EMPIRICALLY-BASED INTERVENTIONS FOR ERROR MONITORING DEFICITS IN DEMENTIA

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ABSTRACT

Empirically-Based Interventions for Error Monitoring Deficits in Dementia
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The diminished ability to perform everyday tasks is a salient problem for individuals diagnosed with a dementia. Recent research suggest that dementia patients detect significantly fewer action errors than age-matched controls; however, very little is known about the derivation of their error monitoring difficulties. The primary aims of my dissertation were to evaluate a novel, task training action intervention (TT-NAT) designed to increase error monitoring in dementia patients, and to pinpoint the relation between error monitoring and neuropsychological processes in participants who receive the task training intervention. Results indicated that dementia participants in the TT-NAT condition produced fewer total errors and detected significantly more of their errors than individuals in the Standard condition ($z = 3.0$ and $t = 3.36$, respectively; $p < .05$). Error detection in the TT-NAT condition was strongly related to the language/semantic knowledge composite index only ($r = .57$, $p = .00$), whereas it was moderately related to both the language and executive composite indices in the Standard condition. No differences in error correction rates were noted, although patients in all groups corrected the majority of errors detected. The findings suggest that the TT-NAT may be a promising intervention for error monitoring deficits in dementia patients, and have considerable implications for neuropsychological rehabilitation.

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This dissertation thesis is dedicated to my husband,
who shared my excitement for the study findings,
encouraged me when I felt frustrated,
and spent countless dinners listening to monologues on the importance of everyday action errors.

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CHAPTER 1

INTRODUCTION

Background

The ability to accurately and efficiently carry out everyday activities is an integral component of functional autonomy. Although basic activities of daily living (ADL's; e.g. eating, grooming) are over-learned, common tasks, they involve a multitude of cognitive processes, including complex on-line monitoring of task goals, environmental cues, and outcomes in order to safely complete the action. As such, everyday actions are particularly sensitive to changes in neurological functioning and represent a significant concern for individuals diagnosed with a dementia (Mioshi et al, 2007; American Psychiatric Association, 2000). The limited corpus of literature on this topic indicates that dementia patients exhibit distinct and dissociable action deficits characterized by high error rates (Ito & Kitagawa, 2005; Giovannetti, Libon, Buxbaum, & Schwartz, 2002), reduced task accomplishment (Giovannetti, Libon, Buxbaum, et al, 2002), and a diminished capacity to handle errors once they have been committed (Mathalon, Whitfield, & Ford, 2003; Bettcher, Giovannetti, MacMullen, & Libon, 2008). Although the egregious error rate generated by dementia patients remains problematic (Giovannetti, Libon, Buxbaum et al, 2002) and relatively unaddressed (Gitlin, Corcoran, Winter, Boyce, & Hauck, 2001; Buxbaum, Schwartz, & Montgomery, 1998), empirical research with older adults suggests that impaired action error detection and correction may signify a more immediate, pressing concern for independent living in this population (Nieuwenhuis et al, 2002; Falkenstein, Hoormann, & Hohnsbein, 2001; Giovannetti, Libon, & Hart, 2002; Bettcher et al, 2008). The primary aim of this study is to evaluate a task training intervention designed to improve error monitoring in individuals diagnosed with a dementia. The action intervention techniques employed in this study were informed by current conceptualizations of the neuropsychological factors responsible for impoverished error monitoring.

Dementia and Everyday Action

Everyday action is defined as behavior in the service of everyday tasks that entails sequencing multiple steps and utilizing objects to accomplish nested goals (Giovannetti, Libon, Buxbaum, et al 2002). The diminished ability to perform everyday tasks is a salient problem for neurologically impaired individuals, and has been associated with depressive symptomology (Cipher & Clifford, 2004; Kiosses & Alexopoulos, 2005), institutionalization (Knopman, Kitto, Deinard, & Heiring, 1988; Hill, Fillit, Thomas, & Chang, 2006), and caregiver burden (DeBettignies, Mahurin, & Pirozzolo, 1990). The evaluation of functional deficits is required to establish a diagnosis of dementia (American Psychiatric Association, 2000), suggesting that everyday action performance holds significance not only for understanding psychosocial aspects of dementia progression, but also for conceptualizations of the neuropathological and neuropsychological changes associated with this degenerative disease (Galasko, Schmitt, Thomas, Jin, & Bennett, 2005).

Typically, evaluation of ADL's in dementia is based on informant-report questionnaires of everyday task performance (Desai, Grossberg, & Sheth, 2004). These assessment methods offer a gross estimation of everyday action performance that can be completed in a relatively short amount of time; however, the information gleaned from these instruments is cursory, underspecified, and prone to reporter bias (Arguelles, Loewenstein, Eisdorfer, & Arguelles, 2001; Zanetti, Geroldi, Frisoni, Bianchetti, & Trabucchi, 1999). For example, while informant-report questionnaires provide important information regarding the domains of everyday functioning that are impaired (e.g. toileting, bathing, preparing meals; Lawton & Brody, 1969), they do not offer details regarding the types of errors produced (e.g. omissions; sequence errors) or the manner in which dementia patients respond to their errors (i.e. error detection or correction).

Recent studies have addressed these concerns by using performance-based measures in controlled laboratory environments. Results from these studies suggest that dementia patients produce significantly higher error rates (Giovannetti, Libon, Buxbaum, et al, 2002; Feyereisen, 1999) and accomplish fewer task goals than age-matched controls (Giovannetti, Libon, Buxbaum, et al, 2002). Similar to other neurologically impaired groups, their error patterns are characterized by high rates of omission errors (failure to perform a task step) and commission errors (inaccurate and sequentially incorrect performance of a task step). While global cognitive functioning is the best predictor of total error rate in dementia patients, recent evidence suggests that specific neuropsychological processes may buttress different types of error patterns (Giovannetti, Schmidt, Gallo, Sestito, & Libon, 2006). In a recent study, Giovannetti and colleagues demonstrated that dementia subtype was a relevant factor in the study of action error performance. Using the Naturalistic Action Test (Schwartz, Buxbaum, Ferraro, Veramonti, & Segal, 2003), the authors reported that while individuals diagnosed with Alzheimer's disease and vascular dementia did not differ on overall task performance, vascular dementia patients produced significantly more errors on all tasks and accomplished fewer task steps when salient distractor items were present in the environment. Considering that vascular dementia is associated with marked executive control deficits, the disorganized and inefficient performance of this patient group may have resulted from their inability to exert appropriate top-down control (Giovannetti et al, 2006). This suggests that neurocognitive profiles associated with dementia subtypes impact the *quality* of performance on everyday activities. Moreover, it indicates that differential neuropsychological profiles are meaningful in parsing out the *locus* of everyday action difficulties. More direct evidence for this conclusion has been reported in a recent study showing different error types on everyday tasks comprise dissociable factors and associate with measures of different neuropsychological processes (Giovannetti et al, 2008).

Error Monitoring Deficits in Dementia

Research with younger adults indicates that the impact of action errors is substantially less taxing if blunders are recognized and rectified in a timely manner (Reason, 1990; Sellen & Norman, 1992; Blavier, Rouy, Nyssen, & de Keyser, 2005); thus, since errors of action may never prove to be wholly avoidable, the ability to accurately and quickly detect one's blunder may represent a more realistic goal for neuropsychological rehabilitation. Given the concerning number of errors dementia patients produce, how do they respond to these blunders? Recent studies using highly controlled and relatively simple laboratory reaction time tasks and forced-choice response tasks suggest that dementia patients detect and correct significantly fewer errors than age-matched controls (Mathalon et al, 2003; Ito & Kitagawa, 2005), who in turn monitor their errors less than healthy younger adults (Band & Kok, 2000; Nieuwenhuis et al, 2002). Results from two naturalistic studies corroborate these findings and further indicate that dementia patients detect between 20% (Giovannetti, Libon, & Hart, 2002) and 34% (Bettcher et al, 2008) of their everyday action errors. Notably, patients diagnosed with a dementia correct the majority of errors they detect (76%), suggesting that the source of difficulty lies in recognizing and/or evaluating the action error (Bettcher et al, 2008).

Few studies have examined microslip corrections in everyday tasks. Microslips are thought to be the most efficient means of correction as they occur before the error is fully executed (e.g. reaching for the wrong item, but stopping oneself before completing the error; Smid, Mulder, & Mulder, 1990; Blavier et al, 2005; Norman, 1981; Giovannetti, Schwartz, & Buxbaum, 2007). Microslips have been attributed to auto-control processes rather than effortful, executive control processes; thus, it is possible that microslips may remain preserved in dementia. In a recent study of healthy participants who were asked to perform a complex coffee-making task under time pressure, microslip error corrections occurred with very high frequency. Bettcher et al (2008) conducted the first and only examination of microslip corrections in everyday tasks among dementia participants. The frequency of detection was somewhat higher compared to past studies of only fully committed, overt errors (Giovannetti, Libon, & Hart, 2002); however, even with microslips, the rate of detection/correction was still extremely low in dementia relative to controls (34% and 74%, respectively).

Bettcher et al. (2008) also were the first to analyze error correction time frames in dementia participants. These analyses revealed that when dementia participants correct their errors, they are more likely to engage in microslip corrections than immediate or delayed corrections. This suggests that auto-control processes are *relatively* preserved in dementia participants and that error detection/correction processes are not substantially slowed. Nevertheless, the overall reduced rate of detections (and as a result, corrections) remains concerning. Taking into consideration the observation that dementia patients correct a high proportion of detected errors, facilitating immediate (optimally) or delayed *detections* of blunders remains essential.

Cognitive Foundations of Error Monitoring

Although patients diagnosed with a dementia detect very few of their action errors, little is known about the derivation of their error monitoring difficulties. The cognitive and human factors literatures on error monitoring shed some light on this issue in younger adult populations, as they offer a plethora of taxonomies that carefully pinpoint the individual's role in the *production* of errors as well as their associated likelihood for *detecting* these action errors (Norman, 1981; Reason, 1990; Zapf & Reason, 1994; Blavier et al, 2005). Within the context of Reason's 1990 model, if an individual formulates an incorrect intention (i.e. he/she does not establish appropriate task parameters), then the subsequent error is referred to as a "mistake." On the other hand, if an individual incorrectly executes a correctly formulated plan, then the resulting error is referred to as a "slip." In order to identify an action as incorrect (i.e. detection), external behavior is monitored and compared to an internal representation of the desired state. As such, planning *versus* execution errors are inherently associated with very different probabilities for individual detection.

