Journal of the International Neuropsychological Society (2002), **8**, 633–644.

DOI: 10.1017.S135561770280131X

Awareness of naturalistic action errors in dementia

TANIA GIOVANNETTI,[1] DAVID J. LIBON,[2] AND TESSA HART[1]

[1]Moss Rehabilitation Research Institute, Philadelphia, Pennsylvania
[2]Crozer Chester Medical Center, Upland, Pennsylvania

(RECEIVED August 21, 2000; REVISED April 30, 2001; ACCEPTED June 5, 2001)

Abstract

Unawareness of deficit is a common feature of degenerative dementia. The present study explored awareness and correction of naturalistic action errors in 54 dementia participants and 10 healthy controls while they performed a series of everyday tasks, such as toast preparation and gift-wrapping. Awareness for everyday task performance and cognitive functioning was also assessed with questionnaire discrepancy scores, and a neuropsychological test protocol was administered. Dementia participants were aware of and corrected a significantly smaller proportion of errors compared to controls ($z = -4.59$, $p < .001$). Awareness and correction of action errors was not significantly correlated with the number of naturalistic errors committed, questionnaire discrepancy scores, or neuropsychological test data. Within-group analyses showed awareness differed across error types, such that participants were aware of a greater proportion of substitution and sequence errors compared to omissions, perseverations, and action addition (i.e., utilization behavior) errors ($z \leq -3.2$, $p \leq .002$ for all analyses). Taken together these data suggest that error awareness and correction during the course of action is not related to error production or awareness measured *via* questionnaire discrepancy scores. Rather, direct assessment of error detection and correction may provide novel information about behavioral monitoring that can not be extrapolated from measures of dementia severity or traditional neuropsychological assessment. (*JINS*, 2002, *8*, 633–644.)

Keywords: Dementia, Awareness, Error detection, Error correction

INTRODUCTION

Performance of naturalistic actions, such as grooming and meal preparation, is often impaired following neurological illness or disease. Naturalistic action performance in neurologically impaired patients and normal controls (NC) has been systematically assessed in our laboratory with the Multi-Level Action Test (MLAT; Schwartz et al., 1998)/Naturalistic Action Test (NAT; Schwartz et al., 2001). Several clinical populations have been studied, including closed head injury (CHI; Schwartz et al., 1998), right (Schwartz et al., 1999) and left-hemisphere stroke (Buxbaum et al., 1998), and dementia (Giovannetti et al., 2002). Results from these investigations support the limited capacity resource theory of naturalistic action deficits, which states that action impairment is best explained by general clinical severity rather than any specific neuropsychological impairment(s) (e.g., executive dysfunction, semantic knowledge degradation, etc.).

Reprint requests to: Tania Giovannetti, Ph.D., Moss Rehabilitation Institute, Korman Building Suite 203B, 1200 West Tabor Road, Philadelphia, PA 19141, USA. E-mail: giovannt@einstein.edu

In addition to naturalistic action errors, we have also explored awareness and correction of errors with the MLAT in participants undergoing inpatient rehabilitation for CHI and have demonstrated that awareness of naturalistic action errors could be reliably measured during task performance (Hart et al., 1998). Hart et al. showed CHI participants were aware of and corrected significantly fewer errors compared to controls. Furthermore, error detection and correction was not significantly correlated with questionnaires that measured patients' abilities to predict or evaluate their performance.

The present study used the methodology set forth in Hart et al. (1998) to explore awareness and correction of naturalistic action errors in a heterogeneous group of dementia participants. Most studies of unawareness in dementia have focused on patients with Alzheimer's disease (AD). These studies have shown that unawareness may vary across participants and functional domain. For example, although many AD patients demonstrate some degree of unawareness, some may show insight into their deficits, especially in the early stages of the disease (Neundorfer, 1997). Overall, however, AD participants tend to be less aware of deficits in memory, higher cognitive functions, and activities of daily living (ADL) compared to psychiatric symptoms and health status (Green et al., 1993; Kotler-Cope & Camp, 1995; Vasterling et al., 1995, 1997).[1]

Awareness for difficulties with ADL in dementia is typically assessed *via* questionnaire discrepancy scores. These measures show that many AD participants significantly overestimate their abilities to perform everyday tasks compared to caregivers' ratings (DeBettignies et al., 1990; McGlynn & Kaszniak, 1991; Ott et al., 1996; Mangone et al., 1991; Vasterling et al., 1997) or actual performance measures (DeBettignies et al., 1990; Kuriansky et al., 1976). Although widely used and efficient to administer, questionnaire discrepancy measures have several drawbacks. First, valid questionnaire data are dependent upon expressive and receptive language abilities, which are often impaired in dementia. Second, questionnaires record only whether patients achieve a task goal, without capturing the quality or efficiency of performance. That is, a patient may be able to report that she is unable to prepare her own meals, but may lack awareness of *why* she is unable to do so. Finally, questionnaire methods require that participants recall and reflect on past events in order to evaluate and update knowledge of their general ADL abilities (i.e., memory/retrospection).

The method of error detection and awareness used by Hart et al. (1998) approaches the study of ADL awareness from a novel perspective. Rather than assessing awareness *via* patients' retrospection, Hart et al.'s method examines awareness during the course of action. Thus, this methodology is not heavily dependent on language skills, as awareness during task performance may be indicated through nonverbal gestures or error correction. Also, awareness for distinct error types may be easily compared to explore whether participants are aware of particular difficulties but not others. In sum, this method may be a more direct measure of error monitoring compared to questionnaire discrepancy data.

Cognitive Mechanisms for Error Monitoring

A closed-loop feedback mechanism, in which external behavior (or the state of the external environment) is monitored and compared to an internal representation of the desired state, has been proposed for naturalistic action error detection and awareness (Norman, 1981; Sellen & Norman, 1992; see also Goldberg & Barr, 1990). This mechanism requires that sufficient cognitive resources are available (above those required to perform the task) to devote to monitoring task performance (Hart et al., 1998; Norman, 1981; Sellen & Norman, 1992). Executive processes are also necessary to allocate and focus attention to relevant behaviors and to compare the internal representation of the goal or action to the actions actually performed. The internal representation of the intended action or goal must be reasonably preserved in order for performance to be evaluated for correctness (Sellen & Norman, 1992).

