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Characterizing Omission Errors in Everyday Task Completion and Cognitive Correlates in Individuals with Mild Cognitive Impairment and Dementia

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Abstract

Objective: Functional ability declines with age and cognitive impairment. This study investigated errors of omission made by community-dwelling older adults completing everyday tasks in a naturalistic setting.

Method: Sixty-five cognitively healthy older adults (HOA), 19 individuals with single domain mild cognitive impairment (sdMCI), 33 individuals with multi-domain MCI (mdMCI) and 13 individuals with dementia completed measures of memory, processing speed, working memory and executive functioning, as well as eight different activities of daily living in a naturalistic environment. Task steps were divided into preparatory, action-oriented, and concluding steps.

Results: For action-oriented steps, the number of omission errors increased with level of cognitive impairment beyond sdMCI (i.e., HOA = sdMCI < mdMCI < dementia). In contrast, for preparatory and concluding steps, the dementia group committed more omission errors than the HOA, sdMCI, and mdMCI groups, which did not differ.

Conclusions: The results suggest that the more complex and integrative action-oriented steps may be the first type of everyday task step to be affected in the process of cognitive decline, with preparatory and concluding steps being preserved longer and only showing decline in later stages of impairment (i.e., dementia). Individuals with sdMCI may use other intact abilities to compensate for task omission errors.

Keywords

activities of daily living; memory; executive function; aging; functional status; instrumental activities of daily living

Introduction

As the older adult population continues to grow worldwide, it is becoming increasingly important to better understand the cognitive aging process and the functional challenges that accompany it. To live independently in the community, individuals must be able to carry out

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everyday activities of daily living including medication and financial management, cooking, and cleaning (Lawton & Brody, 1969). In individuals with mild cognitive impairment (MCI) and dementia, the ability to complete these everyday activities becomes compromised (e.g., Giovannetti, Schmidt, Gallo, Sestito, & Libon, 2006; Gold, Park, Troyer, & Murphy, 2015; Schmitter-Edgecombe, McAlister, & Weakley, 2012). Currently, questions remain as to the types of task steps that cause the most difficulty in everyday activity completion as individuals transition between healthy aging and dementia. Understanding specific steps of task completion that incur the most difficulty when individuals with MCI and dementia complete activities of daily living is important given implications for compensatory strategy and assistive technology development, clinical diagnosis and prognosis, and the addressing of safety concerns. In this study, we characterize the activity stage (i.e., preparatory, action-oriented, concluding) and cognitive correlates of omission errors (i.e., non-completed steps) that occur as healthy older adults and individuals with MCI and dementia complete everyday tasks of daily living in a naturalistic setting.

While commission errors (e.g., substitutions, improper sequencing) are more common than omission errors (e.g., failing to complete a step in a task) in healthy older adults (Balouch & Rusted, 2013), recent research suggests that omission errors may be a unique and distinct type of everyday activity error separate from commission errors in individuals with cognitive impairment (Giovannetti et al., 2008; Schmitter-Edgecombe & Parsey, 2014a). In a cross-sectional study, Schmitter-Edgecombe and Parsey (2014a) found that individuals with MCI and with dementia made significantly more omission errors than healthy older adults when completing tasks of daily living in a naturalistic setting. Number of omission errors was also a significant predictor of functional ability as measured by both an informant-report questionnaire and a performance-based task. In a longitudinal study, Rusted and Sheppard (2002) found that individuals with Alzheimer's disease (AD) committed more omission errors than healthy controls when they completed a tea-making task as they naturally did in their own homes. Moreover, omission errors increased over time with disease progression and when the tea-making task was performed in a novel rather than familiar setting. Research further suggests that omission errors are related to impairment in episodic memory (Giovannetti et al., 2008; Schmitter-Edgecombe & Parsey, 2014a) as well as to reduction in medial temporal lobe and hippocampal volume (Bailey, Kurby, Giovannetti, & Zacks, 2013; Seidel et al., 2013). Together, these study findings indicate that omission errors may be a distinct type of everyday activity error that is related to episodic memory impairment and sets healthy aging apart from MCI and dementia.

Although numerous studies have now shown that omission errors occur in the everyday task completion of individuals with MCI and dementia (e.g., Giovannetti et al., 2008; Giovannetti, Libon, Buxbaum & Schwartz, 2002; Schmitter-Edgecombe & Parsey, 2014; Schmitter-Edgecombe et al., 2012), there is less research that has investigated *where* during activity completion omission errors are occurring. Schwartz and colleagues (1991) developed a method of categorizing an activity into smaller steps based on how crucial a particular step was to the completion of task subgoals. Steps that were central to the completion of subgoals were termed cruxes. Rather than focusing entirely on this concept of centrality, Reed, Montgomery, Palmer, and Pittenger (1995) defined cruxes as central actions that may alter the state of an object through its interaction with another object (e.g., pouring

tea into a cup). In one recent study, in line with the idea that activity steps are represented hierarchically in memory (Cooper, Schwartz, Yule, & Shallice, 2005), Gold and colleagues (2015) divided activity steps into crux actions and noncrux actions. Noncrux actions were described as being supporting actions that involve a single action or object and may facilitate or enable completion of a crux action (e.g., tilting the teapot). The study findings revealed that individuals with MCI completed fewer of both types of actions during activity completion, suggesting impairment with both central and supporting aspects of action steps in individuals with MCI. In addition, crux omission errors were found to be associated with memory, semantic knowledge, and executive functioning, whereas noncrux omission errors were associated only with memory. These results suggest that memory is involved with omission errors across both crux and noncrux actions, whereas other cognitive domains may provide additional support specifically with more central or major actions.

Successful completion of everyday activities also depends upon meeting various temporal, logical and causal constraints. For example, if a household task involves sweeping the kitchen floor, locating and retrieving the broom must be performed before the sweeping activity can commence. As products of earlier activity steps often need to be available for later activity steps to be completed, it is important to understand where in the activity completion cycle omission errors are occurring so that the most appropriate compensatory strategies and aids can be developed for individuals with MCI and dementia. Rather than dividing actions into crux and noncrux, the current study sought to examine errors in activity completion based on temporal stage of activity completion. In the present study, we divide activity steps into three category stages: preparatory, action-oriented and concluding. Preparatory steps are characterized by the steps needed to prepare for the main activity (e.g., locate and retrieve broom). Action-oriented steps are defined by steps related to carrying out the primary activity to be completed (e.g., sweep kitchen), whereas concluding steps represent those steps related to finishing the activity (e.g., return broom to closet). All three stages as well as most individually coded activity steps consisted of both crux and noncrux actions. The current study adds to the literature by examining more global task steps that include both crux and noncrux actions (e.g., fills medication dispenser with medication) across a wider array of eight everyday activities that were completed in a naturalistic setting (i.e., campus apartment). This contrasts with prior studies (e.g., Gold et al., 2015; Giovannetti et al., 2006), many of which were conducted in the laboratory setting using the Naturalistic Action Test (NAT, Schwartz, Buxbaum, Ferraro, Veramonti, & Segal, 2003) or a variant. Furthermore, this study will add to the understanding of activity completion errors by characterizing omissions errors relative to activity completion stage and by investigating pattern of change across the continuum from healthy aging through single-domain MCI (sdMCI), multi-domain MCI (mdMCI) and dementia.