Mistakes represent the most difficult type of error to detect, as the individual experiences little dissonance between the outcome and the initial intention. Thus, if an individual establishes an incorrect intention (a mistake), it is unlikely that the associated outcome will trigger a "mismatch" of the desired state. At this point, detections are likely to occur only in the face of third-person intervention or environmental restrictions. In contrast, "slips" are more readily detected due to the continuity between established intention and appropriate task parameters. Upon producing a slip, the individual may rely on either internal or external feedback to provide evidence of a mismatch between intention and outcome. When slip detections are based on internal evaluation, they are likely to occur quickly and based on pre-attentional control mechanisms (i.e. "microslip" detection). In sum, the opportunity for detection of slips is substantially greater than that for mistakes.

Neuropsychological Underpinnings of Impaired Error Monitoring

Although several studies have investigated the production of slips *versus* mistakes in younger adults (Reason, 1990; Norman, 1981), there is a paucity of literature on this issue in older adults diagnosed with a dementia (Ito & Kitigawa, 2005). Given the differential error detection/correction profiles associated with slips and mistakes, a comprehensive investigation of error monitoring should examine the neuropsychological constructs that may bolster the likelihood of generating these two error types in dementia. For instance, it is possible that the low rate of error detection/correction is due to a high rate of mistakes *versus* slips. If so, then this might imply that error monitoring abilities are relatively preserved in the face of degraded everyday task knowledge. On the other hand, if a large majority of dementia patients' everyday errors were due to undetected slips, this would imply serious deficits in error monitoring with relatively preserved task knowledge. A third possibility is that both knowledge and monitoring deficits are at play. If so, then the relative contribution of each deficit should be carefully characterized. Before further consideration of these hypotheses, the cognitive processes most likely associated with slips *versus* mistakes will be reviewed.

Executive Control

The prefrontal cortex plays a fundamental role in action planning and processing complex action events (Sirigu et al, 1995) and is responsible for the wide range of neurocognitive processes referred to as "executive functions." When an action error is committed, prefrontal cortices are recruited in order to generate and sequence behavior in a meaningful, goal-oriented manner (Ullsperger & von Cramon, 2006). Thus, error monitoring is often subsumed under the superordinate construct of executive functioning in the younger adult literature, as it requires attention and concentration, inhibitory control, planning, and problem solving (Miller & Cohen, 2001). Given this presupposition, impaired error monitoring may stem from specific deficits in executive control. Recent work from our lab provided *partial* support for this assertion; while executive functioning served as the primary predictor for error detection and correction in patients diagnosed with a dementia, it accounted for a small proportion of the variance (Bettcher et al, 2008).

It may be the case that executive control deficits are germane to monitoring slips but not mistakes. That is, executive processes may be necessary to monitor the mismatch between an executed action and the intended plan. However, executive control abilities may not be as relevant to formulating an accurate action plan, which may be more strongly related to semantic knowledge of everyday task parameters (i.e., script content knowledge). Thus, everyday action interventions designed to minimize the impact of executive control deficits on everyday action, might serve to facilitate the detection and correction of action slips but not mistakes. However, this hypothesis has never been evaluated.

Script Content Knowledge

Although the prefrontal cortex is integral to the planning and execution of everyday tasks, recent research suggests that more posterior cortical regions are necessary for the comprehension and representation of task scripts (Sirigu et al, 1995; 1996; Crozier et al, 1999). Scripts refer to goal-directed, routine sequences of action that delineate a well-known activity or situation (e.g. tooth brushing). Scripts identify role players and outcomes, and typically involve action sequencing and object utilization (Schank & Abelson, 1977; Allain, Le Gall, Etcharry-Bouyx, Aubin, & Emile, 1999). Knowledge of scripts offers a template for performing everyday tasks, and thus directly contributes to an individual's ability to effectively interact with and monitor his/her environment.

Research suggests that the manipulation and sequencing of script knowledge requires both executive control/prefrontal cortex and script content knowledge/posterior cortex. For instance, using fMRI Crozier and colleagues (1999) reported bilateral activations in temporal cortices in addition to prefrontal cortical activation on a series of script sequencing tasks. Cosentino and colleagues also recently confirmed a two-component model of script comprehension in patients diagnosed with frontal-temporal dementia and Alzheimer's disease, and further proposed that the prefrontal cortex retrieves semantic knowledge from the temporal cortex and then assembles and systematizes this information into meaningful goal-directed behavior (Cosentino, Chute, Libon, Moore, & Grossman, 2006). Finally, while accurate performance of everyday tasks requires both components of script comprehension, research suggests that individuals may experience a deficit in only one domain. Sirigu and colleagues (1995, 1996) reported that patients with lesions in the prefrontal cortex retain knowledge of the content of scripts even though they are unable to arrange and appropriately execute this knowledge (see also Zanini, Rumiati, & Shallice, 2002).

Semantic knowledge, and more importantly, script content knowledge is particularly relevant to the error monitoring deficits associated with dementia patients. Work with younger adults suggests that when individuals are unclear of task parameters or are unsure of how to use the task stimuli, they are less likely to detect and subsequently correct their errors (Scheffers & Coles, 2000). Among dementia patients with degraded script content knowledge and/or related semantic knowledge, errors in everyday tasks are likely due to *mistakes* rather than *slips;* i.e.

failures in the task plan per se. The failure to understand the task parameters also negatively impacts error monitoring, as patients cannot compare their behavior to an internal representation of the desired outcome. Thus, mistakes represent the most difficult type of error to detect and correct, as the individual initiates the task without a clear idea of what to do and how to use the task objects. Improvement in error detection was anecdotally reported in a singe case study of a patient with severe everyday action difficulties subsequent to carbon monoxide poisoning (FK; Forde, Humphreys, & Remoundou, 2004). His ability to detect his errors increased after training on a tea-making task designed to facilitate his knowledge of the task. Thus, there is reason to propose that brief script training sessions prior to the commencement of everyday activities may promote error monitoring by restoring degraded or incomplete task knowledge and minimizing the production of mistakes.

Current Study

The primary aim of the current study was two fold: 1) to evaluate a task training action intervention designed to increase error monitoring in dementia patients; 2) to pinpoint the relation between error monitoring and neuropsychological processes in participants who receive the task training intervention. In order to accomplish this, participants were administered a neuropsychological protocol that assessed language functioning and semantic knowledge, executive control, and episodic memory. In addition, a novel naturalistic action intervention, referred to as the Task Training NAT, was conducted with recruited participants and compared to existing data from an empirically validated control condition (Standard NAT; Schwartz et al, 1998; Schwartz, Segal, Veramonti, Ferraro, & Buxbaum, 2002; Giovannetti, Libon, Buxbaum, et al, 2002). Action error monitoring rates and time frames were evaluated and compared across both conditions. The Standard NAT requires participants to perform three everyday tasks using objects that are placed before them on a U-shaped table. Limited information or assistance is provided to individuals apart from reading the specific subtask instructions. Participants are not trained or familiarized with the NAT tasks prior to performance. For the purpose of the current study, a novel intervention based on improving script content knowledge was devised. The Task Training (TT-NAT) and Standard NAT involve the same administration and scoring procedures. However, the conditions differ in that a task training session is implemented prior to the initiation of each NAT task in only the TT-NAT. Specific rehabilitation techniques employed in the TT-NAT include identification and description of objects used in the task, as well as presentation of photographed depictions of important task steps. This served to familiarize participants with the task parameters and was designed to improve knowledge of the *content* of the task.

Hypotheses

My first hypothesis was that the improvements in action script knowledge ("task knowledge") would lead to improved action error monitoring in dementia patients. Therefore, I predicted that participants performing the TT-NAT would detect and correct a higher proportion of their action errors than dementia participants performing the Standard NAT.

My second hypothesis was that improvements in action script knowledge would facilitate error monitoring by reducing the likelihood of mistakes. Therefore, I predicted that monitoring failures that occur in the TT-NAT condition would be strongly related to impaired executive control (i.e., slips). Specifically, I predicted that performance on executive control measures would be a significant predictor of error detection and correction rates in the TT-NAT and would explain significantly more error detection/correction variance in the TT-NAT than the Standard NAT.

My third hypothesis was that facilitating everyday task knowledge would lead to rapid and automatic error detection/correction. That is, because the literature postulates that slips are corrected more quickly than mistakes, I predicted that faster rates of error detection and correction would be observed in the TT-NAT compared to the Standard NAT.

A secondary aim of the study was to compare the Task Training NAT to retrospective data of an alternative everyday action intervention, the User-Centered NAT. In a previous study from our lab, participants diagnosed with a dementia demonstrated a reduction in total error rates on the User-Centered NAT relative to the Standard NAT (Giovannetti, Bettcher, et al, 2007); however, the impact of this intervention on error monitoring has yet to be evaluated. In contrast to the Standard NAT and TT-NAT, the organization of the User-Centered NAT is such that the objects used for the same subtask are arranged in closer spatial proximity than objects used for different tasks. Furthermore, objects are placed on the tabletop from left-to-right in the order that they should be used in the task. The environmental adaptations associated with the User-Centered NAT were designed to improve sequence ordering and reduce environmental distractibility.

My fourth hypothesis was that both interventions would be associated with higher error monitoring relative to the Standard NAT. Thus, I predicted that participants performing the TT-NAT and User-Centered NAT would detect and correct a higher proportion of their action errors than dementia participants performing the Standard NAT.

The UC-NAT intervention was designed to improve everyday errors due to failures in executive control. Unlike the TT-NAT, the User Centered NAT (UC-NAT) does not aim to improve script content knowledge. Therefore, my fifth hypothesis was that the User-Centered NAT would reduce the likelihood of slips; therefore, monitoring failures that occurred in this condition would stem from impaired task knowledge (i.e., mistakes). Because mistakes are known to be more difficult to detect/correct, I predicted that participants performing the UC-NAT would detect/correct a significantly smaller proportion of their action errors relative to participants performing the TT-NAT. Furthermore, I predicted that that performance on independent neuropsychological measures of semantic knowledge and language functioning would significantly predict error detection and correction rates only for participants performing the User-Centered NAT.