Based on this model of error detection, unawareness of action errors may arise due to general resource limitations. For example, to explain the low rate of error awareness/correction in CHI participants, Hart et al. (1998) hypothesized that following neurological trauma or illness greater cognitive effort is required to perform everyday, routine tasks. Thus, unawareness of errors in CHI may result from a reduction in the cognitive resources available to allocate to the process of monitoring behavior.

In contrast to the limited resource account, unawareness may arise due to a specific deficit in selective attention, executive functions, and/or semantic knowledge. For example, impaired focused or selective attention may limit one's ability to attend to relevant behaviors in order to *detect* errors. Executive deficits may impair the mental flexibility necessary to *compare* external feedback of ongoing behavior and the environment to the internal representation of the intended goal-state. Finally, vague semantic representations of actions and goals may cause poor awareness of ADL by preventing the *recognition* of errors.

The closed loop feedback account also implies that awareness may vary systematically across errors (Norman, 1981; Sellen & Norman, 1992). For example, awareness and correction will be less likely when the correct action is never initiated or activated (i.e., omission errors) or when the patient intentionally selects an incorrect action. By contrast, errors that occur during the execution of intended actions will create an overt mismatch between the patient's intention and environmental feedback, making error detection more likely (Norman, 1981; Sellen & Norman, 1992).

Studies that have explored the cognitive correlates of awareness for deficits in everyday tasks in dementia have focused almost exclusively on AD. A range of findings has been reported. For example, Vasterling et al. (1997) reported that discrepancies between AD patients' and caregivers' ratings of ADL abilities increase over time, suggesting a relationship between unawareness and dementia severity. Others have reported a relationship between questionnaire discrepancy scores and measures of global cognitive functioning (McGlynn & Kaszniak, 1991; Mangone et al., 1991), executive functions (Ott et al., 1996) and visuoconstructional skill (Mangone et al., 1991). By contrast, investigators using discrepancy scores based on patients' self-ratings and actual task performance have shown no relationship between unawareness and cognitive measures in patients with AD or multi-infarct dementia (DeBettignies et al., 1990).

The present study explored awareness and correction of action errors during the performance of everyday tasks in dementia using the methodology developed by Hart et al. (1998). We predicted that dementia participants would be aware of and correct a smaller proportion of errors compared to healthy elderly controls. We also examined the

[1] Similarly, patients with CHI show considerable variability in awareness across patients, but in general, indicate greater awareness for physical disabilities compared to cognitive or behavioral symptoms (Prigatano, 1996; Prigatano et al., 1990).

relationship between error awareness and performance on neuropsychological tests. If error awareness/correction is linked to general cognitive resources, then we would expect to observe a strong correlation between error awareness and dementia severity (Mini-Mental State Examination). If, however, unawareness is related to specific cognitive deficits, such as executive dysfunction or semantic knowledge degradation, then significant correlations would be observed between tests of these specific functions and indices of error correction and awareness.

The relationship between awareness of ADL performance measured *via* questionnaire discrepancy data and error awareness/correction during the course of action was also investigated. Based on our previous work (Hart et al., 1998), we predicted a weak relationship between awareness measures and questionnaire data. We also hypothesized that questionnaire discrepancy scores, unlike error awareness and correction, would correlate with tests of memory and language

Finally, we explored error awareness across different error types. We predicted that omissions would be detected less than other types of errors (Sellen & Norman, 1992), as omissions occur when the correct action is never activated and also because omissions do not create an obvious mismatch between the patient's intention and the environment.

METHODS

Research Participants

Fifty-four participants were recruited from an outpatient memory clinic (Crozer Chester Medical Center, Chester, Pennsylvania). All participants were evaluated by an assessment team, which included a social worker, psychiatrist, geriatrician, neurologist and neuropsychologist. Results from each patient's examinations (including neuroimaging, blood analyses, neuropsychological data, medical history, and clinical presentation) were pooled and discussed at a team meeting. Consensus was reached regarding the etiology of the patients' memory complaints based on widely accepted diagnostic criteria (American Psychiatric Association, 1994; Chui et al., 1992; McKhann et al., 1984). Participants were included if they were diagnosed with a mild to moderate dementia, regardless of etiology. Participants were excluded if they demonstrated insufficient arousal/attention to tolerate testing, motor/sensory deficits precluding object grasping and use, and/or history of head injury, epilepsy, or previous neurological or psychiatric illness. These participants were also reported in a study of naturalistic action performance (Giovannetti et al., 2002).

Ten healthy, elderly participants were recruited from a database of normal control subjects at the Moss Rehabilitation Research Institute (Philadelphia, Pennsylvania). Participants were included if they were over age 65 and living independently in the community. Although formal dementia screening was not performed, controls had no record nor subjective complaints of memory or cognitive deficits. Control participants also denied record of neurological or psychiatric illness, substance abuse, or traumatic brain injury. Demographic data for dementia and NC participants are reported in Table 1.

Procedures

Dementia participants were tested during two sessions scheduled within a 2-week period. A two to three hour neuropsychological protocol was administered during the first session, and a test of naturalistic action was administered during the second, 1- to 2-hr testing session. Control participants were administered only the test of naturalistic action in a single 1-hr session. Questionnaire and neuropsychological data were not collected from control participants.

Naturalistic Action

A short form of the original MLAT (MLAT–S) was used to assess naturalistic action in both dementia participants and controls (Giovannetti et al., 2002). The MLAT–S requires participants to complete the following three tasks: (1) prepare toast with butter and jelly and coffee with cream and sugar; (2) wrap a gift with related distractor objects (gardening clippers, stapler, etc.) in the array; and (3) pack a lunch box with a sandwich, snack, and a drink and pack a school bag with supplies for school, while several of the necessary objects (knife, thermos lids) are stored out of view in a drawer of additional, and potentially distracting objects (ice tongs, measuring tape, etc.). Performance was videotaped, and errors were classified according to an error taxonomy developed by Schwartz et al. (1998; see Table 2). All MLAT–S errors were summed to produce a total error score. A commission score was calculated by summing all errors excluding omissions. A 78% rate of agreement has been reported for the MLAT scoring procedure (Schwartz et al., 1998). MLAT and MLAT-S procedures are described in more detail in Schwartz et al. (1998, 2002).