We also investigated cognitive correlates of each of the three categories of omission errors. Episodic memory and executive functioning were investigated in this study, as these two cognitive domains have most consistently been related to everyday functioning in the aging and MCI populations (Farias, Mungas, & Jagust, 2005; Mariani et al., 2008; Schmitter-Edgecombe, Parsey, & Lamb, 2014), and both have been linked to omission errors (Gold et al., 2015, Schmitter-Edgecombe & Parsey, 2014). Working memory and processing speed were also examined as behavioral research indicates that individuals with MCI show

cognitive difficulties in these areas (Kirova, Bays, & Lagalwar, 2015; Saunders & Summers, 2011; Schmitter-Edgecombe & Parsey, 2014b). Although there is less research on the relationship between omission errors and working memory and processing speed, individuals with MCI have been found to take longer than cognitively healthy controls to complete both laboratory performance-based measures of everyday functional activities (Wadley, Okonkwo, Crowe, & Ross-Meadows, 2008) and complex everyday tasks administered in a naturalistic environment (Sanders, Low & Schmitter-Edgecombe, 2014; Schmitter-Edgecombe et al., 2012). Salthouse (1996) suggested that when processing speed is slow, actions cannot be successfully completed and products of early processing may no longer be available during later processing for relevant operations or activity completion. Processing speed may therefore be an important variable in omission errors, with the impact of processing speed deficits becoming more significant with later stages of activity completion.

In the current study, healthy older adults (HOA) and individuals with sdMCI, mdMCI and dementia completed several activities of everyday living in a naturalistic environment, as well as neuropsychological tests that assessed the cognitive domains of memory, speeded processing, and executive functioning. As participants were completing naturalistic everyday activity tasks (e.g., watering plants, filling a medication dispenser), omitted steps were coded and divided into three categories: preparatory steps, action-oriented steps, and concluding steps. We hypothesized that individuals with sdMCI, mdMCI and with dementia would commit significantly more omission errors than the HOA. We were especially interested in whether omission errors would occur disproportionately across categories (preparatory, action-oriented, concluding) for individuals with sdMCI, mdMCI and with dementia as compared to healthy controls. Additionally, based on prior research (e.g., Giovannetti et al., 2008; Gold et al., 2015; Schmitter-Edgecombe & Parsey, 2014), we hypothesized that memory would be a significant predictor of all categories of omission errors. We also hypothesized that executive functioning, which was found to be related to errors in central aspects of activity completion (Gold et al., 2015), would be a significant predictor of action-oriented errors, and that processing speed, which may impact later events due to incomplete processing of earlier events, would be a significant predictor of action-oriented and concluding events.

Method

Participants

Participants were 65 cognitively healthy older adults (HOA), 19 individuals with sdMCI, 33 individuals with mdMCI, and 13 individuals with dementia between the ages of 53 and 94 years old (total $n = 130$, $M = 72.25$, $SD = 8.59$). Participants were recruited through community advertisements, health and wellness fairs, previous studies in our laboratory, and physician referrals. The current study was part of a larger research study that investigated the relationship between everyday functioning and cognition in the aging population (Schmitter-Edgecombe, Parsey, & Cook, 2011). Participants completed a medical screening over the phone to rule out known neurological, medical, or psychiatric causes of cognitive dysfunction (e.g., epilepsy, schizophrenia), head trauma with permanent brain lesion, history

of cerebrovascular accidents, and current or recent (within the past year) psychoactive substance abuse.

The initial phone screening also included the Clinical Dementia Rating instrument (CDR) to assess dementia staging (Hughes, Berg, Danziger, Coben, & Martin, 1982; Morris, 1993), and the Telephone Interview of Cognitive Status (TICS; Brandt & Folstein, 2003) to rule out participants with significant cognitive impairment who would not be able to complete the laboratory assessment. Participants were also administered the Geriatric Depression Scale - Short Form (GDS; Yesavage & Sheikh, 1986) to rule out participants who endorsed symptoms of significant depression (indicated by a score greater than 10).

Participants who met initial screening criteria were invited to complete a series of standardized and experimental neuropsychological assessments across two sessions, each lasting approximately 3 hours. The first session occurred in the laboratory setting and included mostly standardized neuropsychological assessment measures. The second session occurred in an apartment located on the Washington State University campus where participants completed several naturalistic tasks (e.g., sweeping, filling a pill holder with correct medications). Sessions were scheduled approximately two weeks apart ($M = 16.10$ days, $SD = 31.29$). As compensation for their time, participants were given pre-paid parking passes for both sessions, a travel stipend, and a report that detailed their performance on the standardized neuropsychological measures administered.

Diagnostic groups were determined by two experienced neuropsychologists who reviewed neuropsychological data, participant and informant interview information, medical records when available, and CDR ratings. Healthy older adult participants denied cognitive changes, scored 0 on the CDR, and performed within normal limits for their age and education level on the TICS. Participants placed into the dementia group met the *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition (DSM-IV; American Psychiatric Association, 2013) criteria for dementia. Inclusion criteria for MCI were consistent with the guidelines of Petersen and colleagues (Petersen et al., 2001; Petersen & Morris, 2005), and included memory impairment for at least 6 months as reported by the individual or informant, scores of 1.5 standard deviations or more below age-matched norms or relative to prior testing scores on measures in one or more cognitive domains, failure to meet DSM-IV criteria for dementia, TICS score within normal limits, and a CDR score of not greater than 0.5. Nineteen of the individuals with MCI met criteria for sdMCI and 33 participants met criteria for mdMCI. Participants who could not be confidently classified into one of the diagnostic categories were excluded from this study.