Exploratory Analyses

Two additional exploratory analyses were performed. First, participant characteristics were compared between participants who demonstrated relatively good error monitoring versus those who demonstrated relatively low error monitoring abilities on the TT-NAT. This analysis was done in order to gain a better understanding of the characteristics of participants who might respond most favorably to the TT-NAT intervention.

Second, to determine whether episodic memory functioning played a contributory role in TT-NAT performance, post-hoc analyses exploring an association between episodic memory ability and error monitoring variables were conducted. Episodic memory functioning represents the keystone to dementia diagnosis according to standard clinical practices (American Psychiatric Association, 2000); however, a relation between episodic memory and action error detection/correction has yet to be documented (Giovannetti, Libon, et al, 2002; Bettcher et al, 2008; Bettcher & Giovannetti, 2009).

CHAPTER 2

METHODS

Participants

Fifty-four participants were recruited for the current study, but 1 participant was disqualified due to subsequent determination that she met an exclusion criteria for the study (cortical stroke). Of the remaining 53 individuals, 42 participants were administered the TT-NAT.

Eleven participants were administered the Standard NAT, and were included in a group with participants selected from a larger database of over 200 participants recruited for prior studies using the Naturalistic Action Test (NAT; Giovannetti, Libon, Buxbaum et al, 2002; Giovannetti et al, 2006). First, however, these 11 new participants were compared to a group of similar (i.e., matched on age, education, and MMSE) participants from the larger database. This was done to determine whether or not participants recruited for the current study were similar to those in the database who were recruited from different sites in the past. Then, 34 Standard-NAT participants were selected from the database based on the inclusion/exclusion criteria of the current study, and the availability of neuropsychological test data. This group of Standard-NAT participants served as a comparison group to evaluate the effect of the TT-NAT. The size of the TT-NAT (n = 42) and Standard NAT (n = 45) groups provided sufficient power (.79) to detect a medium-large effect when alpha (p-value) is set at .05 (Erdfelder, Faul, & Buchner, 1996).

Retrospective data from 34 participants who were administered a User-Centered NAT were also selected from a database of 46 participants. Similar to the Standard NAT participants, the selection criteria were based on inclusion/exclusion criteria stipulated in the current study, in addition to the availability of neuropsychological test data. These participants were compared to those administered the TT-NAT in order to examine the specific effect of the training intervention (UC-NAT; Giovannetti, Bettcher, et al, 2007).

Participants were recruited for this study from three sources: outpatient neurology clinics located at Temple Hospital and Drexel College of Medicine, as well as general outpatient community referrals. The referrals at all locations were comprised of older adults diagnosed with a neurodegenerative dementia. The primary diagnoses were Alzheimer's disease and vascular dementia, although individuals diagnosed with frontotemporal dementia or Parkinson's disease- related dementia were also evaluated. Participants met the following inclusion criteria: (a) between the ages of 65 and 90; (b) Mini-Mental State Examination (MMSE) ≥ 10 and ≤ 26; (c) diagnosis of dementia according to DSM-IV criteria (American Psychiatric Association, 2000). The decision to include all dementia diagnoses in the current study was based on two reasons. First, one of the aims of the study was to evaluate the role of specific neuropsychological processes in error monitoring; thus, the inclusion of varied neuropsychological profiles was crucial to isolating the specific locus of difficulty for dementia patients. Second, recent neuropathology studies have reported considerable overlap between dementia diagnostic syndromes (Victoroff, Goldman, & Henry, 1995; Etiene, Kraft, & Ganju 1998), suggesting that the incidence of a 'pure' dementia (e.g. Alzheimer's disease) may be less common than originally believed. As such, all individuals diagnosed with a primary dementia were included in the study.

Participants were not recruited for the study if they had a history of alcohol/illicit drug abuse in the past month; history of epilepsy, cortical stroke, or any significant traumatic brain injury; diagnosis of a primary psychiatric disorder; mental retardation; or were non-English speaking. The first four exclusion criteria were necessary to eliminate participants whose cognitive functioning or everyday action abilities might be impaired for reasons other than dementia. These exclusion criteria were similar to those used in other studies of everyday action in dementia (Giovannetti, Libon, Buxbaum, et al, 2002; Giovannetti, Bettcher, et al, 2007; Bettcher et al, 2008). Information pertinent to both inclusion and exclusion criteria were obtained from a brief interview, medical chart review, and the administration of a brief assessment of global cognitive functioning (i.e. Mini-Mental Status Exam, Folstein, Folstein, & McHugh, 1975). All participants signed IRB approved informed consents and were compensated $30 for the session. Eligible participants were also be required to sign a separate form, stating that they consented to having their NAT performances videotaped.

Neuropsychological Testing Measures

In order to assess neuropsychological performance, participants' global cognitive functioning, episodic memory, language functioning and semantic knowledge, and executive control abilities were evaluated. The following measures were used for this study:

Mini-Mental Status Exam (Folstein et al, 1975)

This is a 30 item measure of dementia severity. Total scores range from 0-30, with higher scores indicative of better global cognitive functioning. Test-retest reliability has been found to range from .80-.95 over intervals that are less than two months (Spreen & Strauss, 1998). Estimates of internal consistency range from .31 to .96, depending on the population being assessed (Spreen & Strauss, 1998).

Philadelphia Verbal Learning Test (Libon, Mattson, & Glosser, 1996)

Declarative memory was assessed with a nine-word version of the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987). The 9-word list version was chosen due to its utility for individuals with obvious memory impairment, such as individuals presenting with a dementia (Libon, Mattson, et al, 1996). The 9-word list was administered over five trials, followed by a 9-word interference trial. Short and long delayed free recall for the initial list was documented; however, for the current study, the primary dependent variable was accuracy on the delayed recognition memory test (Recognition Discriminability; algorithm = [1-(false positive +misses)/ Total possible correct] x 100). A high recognition discriminability score is associated with the ability to encode new information into long-term memory (Price et al, 2004; Delis et al,1987), and has been found to correlate with the volume of the hippocampal and parahippocampal gyrus (Libon et al, 1998). This measure was used to assist in validating participants' respective dementia diagnoses.

Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 1983)

The BNT is comprised of 60 line drawings, and was administered to participants in order to evaluate confrontational naming. For the current study, the dependent variable was the total number of pictures correctly named during initial naming. The BNT is sensitive to deficits in naming and semantic processing in individuals diagnosed with Alzheimer's disease and subcortical dementias (Kaplan et al, 1983; Barr, Benedict, Tune, & Brandt, 1992; Baum, Edwards, Yonan, & Storandt, 1996), and has excellent test-retest reliability (.94; Sawrie, Chelune, Naugle, & Luders, 1996).

The Word List Generation Task (WLG; Spreen & Benton, 1969; Monsch, Bondi, Butters, & Salmon, 1992)

For this task, participants were allotted 60 seconds to generate animal exemplars. Two dependent variables were calculated from this test: 1) Total number of responses produced, and the 2) Animal Association Index (AI). The animal association index necessitates a special scoring technique that is believed to measure the semantic organization between successive responses (Carew, Lamar, Cloud, Grossman, & Libon, 1997), such that a high AI score reflects relatively intact semantic memory stores. Recent studies have also shown that performance on category fluency tests activate the left temporal lobe (Mummery, Patterson, Hodges, & Wise, 1996; Gourovitch et al, 2000) and are associated with intact semantic knowledge.

Revised Wechsler Memory Scale: Mental Control (WMS-MC; Wechsler, 1945; Lamar, Price, Davis, Kaplan, & Libon, 2002).

The WMS-MC includes four automatized and three non-automatized tasks. The dependent variable was the accuracy index (AcI) derived from the three non-automatized, executive tasks (i.e., months backward, alphabet rhyming, & alphabet visualization). The accuracy indices for each non-automatized task were based on the following algorithm: AcI=[1-(false positive+ misses/ # possible correct)] * 100 (ref). This algorithm yields a percentage score ranging from 0 to 100 (100% correct results in the correct identification of all targets with no misses or false positive responses). A composite AcI score was calculated by averaging the AcI's from these subtests.

Clock Drawing Test (Goodglass & Kaplan, 1983; Libon, Swenson, Barnoski, & Sands, 1993; Libon, Malamut, Swenson, Sands, & Cloud, 1996)

Visuoconstruction ability was assessed by asking patients to 1) draw a clock with the hands set for ten after eleven and 2) copy a picture of a clock. Ten possible errors related to graphomotor impairment, hand/number placement, and executive control were scored for each trial (Libon, Malamut, et al, 1996). Recent research has demonstrated that total errors summed across both conditions are highly correlated with performance on tests of executive control and visuospatial ability. Therefore, the dependent variable used for this study was Total Clock Drawing Errors.

Word Fluency (Spreen & Benton, 1969; Spreen & Strauss, 1998)

Using the letters “F”, “A”, and “S”, participants were given 60 seconds to generate words that began with the specified letter, excluding proper names and numbers. The dependent variable was the total number of words summed across all three trials. This task taps verbal fluency, executive control, and cognitive persistence. In addition, the word fluency task demonstrates good test-retest reliability over the course of 1 year (.70; Snow, Tierney, Zorzitto, Fisher, & Reid, 1988), and has been shown to activate the left dorsolateral prefrontal area of older adults (Gourovitch et al, 2000).

Everyday Action Measures

The Naturalistic Action Test (NAT; Schwartz et al, 2003; Schwartz et al, 2002)

The Naturalistic Action Test is a standardized measure of naturalistic action that requires completion of three everyday tasks in the laboratory: 1) Prepare toast with butter and jelly and prepare instant coffee with cream and sugar; 2) Wrap a gift as a present; 3) Prepare a lunchbox with a sandwich, snack, and a drink and pack a schoolbag with supplies for school. All objects are available on a U-shaped table, which permits easy view and reach of task items. Since the NAT is designed to assess cognitive rather than motor abilities, physical assistance is permitted when necessary; otherwise, the examiner provides no guidance to the participant. In the present study, the NAT is referred to as the "Standard NAT" when it was administered according to the standardized procedures set forth in the test manual.

