Published in final edited form as:

Neuropsychology. 2012 September ; 26(5): 631–641. doi:10.1037/a0029352.

Naturalistic Assessment of Everyday Functioning in Individuals with Mild Cognitive Impairment: The Day Out Task

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Abstract

Objective—The Day Out Task (DOT), a naturalistic task that requires multitasking in a real-world setting, was used to examine everyday functioning in individuals with mild cognitive impairment (MCI).

Method—Thirty-eight participants with MCI and 38 cognitively healthy older adult controls prioritized, organized, initiated and completed a number of subtasks in a campus apartment to prepare for a day out (e.g., determine and gather change for bus, bring a magazine). Participants also completed tests assessing cognitive constructs important in multitasking (i.e., retrospective memory, prospective memory, planning).

Results—Compared to controls, the MCI group required more time to complete the DOT and demonstrated poorer task accuracy, performing more subtasks incompletely and inaccurately. Despite poorer DOT task accuracy, the MCI and control groups approached completion of the DOT in a similar manner. For the MCI group, retrospective memory was a unique predictor of the number of subtasks left incomplete and inaccurate, while prospective memory was a unique predictor of DOT sequencing. The DOT measures, but not the cognitive tests, were predictive of knowledgeable informant report of everyday functioning.

Conclusions—These findings suggest that difficulty remembering and keeping track of multiple goals and subgoals may contribute to the poorer performance of individuals with MCI in complex everyday situations.

Keywords

Ecological Assessment; Instrumental Activities of Daily Living; Multitasking; Dementia; Memory; Planning

The ability to multi-task, or perform concurrent tasks or jobs by interweaving, has been said to be at the core of competency in everyday life (Burgess, 2000). For example, consider the multiple shifts between tasks that can occur when preparing a meal, such as coordinating gathering the spices with chopping the celery, monitoring to see if the water has boiled, and remembering to begin sautéing the onions when the water boils. Although neuropsychologists are often asked to predict everyday functioning from cognitive test performance (Marcotte, Scott, Kamat, & Heaton, 2010), many standardized neuropsychological tests measure a particular cognitive domain (e.g., retrospective memory) using isolated tasks (e.g., list learning) in artificial environments (e.g., laboratory). The correspondence between cognitive resources tapped under such strict administration

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conditions and those that occur in most real-world situations where performance of several tasks may be required and the environment may serve as a cue has been repeatedly questioned (Burgess, 1997; Burgess, Alderman, Evans, Emslie, & Wilson, 1998; Chaytor, Schmitter-Edgecombe, & Burr, 2006). In this study, we examine everyday functioning in individuals with mild cognitive impairment (MCI) by having them complete a naturalistic task that requires multitasking in a real-world setting.

MCI, often considered an early transition stage between normal cognitive aging and dementia (Petersen & Morris, 2005; Winblad et al., 2004), has been associated with impairments in completing complex everyday activities (e.g., finances and medication management; Allaire, Gamaldo, Ayotte, Sims, & Whitfield, 2009; Schmitter-Edgecombe, Woo, & Greeley, 2009; Triebel et al., 2009). To date, much of our understanding of everyday activity completion in the MCI population has come from proxy measures of real-world functioning including self-report, informant-report and performance-based behavioral simulation measures. Each method has distinct advantages and disadvantages. For example, while self-report and informant-report questionnaires may give a reasonably accurate representation of real-world performance given the opportunity for multiple observations, both are subject to reporter bias, which may be especially problematic when working with individuals who lack full awareness of their difficulties (Bertrand & Willis, 1999; Dassel & Schmitt, 2008; Richardson, Nadler, & Malloy, 1995). Furthermore, while performance-based behavioral simulation measures [e.g., Revised Observed Test of Daily Living (Diehl et al., 2005); Test of Everyday Functional Abilities (Cullum et al., 2001)] are objective, quantifiable, repeatable and norm-referenced, they typically require completion of one task at a time (e.g., dialing the telephone, making change) and are conducted in an artificial laboratory environment (Marson & Hebert, 2006; Myers, Holliday, Harvey, & Hutchinson, 1993; Zimmerman & Magaziner, 1994).

In everyday life, successful multitasking requires the ability to draw on a range of cognitive processes acting together to accomplish multiple goals or multi-layered goals (Logie, Law, Trawley, & Nissan, 2010). Prior research suggests that retrospective memory (i.e., learning and remembering of task contingencies), prospective memory (i.e., realization of delayed intentions) and planning represent three essential elements that are involved in multitasking (Burgess, Veitch, Costello, & Shallice, 2000; Logie et al., 2010). Furthermore, both planning and prospective memory are thought to draw upon the products of the retrospective memory resources (Burgess, 2000). While episodic memory impairment is the most prominent symptom associated with amnesic MCI, recent research suggests that prospective memory and planning abilities may also be diminished in persons with MCI (Espinosa et al., 2009; Schmitter-Edgecombe et al., 2009; Werner, Rabinowitz, Klinger, Korczyn, & Josman, 2009; Zhang, Han, Verhaeghen, & Nilsson, 2007). In addition, prospective memory and planning/executive functioning deficits have been helpful in distinguishing individuals with MCI from cognitive healthy older adults and in predicting conversion from MCI to dementia (Blanco-Campal, Coen, Lawlor, Walsh, & Burk, 2009; Bozoki, Giordani, Heidebrink, Berent, & Foster, 2001; Duchek, Balota, & Cortese, 2006; Jones, Livner, & Bäckman, 2006; Rozzini et al., 2007). These findings imply that individuals with MCI should experience difficulties with everyday multitasking situations.