The HOAs ($n = 65$) were demographically matched to the MCI and dementia participants and represent a subsample drawn from a larger study that included 168 cognitively healthy older adults (Schmitter-Edgecombe et al., 2011). As seen in Table 2, the MCI and dementia participants did not differ in age and education from the matched HOA control participants used for this study. In addition, analysis of total omission errors (no detailed analysis) was reported as part of an earlier paper that examined functional change in HOA and individuals with MCI and dementia (Schmitter-Edgecombe & Parsey, 2014a). The study protocol was

reviewed and approved by the Institutional Review Board at Washington State University, and all research was conducted in accordance with the Helsinki Declaration.

Measures

Activity Completion.

Eight Activities.: Participants completed eight activities of daily living in a campus apartment. The eight activities were: filling a medication dispenser, writing out a birthday card with check, operating a DVD player and watching a movie clip, sweeping and dusting, watering houseplants, answering a ringing phone and conversing, cooking soup in microwave and pouring glass of water, and selecting a work outfit (see Table 1; for additional details about each of the activities see Schmitter-Edgecombe et al., 2011; Schmitter-Edgecombe & Parsey, 2014). Prior to beginning each of the eight activities, participants were given verbal instructions by test administrators about the activity to complete. As an example, the instructions for the sweeping and dusting task were: “For this first task, I would like you to sweep the kitchen floor and dust the dining room and the living room. All supplies that you will need are located in the kitchen closet labeled “supply closet”. When you have finished this task, please return the supplies that you used to sweep the floor and dust to the kitchen “supply closet”. Do you have any questions? You may begin.” Once the individual initiated the task, no further instructions or prompts were given. After receiving verbal instructions, participants carried out each activity on the main floor of the apartment while two test administrators independently annotated and coded participant actions from a control room video and annotation system upstairs. The coding system for each activity divided the activities into individual steps necessary for completion. An example of the steps for two activities can be found in Table 1. The number of total steps in each of the activities varied from 3 to 10 ($M = 6.5$, $SD = 2.62$). Omissions were defined as any of these individual steps that were not completed by the participant (e.g., failed to retrieve dustpan and brush). Other errors that were coded and not examined in this study included inefficiencies (e.g., swept kitchen twice), substitutions (e.g., dusted kitchen instead of living room), and irrelevant actions (e.g., swept front entry way in addition to kitchen; see Schmitter-Edgecombe et. al., 2011). If a substitution error occurred and the task step was still completed, the error was coded only as a substitution (e.g., uses kitchen towel to dust dining room).

To analyze where in the task completion process omission errors were occurring, omission errors were broken into the following task stage categories: preparatory steps, action-oriented steps, and concluding steps. Preparatory steps included the activity steps that were necessary to make ready for successful activity completion (e.g., retrieve duster; choose DVD). Action-oriented steps included the activity steps that involved carrying out the required action (e.g., dust dining room; fill medication dispenser, boil water in microwave). Concluding steps were defined as activity steps that represented the end of the activity (e.g., return broom, return medications to cabinet). With the exception of the outfit selection test, all tasks had one or more concluding steps (e.g., turn off TV, return DVD to pile). To place activity steps into their appropriate stage categories, the researchers listed out all steps to task completion for each of the eight activities. The researchers then individually categorized each step. For the two task steps that resulted in disagreement, the researchers discussed the

steps and came to a consensus about the appropriate omission error category. Across the eight activities there were a total of 15 preparatory steps, 26 action-oriented steps, and 11 concluding steps (see Table 1 for example task step labels).

Cognitive Correlates.—Four cognitive domains (memory, executive functioning, working memory and processing speed) were assessed. For each domain, we used three related neuropsychological measures. The neuropsychological measures used for each domain were determined by a principal components analysis that was conducted on a larger subsample of these similar study participants (see Fellows & Schmitter-Edgecombe, 2015). Participants were also administered a measure of global cognitive status.

Memory.—*Memory Assessment Scale - list learning subtask* (MAS; Williams, 1991). Participants are read a list of 12 semantically-related words up to six times, and are asked to recall all the words they can remember after each list administration trial. Participants are then asked to recall the list following both a short-delay (approximately 3 minutes) and a long-delay (approximately 20 minutes). The initial list acquisition score, and the total number of 12 words recalled correctly at both the short and long-delay were used as measures for the memory domain.

Executive functioning.—*Clox 1 and 2* (Royall, Cordes, & Polk, 1998). For this standardized clinical test, individuals are asked to draw and then copy a clock with the hands set to a specified time. Total score for the drawing trial (Clox 1) was used as one measure of executive functioning.

Behavioral Assessment of the Dysexecutive Syndrome (BADS): Zoo map subtest (Wilson, Alderman, Burgess, Emslie, & Evans, 1996). This standardized neuropsychological test requires participants to demonstrate how they would visit a series of specified places in a zoo while following a set of instructions and rules. Participants were given a high-demand condition, which requires participants to determine their own route through the zoo while following the rules and visiting each key location, and a low-demand condition, which requires participants to follow a predetermined route. The zoo map profile score was used as a second measure of executive functioning.

Trail Making Test (Reitan, 1958). This standardized neuropsychological test requires individuals to connect dots, first numbers (Trails A) and then alternating numbers and letters (Trails B), in order as fast and as accurately as possible. To minimize the influence of processing speed, Trails B was regressed on Trails A, with the standardized residual score being used for analysis (Fellows & Schmitter-Edgecombe, 2015).

Working Memory.—*Letter-Number Span and Letter-Number Sequencing subtest* (*Wechsler Adult Intelligence Scale, Third Edition*, Wechsler, 1997). The letter-number span task requires individuals to repeat a series of letters and numbers presented to them orally in the order given. For the standardized letter-number sequencing task, individuals are presented orally with sets of letters and numbers and asked to sequentially order each set. For both tasks, the sets of letters and numbers become increasingly longer and discontinues when an individual provides the incorrect answer for all three trials of a particular series

length. The number of correct trials for each task were both used as a measure of working memory.

Temporal Order Sequencing Task (Schmitter-Edgecombe, Woo, & Greeley, 2009). Following the completion of eight neuropsychological tests, individuals are asked to recall each test. Participants are then provided with eight cards that each contains a description of one of the eight neuropsychological tests completed earlier. This task requires individuals to place the cards in the same order as the tests were completed. The total number of correctly ordered cards was used as the third measure of working memory.

Processing speed.—*Trail Making Test, Part A* (Reitan, 1958). This standardized neuropsychological test requires individuals to connect a set of 25 dots in consecutive numerical order as fast but also as accurately as possible. Time to completion was used as a proxy score for processing speed.