The Standard NAT was standardized on individuals with traumatic brain injury (TBI) and right- and left-hemisphere strokes (Schwartz et al., 2002). Two groups of non-neurologically impaired controls also participated in the validation study, and were age-matched to either the TBI or Stroke groups. An evaluation of the psychometric properties indicates that the Standard NAT displays strong interrater reliability (median weighted kappa = .98) and internal consistency (coefficient alpha = .79). Concurrent validity has been established with a measure of activities of daily living, namely the Functional Independence Measure (FIM, .5 correlation with both physical and cognitive subscales; Schwartz et al, 2003). Furthermore, previous studies indicate that the Standard NAT displays strong predictive validity, which was assessed by comparing Standard NAT performance at Time 1 (at time of discharge from a rehabilitation facility) with an Instrumental Activities of Daily Living scale at Time 2 (4 – 6 months after discharge; $r = .58$; Schwartz et al, 2003).

Prior studies have shown that Standard NAT variables are not affected by education, gender, or motor difficulties (Buxbaum, et al, 1998; Giovannetti, Libon, Buxbaum, et al, 2002; Schwartz et al, 1998, 2002; Sestito, Schmidt, Gallo, Giovannetti, & Libon, 2005). To ensure that there were no significant baseline differences in our current sample relative to previous samples collected at different location sites, 11 additional Standard NAT's were collected prospectively in this study (~25% of sample). These participants were included in the initial randomization of prospective dementia patients, and thus were collected concurrently with individuals participating in the TT-NAT intervention condition. The prospective sample of Standard NAT's were subsequently compared to a retrospective, age- and education-matched sample of dementia participants. No significant differences were noted for Total Errors, Proportion Detected, or Proportion Detected-Corrected ($p > .05$ for all variables)[1]. As such, a hybrid group was formed, consisting of both retrospective (n = 34) and prospective (n = 11) Standard NAT's. This served to increase the power of the study, while solidifying the lack of difference between groups.

User-Centered Naturalistic Action Test (UC-NAT)

A variation of the NAT, the UC-NAT, was also retrospectively examined in this study. In the UC-NAT, objects are grouped together in a meaningful arrangement, such that those that are used for the same task step are in closer spatial proximity than those that are used for different steps (Giovannetti, Bettcher, et al, 2007). For instance, the objects used for making toast are arranged in a cluster separate from the objects used for making coffee. Additionally, objects are arranged on the table from left to right in the order that they should be used in the task. Participants are instructed to work from left to right, using the objects one after another; furthermore, they are also told that the order of the objects will help them get through the task. These environmental adaptations have been shown to improve the everyday action performance in individuals with dementia (Giovannetti, Bettcher, et al., 2007).

Task Training Naturalistic Action Test (TT-NAT)

The Task Training NAT is a novel, theory-based intervention designed to improve script content knowledge, and was used in the current study as the primary prospective measure. The TT-NAT is identical to the Standard NAT in administration and design, with the exception of one key difference: the TT-NAT includes a brief (~10 minutes) training session prior to the

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[1] Additional analyses were conducted at the end of the study, comparing the prospective and retrospective Standard NAT's in the *current* sample (i.e. not utilizing the larger database or matching for age and education). No differences between the groups were noted for age, education, MMSE, or action monitoring variables.

commencement of each of the three tasks. The training session consists of the following two training components: 1) a description and picture presentation of all the items and steps participants should use to complete the task, and 2) a description and video presentation of the items and steps necessary to accomplish the task goals. For example, the first task requires participants to make a cup of instant coffee with cream and sugar, and a single slice of toast with butter and jelly. To suffice criteria 1 of the training session, participants are shown pictures and provided a brief explanation of the following key items/steps of the coffee task: spooning the coffee grounds into the cup of water, spooning the sugar into the cup of water, pouring the cream into the cup, and stirring the coffee with the spoon. To suffice criteria 2 of the training session, participants are subsequently shown a video of the researcher performing the same task (videotaped from the participant perspective), and provided with the same brief description offered in the picture section. In order to ensure that all participants understand the task parameters and thus equate participants on script content knowledge, a pictorial quiz is given at the end of each training session. The quiz was designed to cover primary contents components of each task, and is reviewed with the participant until they answer all questions correctly. Finally, all pictures cues used in the training section of the TT-NAT are placed in front of the patient throughout the duration of the task to prevent decay of task training.

Evaluation of Everyday Action Performance

Video recordings of the Standard NAT and UC-NAT were performed at the time of testing and were available for re-analysis. Participants performing the TT-NAT were also videotaped. All video recordings were viewed and coded for errors of action. Errors of action specifically involve an act or instance that deviates from the prescribed code of behavior. It is an act that fails to achieve what should be done given the procedural context and instructions. The NAT manual describes an extensive coding system for error analysis (Comprehensive Error Score; CES; Schwartz et al., 2003; Schwartz et al., 1998). The CES must be coded from videotape, as it necessitates fine-grained attention to error detail. The CES for participants in the Standard and User-Centered conditions was available from records of prior studies, but was reviewed for errors/inconsistencies for the present study by two coders blind to participant characteristics. The CES for dementia patients participating in the prospective TT-NAT intervention was calculated upon completion of the study.

Microslips

The CES does not capture errors that are not fully executed (i.e., microslip). However, microslips reflect instances of error detection/correction and are highly relevant to the study of error monitoring; thus they were coded for the present study. Microslips are operationally defined as the initiation and termination of an incorrect action before the error was completed (see also Giovannetti, Schwartz, et al, 2007). This includes reaching for or picking up an incorrect item or initiating a behavior that is dissonant with the task goal. For example, picking up, but not using, the garden shears instead of the scissors in the gift-wrapping task would be coded as a microslip. For all analyses, microslips were added to CES errors (i.e., Total Errors).

Error Detection and Correction

For the proposed study, an error monitoring coding system modeled on that of previous studies (Hart, Giovannetti, Montgomery, & Schwartz, 1998; Giovannetti et al, 2002) and recently validated in a study of monitoring deficits in dementia (Bettcher et al, 2008), was utilized for the analysis of error detection and correction. Two raters blind to participant characteristics independently coded NAT videotapes for microslips, error detection, error correction, and the time frame of error correction. Disagreements between the coders were resolved through discussion and/or re-review of videotapes. Inter-rater reliability was assessed for 15 participants selected randomly from the sample.

Error Detection

By definition, all microslips are considered "detected." However, each CES error was further classified as "detected" or "undetected." Error detection is operationally defined as an acknowledgement of mismatch between an individual's executed activity and the prescribed code of behavior for the task. This acknowledgment may present itself in 3 forms: verbalization, failed correction attempt, or an actual correction. To be considered evidence for detection, a verbalization must indicate recognition of the error or the possibility of task mismatch. (i.e., "I think you said to add sugar and cream to the coffee, but I'm adding only cream."). The second mode of acknowledgement involves physical effort to alter the consequences of the error; however, it does not necessitate that the participant *successfully* rectify the error. For example, if an individual places cookies in the pencil case, then proceeds to remove them and place them in the drawer (target=lunchbox), the action is classified as detected, even though the participant failed to accurately correct the error. That is, by removing the cookies from the pencil case, he/she acknowledges the inaccuracy of the action, but fails to properly resolve the problem. Finally, for the purpose of this study, all corrections were considered "detected". The proportion of Total Errors (i.e., CES + microslips) that was detected was calculated for each participant (Proportion Detected = Total Errors Detected / Total Errors).

Table 1. Error Detection and Correction Coding Guide

Monitoring Process	Description	Example
<u>Error Detection</u>		
Verbalization	Individual offers a verbalization indicative of error recognition or a verbalization suggestive of *possible* task mismatch.	e.g.: “Oops…”, “That’s not right…”, “I forgot…”, “I don’t know if this is right…”
Failed Attempt to Correct	Individual demonstrates a failed attempt to rectify the error. This must include a visual effort to alter the previously committed error.	e.g.: An individual places cookies in a pencil case, then proceeds to remove the cookies and place them in a drawer (target=lunchbox).
Error Correction	See below	
<u>Error Correction</u>		
Microslip correction	Individual initiates an incorrect action, but stops himself or herself before the errant action is completed.	e.g. An individuals reaches for, but does not use, the garden shears instead of the scissors in the “gift-wrapping” task.
Correction (“Undoing of an Act”)	Individual rectify or negate their action.	e.g. An individual applies a cap to the thermos, then removes it and adds juice.

Error Correction

Again, all microslips, by definition, are considered “corrected.” Therefore, only CES errors required further coding as either “corrected” versus “uncorrected.” A “correction” was coded when an act was accurately “undone.” Failed attempts to correct errors were coded as “uncorrected.” For example, adding jelly to the bread *before* toasting, was coded as undetected and uncorrected. This sequence error was coded as “detected” and “corrected” if the participant attempts to scrape off the jelly before toasting (i.e., undoing the error). It was coded as “detected” and “uncorrected” if the participant makes only a verbal comment about the erroneous action (“I know this isn’t right.”).

There is obvious overlap between the detection and correction categories, as we assumed that all corrected errors also were “detected.” Therefore, with respect to correction, we were interested in knowing the proportion of “detected” errors that were subsequently corrected. This was calculated as follows: Proportion Detected-Corrected = Total Errors Corrected / Total Errors Detected.

Error Correction Time Frames

All corrected errors were further classified according to the behavior(s) that occurred between the error and its correction: microslip, immediate, or delayed. Microslips are the fastest type of correction, as correction occurs before the error is completed. A corrected error was coded as “immediate,” when the correction occurred directly after the error, without any intervening actions. Corrected errors were classified as “delayed” when the correction occurred after an additional intermediary or off-task action. For example, when a participant closed the lunchbox without the thermos and then packed the pencil case into the schoolbag before correcting the thermos error, then the correction was coded as “delayed.” This method did not punish individuals for working slowly - as long as the correction occurred immediately following the error (i.e., the next action), it was labeled “immediate,” regardless of the time elapsed. For each participant, the proportion of Total Errors Detected coded as “microslip” (Proportion Microslip Correction = Total Microslip / Total Detected), “immediate” (Proportion Immediate Correction = Total Immediate / Total Detected) and “delayed” (Proportion Delayed Correction = Total Delayed / Total Detected) were calculated.

