	47%
Full scale IQ estimate	101.49 (8.93)	104.97 (7.82)

We further divided the AD group into individuals deemed to be impaired in semantic memory based on the SORT task before looking at associations with other neuropsychologic measures. Patients were designated impaired if their total correct memory score was greater than 2 SD below the mean of performance for healthy normal controls for age (normative ranges developed by decade—60 to 70, 70 to 80, 80 and above). Table 6 shows that those AD patients with significant SORT memory impairment also had significantly more false positive memory errors and fewer correctly produced names compared with those AD patients without impairment. Not all aspects of semantic memory were different between the intact and impaired group as there are no significant differences in false negative memory errors.

We then examined for specific dissociations between the SORT variables of the Memory Total Correct and the Correct Names Produced scores within individual AD participants. It has been postulated that deciding if the feature pair results in retrieval of any object is a memory task, while requiring the subject to say the name of the particular object retrieved is more of a lexical access and speech output task. We specifically sought to determine the number of individuals that had a name production impairment (using greater than 2 SD from the mean of the healthy aging control group; mean = 14.83, SD = 1.24) and whether these individuals also had an associated semantic memory impairment. We conducted a χ^2 analysis to determine if these measures might be independent of each other within the AD group. The test for independence was significant, χ^2 (1) = 6.70, $P = 0.01$ (Table 7).

SORT Reliability

An independent group of normal, healthy aging individuals (mean age 79.9 ± 2.3 y) were administered the SORT Task twice. Twenty-five participants were tested and then retested approximately 1 week later. Paired t tests and Pearson product-moment correlations were conducted comparing Times 1 and 2 to assess practice effects and test-retest reliability (Table 8). Regression analyses which included age, education, and NAART

TABLE 5. Means and SD for SORT Variables for AD and Sex, Age, Education, and FSIQ-matched Normal Participants

	Group			
Variable	**AD (n = 38)**	**Normal (n = 38)**	***t***	***P***
Memory total (max. 32)	23.92 (4.47)	29.32 (2.11)*	6.74	†
False positive (max. 16)	5.79 (4.46)	1.89 (1.91)*	−4.95	†
False negative (max. 16)	2.29 (2.49)	0.79 (0.99)*	−3.45	†
Correct names (max. 16)	11.21 (3.51)	14.58 (1.29)*	5.55	†

*Variances significantly different AD vs. normal participants.
†Means significantly different AD vs. normal participants at $P < 0.001$ (equal variances not assumed).

along with Time 1, demonstrated that only Time 1 significantly predicted Time 2.

SORT Correlations

In AD participants, correlations between SORT measures (Memory Total and Correct Names) and neuropsychologic assessments of episodic memory and SORT Correct Names and measures of naming/lexical access (BNT, Animal Fluency, COWAT, Similarities, Cookie Theft, and Vocabulary) were noted.

DISCUSSION

The SORT task was designed as a probe of the semantic memory function of object retrieval from features. Some of the neural mechanisms underlying this process have been delineated in normal individuals using functional imaging and electrophysiologic measures. Administration of this task to a community dwelling convenience sample of healthy, aging controls and patients with AD along with a battery of standard neuropsychologic measures in this study has allowed for assessment of the presence of semantic memory deficits in patients with degenerative disease and changes in semantic memory performance for this function with normal aging.

The SORT memory component demonstrated in the healthy aging population that there was not a ceiling effect to the test, as has been present on other tests of semantic memory when given to a normal control population. In addition, semantic memory test performance in normal aging seems to be relatively consistent and stable across decades spanning from the 60s to the 80s in the normal healthy aging population. SORT memory performance in the normal controls did not differ significantly across demographic variables in general, including age, education, FSIQ, and depression mood. The SORT total memory score and the false positive scores, which have been the scores most often associated with disease states, did not correlate with any neuropsychologic variables. This suggests that these SORT scores probe different processes than do other tests, or at least probe the processes in a distinct way. False negative responses, designating an under-reporting of retrieval, were associated with under-recall in episodic memory tasks and with a task engaging aspects of semantic processing (the Similarities subtest of the WAIS-III). The Similarities subtest of the WAIS-III has been associated with semantic-related functions such as abstraction of meaning and verbal semantic concept formation as well as regions in the left frontal and temporal lobes (Ref. [8] pp 571–572). The SORT has an added advantage over the Similarities test in the aging and demented population in that the SORT requires only a simple yes/no response compared with a detailed verbal description of the relationship between 2 entities as in Similarities, thus providing a more specific assessment of