Symbol Digits Modalities Test (SDMT; Smith, 1991). This standardized neuropsychological measure of processing speed requires individuals to search a key of nine geometric shapes paired with numbers to fill in corresponding numbers that go with the shapes. Both oral and written versions were administered and number of items accurately completed in 90 seconds for each version was used as two additional measures of processing speed.

Global Cognitive Status.—*Telephone Interview for Cognitive Status (TICS)* (Brandt & Folstein, 2003). For this standardized neuropsychological test, participants completed brief cognitive tests that included tests of attention, orientation, memory, knowledge and conceptualization.

Statistical Analyses

Comparisons between HOA, sdMCI, mdMCI and dementia groups on demographic and cognitive tests were examined with one-way analyses of variance (ANOVA). A group (HOA, sdMCI, mdMCI, dementia) by error category (preparatory, action-oriented, concluding) mixed-model ANOVA was performed with error category as the within subject variable. Because omission errors were not normally distributed for each group, an arcsine transformation was applied to calculated proportion data for each error category. That is, we first obtained a proportion of omission errors in each category for each participant by taking the number of omission errors that each participant committed across all eight tasks in a given category (i.e., preparatory, action-oriented, concluding) and divided by the total number of possible omissions for that category. For one individual who was unable to complete a task step because they could not reach an item, the total number of possible steps was adjusted accordingly to account for this step and any other task steps that could not be completed as a result. We then applied the following transformation to normalize the data: $2 * \text{ARCSIN}(\text{SQRT}(x))$. The data from each error category was then compared across groups using one-way ANOVAs with a Bonferroni correction. The raw data along with the transformed data are presented in Table 3.

Hierarchical regression analyses were conducted to examine the relationship between cognitive correlates and omission error subtypes. The neuropsychological tests assessing

each domain (see Table 2) were collapsed across groups, converted into z-scores and averaged to create composites scores representing the domains of memory, executive functioning, working memory and processing speed. The HOA, sdMCI, mdMCI and dementia groups were combined for the regression analyses so as to increase statistical power and the range of variation. It has also been argued that this approach is more effective than a single diagnostic group approach for evaluating functional heterogeneity in older adults (Seligman et al., 2014) where functional deficits have been found to be stronger predictors than an MCI diagnosis of progression to dementia (Pérès et al., 2008; Purser, Fillenbaum, Pieper, & Wallace, 2005). The sample size for the regression analyses was reduced by 1 participant ($n = 129$) as this participant did not one of the tests that composed the speeded processing domain.

Results

Demographic and Neuropsychological Data

Table 2 shows demographic, cognitive data and the cognitive domain composites as a function of diagnostic group. The four groups did not differ in age or education level, $F_s < 1.51$, $p_s > .21$. As expected, there were significant differences in the means for the four groups on all measures assessing memory, $F_s > 36.26$, $p_s < .001$, $\eta^2_s > .46$, executive functioning, $F_s > 9.89$, $p_s < .001$, $\eta^2_s > .20$, processing speed, $F_s > 21.98$, $p_s < .001$, $\eta^2_s > .30$, working memory, $F_s > 3.84$, $p_s < .01$, $\eta^2_s > .08$, and global cognitive status, $F = 30.09$, $p < .001$, $\eta^2 = .42$, as well as on all four computed cognitive domain composite measures, $F_s > 23.57$, $p_s < .001$, $\eta^2_s > .35$. As can be seen in Table 2, post hoc tests (Bonferroni) indicated that the group of participants with dementia performed more poorly than the HOA, sdMCI, and mdMCI groups on all measures and composite scores. The sdMCI group performed more poorly than the HOA only on the memory composite measure and the memory tests, while the mdMCI group performed more poorly than the HOA group on all composites and measures with the exception of Letter-Number span, Clox 1 and the Zoo Map profile score. The mdMCI group also performed more poorly than the sdMCI group on the executive composite measure and on the following measures: TICS, SDMT oral, Trails A, and Trails B residual.

Omissions Error Types

As seen in Table 3, a group by error category ANOVA conducted on the Arcsine transformed data revealed a significant main effect of group, $F(3, 126) = 24.57$, $p < .001$, $MSE = 0.11$, $\eta_p^2 = .37$, with the HOA and sdMCI groups committing fewer omission errors than the mdMCI group ($p_s < .05$) who committed fewer errors than individuals with dementia ($p < .001$). The significant main effect of error type, $F(2, 252) = 44.44$, $p < .001$, $MSE = 2.93$, $\eta_p^2 = .26$, revealed that the largest proportion of errors was committed for action-oriented steps, followed by concluding steps, $F = 9.85$, $p = .002$, and then preparatory steps, $F = 52.68$, $p < .001$. The main effects were also modified by a significant interaction, $F(6, 252) = 3.46$, $p = .003$, $MSE = 0.23$, $\eta_p^2 = .08$. Breakdown of the interaction with one-way ANOVAs revealed that the amount of omission errors differed significantly across groups for all three category error types: preparatory, $F = 12.63$, $p < .001$, $MSE = 1.45$, $\eta^2 = .23$, action-oriented, $F = 24.83$, $p < .001$, $MSE = 2.79$, $\eta^2 = .37$, and concluding, $F =$

18.53, $p < .001$, $MSE = 4.43$, $\eta^2 = .31$. Post hoc comparisons, however, revealed a different pattern of group differences across error categories. For the preparatory and concluding steps, omission errors did not significantly differ between the HOA, sdMCI and mdMCI groups. However, the dementia group omitted significantly more preparatory and concluding steps compared to the other three groups. Within action-oriented steps, the mdMCI group showed significantly more action-oriented omission errors than the HOA group and the sdMCI group, and the dementia group showed significantly more action-oriented omission errors than all three other groups.