In the MCI literature, aside from driving (Wadley et al., 2009), studies have not used direct observation methods in everyday environments to examine performance on more open-ended and ill-structured tasks that require multitasking abilities. Wadley et al. (2009) found that, in comparison to controls, participants with MCI demonstrated subtle functional decrements in both discrete (e.g., making left-hand turns, maintaining proper speed) and overall driving skills and behavior, but these differences were not at the level of frank impairment. Several studies have directly observed individuals with MCI completing

complex activities of daily living, such as making toast and coffee or completing complex financial tasks (e.g., checkbook management), within the laboratory environment (Giovanetti et al., 2008; Griffith et al., 2003). The findings from these studies generally suggest preserved task knowledge in individuals with MCI with difficulties related to applying the task knowledge to the efficient execution of everyday tasks.

One direct observation task that has been used with patients with brain injury to assess everyday multitasking is the Multiple Errands Test (MET, Shallice & Burgess, 1991). Participants are given an instruction sheet and asked to complete a number of tasks in a shopping precinct (e.g., buy a loaf of bread) while following a set of rules (e.g., only enter a shop to buy something). Shallice and Burgess (1991) found that patients showed a variety of errors on the MET, including breaking rules, leaving items unfinished, and forgetting to carry out prospective memory items. They concluded that the patients had a problem with implementing and/or keeping track of their intentions to swap to other tasks.

The primary aims of this study were: (1) to assess everyday functional ability in an MCI population using a novel, naturalistic task that involves multitasking, which we call the “Day Out Task” (DOT), (2) to increase understanding of the nature of the relationship between cognitive predictors (i.e., retrospective memory, prospective memory and planning) and MCI participants’ performances on the ill-structured, naturalistic DOT task, and (3) to determine whether cognitive predictors or DOT variables better predict knowledgeable-informant report of everyday functional status. Individuals with MCI and cognitively healthy older adults completed a variety of subtasks designed to prepare for a day out with a friend (e.g., determine amount of money and gather change needed for a bus ride, bring a magazine to read). They were told to multi-task and interweave the tasks in order to complete the tasks in a way that feels natural and most efficient. Consistent with the definition of multitasking, completion of the DOT required prioritization of competing demands and the creation, maintenance, and activation of delayed intentions, as well as the ability to switch between tasks. For example, when completing the DOT, participants had to prioritize, organize and initiate a number of different subtasks. They also had to decide for themselves when they would realize delayed intentions and when they had reached completion of each subtask and the overall task.

We hypothesized that individuals with MCI would perform more poorly on the DOT, and difficulties with retrospective memory, prospective memory and planning abilities would uniquely account for difficulties associated with DOT performance. More specifically, while retrospective and prospective memory were hypothesized to be predictive of subtasks being completed inaccurately and incompletely, prospective memory and planning abilities were hypothesized to be associated with task sequencing abilities. We also expected to find a significant relationship between the DOT performance of individuals with MCI and significant other report of everyday functional abilities.

Method

Participants

Participants were 38 persons with MCI (21 female, 17 male) and 38 healthy older adults (27 female, 11 male), age 50 or older. Participants were recruited through advertisements, community health and wellness fairs, physician referrals, referrals from local agencies working primarily with older adults, and from past studies in our laboratory. The initial screening procedure included a medical interview to rule out medical exclusionary criteria, 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 exclude individuals who scored below

27 on the TICS (equivalent to the normality cutoff score of 24 on the Mini Mental Status Exam; Measso, Cavarzeran, Zappalà, & Lebowitz, 1993).

All participants who met initial screening criteria completed a battery of standardized and experimental neuropsychological tests in a laboratory. This evaluation was followed, typically one week later, by an assessment of participants' ability to complete complex activities of daily living within an apartment located on the Washington State University (WSU) campus. Each testing session lasted approximately 3 hours and was usually completed by different examiners. Scoring of all data was completed following the second testing session.

Interview, testing and collateral medical information (results of laboratory and brain imaging data when available) were carefully evaluated to determine whether each participant met clinical criteria for MCI. Inclusion criteria for MCI were consistent with the diagnostic criteria defined by Petersen and colleagues (Petersen et al., 2001; Petersen & Morris, 2005) and with the criteria outlined by the National Institute on Aging-Alzheimer's Association workgroup (Albert et al., 2011). In addition, participants could not endorse symptoms of severe depression as evidence by a Geriatric Depression Scale (GDS) - Short Form (Sheikh & Yesavage, 1986) score < 10. The majority of participants met criteria for amnesic MCI ($N = 33$, nonamnesic $N = 5$), as determined by scores falling at least 1.5 standard deviations below age-matched (and education when available) norms on at least one memory measure. Participants with both single-domain ($N = 17$) and multi-domain ($N = 21$) MCI (attention and speeded processing, memory, language, and/or executive functioning) are represented in this sample. See supplemental materials for additional details regarding study inclusion and exclusion criteria, MCI diagnosis, the neuropsychological tests and measures used in the evaluation of MCI and summary neuropsychological testing data for the MCI and control groups.