Table 2. Error Detection and Correction Variables

NAT Errors	
	Total Errors (CES Errors + Microslips)
Error Detection	
	Proportion Detected (Total Detected/Total Errors)
Error Correction	
	Proportion Detected-Corrected (Total Corrected/Total Detected)
Error Correction Time Frame	
	Proportion Microslip Correction (Total Microslip/Total Detected)
	Proportion Immediate Correction (Total Immediate/Total Detected)
	Proportion Delayed Correction (Total Delayed/Total Detected)

Procedure

All participants were tested at the Cognitive Neuropsychology Laboratory at either Temple University or Drexel University. All participants were administered a neuropsychological protocol, followed by the TT-NAT intervention (or Standard NAT for 11 participants). The testing session lasted approximately two and a half to three hours. NAT performance was videotaped for subsequent analysis by the investigators. Participants who completed the Standard NAT or UC-NAT conditions in past studies also underwent neuropsychological testing prior to administration of the NAT tasks.

Statistical Analyses

Preliminary analyses included a calculation of the mean and standard deviation for each variable. The normality of all variables was examined to verify that the assumptions for using particular tests were met. In order to answer the question, is the TT-NAT intervention associated with higher rates of error detection and correction compared to the Standard NAT, separate between-sample comparisons were performed for NAT Proportion Detected and Proportion Detected-Corrected. Independent t-tests were used for variables that were normally distributed (or could be transformed); Mann-Whitney tests were used for variables that did not meet assumptions of normality. Effect sizes for all TT-NAT versus Standard NAT analyses were estimated using Cohen's d calculations (Cohen, 1988). To correct for multiple statistical comparisons, the Bonferonni method was utilized; thus, the p-value necessary for obtaining statistical significance for each comparison was set at .025.

To address the hypothesis that error monitoring behavior in dementia patients who received the TT-NAT would be related to executive control processes, a composite score was calculated for executive control indices. Raw neuropsychological data from the Clock Drawing Test, Mental Control, and Word Generation Task were significantly correlated (r's > .40); therefore, they were converted to z-scores and then averaged to create an executive control composite score. The purpose of this calculation was to reduce collinearity between these neuropsychological variables. A similar procedure was conducted for the language/semantic knowledge measures that were correlated (i.e., Category Fluency and Boston Naming Test; r = .59, p = .00). Z-scores from the Category Fluency and Boston Naming Test were averaged to create a language/semantic knowledge composite score. The AI measure was not correlated with any neuropsychological measured utilized in the study, thus was analyzed separately from the composite indices.

Next, Pearson correlation coefficients were calculated to evaluate the relations between TT-NAT Proportion Detected and neuropsychological test scores (i.e. MMSE and composite indices). Similarly, the relation between TT-NAT Proportion Detected-Corrected and the same three neuropsychological test scores was also evaluated. Two participants were missing more than two neuropsychological test scores for unknown reasons and were not included in correlation/regression analyses. Verbal fluency measures were missing for two participants and were replaced using a regression equation derived from the neuropsychological data of participants without missing data. This method also was used to replace the missing non-automatized mental control score for two other participants.

When more than one neuropsychological variable was significantly correlated to the Detection/Correction variables (i.e., Standard NAT Proportion Detected and Standard NAT Proportion Detected-Corrected), stepwise regression analyses were performed to determine the multivariate relations (i.e., which cognitive measures or combinations of measures were predictive of error monitoring). Executive composite, language composite, and MMSE scores were entered in the stepwise regressions.

In order to address the hypothesis that the TT-NAT was associated with faster correction times than the Standard NAT, between-sample comparisons were conducted for Proportion Microslip Correction and Proportion Immediate Correction, and Proportion Delayed Correction. Independent t-tests were used for variables that were normally distributed (or could be transformed); Mann-Whitney tests were used for variables that did not meet assumptions of normality. To correct for multiple statistical comparisons, we utilized the Bonferonni method;

thus, the p-value necessary for obtaining statistical significance for each comparison was set at .017.

Finally, all secondary analyses were addressed using similar statistical procedures, namely between group independent t-tests (or Mann-Whitney Tests), correlation analyses, and multiple regression (when necessary).

CHAPTER 3

RESULTS

Sample Characteristics

As shown in Table 3, the primary dementia groups (n = 42 TT-NAT participants; n = 45 Standard NAT participants) were comparable in age and dementia severity, and did not significantly differ in the distribution of men vs. women or ethnicity (i.e. proportion of African-Americans vs. Caucasians). On average, the TT-NAT participants had a higher level of education; however, consistent with prior studies (Buxbaum et al, 1998; Schwartz et al, 1999), correlations between education and NAT variables were not significant (for all groups: Percent Detected, $r = .07$, $p = .48$; Percent Detected-Corrected, $r = .11$; $p = .23$). Therefore the modest between-group difference for education was inconsequential for the primary analyses.

Table 3. Demographic Data Across All Groups

	Group			**Analyses**	
	TT-NAT	Standard NAT	U-C NAT	TT-NAT vs Standard NAT	TT-NAT vs UC-NAT
	M(SD)	M(SD)	M(SD)	t value	t value
Age	76 (6.2)	78 (5.7)	79 (4.8)	-1.9	-2.7*
Education	13 (2.9)	12 (1.9)	12 (1.9)	3.2*	3.4*
MMSE (Mini-Mental Status)	22 (3.2)	22 (3.2)	22 (3.0)	0.19	0.06
	n (%)	*n* (%)	*n* (%)	chi square value	chi square value
Sex (*n*, % women)	29 (69%)	40 (89%)	30 (88%)	5.21	3.98
Ethnicity (*n*, % African-American)	20 (48%)	11 (24%)	2 (6%)	5.08	15.91*

* $p < .05$

In terms of the secondary aims of the study, the UC-NAT group (n = 34) was also evaluated. Significant group differences in age and education, as well as the distribution of African-Americans vs. Caucasians were noted between the TT-NAT and the UC-NAT participants. Consistent with the previous analyses, age, education, and ethnicity were not related to any of the primary outcome variables.

Inter-Rater Reliability

The raters demonstrated 97.8% agreement in coding all errors as detected or corrected (Cohen's kappa .95). They consistently agreed on error correction time frames (100% agreement; Cohen's kappa 1.0).

NAT Errors

On average, dementia participants produced significantly fewer Total Errors in the Task Training (TT-NAT) Condition relative to the Standard NAT Condition (9.8 and 16.9 errors, respectively; $z = -3.0$, $p = .002$; d = .72).

Dementia participants also demonstrated a trend toward producing fewer Total Errors in the User-Centered (UC-NAT) Condition relative to the Standard Condition (12. 4 and 16.9, respectively; $z = -1.72$, $p = .08$, d = .43). Although not statistically significant, a trend was also noted for participants in the TT-NAT condition to produce fewer Total Errors than those in the UC-NAT condition ($z = -1.44$, $p = .15$; d = .32).

Hypothesis Testing

Hypothesis 1: TT-NAT and Rates of Error Monitoring

Consistent with my prediction, participants performing the TT-NAT detected a higher proportion of their action errors than dementia participants performing the Standard NAT (See Table 4). Unlike previous studies (Bettcher et al, 2008; Giovannetti, Libon, et al, 2002), the participants' total error rate was significantly related to the proportion of errors detected (r = -.33). An ANCOVA was conducted with total errors as the covariate ($F(1, 83) = 4.9$, $p = .03$); the effect of intervention condition (i.e. Standard vs. TT-NAT) remained significant ($F(1, 83) = 6.2$, $p = .02$).

Although I predicted that error correction rates (i.e. Proportion Detected-Corrected) would also be higher in the TT-NAT Condition relative to the Standard Condition, these rates were comparable between the two groups (See Table 4). The participants' total error rate was not significantly related to the proportion of errors corrected out of detected ($r = -.16$, $p = .12$). Consistent with previous studies of error monitoring (Giovannetti et al, 2002; Bettcher et al, 2008), dementia participants corrected the majority of errors they detected.

Table 4. Means and Standard Deviations for Action Monitoring Variables Across Primary Groups

	TT-NAT (n=42)		Standard NAT (n=45)				
	M	SD	M	SD	*z/t*	*P*- Value	Effect Size/ d
Proportion Detected (Total Detected/Total Errors)	48.62	25.89	32.68	17.62	t = 3.36	0.001	0.72
Proportion Detected-Corrected (Total Corrected/Total Detected)	85.30	19.73	83.26	23.06	z = -0.29	0.76	0.10

Hypothesis 2: TT-NAT and Neuropsychological Processes

Counter to prediction, error monitoring variables in the TT-NAT condition were *not* related to executive control measures.[2] Notably, a significant and robust relation between Proportion Detected and the language/semantic knowledge composite index was found (r = .57, p = .00). Also of note, Proportion Detected and Proportion Detected-Corrected were not related to the MMSE (r = .14 and r_s = -.02, respectively), while Total Errors was significantly correlated with the MMSE (r = -.56, p = .00).

Table 5. Correlations for Neuropsychological and Action Monitoring Variables by Group.

	TT-NAT		Standard NAT*	
	Proportion Detected r	Proportion Detected-Corrected r_s	Proportion Detected r_{pc}	Proportion Detected-Corrected r_{pc}
Language Comp	.57***	-.15	.31**	.09
Executive Comp	.24	.11	.36***	.08

* Partial correlations were conducted, controlling for Mini-Mental Status Exam (MMSE)
** $p < .05$
***$p < .025$

[2] Results remained the same when examining the relationship between error monitoring variables and *individual* executive control measures (rather than composite indices).

As shown in Table 5, the monitoring variable, Proportion Detected-Corrected (i.e. proportion of errors corrected, of the one's detected), was not associated with any neuropsychological measure or composite index measured in the TT-NAT condition. The AI score (not shown in the table) was not related to any monitoring variable assessed (r's < .20).