In summary, for preparatory and concluding step omission errors, no significant differences were found between the HOA and both the sdMCI and mdMCI groups, but significant differences emerged for the dementia group. For action-oriented omission errors, compared to the HOA and sdMCI groups, the mdMCI group committed significantly more action-oriented omission errors with the number increasing further for the dementia group. To determine whether action-oriented steps were being omitted because the preparatory step had been omitted, each action-oriented error was coded as being due either to a preparatory step incompleteness or an error in the action-oriented step itself. For each participant, each of these two error causes was then divided by the total number of action-oriented errors committed and multiplied by 100 to get a percentage. Individuals who did not commit any action-oriented errors (i.e., 19 HOA, 6 sdMCI, 4 mdMCI) were not included in the analysis. A 4 (group) by 2 (error cause) ANOVA revealed that a highest percentage of action-oriented errors occurred because of a failure in the action-oriented step itself (63%) rather than a failure in task preparation (37%), $F(1, 97) = 10.51$, $p = .002$, $MSE = .25$, $\eta_p^2 = .10$. A similar pattern was found across all groups and this was supported by the lack of a significant interaction between error cause and group, $F = 1.19$, $\eta_p^2 = .04$,

Association between cognitive domains and categories of omission errors

Correlations among the omission error categories and predictor variables are shown in Table 4. To reduce the number of demographic predictors (i.e., age, education, gender), we examined for relationships between demographic and criterion variables. As age was the only demographic variable that correlated significantly with the omission error categories, it was entered in the first block of the regression models. The cognitive composite measures of memory, executive functioning, working memory and speeded processing were entered in block 2. Separate regressions were conducted for the preparatory, action-oriented and concluding omission error categories. There was no significant multi-collinearity among the five predictor variables (Variance Inflation Factors $< .1$). Regression model data can be found in Table 5.

The cognitive composite measures accounted for significant variance over and above age for preparatory step omissions, $R^2 = .30$, $F(4,123) = 14.52$, $p < .001$, $R^2 = .37$, action-oriented step omissions, $R^2 = .38$, $F(4,123) = 18.96$, $p < .001$, $R^2 = .44$, and concluding step omissions, $R^2 = .26$, $F(4,123) = 16.65$, $p < .001$, $R^2 = .40$. As hypothesized, when all five independent variables were entered in the regressions, memory emerged as a significant predictor for each omission error category, $t > 2.10$, $ps < .05$. Furthermore, while processing speed also emerged as a significant predictor for action-oriented omission step errors ($t =$

$-2.645, p < .01$), working memory also emerged as a significant predictor for both preparatory, $t = -2.35, p < .05$, and concluding, $t = -2.47, p < .05$, step omission errors. To examine the potential impact of overall functioning on the findings, the regressions were rerun with a measure of global cognitive status (i.e., TICS) in block 1 with age, followed by the cognitive composite measures in block 2. The pattern of findings was identical.

Conclusion

Given the temporal and causal constraints of many everyday activities, we characterized omission errors in HOAs and individuals with sdMCI, mdMCI and dementia by dividing activity steps into preparatory, action-oriented and concluding steps. Consistent with prior research (Giovannetti et al., 2008; Gold, 2015; Schmitter-Edgecombe & Parsey, 2014), and the functional deficits required for a diagnosis of dementia, omission errors were highest in the dementia group and pervasive across all three omission error categories. Furthermore, the omission errors of individuals with dementia appeared to snowball such that it became more difficult for participants to accurately reach and complete the concluding task steps of the activities.

Currently, there are mixed findings concerning whether individuals with sdMCI and mdMCI experience different degrees of everyday functional difficulties. As measured by self-report and informant-report ratings of everyday functioning, some studies found greater functional difficulties for mdMCI compared to sdMCI (Artouli & Brandt, 2010; Schmitter-Edgecombe, Woo & Greeley, 2009), while other studies did not (Teng, Becker, Woo, Cumming & Lu, 2010). By having participants complete everyday tasks within a naturalistic real-world environment, this work contributes to the literature by demonstrating that task omission errors were higher in a mdMCI group compared to both HOA and sdMCI groups. This suggests that individuals with mdMCI likely experience greater difficulty than individuals with sdMCI completing everyday tasks as the end result of most omission errors is either incomplete or inaccurate task performance. Furthermore, although individuals with both sdMCI and mdMCI performed more poorly than the HOAs on the memory composite, individuals with mdMCI also performed more poorly than the HOAs on all remaining composite measures and more poorly than the sdMCI on the executive composite. This may suggest that when impairment remains largely within the memory domain, individuals with sdMCI can use other intact abilities to help compensate for omission errors that may lead to functional difficulties.

We also found that the largest proportion of omission errors occurred for action-oriented steps followed by concluding steps and then the preparatory steps. It makes sense that the lowest proportion of errors would be found in the preparatory steps as future task steps rely on earlier steps being completed either successfully or with a substitute item. For example, an individual would not be able to write a birthday wish in a birthday card or put the card in an envelope without first retrieving the birthday card or another type of substitute card (e.g., thank you card). Of note, when action-oriented step omissions occurred they were significantly more likely to occur because of failure of the action-oriented step itself rather than a failure in task preparation. This suggests that some intention for the use of the item was activated but there may have been difficulty in accurately completing the action-oriented

step or the initial intention may have been forgotten or not easily retrieved. The greater number of task step errors for action-oriented steps may also partly reflect the greater complexity of these task steps. More specifically, although all omission error categories (preparatory, action-oriented, concluding) included both crux and noncrux actions, the action-oriented steps required greater integration of crux (pouring water into glass) and noncrux (tilting pitcher) actions within the same task step (e.g., fill medication dispenser compared to retrieve medication dispenser). Previous literature has found that both crux and noncrux omissions were impaired in individuals with amnesic MCI (Gold et al., 2015).

In contrast to many prior studies that examined crux and noncrux actions as participants completed performance-based tasks in a laboratory (e.g., make tea), we examined more global task steps across a wider array of eight everyday activities in a naturalistic setting. Consistent with the complexity explanation for the action-oriented steps, individuals with mdMCI showed significantly higher numbers of omission errors in action-oriented steps compared to sdMCI and HOAs, while the three groups did not differ significantly in omission errors for preparatory or concluding steps. This suggests that steps related to both initiating and gathering items to begin and to complete activities, which also required less integration between crux and noncrux actions, appear to remain relatively intact in individuals with mdMCI. Contrastingly, the dementia group committed more omission errors across all omission error categories. These findings suggest that action-oriented steps may be affected by milder levels of cognitive impairment, but still may require impairment beyond the memory domain as individuals with sdMCI did not differ significantly from controls in action-oriented errors.