Each MCI participant was closely matched with a healthy older adult participant in terms of age ($t < 1$; MCI: $M = 70.58$ years, $SD = 8.60$; controls: $M = 69.34$ years, $SD = 7.95$) and education ($t < 1$; MCI: $M = 15.05$ years, $SD = 2.93$; controls: $M = 15.18$ years, $SD = 2.65$). There was also no significant difference in the gender distribution of the two groups, $\chi^2(1) = 2.04$, $p = .15$. The healthy older adult control participants reported no history of cognitive changes, had a CDR score of 0, and a GDS < 10. Because this study was conducted as part of a larger study (Schmitter-Edgecombe, Parsey, & Cook, 2011), with the MCI and healthy older adult samples recruited and tested during the same time period, the control group represents a subsample of the 168 healthy older adults who best demographically matched the MCI participants.

All participants were given a report documenting their performance on the neuropsychological tests, as well as pre-paid parking passes, as compensation for their time. Participants who traveled to the laboratory from outside Whitman or Latah County were also provided a \$50 voucher for travel reimbursement. This protocol was reviewed and approved by the Institutional Review Board at WSU.

Measures

Day Out Task—Participants completed the DOT within a campus apartment. This task was developed for the purposes of this study. Prior to completing the DOT, participants had completed several other everyday tasks (e.g., sweeping and dusting, watering plants) and were familiar with the apartment layout (e.g., living room, dining room, kitchen) and the location of cupboards and closets. Participants were told to imagine that they were planning for a day out, which would include meeting a friend at a museum at 10:00 am and later traveling to the friend's house for dinner. The eight subtasks that needed to be completed to

prepare for the day out were then clearly explained (see supplemental materials for complete task instructions) and participants were provided with a detailed written list of the subtasks (see Table 1). Participants were also given the opportunity to ask questions. Prior to beginning the DOT, participants were reminded to multi-task and interweave tasks so that the tasks could be completed efficiently.

While participants were completing the DOT, two examiners who were blind to group status remained upstairs, watching participant performances through live feed video and communicating if necessary through an intercom system. As participants completed the DOT, the examiners recorded the time each subtask began and ended, events being interweaved, and subtask goals being completed (e.g., moves to kitchen, retrieves heating pad, microwaves heating pad). Subtask accuracy scores and overall task accuracy and task sequencing scores were later assigned by coders who watched the video. Table 2 provides detailed code assignment information for the subtask accuracy scores (i.e., complete/efficient; complete/inefficient; incomplete/inaccurate; never attempted) as well as the scoring rubrics used to derive an overall task accuracy score and the task sequencing score.

Scoring Reliability—The video data, in conjunction with the examiner recorded data for the DOT, was coded by two scorers working together and then double checked by authors C.M. and A.W. All scorers were blind to group membership. To assess for inter-rater reliability, total discrepancies in scores were summed. Agreement was 96.92% for subtask accuracy scores and 99.27% for task sequencing. A list of potential situations that would result in each of the eight subtasks being coded as complete, inefficient, or incomplete was generated (see Table 2 for general guiding principles for scoring and the supplemental materials for a specific subtask example). If a new situation arose that was not detailed on the master code list, the coders discussed the situation and added the new information to the master list.

Cognitive Variables—The cognitive predictor variables represent three cognitive constructs prior research suggests play an essential role in multitasking (Burgess et al., 2000; Logie et al., 2010): retrospective memory, prospective memory and planning.

Memory Assessment Scale (MAS): Prose Memory subtest—(Williams, 1991). Participants were read a short story, which consisted of 3 sentences and told to remember the story. The story was read one time. Immediately and after a long-delay filled with other tasks, participants were asked to answer nine questions about the story (e.g., What color was the car?). The total of the nine questions correctly answered about the story at the long-delay was used as the measure of retrospective memory.

Activity-Based Multiple Memory Processes Paradigm: Prospective Memory Test—(Schmitter-Edgecombe et al., 2009). The stimuli for this task included eight neuropsychological tests (e.g., Trail Making Test, Boston Naming Test) that each lasted between 3-15 minutes in length. Prior to beginning the sequence of eight neuropsychological tests, participants were told we wanted to see how well they could remember to do something in the future without being reminded. They were asked to pretend that they needed to give pain medication to a friend several times during the course of the next hour. Participants were told that following completion of each activity they would be asked to rate how challenging they found the task on a scale from '1' (fairly easy) to '5' (very challenging). After completing the task challenge rating for the activity, they were to remember to ask the examiner for the pill bottle so that their friend could receive the pain medication. The pill bottle was kept out of sight during completion of the activities. The first activity (i.e., neuropsychological test) did not begin until it was clear that the participant

understood the prospective memory instructions. No future reference to the prospective memory task was made once the first activity began. Prospective memory was represented by the number of times (eight maximum) that the pill bottle was correctly requested.

Behavioral Assessment of the Dysexecutive Syndrome (BADS): Zoo Map subtest—(Wilson, Alderman, Burgess, Emslie, & Evans, 1996). Participants were given a map of a zoo along with a list of instructions stating places they had to visit (e.g., bird sanctuary, picnic area) and rules they had to follow (e.g., only taking one camel ride). Participants completed both a high demand condition that required the participant to formulate a planned route to take through the zoo and a low demand condition that required the participant to execute a predetermined route. The Zoo Map was scored in accordance with the standardized instructions of the BADS battery (Wilson et al., 1996). The Zoo Map profile score (four maximum) was used as the measure of planning.