Awareness and Correction of Naturalistic Action Errors

Awareness and correction of MLAT–S errors was scored according to the procedure of Hart et al. (1998). An error was coded as "aware" if the participant corrected it either immediately or at any point in the task. Unsuccessful attempts to correct the error were also coded as indicating awareness. In addition to corrections, awareness was coded for a finite set of behavioral reactions to the error, including verbalizations or exclamations indicating knowledge of the error and distinctive manual and facial gestures. Hart et al. (1998) demonstrated a 95% rate of agreement for this scoring method (Cohen's kappa statistic = .85).

The number of errors coded as "aware" was divided by the number of MLAT–S errors and multiplied by 100 (aware–total). This calculation was also performed for both com-

Table 1. Group means and standard deviations of demographic variables

Variable	Dementia participants (n = 54) M (SD, range)	Controls (n = 10) M (SD, range)	t (df)	p
Age	76.4 (9.3, 60–88)	72.5 (3.7, 66–80)	2.4 (62)	.02
Education	11.6 (2.3, 6–19)	13.4 (3.7, 9–19)	−1.5 (10)*	.17
MMSE	22.2 (3.5, 12–26)	—		

Variable	Dementia participants (n = 54) n (%)	Controls (n = 10) n (%)	Chi-square: Chi-square (df)	Chi-square: p
Gender				
Male	16 (30)	3 (30)	.001 (1)	.98
Female	38 (70)	7 (70)		
Diagnosis				
Alzheimer's disease**	9 (17)	—		
Vascular dementia***	18 (33)	—		
Parkinson's disease†	10 (19)	—		
Dementia due to multiple etiologies†	14 (26)	—		
Substance induced persisting dementia†	3 (6)	—		

*T value for unequal variances reported, because Levene's test for equality of variances was significant (F = 5.2, p = .03).
**McKhann et al., 1984; ***Chui et al., 1992; †American Psychiatric Association, 1994.

Table 2. Multi-level action test error taxonomy

Error category	Definition	Example
Substitution	semantically related or perceptually similar alternate object selected in place of target object	spread butter with spoon (instead of knife)
Gesture substitution	correct object is used, but with incorrect gesture	spoon (rather than pour) cream into coffee
Spatial misorientation	misorientation if the object relative to the hand or another object	grasp wrong end of scissors
Spatial misestimation	spatial relationship between two or more objects is incorrect	wrapping paper cut too small for gift
Tool omission	action is performed without appropriate implement	spread mustard with finger
Omission	coded only when a step or subtask is never attempted	failure to add coffee to mug
Perseveration	repetitive movements or duplications of steps or subtasks	stir coffee for extended period of time; make two sandwiches
Sequence/anticipation–omission	anticipation of step which entails a subsequent omission	seal thermos before filling
Sequence/reversal	steps or subtasks performed in reverse order	stir mug of water, then add instant coffee grinds
Action addition	action not readily interpretable as a step in the task at hand, includes "utilization behavior" and anomalous actions	pack non-school items, such as mustard or aluminum foil in school bag
Quality	inappropriate or inexact quantity	fills thermos with juice to the point of overflow

mission [aware–commission = (number of "aware" commission errors/MLAT–S commission errors) × 100] and omission errors [aware–omission = (number of "aware" omission errors/MLAT–S omission errors) × 100]. This formula was also used to calculate the proportion of "aware" errors for each MLAT–S error type (i.e., sequence, object substitution, action addition, etc.).

The proportion of errors that was corrected was also calculated separately. This calculation was performed only for commission errors [corrected–commission = (sum of corrected errors/sum of commission errors) × 100], because omission errors, by definition, could not be corrected (i.e., MLAT–S omissions are coded only if a step is *never* performed during the course of the task). In summary, the following dependent variables were coded: *aware–total*, *aware–commission*, *aware–omission*, *percentage aware for each error type*, and *corrected–commission*.

Self and Informant ADL Questionnaire

Dementia participants were administered a modified version of the Instrumental Activities of Daily Living and Physical Self-Maintenance Scales developed by Lawton and Brody (1969), which required patients to rate their ability to perform 15 tasks (e.g., grooming, transportation, etc.). Each task is assigned one score from the following three-point scale[2]: 1 = *participant performs the task independently*; 2 = *participant requires assistance to perform the task*; or 3 = *participant is entirely dependent on others to perform the task*. Behavioral descriptions are anchored to each number on the scale to make the rating less subjective. The total score can range from 15 (*participant performs all tasks independently*) to 45 (*participant is completely dependent on others to perform all tasks*). Caregivers who had at least weekly contact with the participant were also asked to evaluate patients' performance with this measure. An ADL *discrepancy score* was calculated by subtracting the participant score from the informant score (range of possible scores = −30 to +30), with a higher number indicating more impaired awareness. For some items, participants (and their caregivers) reported that they had never performed the task. For example, some participants stated that they had always relied on their spouse for certain activities (e.g., laundry, transportation, etc.). In these cases, the item was omitted and the participant's score was prorated including only the tasks that he/she had routinely performed. However, items were omitted relatively infrequently (i.e., 5 dementia participants omitted one item and 2 omitted two items; 3 caregivers omitted three items and 4 omitted two items). In sum, a *participant ADL rating*, *caregiver ADL rating* and an *ADL discrepancy score* were derived from this questionnaire.

[2]Lawton and Brody's (1969) original questionnaire required participants to rate behavior on a scale of 1–5 for some items. In this revision, we adopted the 1–3 scale for all questionnaire items for consistency of measurement across items.

Self and Informant Cognitive-Behavioral Functioning Questionnaire

A 29-item questionnaire, closely modeled after the Anosognosia Questionnaire–Dementia of Migliorelli et al. (1995), was used to assess awareness for memory, higher cognitive functions, and psychiatric symptoms (see Lamar et al., 2000). Similar to the questionnaire designed by Migliorelli et al., the frequency of everyday problems (e.g., "Do you lose things in your home?") is assessed using a 4-point rating anchored at *never* (zero points) and *always* (three points). Total scores range from zero to 87. The questionnaire differs from that of Migliorelli et al. in that it is written in more simplified language (e.g., the item "Do you have problems orienting yourself in a new place?" was changed to "Do you get confused in new places?"). Patients were asked to rate their own behavior and caregivers were asked to rate the patients' current abilities (*participant* and *caregiver cognitive ratings*). A *cognitive discrepancy score* was calculated (informant score − patient score), which ranged from −87 to +87, with a higher score indicating more impaired awareness. When patients or caregivers omitted questionnaire items, scores were prorated (22 dementia participants omitted one item, 4 omitted two items, 1 omitted three items; 8 caregivers omitted one item, 6 omitted two items, 2 omitted three items, 4 omitted four items). Migliorelli et al. (1995) reported good reliability and validity using this method (see also Lamar et al., 2000).