As a means of comparison, correlation and regression analyses were also conducted for the Standard NAT. The MMSE was related to Proportion Detected (r = .38, p = .01), Proportion Detected-Corrected (r_s = .3, p = .05), and Total Errors (r = -.49, p = .001). Partial correlations (controlling for MMSE) were conducted to isolate the relations between the neuropsychological composite indices and error monitoring variables in the Standard NAT condition. Similar to the findings in the TT-NAT condition, neither of the neuropsychological composite indices were related to Proportion Detected-Corrected. As shown in Table 5, Proportion Detected was significantly related to both the executive control and language/semantic knowledge composite indices. A regression analysis indicated that the best model for Proportion Detected in the Standard NAT condition accounted for only 12% of the variance, and included the executive control composite as the sole predictor (β = .35; t = 2.34; p = .02).

Hypothesis 3: TT-NAT and Error Correction Times

As shown in Table 6, no significant differences between groups were documented for the error time frame analyses. Overall, both groups made more microslip error corrections than delayed error corrections (TT-NAT: z = -2.90, p = .005; Standard NAT: z = -2.40, p = .018), indicating a relatively quick response to detected errors. A non-significant trend for TT-NAT participants to produce more immediate corrections than delayed corrections, (z = -1.9, p = .056) was also noted. No differences between microslip and immediate corrections were found for either group.

Table 6. Means and Standard Deviations for Time Frame Variables Across Primary Groups

	TT-NAT (n= 42)		Standard NAT (n=45)				
	M	SD	M	SD	z	*P*- Value	Effect Size/ d
Proportion Immediate Corrections (Total Immediate/Total Detected)	30.02	30.01	26.87	28.39	-0.34	0.74	0.11
Proportion Delayed Corrections (Total Delayed/Total Detected)	16.76	25.25	19.98	24.40	-1.10	0.27	-0.13
Proportion Microslip Corrections (Total Microslip/Total Detected)	38.68	30.87	36.23	30.27	-0.59	0.56	0.08

Hypothesis 4: UC-NAT and Error Monitoring

As shown in Figure 1, individuals in the UC-NAT condition detected more errors than individuals in the Standard NAT condition; however, this small difference (d = .30) was not statistically significant ($t = -1.3$, $p = .18$). No differences were noted between the two groups for Proportion Detected-Corrected ($z = -1.0$, $p = .29$).

In line with my prediction, individuals in the UC-NAT condition detected their errors less than individuals in the TT-NAT condition. This non-significant trend ($t = 1.78$, $p = .08$; d = .42) suggests that overall, dementia participants in the TT-NAT condition detected more errors than UC-NAT participants, who in turn detected more errors than individuals in the Standard NAT condition; however, only the TT-NAT condition was associated with a statistically higher rates of error detection than the Standard Condition.

Contrary to prediction, no significant differences were found between the UC-NAT and TT-NAT for error corrections (Proportion Detected-Corrected).

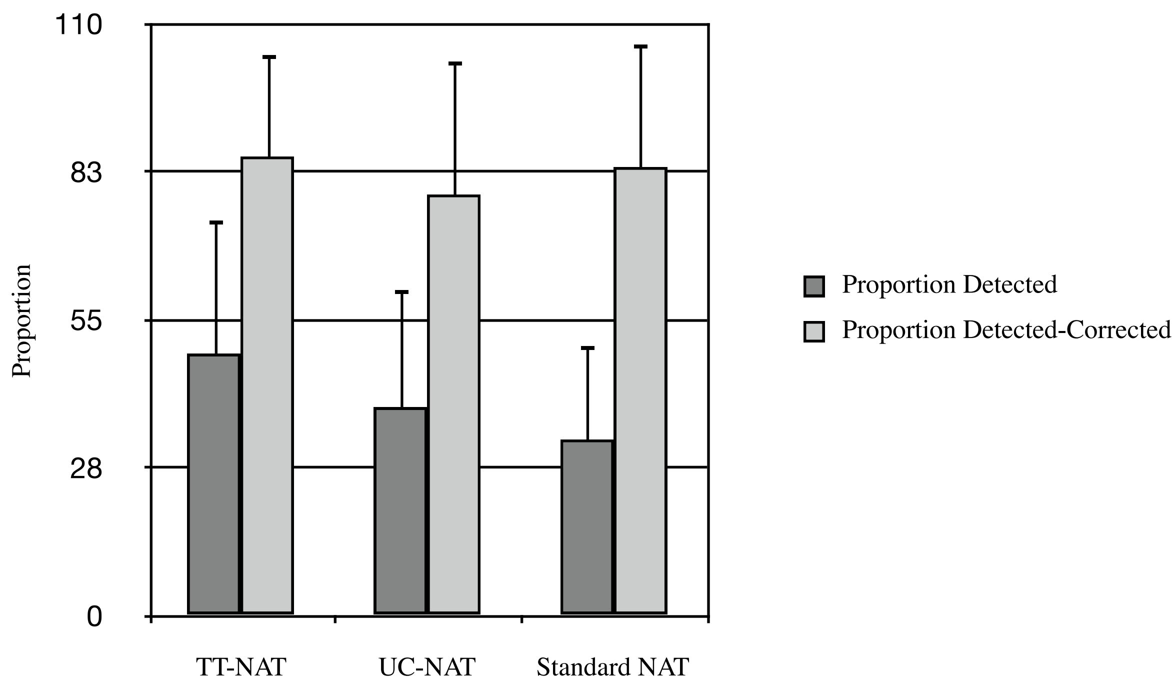

Figure 1. Proportion Detected and Proportion Detected-Corrected by Group (Error Bars Represent +1 SD)

Hypothesis 5: UC-NAT and Neuropsychological Processes

The MMSE was related to Total Errors (r = -.49, p = .003). In addition, the MMSE significantly correlated with Proportion Detected (r = .41, p = .02) and Proportion Detected-

Corrected (r_s = .35, p = .04). After controlling for MMSE, neither Proportion Detected nor Detected-Corrected were related to the composite indices.[3]

Exploratory/Post-Hoc Analyses

Exploratory Analysis 1: TT-NAT Participants Whose Performance Exceeded Standard NAT Participants

Demographic and neuropsychological data were examined for individuals in the TT-NAT condition whose Proportion Detected exceeded +1.5 SD based on Standard NAT participant performance (i.e. Proportion Detected ≥ 59%). Individuals in the TT-NAT who met this criteria ("high detectors;" 33.33% of the sample; n = 14) were subsequently compared to individuals whose Proportion Detected rates fell below the stipulated benchmark ("low detectors;" n = 28).

As shown in Table 7, individuals who performed best on the TT-NAT demonstrated significantly higher language/semantic knowledge composite scores and exhibited a non-significant trend toward performing better on the executive control composite. It's important to qualify these results by highlighting that only 14 individuals in the TT-NAT condition met the "high detector" criteria, thus these analyses were statistically underpowered to detect medium effects. No significant differences were noted between the high vs. low detectors in the TT-NAT condition for age, education, MMSE, or episodic memory functioning.

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[3] As shown, the MMSE was only marginally related to the language composite index. Although a more conservative approach was taken by conducting a partial correlation, controlling for the MMSE did not affect the outcome for this index.

Table 7. Means and Standard Deviations for Demographic and Neuropsychological Variables by Detector Group

	High Detectors N = 14	Low Detectors N = 28	High Detectors Vs. Low Detectors	
	M (SD)	M (SD)	t value	p value
Age	74.1 (5.7)	76.4 (6.4)	1.1	.27
Education	14.1 (3.0)	13.1 (3.1)	-1.0	.30
MMSE	23.3 (3.4)	22.6 (3.0)	-0.8	.44
PVLT Index	80.8 (14.9)	71.6 (16.7)	-1.7	.09
Language Composite*	0.59 (.70)	-0.27 (.82)	-3.4	.00
Executive Composite*	0.36 (.73)	-0.11 (.74)	-1.9	.06

* Means and Standard Deviations reflect Z-scores.

Exploratory Analysis 2: Episodic Memory

To determine whether episodic memory functioning played a contributory role in TT-NAT performance, post-hoc analyses comparing the PVLT recognition discriminability index and Proportion Detected / Proportion Detected-Corrected were conducted. Consistent with previous findings, episodic memory performance was not related to error monitoring variables in the Standard or UC-NAT ($p > .05$), nor was it related to Proportion Detected-Corrected in the TT-NAT; however, Proportion Detected and the PVLT index for the TT-NAT were significantly correlated ($r = .40$, $p = .01$), suggesting that better episodic memory abilities were associated with a higher proportion of detected action errors.

CHAPTER 4

DISCUSSION

Overview of Primary Findings

Consistent with my prediction, dementia participants in the TT-NAT condition performed better than participants in the Standard NAT condition. Specifically, TT-NAT participants produced fewer overall errors and detected more errors than Standard NAT participants. This suggests a significant benefit of the task training condition for overall error production and monitoring. No differences were noted for error correction or time frame analyses, indicating that while participants detected more errors in the TT-NAT condition, they did not correct proportionally more errors than Standard NAT participants, nor were their corrections implemented more rapidly. The results from this study have direct implications for both caregiver training and neuropsychological rehabilitation, as patients diagnosed with a dementia may benefit from targeted interventions that address impoverished task knowledge.

TT-NAT: Reducing Mistakes and Increasing Detection, One Picture at a Time

The Task Training NAT (TT-NAT) was designed to ameliorate error monitoring problems due to degradation in task knowledge or "planning errors." The intervention was associated with markedly higher error detection rates compared to the Standard condition, with dementia participants detecting nearly half of their action errors (48.6%). In evaluating the TT-NAT's efficacy, it is imperative to consider how the TT-NAT intervention induced higher error detection rates. As such, the TT-NAT will be appraised in terms of both the design and the outcome of the intervention.