Everyday Functional Status Measure

Knowledgeable Informant report about Instrumental Activities of Daily Living (IADLs)

Knowledgeable informants completed an interview consisting of 50 questions (e.g., uses a telephone book, address book or directory assistance to look up unfamiliar numbers) which indexed the following ten IADL domains: using the phone, traveling, shopping, preparing meals, household activities, conversation, organization, social functioning, medication management, and financial management. Knowledgeable informants rated participant skill level (capacity) for each IADL domain using a Likert scale, ranging from '1' (independent, as well as ever, no aid) to '8' (not able to complete activity anymore). Categories for indicating that the participant "does not need to complete the activity" or that there is "no basis for judgment" were also presented. The 50 questions were averaged to provide a total score. Sixty-six informants completed the interview (N = 36 MCI, N = 30 controls); 65% of the informants were spouses/partners, 23% were children, 5% were friends, 3% were niece/nephew, 2% were siblings, and 2% were grandchildren.

Results

Analyses

T-tests were used to compare the MCI and control groups on the predictor and functional status variables. T-tests were also used to compare group performances on the DOT measures. In cases where the assumption of normality was not met, the non-parametric Mann-Whitney U Test was used. Effect sizes (Cohen's d) were calculated to indicate the relative strength of significant group differences and can be found in Tables 3 and 4. Hierarchical regression analyses were used to examine the relationship between cognitive predictors (i.e., retrospective memory, prospective memory and planning) and DOT task performances and everyday functioning as measured by knowledgeable informant report. Given the small sample size, the number of demographic variables that were controlled for in the first block of the regressions was reduced by first examining for significant correlations between the demographic factors and the criterion variables. The cognitive predictors were then entered simultaneously in the second block.

Cognitive Predictor and Functional Status Data

Table 3 shows the mean summary data for the cognitive predictor variables (i.e., MAS delayed prose recall, Activity Paradigm prospective memory, and Zoo Map profile score) and for the functional status measure. Cohen's d effect sizes are also reported. T-tests revealed that the MCI group performed more poorly than the healthy older adult controls on all three cognitive predictor variables. In addition, knowledgeable informants reported more

difficulties with complex everyday activities for the individuals with MCI relative to the healthy older adult controls.

Day Out Task

The means and standard deviations for the measures derived from the DOT can be found in Table 4. Cohen's d effect sizes are also reported. Because the MCI and control groups significantly differed in Shipley vocabulary performance, before comparing across groups, we checked to see whether there were any significant correlations between the DOT measures and performance on the vocabulary test. Correlational analyses revealed no significant relationships for either the MCI group, r 's between $-.29$ and $.30$, p 's $> .05$, or the control group, r 's between $-.10$ and $.17$, p 's $> .05$.

As can be seen in Table 4, t -tests conducted on the DOT measures revealed no significant difference between the MCI group and the cognitively healthy control group in the amount of time participants took to plan for the DOT, $t = 1.01$. However, the time needed for the MCI participants to complete the DOT was longer than that required by controls, $t(74) = 2.59$, $p = .01$. In addition, the overall accuracy score derived for DOT performance, which ranged from "1" all eight tasks completed efficiently to "5" more than four tasks left incomplete/inaccurate or not attempted (see Table 2), was poorer for the MCI participants relative to controls, $t(74) = 2.68$, $p < .01$. Examination of the individual data revealed that while nearly half (45%) of the MCI participants showed significantly compromised completion of the DOT task by leaving three or more of the eight subtasks incomplete/inaccurate or not attempted (see Table 2), only 13% of the control participants made a similar level of error.

To assess for group differences in DOT subtask completion, comparisons were made between the MCI and control group in the number of subtasks left complete/efficient, complete/inefficient, incomplete/inaccurate, and never attempted. Analyses were conducted using both parametric (t -tests) and non-parametric (Mann-Whitney U Test) statistics as the number of subtasks incomplete/inaccurate was not normally distributed for the control group and the number of subtasks not attempted was not normally distributed for either group. Both type of analyses revealed identical findings and the t -test statistics are reported below. As can be seen in Table 4, the MCI group completed fewer subtasks labeled as complete/efficient, $t(74) = -2.59$, $p = .01$, and more subtasks labeled as incomplete/inaccurate, $t(74) = 2.85$, $p < .01$. There were no group differences in the number of the eight subtasks labeled as complete/inefficient, $t(74) = -.13$, or that were never attempted, $t(74) = .77$. Of note, few subtasks were never attempted by the MCI ($M = .18$) and control ($M = .16$) participants, with both groups initiating nearly all of the eight subtasks. Evaluation of the individual subtask data revealed that with the exception of the magazine, medication and exit subtasks, more than twice as many individuals in the MCI group left the remaining five subtasks incomplete and inaccurate compared to the control group. The pattern of data indicates that while both groups began a similar number of subtasks, compared to controls, the MCI group completed fewer subtasks efficiently and accurately and more subtasks incompletely and inaccurately.