Consistent with prior research (Giovannetti et al., 2008; Gold et al., 2015) and our hypothesis, across all categories of omission step errors, episodic memory played an important role in predicting omission errors. The executive functioning composite, which was composed largely of planning and set-shifting measures, did not emerge as a significant predictor. Although executive functioning abilities are also needed to formulate and guide subgoals throughout task completion, episodic memory deficits that lead to task goals being left incomplete, being forgotten, or being completed inaccurately may have weakened the relationship with executive functioning abilities for the action-oriented and concluding omission steps. Memory was not the only significant predictor of omission errors. The working memory composite emerged as a significant predictor in the preparatory and concluding steps. Similar to executive abilities, working memory is important to goal completion given its role in holding information on-line as subgoals are being completed throughout the task. If individuals are unsuccessful at maintaining task goals within working memory, this could influence ability to accurately complete task steps. We also found that the processing speed composite predicted action-oriented step errors. In several recent studies, individuals with MCI have been found to both take longer and perform more inaccurately when completing everyday tasks of daily living (Wadley et al., 2008; Schmitter-Edgecombe, McAlister & Weakley, 2012). Processing speed may play a role in impacting later events due to incomplete processing of earlier events, thereby resulting in greater omissions for later more integrative, time intensive and complex action-oriented task steps. Future research will be needed to explore these hypotheses and to better understand the nature of the relationship between omission error types and cognitive correlates. Of note, the

observed relationships between the cognitive composite measures and error types remained even when we entered global cognitive status into the regression analyses as a general proxy for disease severity.

The present study contributes to the larger body of literature on functional impairment by investigating types of omission errors that occur during everyday activities in HOA and individuals with sdMCI, mdMCI and dementia, and the cognitive correlates of these errors. The highly educated nature of our sample limits generalizability to more heterogeneous populations. In addition, our composite measures and regression analyses were limited by the neuropsychological measures administered in this study. Furthermore, some of the neuropsychological measures used to form the composite measures were also used in diagnosis. While the everyday task completion paradigm in this study occurred in a naturalistic environment, future studies should investigate non-scripted, real-life activity completion with individuals in more naturalistic environments, such as their own homes, to gain a more accurate understanding of how impairment impacts functional ability. Future studies could also manipulate the complexity level of specific tasks to determine the effect that increasing task difficulty has on cognitive correlates.

In this study, omission errors in everyday task completion were examined according to three omission category stages (preparatory, action-oriented, and concluding) across HOA, and individuals with sdMCI, mdMCI and dementia. Results revealed that action-oriented steps become impaired first and were evident in individuals with mdMCI but not sdMCI, suggesting that when impairment remains largely within the memory domain other intact abilities may help to compensate for omission errors. More significant omission errors, which were evident across all error types, were found in individuals with dementia. In addition, because significant errors occurred in both the preparatory and action-oriented steps for persons with dementia, the errors appeared to mount such that it became more difficult to reach or accurately complete task steps at the later stages in activity completion. Memory was most strongly related to omission errors across all categories of omission errors. However, memory was never the only significant predictor and there was some evidence to suggest that working memory was important to preparatory and concluding steps, while processing speed was more important for action-oriented steps. Identifying what specific types of steps are left incomplete during everyday task completion can aid in early detection of cognitive impairment and the development and placement of compensatory strategies to aid individuals in completing necessary tasks, helping individuals remain independent longer into the cognitive impairment process.

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References

- American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.). Washington, DC: American Psychiatric Association.
- Bailey HR, Kurby CA, Giovannetti T, & Zacks JM (2013). Action perception predicts action performance. *Neuropsychologia*, 51(11), 2294–2304. [PubMed: 23851113]
- Balouch S & Rusted JM (2013). Age-related changes in error monitoring of an everyday task. *Journal of the International Neuropsychological Society*, 19(7), 763–772. [PubMed: 23702346]
- Bell-McGinty S, Podell K, Franzen M, Baird AD, & Williams MJ (2002). Standard measures of executive function in predicting instrumental activities of daily living in older adults. *International Journal of Geriatric Psychiatry*, 17, 828–834. [PubMed: 12221656]
- Brandt J, & Folstein M (2003). *Telephone Interview for Cognitive Status*. Lutz, FL: Psychological Assessment Resources, Inc.
- Cahn-Weiner DA, Boyle PA, & Malloy PF (2002). Tests of executive function predict instrumental activities of daily living in community-dwelling older individuals. *Applied Neuropsychology*, 9(3), 187–191. [PubMed: 12584085]
- Cahn-Weiner DA, Malloy PF, Boyle PA, Marran M, & Salloway S (2000). Prediction of functional status from neuropsychological tests in community-dwelling elderly individuals. *The Clinical Neuropsychologist*, 14(2), 187–195. [PubMed: 10916193]
- Cooper RP, Schwartz MF, Yule P, & Shallice T (2005). The simulation of action disorganization in complex activities of daily living. *Cognitive Neuropsychology*, 22, 959–1004. [PubMed: 21038286]
- Farias ST, Mungas D, & Jagust W (2005). Degree of discrepancy between self and other-reported everyday functioning by cognitive status: Dementia, mild cognitive impairment, and healthy elders. *International Journal of Geriatric Psychiatry*, 20(9), 827–834. [PubMed: 16116577]
- Giovannetti T, Bettcher BM, Brennan L, Libon DJ, Kessler RK, & Duey K (2008). Coffee with jelly or unbuttered toast: Commissions and omissions are dissociable aspects of everyday action impairment in Alzheimer's disease. *Neuropsychology*, 22(2), 235–245. [PubMed: 18331166]
- Giovannetti T, Libon DJ, Buxbaum LJ, & Schwartz MF (2002). Naturalistic action impairments in dementia. *Neuropsychologia*, 40, 1220–1232. [PubMed: 11931925]
- Giovannetti T, Schmidt KS, Gallo JL, Sestito N, & Libon DJ (2006). Everyday action in dementia: Evidence for differential deficits in Alzheimer's disease versus subcortical vascular dementia. *Journal of the International Neuropsychological Society: JINS*, 12, 45–53. [PubMed: 16433943]
- Gold DA, Park NW, Troyer AK, & Murphy KJ (2015). Compromised naturalistic action performance in amnesic mild cognitive impairment. *Neuropsychology*, 29, 320–333. [PubMed: 25151114]
- Goldenberg G, Hartmann-Schmid K, Sürer F, Daumüller M, & Hermsdörfer J (2007). The impact of dysexecutive syndrome on use of tools and technical devices. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, 43, 424–435. [PubMed: 17533765]
- Hughes CP, Berg L, Danziger WL, Coben LA, & Martin RL (1982). A new clinical scale for the staging of dementia. *The British Journal of Psychiatry*, 140(6), 566–572. [PubMed: 7104545]
- Jefferson AL, Paul RH, Ozonoff A, & Cohen RA (2006). Evaluating elements of executive functioning as predictors of instrumental activities of daily living (IADLs). *Archives of Clinical Neuropsychology*, 21(4), 311–320. [PubMed: 16814980]
- Kirova AM, Bays RB, & Lagalwar S (2015). Working memory and executive functioning decline across normal aging, mild cognitive impairment and Alzheimer's disease. *Biomed Research International*, vol. 2015, Article ID 748212, 9 pages.
- Lawton MP, & Brody E (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *The Gerontologist*, 9, 179–185. [PubMed: 5349366]
- Lewis MS, & Miller LS (2007). Executive control functioning and functional ability in older adults. *The Clinical Neuropsychologist*, 21, 274–285. [PubMed: 17455018]
- McAlister C, Schmitter-Edgecombe M, & Lamb R (in press). Examination of variables that may affect the relationship between cognition and functional status in individuals with mild cognitive impairment: a meta-analysis. *Archives of Clinical Neuropsychology*.