The design of the TT-NAT offered numerous advantages over the Standard NAT that likely boosted error detection in participants. First, the intervention provided a scripted, pictorial description of the objects used in each task. This minimized the effect of degraded object knowledge and degraded object-action associations on performance, as it identified the appropriate objects necessary to complete each task as well as which objects should be used together (e.g. "For the coffee, you spoon the coffee grounds into the cup of water. These are the instant coffee grounds, and this is the cup of water"). Second, the training also included a video presentation of the task, filmed from the participants' perspective. This reduced the need for participants to mentally rotate the actions depicted in the video, and thereby increased the continuity between the training and the required tasks. Third, the intervention also incorporated a salient visual component to each of the training steps (e.g. pictorial display, video presentation, and picture quiz). This ensured that the modality of training was consistent with the modality of testing. These three factors may have been helpful in solidifying the task plan for participants, and improving the likelihood for error detection.

In addition to the design of the TT-NAT, the outcome of the intervention necessitates further review. Did the TT-NAT effectively alter the error pattern produced by participants, or did it mitigate error monitoring failures? More specifically, was the increased error detection rate in TT-NAT participants primarily a byproduct of fewer mistakes rather than improved performance monitoring? The design of the TT-NAT was couched in the theory that improving task knowledge should reduce the likelihood of mistakes. Although errors are inevitable features of human action (Reason, 1990), the study aimed to influence the *likelihood* of producing errors that are cognitively taxing to recognize and explain. As discussed in the introduction, the opportunity for the detection of slips (i.e. execution errors) is substantially greater than for the detection of mistakes (i.e. planning errors), due to the continuity between task parameters and the individual's action plan. By modifying the error pattern toward the production of slips and away from mistakes, error detection should ensue with greater facility. Notably, the results of the current study offer evidence both for and against the hypothesis that mistakes (i.e. planning errors) were reduced in the TT-NAT. Evidence suggesting that planning errors were not addressed in their entirety include the lack of effect on error monitoring time frames, and the absence of a relation between the executive control composite and error monitoring variables in the TT-NAT (discussed more comprehensively in later sections). One interpretation of these findings is that mistakes were not specifically reduced in the TT-NAT, and that participants continued to produce a combination of slips and mistakes. Despite their improved overall performance, participants did not *detect* the majority of errors produced; as such, a combined, but not targeted reduction in mistakes (and slips) remains possible.

Notwithstanding this interpretation, there is striking evidence in support of the hypothesis that mistakes were reduced in the TT-NAT. The TT-NAT was associated with markedly higher error detection rates in participants- a pattern that is strongly associated with the production of slips rather than mistakes in the cognitive neuroscience literature (Blavier et al, 2005; Reason, 1990, Sellen, 1992; Sellen, 1994; Z). Mistakes frequently necessitate external intervention for detection, given the erroneous development of the task plan; this is a laborious, inefficient and frequently unavailable option for participants in the study (and in everyday life; Reason, 1990). As such, it is unlikely that error detection rates would significantly increase without a coinciding decline in mistakes. This is certainly *not* to say that mistakes were eliminated in the TT-NAT, but instead points to a significant reduction in overall mistake production rate. Although error monitoring was ostensibly improved, the results suggest that the efficacy of the TT-NAT was likely supported by the reduction in planning errors (i.e. mistakes). It is important to highlight, however, that without a definitive measure of mistakes vs. slips, this issue cannot be completely resolved in the current study.

The Role of Language and Executive Control in TT-NAT Detections

Pursuant to the evaluation of the TT-NAT, the results also beckon the question of how this intervention was successful for a *range* of dementia subtypes with varying neuropsychological impairments. I predicted that the TT-NAT's mechanism of action would be its ability to circumvent error monitoring problems due to degraded task knowledge. As such, error monitoring breakdowns subsequent to the training should be due to executive dysfunction rather than language/semantic knowledge impairments. The results suggest a different, and potentially more parsimonious evaluation of the intervention: namely, *relatively* spared and accessible linguistic abilities seem to be a crucial prerequisite for the training session to work. To clarify, the better a participant performed on language/semantic knowledge tests prior to the training, the more likely they were to detect their errors in the TT-NAT condition. This composite index explained more variance in TT-NAT condition relative to the Standard condition, suggesting that semantic knowledge/linguistic abilities are necessary to significantly benefit from the intervention (Patterson, Nestor, & Rogers, 2007). It may be that participants interpreted the training within the context of their own task representations, regardless of how accurate or complete these internal representations were (Funnell, 2001). Thus, in order to cognitively appreciate the training session, retrievable knowledge of objects and their respective uses was advantageous. In addition, the strong relation between the language/semantic knowledge composite and error detection rates indicates that while task knowledge impairments were ameliorated, they were not completely *circumvented* by the intervention.

Another important facet of this study is the lack of connection between executive control processes and error detection in the TT-NAT. This represents a departure from the Standard condition, where both tests of language/semantic knowledge and executive control buttressed error monitoring performance. This result was surprising, as detecting an error often necessitates a host of executive processes, including attention, inhibition, and working memory (Miller & Cohen, 2001). It is unclear why detection rates were not related to executive control processes in the TT-NAT; however, the reduction in planning errors is likely germane to this finding (or lack thereof). According to cognitive neuroscience models of error production and monitoring, slips are easier to detect and evaluate than mistakes (Norman, 1981; Reason, 1990; Zapf & Reason, 1994; Blavier et al, 2005). Although I postulated that executive control process were likely related to the detection of slips, it may simply be that the detection process is cognitively less taxing and requires less mental flexibility when participants are trained on task parameters. Futhermore, the provision of a cue card outlining the task components may have reduced the need to hold competing action plans in working memory. Although this may seem relatively straightforward and intuitive, it's an important finding for circumventing and ultimately rehabilitating error monitoring failures in dementia. It suggests that the intervention may be widely used with participants who have mild to moderate (but not severe) semantic impairments, and that the efficacy of the intervention is not deleteriously affected by executive dysfunction in participants.

An unexpected finding was the modest association between Proportion Detected and episodic memory functioning in TT-NAT participants. This relation was not observed in the other two conditions, and has not been reported in previous studies from our lab (Bettcher et al, 2008; Giovannetti et al, 2002). This finding suggests that participants' capacity to encode new information was related to their propensity to detect an action error. The association suggests a role, albeit small, for episodic memory functioning in the TT-NAT intervention. Although cue cards were provided to participants to minimize the burden of episodic memory deficits, the training does necessitate a basic level of encoding in order to fully understand and subsequently retrieve the information. As such, individuals with severe episodic memory deficits may have been at a slight disadvantage.

Error Correction: A Neuropsychological Enigma

In terms of error correction (i.e. Proportion Detected-Corrected), no differences were observed between the TT-NAT and Standard condition. This finding is not all together surprising, as participants in both conditions corrected the majority of errors they detected. Although the small difference in correction rates was in the anticipated direction, with TT-NAT participants correcting more errors than Standard participants, ceiling effects may have prevented a more comprehensive evaluation of the finding. Furthermore, the results provide additional support for the assertion that error correction is not the central point of concern for individuals diagnosed with dementia (Bettcher et al, 2008); the source of their difficulty lies within the domain of detecting and evaluating action errors.

Participants in the TT-NAT and Standard conditions also demonstrated comparable error correction time frames, suggesting that the correction process as a whole was not qualitatively altered by the training intervention. Notably, the majority of errors corrected were repaired quite rapidly in both groups. More specifically, delayed error corrections represented the minority of corrections produced by participants, indicating that the correction process was not substantially slowed for either group.

Although the production and rapidity of error corrections represented a relative strength for dementia participants, the neuropsychological foundations supporting this process remain a quandary. Proportion Detected-Corrected was not related to any of the neuropsychological tests used in the study for the TT-NAT condition, and was only marginally related to a measure of general cognitive functioning (MMSE) for the Standard condition. Previous work from our lab demonstrated a modest correlation between measures of visuoconstructional ability (Clock Drawing Total Errors; $r_s = -.28$) and error correction in the Standard NAT; however, this explained only a small proportion of the variance for Proportion Detected-Corrected (11%; Bettcher et al, 2008). Furthermore, additional steps were taken in the current study to reduce the effects of collinearity and control for general cognitive functioning (MMSE). As such, the present study represents a more rigorous approach to evaluating the neuropsychological foundations of error monitoring processes in dementia. Considering the lack of significant relations between error correction and tests of specific neuropsychological processes, it is worth evaluating why this construct remains enigmatic.

One appreciable reason for this finding (or lack thereof) is that the cognitive protocol used in the study may not have adequately addressed the neuropsychological processes involved in error correction. Although I attempted to incorporate the most frequently utilized measures of executive functions, language, and memory for the current study, a comprehensive neuropsychological evaluation was not employed. As a result, measures not included in the current study may have been more optimal predictors of action error correction. For example, once an individual detects an error, they must determine how to resolve the issue in the form of a correction. This likely entails problem-solving, inhibition, and abstraction abilities that were underrepresented in the study's neuropsychological protocol. Furthermore, the neuropsychological evaluation of *everyday action* knowledge is understudied (Funnell, 2001). There are very few standardized instruments available to evaluate semantic knowledge and no standardized, published, and validated measures of everyday action knowledge; thus, language measures were used to assess semantic knowledge more generally in the present study. It is important to note that recent studies suggest that semantic knowledge for objects or everyday action may be represented or stored differently than knowledge for other domains (e.g., animals, foods, etc; Funnell, 2001; Patterson et al, 2007). As such, error correction may be more strongly related to action-specific semantic measures.

Alternatively, other factors not assessed in the study may have played a role in the correction process, including mental fatigue, effort, and general interest in the task. Anecdotally, several participants noted that their behavior was incorrect (i.e. a detection), but dismissed the need to correct the problem given that no one would actually eat the item (Task 1, 3) or receive the gift (Task 2). Although these individuals were encouraged to complete the task as instructed, several participants downplayed the importance of correcting errors, particularly at the end of the task. Fatigue and effort are influential factors reported in the cognitive neuroscience and aviation literatures on error monitoring; these factors may have played a role in the current study (Boksem, Meijman, & Lorist, 2006; Kontogiannis & Malakis, 2008; Sarter & Alexander, 2000).

In order to quantify their significance and evaluate their contributory role in the error monitoring process, these variables should be addressed in future action studies.