Next we turn to the question of whether the poorer performance of the MCI group was related to difficulties with sequencing the subtasks. Analysis of the DOT sequencing score revealed no significant differences between the MCI ($M = 3.53$) and control ($M = 3.74$) groups in task sequencing, $t = -.74$. There were also no group differences on any of the six correct activity sequences that made up the DOT sequencing score (see Table 2), χ^2 's(1) $< .49$, p 's $> .05$. In addition, the MCI ($M = 4.87$) and control ($M = 5.29$) groups did not differ in the number of the eight subtasks that were interweaved during DOT completion, $t(74) = .$

58. These findings suggest that poorer task sequencing does not account for the MCI group's poorer DOT performances.

Regression Analyses

Hierarchical regression analyses were completed to identify whether measures of retrospective memory (RM: MAS delayed prose memory), prospective memory (PM: Activity Paradigm) and planning (Zoo Map profile score) could predict performance on the DOT for the MCI group. The following primary outcome measures from the DOT, representing different domains of performance, were examined: total time, overall task accuracy score, subtasks incomplete/inaccurate, and sequencing score. Correlations amongst the predictor and criterion variables can be found in Table 5. To reduce the number of predictor variables included in the regression analyses, we first examined correlations between the demographic factors of age, education and gender and the DOT measures and predictor variables. As can be seen in Table 6, there were no correlations between the demographic variables and the cognitive predictors. If age, education or gender significantly correlated with the DOT outcome measure (see Table 6), it was entered in the first block of the regression. The three cognitive predictor variables were then entered simultaneously in the next block to determine if they held any unique and predictive value for each of the DOT measures. There was no multicollinearity amongst the three cognitive predictor variables, as the Variance Inflation Factors for each variable were less than 1.3. Sample size for the regression analyses was 35 as three of the MCI participants did not complete the Zoo Map test.

Age accounted for significant variance in DOT total time, $R^2 = .26$, $F(1, 32) = 11.45$, $p = .002$. When the cognitive predictors were added [$\Delta F(3, 29) = 2.56$, $p = .07$; total $R^2 = .42$], it was found that age ($B = .46$, $t = 3.14$, $p < .01$) and the RM measure ($B = -.34$, $t = -2.49$, $p < .05$) significantly predicted DOT total time, while the planning ($B = -.16$, $p = .31$) and PM ($B = .20$, $p = .21$) measures did not. For the DOT accuracy score, the cognitive predictors (variance accounted for represented by R^2 change: ΔR^2) did not account for significant variance over and above that accounted for by age and education [$\Delta R^2 = .13$, $\Delta F(3, 28) = 1.95$, $p = .14$; total $R^2 = .39$]. In addition, there were no significant predictors for the DOT accuracy score [B 's: age = .20, education = -.24, RM = -.25, PM = -.19, and planning = -.17, p 's $> .12$]. For the DOT subtask incomplete/inaccurate score, the cognitive predictors accounted for significant variance over and above that accounted for by education [$\Delta R^2 = .19$, $\Delta F(3, 29) = 3.02$, $p < .05$; total $R^2 = .39$]. Both education ($B = -.34$, $t = -2.27$, $p < .05$) and the RM measure ($B = -.33$, $t = -2.12$, $p < .05$) accounted for unique variance, while the PM ($B = -.07$, $p = .66$) and planning ($B = -.19$, $p = .23$) predictors did not. Finally, for the DOT sequencing score, the cognitive predictors accounted for a significant amount of the variance, $R^2 = .33$, $F(3, 30) = 4.89$, $p < .01$, with the PM measure ($B = .51$, $t = 3.02$, $p = .005$), but not the RM ($B = -.01$, $p = .95$) and planning ($B = .16$, $p = .33$) measures, emerging as a unique predictor. These findings suggest that the DOT measures were capturing differing aspects of DOT task performance. While prospective memory was important for task sequencing, retrospective memory was predictive of tasks being completed inaccurately and incompletely.¹

Regression Analyses: Predicting Everyday Functioning

Next we examined whether the DOT measures or the cognitive variables would be more predictive of everyday functioning for the MCI group as measured by knowledgeable

¹All regression analyses were rerun with age, education and gender entered in the first block of the regression followed by the cognitive predictors in the second block. The pattern of data and unique cognitive predictors were the same as those performed with fewer predictor variables given the current sample size (see supplemental materials).

informant report of IADL performance. A total of 36 MCI participants had knowledgeable informant data available for the IADL measure. Because neither age, education, nor gender correlated with the knowledgeable informant IADL measure, these variables were not entered into the regression analyses. Regression analyses revealed that the cognitive predictors did not account for significant variance in knowledgeable informant report of IADL performance, $R^2 = .08$, $F(3, 28) = .84$, $p = .49$. There were also no unique cognitive predictors of IADL performance [B 's: RM = $-.09$, PM = $-.12$, and planning = $-.18$, p 's $> .35$]. In contrast, the four DOT measures were found to account for significant variance, $R^2 = .35$, $F(4, 29) = 4.13$, $p = .008$, with the sequencing score ($B = -.62$, $t = -3.83$, $p = .001$) emerging as the only unique predictor [DOT B 's: total time = $.11$, accuracy score = $-.10$, and incomplete/inaccurate score = $-.33$, p 's $> .44$]. In addition, when the DOT measures were entered in the second block of the regression following the cognitive predictors, the DOT sequencing score remained the only unique predictor of IADL performance, $B = -.45$, $t = -1.99$, $p = .05$; total $R^2 = .32$; $\Delta R^2 = .24$.²

Discussion

Most traditional neuropsychological tests assess isolated cognitive abilities in artificial environments and have uncertain predictive validity, especially with regards to real-world functioning (Burgess et al., 2006; Goldstein, 1996). In this study, we assessed the ability of individuals with MCI to prepare for a day out using the DOT, which requires prioritization, organization, and maintenance of multiple goals and subgoals in a real-world setting. We also sought to identify cognitive correlates (i.e., retrospective memory, prospective memory, and planning) of performance on the DOT for individuals with MCI, and to determine whether the cognitive correlates or DOT measures were better predictors of knowledgeable informant report of everyday functional status.