- Morris JC (1993). The Clinical Dementia Rating (CDR): Current version and scoring rules. *Neurology*, 43(11), 2412–2414.
- Park NW, Lombardi S, Gold DA, Tarita-Nistor L, Gravely M, Roy EA, & Black SE (2012). Effects of familiarity and cognitive function on naturalistic action performance. *Neuropsychology*, 26(2), 224–237. [PubMed: 22201302]
- Petersen RC, Doody R, Kurz A, Mohs R, Morris J, Rabins P, ... Winblad B (2001). Current concepts in mild cognitive impairment. *Archives of Neurology*, 58(12), 1985–1992. [PubMed: 11735772]
- Petersen RC, & Morris JC (2005). Mild cognitive impairment as a clinical entity and treatment target. *Archives of Neurology*, 62(7), 1160–1163. [PubMed: 16009779]
- Reed ES, Montgomery M, Palmer C & Pittenger J (1995). Method for studying the invariant knowledge structure of action: Conceptual organization of an everyday action. *The American Journal of Psychology*, 108(1), 37–65.
- Reitan RM (1958). Validity of the Trail Making Test as an indicator of organic brain damage. *Perceptual and Motor Skills*, 8(3), 271–276. 10.2466/pms.1958.8.3.271
- Royall DR, Cordes JA, & Polk M (1998). CLOX: An executive clock drawing task. *Journal of Neurology, Neurosurgery & Psychiatry*, 64(5), 588–594.
- Rusted J & Sheppard L (2002). Action-based memory in Alzheimer's disease: A longitudinal look at tea making. *Neurocase*, 8(1–2), 111–126. [PubMed: 11997490]
- Salthouse TA (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review*, 103(3), 403–428. 10.1037/0033-295X.103.3.403 [PubMed: 8759042]
- Sanders C, Low C, & Schmitter-Edgecombe M (2014). Assessment of planning abilities in individuals with mild cognitive impairment using an open-ended problem-solving task. *Journal of Clinical and Experimental Neuropsychology*, 36, 1084–1097. [PubMed: 25513952]
- Saunders NLJ, Summers MJ (2011). Longitudinal deficits to attention, executive and working memory in subtypes of mild cognitive impairment. *Neuropsychology*, 25, 237–248. [PubMed: 21381828]
- Schmitter-Edgecombe M, McAlister C, & Weakley A (2012). Naturalistic assessment of everyday functioning in individuals with mild cognitive impairment: The day-out task. *Neuropsychology*, 26(5), 631–641. [PubMed: 22846035]
- Schmitter-Edgecombe M, Parsey C, & Cook DJ (2011). Cognitive correlates of functional performance in older adults: Comparison of self-report, direct observation, and performance-based measures. *Journal of the International Neuropsychological Society*, 17(05), 853–864. [PubMed: 21729400]
- Schmitter-Edgecombe M, & Parsey CM (2014a). Assessment of functional change and cognitive correlates in the progression from healthy cognitive aging to dementia. *Neuropsychology*, 28(6), 881–893. [PubMed: 24933485]
- Schmitter-Edgecombe M & Parsey C (2014). Cognitive correlates of functional abilities in individuals with mild cognitive impairment: comparison of questionnaire, direct observation and performance-based measures. *The Clinical Neuropsychologist*, 28, 726–746. [PubMed: 24766574]
- Schmitter-Edgecombe M, Woo E, & Greeley DR (2009). Characterizing multiple memory deficits and their relation to everyday functioning in individuals with mild cognitive impairment. *Neuropsychology*, 23(2), 168–177. [PubMed: 19254090]
- Schwartz MF, Buxbaum LJ, Ferraro M, Veramonti T, & Segal M (2003). *The Naturalistic Action Test*. Bury St. Edmunds: Thames Valley Test Company.
- Schwartz MF, Reed ES, Montgomery M, Palmer C, & Mayer NH (1991). The quantitative description of action disorganisation after brain damage: A case study. *Cognitive Neuropsychology*, 8(5), 381–414.
- Schwartz MF (2006). The cognitive neuropsychology of everyday action and planning. *Cognitive Neuropsychology*, 23, 202–221. 10.1080/02643290500202623 [PubMed: 21049328]
- Seidel GA, Giovannetti T, Price CC, Tanner J, Mitchell S, Eppig J, & Libon DJ (2013). Neuroimaging correlates of everyday action in dementia. *Journal of Clinical and Experimental Neuropsychology*, 35(9), 993–1005. [PubMed: 24131088]
- Smith A (1991). *Symbol digit modelatities test*. Los Angeles, CA: Western Psychological Services.
- Tuokko HA, Frerichs RJ, & Kristjansson B (2001). Cognitive impairment, no dementia: Concepts and issues. *International Psychogeriatrics*, 13(Supplement S1), 183–202.

- Wadley VG, Okonkwo O, Crowe M, & Ross-Meadows (2008). Mild cognitive impairment and everyday function: evidence of reduced speed in performing instrumental activities of daily living. *American Journal of Geriatric Psychiatry*, 16, 416–424.
- Wechsler DA (1997). *Wechsler Adult Intelligence Scale* (3rd ed.). New York, NY: The Psychological Corporation.
- Williams JM (1991). *Memory Assessment Scales Professional Manual*. Odessa, FL: Psychological Assessment Resources, Inc.
- Wilson BA, Alderman N, Burgess PW, Emslie H, & Evans JJ (1996). *Behavioural Assessment of the Dysexecutive Syndrome*. Bury St Edmunds: Thames Valley Test Company.
- Yesavage JA, & Sheikh JJ (1986). Geriatric Depression Scale (GDS). *Clinical Gerontologist*, 5(1–2), 165–173.