TABLE 6. Adjusted Means and Standard Errors for AD SORT (Memory Total) Normal Versus Impaired With Age as a Covariate

	AD Participants		
Variable	**SORT (Memory Total) Normal (n = 20)**	**SORT (Memory Total) Impaired (n = 18)**	***F* (2, 35)**
Memory total (max. 32)	28.19 (0.529)	20.08 (0.500)	61.81**
False positive (max. 16)	2.00 (0.701)	9.20 (0.663)	27.16**
False negative (max. 16)	1.81 (0.614)	2.72 (0.581)	0.73
Correct names (max. 16)	12.65 (0.794)	9.92 (0.750)	4.18*

*$P < 0.05$.
**$P < 0.001$.
Note that the only demographic variable that was significantly different between AD SORT groups was age, $t(36) = -2.30$, $P < 0.05$; therefore age was included as a covariate in the above analyses. Age for normal SORT was 73.11 y; age for impaired SORT performers was 78.86 y. Education, sex, FSIQ, MMSE, and CDR were not significantly different for these groups.

TABLE 7. AD Participants Who Showed an Impairment in Memory Total Performance, Correct Name Performance or Both, χ^2 (1) = 6.70, $P = 0.01$

	Correct Name Scores	
Memory Total Scores	**Normal**	**Impaired**
Normal	11	7
Impaired	4	16

semantic memory in dementia patients who may appear impaired in semantic memory when they are actually having difficulty only in word finding or verbal generative capacity. This is reflected in our data, as the SORT correlates significantly with Similarities in the normal aging cohort, but is not correlated with Similarities in the demented population.

This study has demonstrated several key aspects concerning the utility of the SORT task in the normal aging and degenerative population. The test provides a direct measure of semantic memory, with the major prerequisite capabilities being comprehension of the 2 feature words and being able to respond yes/no if they result/do not result in object retrieval. The test engages fewer nonsemantic cognitive processes in its performance than other putative tests of semantic memory commonly used in the assessment of patients with dementia. As noted previously the BNT and COWAT engage multiple other cognitive components unrelated to semantic processing that are also at risk for dysfunction in degenerative disease.[22–26] The SORT also proved to be short in terms of administration time, easy to administer and score, and well tolerated in aging and dementing patients.

The SORT memory component showed in this study and in a related study in patients with amnestic MCI[27] that it is sensitive to detecting semantic memory impairments. In the case of amnestic MCI, the SORT task identified the roughly one-third of these patients who had a semantic memory deficit that had not been previously reported or characterized in this population, perhaps due to the lack of sensitivity of the measures used to access semantic memory. In the case of AD, SORT detected approximately half of patients classified in the mild-to-moderate range of the disease, which is consistent with other studies assessing semantic deficits in AD with less specific measures.

With the larger number of healthy normal controls in this study, and the skew toward female participants and slightly higher than mean estimated IQ, we selected post hoc a group from the healthy control cohort that was frequency matched for age, sex, education, and estimated FSIQ (Table 4). There are significant differences between the healthy aging group and the AD patient group on all of the SORT variables, demonstrating the overall sensitivity of the test for detecting semantic memory differences in this patient population (Table 5). We then assessed the association of the SORT memory variables with the neuropsychologic tests scores for the healthy normal controls, AD patients with semantic memory deficits and those without deficits. There were no significant correlations in the healthy control group between SORT memory variables for memory total correct and false positives and other neuropsychologic measures, further demonstrating that the SORT does interrogate an aspect of cognitive function that is distinct from those aspects assessed by other tests.