The Interventions: TT-NAT vs UC-NAT

In addition to the prospective TT-NAT intervention, data from a retrospective intervention, the User-Centered NAT, was also evaluated in the secondary analyses. The User-Centered NAT was designed to minimize the likelihood of execution errors rather than planning errors, and thus offered a relevant theory-based comparison to the TT-NAT condition. Consistent with my prediction, TT-NAT participants demonstrated a trend toward detecting more errors than individuals in the UC-NAT condition. Although not statistically significant, the relative benefit of the TT-NAT compared to the UC-NAT for error detection rates is clinically meaningful. It suggests that while the UC-NAT condition improves overall error performance, it does not substantially enhance error detection compared to the Standard version of the task. Furthermore, the relative superiority of the TT-NAT for error detection rates also points to a wider range of implementation for the task training intervention compared to the user-centered intervention. The implications for rehabilitation treatment are discussed more thoroughly in the following section.

Contrary to my prediction, the UC-NAT monitoring variables were not related to the language/semantic knowledge composite index. Although we previously reported a relation between Proportion Detected-Corrected and the Boston Naming Test, this association was not demonstrated with the composite index, nor was it evident for the Boston Naming Test alone after controlling for general cognitive functioning (MMSE). The moderate correlation between both monitoring variables and the MMSE suggests that general cognitive functioning is the best predictor of error detection and correction in the UC-NAT intervention. This may be partially due to the heterogenous nature of everyday action monitoring and the need for general cognitive resources (Schwartz et al, 1998); however, this does not fully address the lack of association between *specific* neuropsychological processes and error correction in both the TT-NAT and UC-NAT conditions. As stated previously, a more comprehensive neuropsychological protocol containing action-specific measures of semantic knowledge and more diverse executive measures may be useful in future studies.

Implications for Rehabilitation

The current study has significant implications for applied interventions, as dementia patients may benefit from strategies that focus on increasing detection of committed errors. In determining who would benefit most from the task training intervention in real-world settings, it is important to consider the goal of the treatment. An important aim for rehabilitation might be to decrease overall error production in everyday tasks. Considering that the Total Error rate was significantly related to the measure of general cognitive functioning (MMSE), the TT-NAT and the UC-NAT interventions would be more effectual with patients diagnosed with a mild (preferably) to moderate dementia. Families and caretakers may find this goal to be more tenable and more clinically meaningful in their everyday lives than addressing action monitoring problems, particularly if their loved one is generating a large number of errors on a daily basis.

Another goal for rehabilitation might be to improve error detection in a patient's everyday life. Within this context, the TT-NAT demonstrates better outcomes relative to the UC-NAT and superior outcomes relative to the Standard NAT for all patients. Although strong effects were noted for the entire TT-NAT group, the current study suggests a couple of factors to keep in mind when identifying suitable candidates. The task training intervention worked best for individuals whose performance on tests of language/semantic knowledge was *relatively* spared. This is not to say that these individuals demonstrated intact language functioning; instead, it indicates that participants experienced the greatest benefit if they exhibited only mild to moderate language impairments. A second consideration is that general cognitive functioning was not related to error detection in the TT-NAT condition; thus, the TT-NAT condition was associated with higher error detection rates, irrespective of dementia severity. This finding is encouraging for neuropsychological rehabilitation, as it suggests that improved action monitoring in individuals with moderate to severe dementia is an attainable goal. In sum, the TT-NAT offers a promising intervention for error detection difficulties in dementia patients, irrespective of severity, and may result in better outcomes for individuals who exhibit a relative strength in language abilities.

The implications for employing the TT-NAT in a rehabilitation setting are heartening, and point to a more evidence-based approached to everyday action treatment in dementia. For older adults with specific interests (e.g. cooking) or a daily routine (e.g. doing laundry), this intervention offers a potentially viable means of enhancing their autonomy, as well as encouraging their engagement in previously enjoyed tasks. However, it's also important to address the feasibility of this intervention for family training, with the ultimate goal being to apply these techniques in the home. A large scale effectiveness study should be conducted to properly evaluate this question, as changes in health care and insurance coverage necessitate both feasibility and time efficiency in disseminating intervention techniques to families. Results from the current study suggest that this is *not* a cumbersome intervention. The training sessions required only approximately 5-10 minutes prior to each task, and were inexpensive to conduct:

they only necessitated task pictures (taken from a home camera) and a brief video. The adaptability of the intervention to more technologically savvy older adults was not addressed in the current study. It remains to be seen whether similar presentation of the intervention on a smartphone would be equally efficacious, but is an important consideration for the aging baby-boomer generation. In sum, the TT-NAT demonstrates considerable promise as a tool for ameliorating everyday monitoring problems in a rehabilitation context.

Limitations

Although the study offered a novel, naturalistic approach to improving action performance in dementia patients, it also faced several limitations. First, the study did not incorporate a measure of action knowledge before commencement of the training section in the TT-NAT condition. The reason for this stems from the limited availability and questionable psychometric properties of these assessments. As stated previously, action-specific semantic knowledge is relatively understudied and standardized assessment of this domain in a clinical setting is rare; however, the burgeoning literature on this topic suggest that action-specific semantic knowledge is highly relevant to everyday activities and may differ from general semantic knowledge (Funnell, 2001). A measure of action-specific semantic knowledge would have been useful in this study to more accurately assess the role of language in the TT-NAT condition.

An additional limitation is the use of entirely retrospective data for the small UC-NAT group (as opposed to the prospective TT-NAT and hybrid Standard NAT). The retrospective collection of data thwarted the ability to conduct a comprehensive head-to-head analysis of the two interventions. Although the current study and previous research suggests that demographic variables should not impact error monitoring variables in dementia patients (Bettcher et al, 2008; Giovannetti, Libon, et al, 2002), interpretations of the UC-NAT were more conservative due to the lack of prospective randomization to the two interventions. It's important to underscore that this was not the primary aim of the current study, but reflects a limitation in the types of questions that could be addressed regarding the two interventions.

Finally, the determination of whether an individual is truly aware of his/her errors remains a challenging, albeit crucial feature of this research. This study relied on verbalizations and failed or successful attempts to correct errors to indicate detection; yet, error awareness may have occurred without overt signs of detection. As a result, error detection variables may have underestimated participants' error awareness.

Future Directions

Careful consideration of the results and limitations of the current study point to three primary issues that should be addressed in future studies: error monitoring intervention comparisons, generalizability, and maintenance of effects. In terms of the intervention comparisons, a randomized, head-to-head evaluation of the interventions (TT-NAT vs UC-NAT) should be conducted to isolate the relative benefits of each condition for dementia participants. This study would also serve to solidify the superiority of the TT-NAT for error detection rates in a prospective design.

Results from the current study also suggests a need to evaluate the generalizability of the TT-NAT intervention. Although the current study demonstrated superior error detection rates in the TT-NAT condition relative to the Standard NAT condition, it does not address whether the training principles translate to the home environment, and whether training on one task can be transferred to a similar task (e.g. making coffee, and subsequently making tea). This would be important information in determining the functional utility and applicability of the training.

Finally, future studies should address the maintenance of task training effects over time. In the current study, the training session and task execution occurred back to back to evaluate error monitoring performance in an optimal setting. In order to determine the amount of time that lapses before a patient needs a 'booster' training, or to identify whether patients need continual exposure to the training sessions can only be adequately answered in a 2+ time point study.

Conclusion

Improving everyday action in patients' lives is a complex and, at times, nebulous goal, as it frequently involves factors that are difficult to capture in research: namely, individualization and ecological validity. The current study purported to address error monitoring impairments in dementia using a naturalistic, theory-based intervention for planning deficits. Results suggest that the Task-Training Naturalistic Action Test is associated with lower total errors and higher error detection rates than the Standard condition. These findings have considerable implications for rehabilitation and caregiver training, as patients may benefit from targeted action interventions that address mild to moderate degradations in task knowledge.

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APPENDIX:

SCRIPT CONTENT QUIZ

TASK 1

I am going to ask you a few questions about the task. Please point to the picture that you think best answers my question.

1. **Pictures presented: one slice of bread, two slices of bread, three slices of bread**

Please point to the correct number of slices of bread to toast

Correct answer: one slice

2. Pictures presented: eat the bread, place slice of bread in toaster, place bread back into bread bag

Before putting butter and jelly on the toast, what should you do with the bread?

Correct answer: place slice of bread in toaster

3. Pictures presented: 1) jelly, sugar, creamer; 2) coffee grinds, butter, and cream; 3) coffee grinds, sugar, and creamer

When making instant coffee, you should put what items into the cup of water?

Correct answer: 3) coffee grinds, sugar, creamer

4. Pictures presented: jelly, butter, coffee grinds

After toasting the slice of bread, which condiment should be applied to the bread first?

Correct answer: butter

TASK 2

I am going to ask you a few questions about the task. Please point to the picture that you think best answers my question.

1. Pictures presented: wrapping paper, paper bag, bow

Upon putting a gift in a box, what should you wrap a gift with?

Correct answer: wrapping paper

2. Pictures presented: scotch tape, garden shears, baby doll

Which of these items should be the gift in this task?

Correct answer: baby doll

3.Pictures presented: garden shears, scissors, electrical tape

Which of these items would be the best to use to cut the wrapping paper?

Correct answer: scissors

4.Pictures presented: bow, paper bag, electrical tape

Which of these items is the last thing you should put on a gift?

Correct answer: bow

TASK 3

I am going to ask you a few questions about the task. Please point to the picture that you think best answers my question.

1. Pictures presented: lunchbox, bread, aluminum foil

When making a sandwich, you should put lunch meat on ______?

Correct answer: bread

2. Pictures presented: sandwich, thermos, cookies, markers

Two of these items should be wrapped in foil for a lunch; which ones are they?

Correct answer: sandwich, cookies

3. Pictures presented: markers, pencils, notebook; sandwich, stapler, toothbrush; sandwich, cookies, thermos

Which three things should be packed in the lunchbox?

Correct answer: sandwich, cookies, thermos

4. Pictures presented: lunchbox, thermos cap, thermos

Juice should be poured into what object?

Correct answer: thermos

5. Pictures presented: markers, pens/pencils/compass, sandwich, notebook, juice bottle

Three of these supplies go into the schoolbag. Point to the three pictures that should be packed in the schoolbag.

Correct answer: markers, pens/pencils/compass, notebook