Table 1.**Example Steps for Cooking and Birthday Card Tasks**

Step	Category
<i>Cooking Soup and Pouring a Glass of Water</i>	
1. Retrieve all cooking materials from Cupboard A	Preparatory
2. Fill measuring cup with water	Action-oriented
3. Heat up water in microwave	Action-oriented
4. Pour water into cup of noodle soup container	Action-oriented
5. Allow water to simmer in covered container	Action-oriented
6. Retrieve pitcher of water from refrigerator	Preparatory
7. Pour glass of water from pitcher	Action-oriented
8. Return pitcher to refrigerator	Concluding
<i>Writing out a Birthday Card with Check</i>	
1. Retrieve birthday card	Preparatory
2. Retrieve check	Preparatory
3. Write birthday card wish	Action-oriented
4. Write check	Action-oriented
5. Place card and check in envelope	Action-oriented
6. Address envelope	Action-oriented
7. Place envelope in mail slot	Concluding

Table 2.

Means and Standard Deviations of Demographic and Cognitive Variables

Variable or Test	Group							
	Healthy Older Adults n = 65 63.1% female		Single-domain MCI n = 19 52.6% female		Multi-domain MCI n = 33 48.5% female		Dementia n = 13 23.1% female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Demographics								
Age	72.34	8.78	70.53	9.35	71.37	8.39	76.62	5.95
Education (years)	15.88	2.75	16.00	2.69	15.18	3.37	16.00	3.16
Global Cognitive Status								
TICS	34.03	2.64	34.00	3.37	31.77 ^{a,b}	2.73	26.23 ^{a,b,c}	3.17
Memory								
MAS list acquisition	60.52	5.72	50.89 ^a	8.82	46.73 ^a	11.07	33.85 ^{a,b,c}	11.92
MAS list short-delay	11.00	1.16	7.63 ^a	3.70	7.39 ^a	3.65	3.23 ^{a,b,c}	3.85
MAS list long-delay	11.31	0.79	8.42 ^a	3.32	7.85 ^a	4.06	3.38 ^{a,b,c}	3.50
Executive Functioning								
Clox 1	12.65	2.08	12.47	2.09	11.73	2.39	8.50 ^{a,b,c}	3.37
Zoo Map profile	2.38	1.09	2.11	1.10	1.76	1.13	0.25 ^{a,b,c}	0.46
Trails B residual	80.65	25.54	81.17	30.79	129.15 ^{a,b}	64.26	205.36 ^{a,b,c}	79.90
Working Memory								
LN span	11.77	2.25	11.32	2.79	10.61	1.71	9.92 ^a	1.71
LN sequencing	10.09	2.54	9.28	2.72	7.82 ^a	2.32	5.00 ^{a,b,c}	2.45
Temporal Order	4.52	1.63	3.74	1.69	3.22 ^a	1.86	1.38 ^{a,b,c}	1.41
Processing Speed								
Trails A	33.81	9.99	32.00	11.19	42.36 ^{a,b}	14.40	61.67 ^{a,b,c}	22.72
SDMT Written	47.36	9.20	41.95	9.38	36.70 ^a	10.05	23.73 ^{a,b,c}	13.56
SDMT Oral	54.02	10.84	48.16	9.91	39.61 ^{a,b}	10.57	25.55 ^{a,b,c}	12.02
Cognitive Domains								
Memory	0.60	.28	-0.24 ^a	.81	-0.42 ^a	.94	-1.56 ^{a,b,c}	.91
Executive	0.89	.64	0.86	.61	0.21 ^{a,b}	.86	-0.78 ^{a,b,c}	.82
Working Memory	0.33	.61	0.02	.72	-0.33 ^a	.46	-1.04 ^{a,b,c}	.50
Processing Speed	0.39	.61	0.12	.59	-0.35 ^a	.64	-1.38 ^{a,b,c}	1.42

Note. SD = standard deviation; TICS = Telephone Interview of Cognitive Status; MAS = Memory

Assessment Scale; LN = Letter-Number; SDMT = Symbol Digit Modalities Test.

^a significant difference when compared with HOA group^b significant difference when compared with Single-domain MCI group

^c significant difference when compared with Multi-domain MCI group

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Table 3.

Mean Arcsine Transformed Proportion of Omission Errors by Omission Type and Group (raw mean proportions in parentheses)

Variable	Group							
	Healthy Older Adults (n = 65)		Single-domain MCI (n = 19)		Multi-domain MCI (n = 33)		Dementia (n = 13)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Omission Categories								
Preparatory	0.23 (.04)	0.30 (.05)	0.20 (.03)	0.30 (.05)	0.42 (.08)	0.39 (.09)	0.82 ^{a,b,c} (.18)	0.39 (.14)
Action-oriented	0.45 (.05)	0.39 (.05)	0.39 (.06)	0.31 (.06)	0.66 ^{a,b} (.14)	0.41 (.12)	1.51 ^{a,b,c} (.32)	0.61 (.15)
Concluding	0.35 (.08)	0.29 (.08)	0.41 (.08)	0.46 (.10)	0.73 (.18)	0.62 (.20)	1.18 ^{a,b,c} (.47)	0.38 (.28)

^a significant difference when compared with HOA group

^b significant difference when compared with single-domain MCI group

^c significant difference when compared with multi-domain MCI group

Table 4.

Correlations between Omission Error Categories, Demographics, and Cognitive Domains

Variable	Omission Error Categories		
	Preparatory	Action-oriented	Concluding
Demographics			
Age	.28 *	.24 *	.38 **
Education	.03	.04	.08
Gender	.15	.12	.08
Cognitive Domains			
Memory	-.52 **	-.58 **	-.53 **
Executive Functioning	-.43 **	-.49 **	-.48 **
Working Memory	-.53 **	-.54 **	-.56 **
Processing Speed	-.51 **	-.57 **	-.51 **

*
 $p < .05$ **
 $p < .001$

Table 5.

Summary of Regression Models

Variables	Omission Error Category Type		
	Preparatory Omissions	Action-oriented Omissions	Concluding Omissions
Model 1			
Age	.27 [*]	.24 [*]	.38 ^{**}
Total R ²	.07	.06	.15
F for R ²	10.00 [*]	7.59 [*]	21.59 ^{**}
Model 2			
Age	.04	-.04	.17 [*]
Memory	-.26 [*]	-.28 [*]	-.24 [*]
Executive	-.08	-.13	-.11
Working Memory	-.23 [*]	-.14	-.24 [*]
Speed	-.15	-.27 [*]	-.08
R ²	.30	.38	.26
F for R ²	14.52 ^{**}	18.96 ^{**}	16.65 ^{**}
Total R ²	.37	.44	.40

Note. Standardized Beta Coefficients presented for predictors.

^{*}
 $p < .05$

^{**}
 $p < .001$.