We found that individuals with MCI performed more poorly than cognitively healthy controls on the naturalistic DOT. This is consistent with data derived from self- and informant-report questionnaires and performance-based laboratory tests, which suggest that individuals with MCI experience difficulties completing complex everyday activities (e.g., financial and medication management; Griffith et al., 2003; Schmitter-Edgecombe et al., 2009; Tabert et al., 2002). The poorer DOT performance of the MCI group was reflected in the time it took for DOT task completion and in overall DOT task accuracy. When compared to controls, the MCI group also completed significantly fewer subtasks completely and efficiently while completing significantly more subtasks incompletely and inaccurately. The groups did not differ in the number of subtasks completed inefficiently.

Despite the poorer DOT task accuracy of the MCI participants, the MCI and cognitively healthy control groups generally approached the DOT in a similar manner. This is supported by findings of no group differences in the number of DOT subtasks initiated, the number of DOT subtasks interweaved and the DOT sequencing score. Consistent with prior studies that have directly evaluated performances of individuals with MCI on everyday tasks within the laboratory (Giovannetti et al., 2008; Griffith et al., 2003), the MCI participants appeared to have knowledge of what to do for the DOT but were not always capable of using that knowledge to completely and accurately reach the task goals and subgoals.

²The three regression analyses predicting everyday functioning were rerun with age, education and gender entered in the first block. The pattern of data and unique cognitive predictors were the same as those performed with fewer predictor variables due to sample size. Even after controlling for both demographic and cognitive predictors in the first two blocks of the analyses, the DOT sequencing score remained the only unique predictor of IADL performance, $B = -.63$, $t = -2.30$, $p < .05$; total $R^2 = .37$; ΔR^2 with cognitive predictors = $.10$; ΔR^2 with DOT measures = $.26$.

One prominent model of multitasking suggests that there are different cognitive systems involved in multitasking that interact (Burgess et al., 2000), namely retrospective memory, prospective memory and planning. Results from the regression analyses showed that retrospective memory was predictive of the number of subtasks left incomplete and inaccurate by the MCI participants. This appears consistent with the model of multitasking put forth by Burgess et al. (2000), which suggests that retrospective memory (important for task and task rules) drives both planning and intentionality. If an individual has difficulty remembering and keeping track of multiple goals and subgoals, it will likely become more difficult to prospectively implement intentions or to plan for further task completion resulting in subtasks being left incomplete or completed inaccurately. Prior studies have identified memory impairment as one of the more significant cognitive determinants that limit autonomy in complex daily activities for persons in the early stages of dementia (e.g., Farias, Mungas, & Jagust, 2005; Kazui et al., 2005; Tuokko, Morris, & Ebert, 2005).

Regression analyses further revealed that prospective memory emerged as a unique predictor of DOT task sequencing. It stands to reason that if delayed intentions cannot be realized at the proper time, task sequencing will be affected. Consistent with research suggesting that there are different cognitive systems involved in multitasking (Burgess, 2000; Burgess et al., 2000; Cook, 2008), these data suggest that the DOT measures may be capturing different aspects of multitasking performance that may rely more or less significantly on different underlying cognitive processes. Although additional research is needed, we recently found a uniquely different pattern of data suggestive of executive functioning difficulties, when comparing the performances of younger and older adults on the DOT (McAlister, Tam, & Schmitter-Edgecombe, 2011). More specifically, when compared to younger adults, older adults showed poorer DOT sequencing. There were no group differences in the number of tasks left incomplete and inaccurate. However, the older adults performed more subtasks completely but inefficiently while the younger adults performed more subtasks both completely and efficiently. This may suggest that while executive difficulties may lead to some problems with the efficiency of everyday task performances, more significant impairments with everyday activities (e.g., incomplete/inaccurate performances) may occur once memory becomes significantly impaired.

We also examined whether the naturalistic DOT would be more predictive than the cognitive correlates of everyday functional status as measured by knowledgeable informant report of IADLs. Across prior studies, the variance in functional status that has been attributed to cognitive correlates has widely varied (e.g., 0% to 80%; Royall et al., 2007). We found that the cognitive predictors (retrospective memory, prospective memory and planning) did not account for significant variance (8%) in knowledgeable-informant report of MCI participants' IADL performances. In contrast, the DOT measures accounted for significant variance (35%), with the task sequencing score emerging as a significant predictor. Furthermore, the DOT sequencing score continued to emerge as a significant predictor even after the cognitive (and demographic) predictors were controlled for in the regression analysis. These results are consistent with a recent study which found that a direct observation measure of older adults performing IADL activities was predictive of self-reported IADL performance, while neuropsychological tests assessing general cognitive functioning, speeded processing, memory, visuo-perceptual abilities and executive functioning were not (Schmitter-Edgecombe et al., 2011).

Currently, there is no "gold standard" for clinically assessing everyday functional status. In the research literature, self-report, informant-report and performance-based measures have all been used as proxies for real-world functioning. The question of which method for assessing everyday functional status most closely approximates actual real-world behavior currently remains debatable (Farias, Harrell, Neumann, & Houtz, 2003). It has been argued

that direct observation of individuals within the everyday environment will likely provide the most valid determination of everyday functional status (Marcotte et al., 2010). While this study afforded an opportunity to collect direct observation data within an everyday environment, participants were not tested in their own homes nor were repeated measurements of the same everyday activities collected.