Neuropsychological Assessment

Dementia participants were administered a neuropsychological test protocol, which included the Mini Mental-State Examination (MMSE; Folstein et al., 1975), Geriatric Depression Scale (GDS; Yesavage, 1986), measures of executive functioning, semantic knowledge, episodic memory, motor functioning, and visuoconstructional skills. Table 3 describes the test battery.

Principal Component Analysis of Neuropsychological Tests

A principal-component analysis (PCA) was performed to reduce the neuropsychological test data into fewer conceptually relevant factors for subsequent correlation analyses. The Eigenvalue criterion (Eigenvalue >1) was used to determine the number of factors extracted, and varimax rotation was done to simplify the interpretation of factors. The PCA included all test scores except for the MMSE and GDS. A three-factor solution accounting for 68.4% of the variance resulted with WAIS–R Similarities, Boston Naming Test, and Semantic Probe Errors as the first factor (Eigenvalue = 3.9; 43.2% of the variance); Mental Control, Graphical Sequences–Dementia Version, and Clock Drawing Test as a second factor (Eigenvalue = 1.2; 13.1% of the variance); and Phonemic Word List Generation, Animal Naming, and California Verbal Learning Test as a third factor

Table 3. List of neuropsychological tests

Test	Description
Executive functioning	
Boston Revision of the Wechsler Memory Scale–Mental Control subtest (WMS–MC)*	accuracy of performance on three nonautomatized tasks (months backward, alphabet rhyming, and alphabet visualization) calculated with the following algorithm: AcI = [1 − (false positive + misses)/(# possible correct)] × 100
Goldberg Graphical Sequences Test–Dementia Version (GST–D)**	number of perseverations made when drawing a series of geometric shapes, objects and letters
Phonemic word list generation (FAS)***	number of words produced in 60 seconds beginning with *F*, *A*, or *S*, excluding proper nouns
WAIS–R Similarities subtest****	superordinate category or feature shared by word pairs
Language and semantic knowledge	
Animal Naming	number of animal names produced in 60 s
Semantic Probe Test+	64 forced-choice questions assess knowledge of the perceptual and functional attributes of tools and animals
Boston Naming Test++	Participants must name 60 line drawings of everyday objects. The dependent measure was the number correct without cues.
Episodic memory	
California Verbal Learning Test–Dementia Version (CVLT–D)#	number of correct words produced across five trials
Visuoconstructional skills	
The Clock Drawing Test–Copy Condition##	ten possible errors are scored in participants' copy of clock face (hands set to ten after eleven)
Depression	
Geriatric Depression Scale###	15 yes/no questions assess depression symptoms

*Cloud et al., 1994; **Lamar et al., 1997; ***Spreen & Strauss, 1991; ****Wechsler, 1987; +Cloud et al., 2001; ++Kaplan et al., 1983 #Libon et al., 1996 ##Libon et al., 1993; ###Yesavage, 1986.

(Eigenvalue = 1.1; 12.1% of the variance). The three factors were interpreted as representing the following neuropsychological operations: (1) Language–Semantic Knowledge; (2) Executive Functions; and (3) Language and Memory Retrieval. Component scores reflecting each participant's performance on each factor were generated for subsequent correlation analyses.

Statistical Analyses

Several of the dependent variables were not normally distributed and were transformed for parametric analyses: MLAT–S commission errors (square root), omission errors (square root), MMSE (squared). Other variables were not normally distributed and could not be transformed due to

Table 4. Factor structure for neuropsychological test data

Measure	Factor 1 Language–Semantic Knowledge	Factor 2 Executive Functions	Factor 3 Language and Memory Retrieval
WAIS–R Similarities	*.82*	−.12	.09
Semantic Probe Test	*−.72*	.37	−.22
Boston Naming Test	*.88*	−.14	.23
Mental Control	.44	*−.72*	.08
Graphical Sequences Test	−.14	*.82*	−.08
Clock Drawing Test	−.06	*.71*	−.17
Phonemic WLG	−.06	−.17	*.87*
Animal Naming	.44	−.15	*.70*
CVLT Free Recall Trials 1–5	.32	−.05	*.60*

Note. WLG = Word List Generation. CVLT = California Verbal Learning Test. Italics indicates each measure's highest factor loading.

the high frequency of zero values: awareness–total, awareness–omission, corrected–commission, and Geriatric Depression Scale. One-way analyses of variance, independent sample *t* tests, and Pearson product-moment correlations were performed with all normal and transformed variables. The following nonparametric analyses were performed with variables that could not be transformed: Mann-Whitney *U*–Wilcoxon Rank Sum *W* Tests (corrected for ties), Spearman Rank Order correlations, and Wilcoxon Matched-Pairs Signed Ranks. Bonferroni correction was used to interpret significance for all analyses

RESULTS

Demographic Variables

As shown in Table 1, the dementia and NC groups did not significantly differ with respect to education (*t* tests) or gender (chi-square). However, dementia participants were significantly older than controls $[t(62) = 2.4,\ p = .02]$. Consequently, age was covaried in all subsequent between group parametric analyses.

Interrater Reliability

MLAT–S error and awareness interrater reliability was assessed for two scorers (T.G. & a less experienced coder) with a subset of 10 participants, selected randomly from the entire dementia sample. A 79% rate of agreement was obtained for the MLAT–S error scoring. Interrater reliability for awareness codes was assessed using only those errors for which there was MLAT–S scoring agreement (96/121). A 93% rate of agreement, with Cohen's kappa statistic of .82, was obtained for the awareness scoring system.

Between Group Analyses

Errors on MLAT–S

Table 5 shows dementia participants made significantly more MLAT–S errors compared to controls $[F(1,61) = 18.7,\ p < .001]$. This difference was observed for both omissions $[F(1,61) = 28.2,\ p < .001]$, and commissions $[F(1,61) = 27.1,\ p < .001]$.