The SORT test was not originally designed as a test of lexical access per se, but we added the aspect of producing the name of the retrieved object in addition to the object retrieval decision that was investigated with fMRI and electrophysiology studies. This added component of assessing lexical access in addition to semantic memory for the same item in this test, coupled with the fact that the 2 components produce different measures that are dissociable, shows that the SORT has the capability to measure 2 distinct separate processes (semantic retrieval and lexical access). It also shows that there are instances of dissociation between semantic memory and lexical access impairments in the AD patients and that these 2 measures appear to function independently (Table 7). Our stimuli were chosen specifically to find pairs that met criteria for object retrieval, and resulted in object names that were of high familiarity and frequency and that did not yield an optimal spectrum of difficulty. However, given the scores obtained in the healthy normal population, the name production scores of the test appear to allow for detection of name production deficits in AD (Tables 6, 7).

On examination of those with a semantic memory deficit compared to those without, there is a significant difference in name production scores also (Table 6). The

TABLE 8. Test-retest Reliability for SORT Measures in Normal Adults (n = 25)

Sort Variable	Time 1	Time 2	Mean Diff.	*r*
Memory total	28.64 (1.89)	28.92 (2.40)	0.28 (1.06)	0.90**
False positive	2.60 (2.24)	2.08 (2.45)	− 0.52 (0.92)*	0.93**
False negative	0.76 (0.72)	1.00 (0.91)	0.24 (0.72)	0.63**
Correct names	14.32 (1.28)	14.40 (1.50)	0.08 (0.57)	0.93**

*$P < 0.01$.
**$Ps < 0.001$.
Diff. indicates difference (Time 1-Time 2).

name production aspect of the SORT thus appears able to distinguish between healthy controls and AD patients, and between AD patients with a SORT semantic memory deficit and those without in terms of name output, when using group comparisons. These findings would be expected, in that those with impairment in the semantic retrieval of an object are not going to be able to produce its name. The "correct names total" score does not penalize the patients for false positive memory errors (by far the most common) and incorrect names produced from these incorrect retrieval trials. This is best shown by differences of dissociations between intact and impaired performance for SORT Memory Total and Correct Names Produced scores for individuals with AD (Table 7).

The SORT has robust test-retest reliability in the healthy aging control population. In the healthy aging control group, the SORT memory measures (Memory Total and False Positives) showed no significant associations with other neuropsychologic variables, suggesting that these variables provide a unique metric in normal aging.

False Negative and Correct Name Production were significantly associated with a number of Logical Memory variables, Similarities, and Matrix Reasoning. These SORT variables have some obvious parallels to these tests—false negative responses can result from a lack of retrieval that is also seen in episodic memory measures; both false negative responses and correct name production could plausibly play a role in poor similarity judgments. In AD participants, there were correlations between a number of different SORT measures and neuropsychologic tests that engage some components of semantic processing (BNT, Animal Fluency, COWAT, Similarities, Cookie Theft, and Vocabulary).

As noted above, the SORT may assess both semantic retrieval and lexical access/name production as separable processes. The present study showed that 23 of 38 patients had a significant name production deficit, with 16 of those 23 having detectable semantic memory deficits. Thus, 61% of patients with AD were found to have a name production deficit, with 70% of those having an associated semantic memory deficit that could account for the name production deficit. The remaining 30% of those with a name production deficit, without a semantic memory deficit, could represent AD patients with a lexical access impairment who have intact semantic memory, that the SORT task was not sensitive to such a deficit, or that patients can recognize from lexical co-occurrence that items are related without clearly intact semantic memory.[28] The utility of the SORT to distinguish between these 2 aspects of cognition, in the same test administration for the same target stimuli, demonstrates a unique aspect of this test to distinguish between these 2 distinct deficits.

In conclusion, we have shown that the SORT is useful in accurately and reliably assessing semantic memory in patients undergoing dementia, with the only requirements for test performance being comprehension of 2 feature words and responding affirmatively or negatively if the objects do or do not result in retrieval of an object. The test should be considered to be included in batteries assessing multiple cognitive functions for patients with dementing illnesses.

ACKNOWLEDGMENTS

The authors thank Dr D. T'ib for helpful suggestions and Kathy Tyler-King, Andrew Howard, Dr Roger Williams for invaluable assistance in data collection.

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