In a recent study, our laboratory found that two proxy measures of everyday status (i.e., self-report of IADLs and a performance-based test), which did not correlate with each other, were both significant predictors of everyday functioning in healthy older adults (Schmitter-Edgecombe et al., 2011). The everyday functioning measure was derived from direct observation of older adults completing eight complex activities of daily living (e.g., filling a medication dispenser, watering plants) within the WSU apartment. We hypothesized that both assessment methods may be measuring different aspects of everyday performance, with the self-report measure tapping into knowledge gained through multiple experiences completing everyday tasks and the performance-based measure (i.e., the Everyday Problems Test, Willis & Marsiske, 1993) tapping into the ability to use and apply everyday problems. Future research should continue to work towards development of a quick, efficient and reliable measure of everyday functioning that can be given in the office environment. Comparing naturalistic assessments with IADL questionnaire responses, performance-based measures and cognitive tests may assist with this endeavor. Another important future question is whether early impairments in everyday abilities could be detected using more complex, multi-tasking situations. In addition, the question of whether such measures could be used to predict who is most likely to transition to dementia should be explored.

Regarding study limitations, our sample of MCI and cognitively healthy older adult controls was predominantly Caucasian, highly educated, and reported low rates of depressive symptomology. They were also diagnosed in a research laboratory using criteria defined by Petersen and colleagues. This contrasts with other clinical and community-based samples in the literature and limits the generalizability of our results. Findings from the regression analyses were also limited by study sample size and to the specific neuropsychological measures chosen as the predictor variables to represent the cognitive constructs of retrospective memory, prospective memory and planning. In addition, although drawing on common everyday skills, the DOT is a novel task which may have required participants to perform subtasks that they had not encountered before. Furthermore, all subtasks were clearly written on a list and available to participants, which is different from many real-world situations. It is possible that multitasking in highly familiar, premorbidly practiced situations or in those that do not involve access to a list might show a different pattern of findings.

In conclusion, this work was conducted in a simulated home environment, providing a more naturalistic and ecologically valid format for assessment of everyday activities and multitasking. Although the MCI participants initiated and sequenced critical aspects of the DOT in a manner similar to controls, it took them longer to complete the DOT and more subtasks were left incomplete and inaccurate. Reduced retrospective memory difficulties were predictive of the number of subtasks left incomplete and inaccurate, suggesting that difficulty remembering and keeping track of multiple goals and subgoals may have contributed to the poorer performance of the MCI group. This data suggests that individuals with MCI will likely require extra time when completing complex everyday tasks, especially when a degree of novelty is involved. In addition, reducing demands on retrospective memory by using lists and checking tasks and subtasks off as they are completed, may prove helpful.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This study was partially supported by grants from the Life Science Discovery Fund of Washington State; NIBIB (Grant #R01 EB009675); and NSF (Grant DGE-0900781) to M.S.E. No conflicts of interest exist. We thank Chad Sanders and Jennifer Walker for their assistance in coordinating data collection. We also thank members of the Aging and Dementia laboratory for their help in collecting and scoring the data.

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Table 1

List of Goals Given to Participants to Assist with Completion of the Day Out Task.

Day Out Task
The activities below can be completed in any order. Please multi-task and interweave to complete the tasks in an efficient and natural way. When you have finished the tasks, take the picnic basket to the front door. ^a
Gather correct change from organizer on dining room table for the bus ride.
Take motion sickness medication "Dramamine" located in kitchen cupboard "A" just prior to leaving the house.
Plan bus route, determine time needed for the trip, cost of bus fare, and time that must leave house to make bus (it takes 15 minutes to walk to bus stop).
Microwave heating pad located in kitchen cupboard "B" for 3 minutes to take on bus.
Choose a magazine on coffee table for the bus ride.
Pack all items in a picnic basket, which can be found in the hallway closet labeled "clothes closet."
^b Gather recipe items from kitchen cupboard "A" and refrigerator.
^b Locate recipe for "Spaghetti" in recipe book, which is located in kitchen cupboard "B."
Total time for bus trip: _____
Cost of bus fare: _____
Time must leave house to get to museum by 10:00 a.m. (note: it takes 15 minutes to walk to the bus stop) _____

Note: List was printed in 22 inch Times New Roman font

^a counted as "exit" subtask

^b counted as one subtask: "recipe book and ingredients"