Error awareness and correction

Table 5 also shows that dementia participants were aware of a significantly smaller proportion of total (aware–total: $z = -4.59$, $p < .001$) and commission [aware–commission: $F(1,60) = 30.1$, $p < .001$] errors compared to NC participants. Of note was the fact that error awareness for mild dementia patients (MMSE > 23; $n = 19$; aware–total: $M = 23$, $SD = 27$) was comparable to the mean awareness scores for the entire dementia sample. The between group analysis for aware–omission ($z = -2.44$, $p = .015$) was not significant after Bonferroni correction; however, only 3 control participants made omission errors. Spearman rank-order correlations revealed no significant relationship between any of the MLAT–S error or awareness variables and age, suggesting that these findings may not be explained by group differences in age.

Dementia participants corrected significantly fewer commission errors than controls [corrected–commission: $F(1,60) = 38.7$, $p < .001$]. On average, dementia participants corrected 79% ($SD = 33.9$) of the errors for which they indicated awareness. By contrast, controls corrected all MLAT–S errors (100%) for which they indicated awareness.

Table 5. Group means and standard deviations of MLAT–S errors and awareness variables

Variable	Dementia participants ($n = 54$) *M* (*SD*)	Controls ($n = 10$) *M* (*SD*)	ANOVA/Mann-Whitney *U*–Wilcoxon Rank Sum *W* Test (corrected for ties) *F*(*df*)/*Z*	*p* value*
MLAT–S errors				
Total	16.4 (9.29)	2.1 (1.0)	18.7 (1, 61)	<.001
Omission	7.6 (6.1)	.40 (.70)	28.2 (1, 61)	<.001
Commission	8.8 (5.2)	1.6 (.96)	27.1 (1, 61)	<.001
Awareness/correction variables				
Aware–total	($n = 54$) 20.2 (20.8)	($n = 10$) 73.3 (23.8)	−4.59	<.001
Aware–omission	($n = 53$) 5.2 (16.1)	($n = 3$) 50.0 (50.0)	−2.44	.015
Aware–commission	($n = 54$) 31.9 (24.6)	($n = 9$) 81.4 (22.7)	30.1 (1, 60)	<.001
Corrected–commission	($n = 54$) 27.2 (25.4)	($n = 9$) 81.4 (22.7)	38.9 (1, 60)	<.001

Note. *Bonferroni corrected p value (.05/7) = .007.

Correlation Analyses

MLAT–S errors

The relationship between MLAT–S errors and awareness/correction variables was examined with Spearman rank-order correlation analyses. Table 6 shows awareness–total was significantly negatively correlated with omission errors ($r = -.39$, $p = .001$), but no other correlations reached statistical significance.

Demographic variables

In a study of MLAT performance following right-hemisphere stroke, Schwartz et al. (1999) observed a significant correlation between errors and age. Therefore, correlation analyses were performed to explore the relationship between demographic variables and awareness scores among dementia participants. Awareness measures were not correlated with age or education, and there were no between-group differences in awareness variables across participants with different dementia diagnoses.[3] However, as shown in Table 7, women had higher scores for awareness–total ($z = -3.14$, $p = .002$), awareness–commission [$F(1,52) = 10.0$, $p = .003$], and corrected–commission ($z = -2.84$, $p = .005$) compared to men. This difference could not be explained by differences in dementia severity (MMSE: Men: $M = 23.1$, $SD = 2.7$; Women: $M = 21.8$, $SD = 3.7$) or MLAT–S errors between men and women (see Giovannetti et al., 2001).

Neuropsychological tests

Univariate correlations were performed between neuropsychological test composite scores, MMSE, GDS and error awareness variables. Results showed no significant relationships between aware–total, aware–omission, aware–commission, and corrected–commission and the neuropsychological composite scores, MMSE or GDS (*r*s = .011–.203). When correlations between the separate neuropsychological test scores and awareness variables were analyzed, none were significant after Bonferroni correction (*r*s = .003–.340).

Questionnaire Data

Paired-sample *t* tests between participant ratings (ADL: $M = 21.5$, $SD = 5.8$; Cognitive: $M = 15.8$, $SD = 10.4$) and caregiver ratings (ADL: $M = 24.1$, $SD = 6.5$; Cognitive: $M = 36.1$, $SD = 19.5$) showed that participants significantly overestimated their cognitive and ADL abilities relative to caregiver reports [ADL Questionnaire: $t(34) = 2.7$, $p = .012$; Cognitive Questionnaire: $t(46) = 7.6$, $p < .001$]. There were significant positive correlations between MLAT–S error measures and both the caregiver ADL rating (total $r = .60$, $p < .001$; commission $r = .38$, $p = .011$; omission $r = .60$, $p < .001$) and the caregiver cognitive rating (total $r = .54$, $p < .001$; commission $r = .52$, $p < .001$; omission $r = .40$, $p = .004$). For participants, the ADL rating and two MLAT–S error measures were significantly positively correlated, although less so than caregiver ratings (total $r = .45$, $p = .003$; omission $r = .40$, $p = .002$). There was no significant relationship between the participant ADL rating and MLAT–S omissions and the participant cognitive rating was not significantly correlated with any MLAT–S error measure.

There were no significant correlations between the MLAT–S awareness variables (aware–total, aware–omission, aware–commission, and corrected–commission) and the ADL or cognitive discrepancy scores. Correlation analyses between the questionnaire discrepancy scores and neuropsychological composite scores, MMSE, and GDS showed a significant negative correlation between the cognitive discrepancy score and the MMSE ($r = -.31$, $p = .03$). No other correlations were significant. However, when correlations between the separate neuropsychological test scores and questionnaire discrepancy scores were analyzed, there was a significant negative correlation between the ADL discrepancy score and similarities ($r = -.54$, $p = .001$) and a significant positive correlation between the cognitive discrepancy score and errors on the Semantic Probe Test ($r = .43$, $p = .004$)[4].

Table 6. Spearman rank order correlation analyses for MLAT–S awareness variables and errors for dementia participants ($n = 54$)

MLAT–S errors	Aware–total *r*, *p**	Aware–commission *r*, *p**	Aware–omission *r*, *p**
Total	−.25, .067	−.16, .238	−.10, .498
Commission	−.04, .769	−.17, .215	−.04, .774
Omission	−.39, .001	−.16, .263	−.14, .327

*Bonferroni corrected *p* value (.05/3) = .017.

Within-Group Analyses – Error Awareness by MLAT – S Error Type

As predicted, Wilcoxon Matched-Pairs Signed-Ranks tests showed dementia participants obtained higher aware–commission scores ($M = 32.0$, $SD = 24.6$) compared to aware–omission scores ($M = 5.3$, $SD = 16.13$; $z = -5.53$, $p < .001$). Differences in awareness scores were also analyzed for each error type. Several error types were not included in these analyses because they occurred too infrequently (e.g., gesture substitution: $n = 10$; spatial misorientation: $n = 15$; spatial misestimation: $n = 10$; tool omission:

[3]Because there were too few participants with substance-induced persisting dementia ($n = 3$), this group of patients was not included in this analysis.

[4]Bonferroni correction for these analyses = .005.

Table 7. Means for awareness variables in men and women

Variable	Men (n = 16) M (SD)	Women (n = 38) M (SD)	ANOVA/Mann–Whitney U–Wilcoxon Rank Sum W Test (corrected for ties) $F(df)/Z$	p value*
Aware variables				
Aware–total	9.4 (10.4)	24.8 (22.4)	−3.14	.002
Aware–omission	1.8 (5.3)	6.7 (18.8)	−0.68	.500
Aware–commission	16.9 (19.6)	38.3 (23.9)	10.0 (1, 52)	.003
Correction				
Corrected–commission	14.0 (19.3)	32.8 (25.7)	−2.84	.005

*Bonferroni corrected p value (.05/4) = .013.

$n = 7$; quality: $n = 5$). The difference in awareness between object substitution (M = 50.1, SD = 44.6) and sequence errors (M = 35.0, SD = 34.8) was not significant. However, participants were aware of a significantly greater proportion of object substitution and sequence errors compared to action additions (M = 7.8, SD = 17.0; substitution *vs*. action addition: $z = -3.2$, $p = .002$; sequence *vs*. action addition: $z = -3.6$, $p < .001$) and omissions (M = 5.3, SD = 16.1; substitution *vs*. omission: $z = -4.4$, $p < .001$; sequence *vs*. omission: $z = -4.4$, $p < .001$). Participants were not aware of any perseverative errors.

DISCUSSION

Awareness for action errors in dementia was explored during the course of naturalistic task performance. Dementia participants were aware of and corrected a significantly smaller proportion of their naturalistic action errors compared to controls. Error awareness and correction scores were not significantly correlated with the number of action errors, awareness measures derived from questionnaire methods, or neuropsychological test scores. Awareness differed significantly across naturalistic action error type, such that dementia participants were aware of a greater proportion of sequence and substitution errors compared to omissions, perseverations, and action addition errors.

Error Awareness in Dementia *versus* Control Participants

As predicted, dementia patients were aware of and corrected a significantly smaller proportion of action errors compared to controls. A weakness of our study is that controls were not administered the neuropsychological test protocol but were screened for dementia by self-report. Nonetheless, we found that on average our controls indicated awareness for 73% of their errors, a rate comparable to that reported by Hart et al. (1998) for a group of young, healthy controls (M age = 33.7, SD = 10.4; M awareness score = 74%). Dementia participants, by contrast, indicated awareness for an average of 20% of their MLAT errors, with comparable awareness scores (23%) observed even for patients with mild dementia (MMSE > 23). These results suggest that naturalistic error detection and correction is a serious problem for patients with dementia, even in the early stages of the disease.

One may wonder whether the between group difference in error awareness may be attributed to differences in overall error rate, as dementia participants demonstrated a significantly higher naturalistic action error rate compared to controls. It is possible that the high error rate in dementia participants may have afforded a greater "opportunity" for unawareness. Although there was a significant negative correlation between MLAT–S omissions and awareness for total MLAT errors (aware–total), there was no significant correlation between MLAT–S commission errors and awareness scores. Therefore, the low awareness scores for commissions in dementia participants (32%) relative to controls (81%) can not be entirely explained by the between group difference in commission error rate. This implies that error-monitoring processes may be distinguished from the mechanisms responsible for error production.

Cognitive Correlates of Error Awareness

Contrary to prediction, there was no significant relationship between dementia severity and error awareness or correction, and, therefore, unawareness of errors can not be attributed to a decline in general cognitive resources. Past studies, that have shown a significant relationship between awareness and dementia severity, included participants with much lower MMSE scores (e.g., MMSE < 15: Mangone et al., 1991; McGlynn & Kaszniak, 1991; Vasterling et al., 1997) than those of participants in the present study (e.g., MMSE range for this study = 12–26). It is possible that a significant relationship between dementia severity and awareness measures would have emerged if more severely impaired patients were included in the study. However, past MLAT studies have shown that omissions, which are detected significantly less often than commissions, increase significantly as a function of clinical severity (Buxbaum et al., 1999; Giovannetti et al., 2001; Schwartz et al., 1998, 1999).

Thus, awareness data obtained from more severe patients may be subject to floor effects. Future studies with more severely impaired participants are necessary to learn whether the MLAT–S is a good instrument for exploring error awareness in individuals with advanced dementia.

Non-significant correlations between awareness scores and specific neuropsychological tests do not support a link between error awareness/correction and any single neuropsychological process (e.g., executive functions, semantic knowledge, etc.). Direct assessment of error detection and correction may provide novel information about behavioral monitoring that cannot be extrapolated from traditional neuropsychological test scores, at least in a heterogeneous dementia sample. However, it is possible that performance on neuropsychological tests may explain error awareness and detection for patients with specific dementia syndromes or more circumscribed cognitive impairments (e.g., semantic dementia).

Analyses of demographic variables showed no relationship between awareness scores and age, education, or dementia etiology. Unexpectedly, however, women were aware of a significantly higher proportion of action errors compared to men, and this could not be explained by a difference in dementia severity. Sevush and Leve (1993) showed that women were less likely to report memory difficulties compared to men in a sample of 128 AD patients; however, gender differences in ADL awareness have never before been reported. It is possible that elderly women are more familiar with the tasks administered in the MLAT–S, and, therefore, require fewer cognitive resources to complete the tasks (making more resources available for monitoring). If this were true, then women should make fewer MLAT–S errors relative to men, but this is not the case (see Giovannetti et al., 2002). Thus, we have no explanation for the gender difference, but suggest that it is an interesting finding that warrants further investigation.

Questionnaire Scores

The relationship between the caregiver ADL rating and MLAT–S errors suggests that performance on the MLAT–S tasks (e.g., *make toast and coffee*, *wrap a present*, etc.) may generalize to home performance of various ADL (Giovannetti et al., 2002). Participant ADL rating and MLAT–S errors were also significantly correlated, however, these correlations were not as strong or consistent (i.e., there was no significant correlation between participant ADL rating and commission errors) as those between MLAT–S errors and caregiver ADL ratings. Nonetheless, the significant relationship between the participant ADL scores and MLAT–S errors suggests that participants indicated some degree of awareness of naturalistic action difficulties on the ADL questionnaire.

Correlations between the MLAT–S awareness variables and the ADL discrepancy score were not significant. Therefore, it is possible that these methods assess different aspects of ADL awareness. That is, patients who indicate awareness of ADL performance on questionnaires may still demonstrate limited awareness of errors during the course of naturalistic task performance and vice versa. We hypothesized that questionnaire data may rely more heavily on language and memory processes relative to error detection and correction, and we also suggested that error detection and correction may be a more direct measure of error monitoring. Although there was no evidence that the ADL discrepancy score was linked to memory, there was a significant correlation between the ADL discrepancy score and a verbal measure of concept formation (Similarities). Inconsistent with our hypothesis that error detection and correction measures are more direct measures of on-line behavioral monitoring relative to questionnaire data, MLAT–S awareness measures were not related to neuropsychological tests of executive functioning. In sum, we conclude that although questionnaire data may require greater language skills, questionnaire methods are not inferior awareness measures relative to assessment of error detection/correction during the course of action. Rather, our data simply suggest that these methods may assess distinct aspects of ADL awareness.

The correlations between the caregiver cognitive rating and MLAT–S errors are consistent with past studies showing a link between naturalistic action performance and general cognitive functioning (see Buxbaum et al., 1998; Giovannetti et al., 2002; Schwartz et al., 1998, 1999, 2002). The cognitive–behavioral discrepancy score significantly correlated with measures of global cognitive functioning (MMSE) and a verbal test of semantic knowledge. Thus, the cognitive correlates for awareness of cognitive and behavioral problems may differ from the cognitive processes related to awareness for ADL difficulties. This finding demonstrates the importance for future studies of dementia to carefully define the type of awareness under investigation.

Awareness across Error Types

The closed-loop error monitoring account states that an internal representation of an action and feedback from the environment are necessary for successful error monitoring. The fact that participants were aware of a significantly larger proportion of commission errors compared to omissions is consistent with our prediction based on this model. That is, presumably, omissions occur because participants fail to activate or lack the internal representation for an action, which makes error detection extremely unlikely in these situations.

Among commission errors, participants were aware of a significantly larger proportion of substitution and sequence errors compared to action additions and perseverations. Based on the closed-loop model, we may conclude that sequence and substitution errors reflect actions that are inconsistent with the participants' internal representation or plan. Action addition errors, on the other hand, may actually be intended by the participant more often than other errors. Perseverations are known to reflect deficient monitoring, and, therefore, it is not surprising that these errors are never detected.

Conclusions

Error awareness and correction is significantly impaired in dementia, even in mild stages of the disease. The relationship between error awareness and correction and dementia severity, neuropsychological tests, and questionnaire methods is not transparent and requires further investigation. Unawareness of deficit in dementia has been associated with increased caregiver burden (DeBettignies et al., 1990; Seltzer et al., 1997) and patients' failure to take precautions for safety (Cotrell & Wild, 1999). In the present study, dementia participants successfully corrected 79% of the errors for which they indicated awareness. This underscores the need for future studies of error awareness, as greater understanding of this phenomenon may facilitate ADL independence and safety in elderly patients with dementia.

ACKNOWLEDGMENTS

This research was conducted in partial fulfillment of the requirements for Tania Giovannetti's doctoral degree and was supported in part by NIH National Research Service Grant # 5132HD07425 and internal funds from Moss Rehabilitation Hospital. We thank Marissa Carey, Melissa Lamar, and Monica Tompson for their help with collecting neuropsychological test data and Daniel Cutrone for scoring videotapes for interrater reliability analyses. We also thank Dr. Igor Grant and three anonymous reviewers for their helpful comments on an earlier version of this manuscript.

REFERENCES

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Buxbaum, L.J., Schwartz, M.F., & Montgomery, M.W. (1998). Ideational apraxia and naturalistic action. *Cognitive Neuropsychology*, *15*, 617–643.

Chui, H.C., Victoroff, J.I., Margolin, D., Jaust, W., Shankle, R., & Katzman, R. (1992). Criteria for the diagnosis of ischemic vascular dementia proposed by the state of California Alzheimer's Disease Diagnostic and Treatment Centers. *Neurology*, *42*, 473–480.

Cloud, B.S., Libon, D.J., Giovannetti, T.G., & Lamar, M. (2001). *Semantic knowledge in dementia: Effects of category and attribute type on the breakdown of knowledge*. Manuscript submitted for publication.

Cloud, B.S., Swenson, R., Malamut, B.L., Kaplan, E., Sands, L.P., Gitlin, H., & Libon, D.J. (1994). The Boston revision of the Wechsler Memory Scale–Mental Control Subtest. *Journal of the International Neuropsychological Society*, *1*, 354.

Cotrell, V. & Wild, K. (1999). Longitudinal study of self-imposed driving restrictions and deficit awareness in patients with Alzheimer's disease. *Alzheimer's Disease and Associated Disorders*, *13*, 151–156.

DeBettignies, B.H., Mahurin, R.K., & Pirozzolo, F.J. (1990). Insight for impairment in independent living skills in Alzheimer's disease and multi-infarct dementia. *Journal of Clinical and Experimental Neuropsychology*, *12*, 355–363.

Folstein, M.F., Folstein, S.E., & McHugh, P.R. (1975). Mini-Mental State: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*, 189–198.

Giovannetti, T., Libon, D.J., Buxbaum, L.J., & Schwartz, M.F. (2002). *Naturalistic action impairments in dementia*. *Neuropsychologia*, *40*, 1220–1232.

Goldberg, E. & Barr, W.B. (1990). Three possible mechanisms of unawareness of deficit. In G.P. Prigatano & D.L. Schacter (Eds.), *Awareness of deficit after brain injury: Theoretical and clinical aspects*. New York: Oxford University Press.

Green, J., Goldstein, F.C., Sirockman, B.E., & Green, R.C. (1993). Variable awareness of deficits in Alzheimer's disease. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology*, *6*, 159–165.

Hart, T., Giovannetti, T., Montgomery, M.W., & Schwartz, M.F. (1998). Awareness of errors in naturalistic action following traumatic brain injury. *Journal of Head Trauma and Rehabilitation*, *13*, 16–28.

Kaplan, E.F., Goodglass, H., & Weintraub, S. (1983). *The Boston Naming Test* (2nd ed.). Philadelphia: Lea & Febiger.

Kotler-Cope, S. & Camp, C.J. (1995). *Anosognosia in Alzheimer's disease*. Alzheimer Disease and Associated Disorders, *9*, 52–56.

Kuriansky, J.B., Gurland, B.J., Fleiss, J.L., & Cowan, D. (1976). The assessment of self-care capacity in geriatric psychiatric patients by objective and subjective methods. *Journal of Clinical Psychology*, *32*, 95–102.

Lamar, M., Cloud, B., Giovannetti, T., & Libon, D.J. (2000). Anosognosia revisited in dementia [Abstract]. *Journal of the International Neuropsychological Society*, *6*, 178.

Lamar, M., Podell, K., Carew, T.G., Cloud, B.S., Resh, R., Kennedy, C., Goldberg, E., Kaplan, E., & Libon, D.J. (1997). Perseverative behavior in Alzheimer's disease and subcortical vascular dementia. *Neuropsychology*, *11*, 523–534.

Lawton, M.P. & Brody, (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *Gerontologist*, *9*, 179–186.

Libon, D.J., Mattson, R., Glosser, G., Kaplan, E., Malamut, B.L., Sands, L.P., Swenson, R., & Cloud, B.S. (1996). A nine word dementia version of the California Verbal Learning Test. *Clinical Neuropsychologist*, *10*, 237–244.

Libon, D.J., Swenson, R.A., Barnowski, E.J., & Sands, L.P. (1993). Clock Drawing as an assessment tool for dementia. *Archives of Clinical Neuropsychology*, *8*, 405–415.

Mangone, C.A., Hier, D.B., Gorelick, P.B., Ganellen, R.J., Langenberg, P., Boarman, R., & Dollear, W.C. (1991). Impaired insight in Alzheimer's disease. *Journal of Geriatric Psychiatry and Neurology*, *4*, 189–193.

McGlynn, S.M. & Kaszniak, A.W. (1991). When metacognition fails: Impaired awareness of deficit in Alzheimer's disease. *Journal of Cognitive Neuroscience*, *3*, 183–189.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadan, E.M. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS–ADRDA work group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology*, *34*, 939–943.

Migliorelli, R., Teson, A., Sabe, L., Petracca, G., Petracchi, M., Leiguarda, R., & Starkstein, S.E. (1995). Anosognosia in Alzheimer's disease: A study of associated factors. *Journal of Neuropsychiatry*, *7*, 338–344.

Neundorfer, M.M. (1997). Awareness of variability in awareness. *Alzheimer Disease and Associated Disorders*, *11*, 121–122.

Norman, D. (1981). Categorization of action slips. *Psychological Review*, *88*, 1–15.

Ott, B.R., Lafleche, G., Whelihan, W.M., Buongiorno, G.W., Albert, M.S., & Fogel, B.S. (1996). Impaired awareness of deficits in Alzheimer Disease. *Alzheimer Disease and Associated Disorders*, *10*, 68–76.

Prigatano, G.P. (1996). Behavioral limitations TBI patients tend to underestimate: A replication and extension to patients with lateralized cerebral dysfunction. *Clinical Neuropsychology*, *10*, 191–201.

Prigatano, G.P., Altman, I.M., & O'Brien, K.P. (1990). Behavioral limitations that brain injured patients tend to underestimate. *Clinical Neuropsychology*, *4*, 163–176.

Schwartz, M.F., Buxbaum, L.J., Montgomery, M.W., Lee, S.S., & Coslett, H.B. (1999). Naturalistic action production following right hemisphere stroke. *Neuropsychologia*, *37*, 51–56.

Schwartz, M.F., Buxbaum, L.J., Veramonti, T., Ferraro, M., & Segal, M. (2002). *The Naturalistic Action Test*. Bury, St. Edwards: Thames Valley Test Company.

Schwartz, M.F., Montgomery, M.W., Buxbaum, L.J., Lee, S. S., Carew, T.G., Coslett, H.B., Ferraro, M., Fitzpatrick-DeSalme, E.J., Hart, T., & Mayer, N. (1998). Naturalistic action impairment in closed head injury. *Neuropsychology*, *12*, 13–28.

Sellen, A.J. & Norman, D.A. (1992). The psychology of slips. In B.J. Baars (Ed.), *Experimental slips and human error: Exploring the architecture of volition*. New York: Plenum Press.

Seltzer, B., Vasterling, J.J., Yoder, J., & Thompson, K.A. (1997). Awareness of deficit in Alzheimer's disease: Relation to caregiver burden. *Gerontologist*, *37*, 20–24.

Sevush, S. & Leve, N. (1993). Denial of memory deficit in Alzheimer's disease. *American Journal of Psychiatry*, *150*, 748–751.

Spreen, O. & Strauss, E. (1991). *A compendium of neuropsychological tests: Administration, norms and commentary*. New York: Oxford University Press.

Vasterling, J.J., Seltzer, B., Foss, J.W., & Vanderbrook, V. (1995). Unawareness of deficit in Alzheimer's disease: Domain-specific differences and disease correlates. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology*, *8*, 26–32.

Vasterling, J.J., Seltzer, B., & Watrous, W.E. (1997). Longitudinal assessment of deficit unawareness in Alzheimer's disease. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology*, *10*, 197–202.

Wechsler, D. (1987). *Wechsler Adult Intelligence Scale–Revised manual*. New York: The Psychological Corporation.

Yesavage, J. (1986). The use of self-rating depression scales in the elderly. In L.W. Poon (Ed.), *Handbook of clinical memory assessment of older adults* (pp. 213–217). Washington, DC.: American Psychological Association.