Table 2**Coding Schema Used to Derive Measures for the Day Out Task**

Subtask Completion Score (assigned for each of the 8 subtasks)	
1	= <i>Complete/Efficient</i> . Assigned when subtask completed accurately and efficiently.
2	= <i>Complete/Inefficient</i> . Assigned when subtask completed in a way that the overall DOT goal can be met but subtask completion is inefficient (e.g., pretends to take pill too early, carries items to front door in hand rather than picnic basket, gathers more items than needed for recipe, searches multiple locations for items).
3	= <i>Incomplete/Inaccurate</i> . Assigned when subtask is left incomplete (e.g., fails to pack gathered item in picnic basket, fails to pretend to take pill, fails to remove heating pad from microwave) or is completed inaccurately (e.g., fails to retrieve enough change for bus, pretends to take wrong pill, grabs reading material other than magazine for bus ride).
4	= <i>Never Attempted</i> . Assigned when subtask failed to be initiated.
<i>Overall Task Accuracy Score</i>	
1	= All eight tasks completed efficiently
2	= All eight tasks completed; either efficiently or inefficiently.
3	= One or two tasks left incomplete/inaccurate or not attempted, the remainder completed either efficiently or inefficiently.
4	= Three or four tasks left incomplete/inaccurate or not attempted, the remainder completed either efficiently or inefficiently.
5	= More than four tasks left incomplete/inaccurate or not attempted, the remainder completed either efficiently or inefficiently.
<i>Task Sequencing Score</i>	
Number of six activities correctly sequenced.	
1	Heating pad started as one of first four activities.
2	Picnic basket retrieved as one of first four activities.
3	Cost of bus route determined prior to first attempt at retrieving change.
4	Recipe read prior to retrieving food items.
5	Dramamine pill taken within the last 2 minutes of task.
6	Picnic basket moved to front door as one of last two activities.

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Table 3

Mean Summary Data for the Cognitive Predictor Variables and the Functional Status Measure for the Mild Cognitive Impairment (MCI) and Healthy Older Adult Control Groups

Task Measures	MCI		Control		Cohen's d
	Mean	SD	Mean	SD	
<i>Cognitive Predictors</i>					
RM: MAS Prose Memory	4.84 ^a	1.46	6.29	1.41	1.01 ^{**}
PM: Activity Paradigm	4.55	3.53	6.36 ^b	2.39	.60 ^{**}
Planning: BADS Zoo Map	1.83 ^c	1.04	2.40 ^c	1.14	.53 [*]
<i>Everyday Functional Status</i>					
KI/IADL Interview [#]	1.68 ^b	.68	1.36	.59	.50 [*]

Notes. RM = Retrospective Memory; MAS = Memory Assessment Scale; PM = Prospective Memory; BADS = Behavioral Assessment of the Dysexecutive Syndrome; KI = Knowledgeable Informant; IADL = Instrumental Activities of Daily Living.

[#] Lower score represents better performance.

^a Data available for 37 participants.

^b Data available for 36 participants.

^c Data available for 35 participants.

^{*} *p* .05,

^{**} *p* < .01

Table 4
Mean Summary Data for the Day Out Task for the Mild Cognitive Impairment (MCI) and Healthy Older Adult Control Groups

Task Measures	MCI		Control		Cohen's d
	Mean	SD	Mean	SD	
DOT Test Variables					
Overall Task					
Planning Time (sec)	47.17	44.69	37.89	31.00	.24
Completion Time (min)	14.29	4.92	11.71	3.65	.60**
Accuracy Score [#]	3.26	1.13	2.63	0.91	.61**
Sequencing Score	3.53	1.25	3.74	1.25	.17
Tasks Interweaved	4.87	1.16	5.29	1.07	.38
Subtask Completion Scores					
Complete/Efficient	3.26	1.81	4.37	1.91	.60**
Complete/Inefficient [#]	2.39	1.67	2.45	1.75	.04
Incomplete/Inaccurate [#]	2.16	2.00	1.03	1.40	.65**
Never Attempted [#]	0.18	0.61	0.16	0.68	.03

Notes. See Table 4 for coding schema.

[#] Lower score represents better performance.

* $p < .05$,

** $p < .01$

Table 5

Correlations between the Day Out Task Measures and the Cognitive Predictors and Functional Status Measure for the Mild Cognitive Impairment (MCI) Group.

Variables	1	2	3	4	5	6	7	8
1. Total time [#]	---							
2. Accuracy Score [#]	.45*	---						
3. Incomplete/Inaccurate [#]	.35*	.86**	---					
4. Sequencing Score	-.28	-.63**	-.42*	---				
5. Retrospective Memory (MAS Prose Recall)	-.31	-.39*	-.46**	.20	---			
6. Prospective Memory (Activity Paradigm)	-.22	-.32*	-.36*	.60**	.36*	---		
7. Planning (BADS Zoo Map)	-.29	-.40**	-.34*	.30	.19	.34*	---	
8. Functional Status [#] (KI IADL interview)	.18	.25	.13	-.57**	-.24	-.30	-.23	---

Notes. Total correct raw score was used for all neuropsychological measures. MAS = Memory Assessment Scale; BADS = Behavioral Assessment of the Dysexecutive Syndrome; KI = Knowledgeable Informant; IADL = Instrumental Activities of Daily Living.

[#] Lower score represents better performance.

* $p < .05$;

** $p < .005$

Table 6

Correlations between Demographic Variable and the Day Out Task Measures, Cognitive Predictors and Functional Status Measure for the Mild Cognitive Impairment (MCI) Group.

Variables	Demographic Variable		
	Age	Education	Gender
DOT Total Time [#]	.51 **	-.14	.15
DOT Accuracy Score [#]	.35 *	-.39 *	.10
DOT Incomplete/Inaccurate [#]	.29	-.41 *	.11
DOT Sequencing Score	-.17	.10	.00
Retrospective Memory (MAS Prose Recall)	-.17	.13	.14
Prospective Memory (Activity Paradigm)	-.23	.08	.30
Planning (BADS Zoo Map)	-.25	.24	-.02
Functional Status [#] (KI IADL interview)	.18	-.09	.11

Notes. Total correct raw score was used for all neuropsychological measures. MAS = Memory Assessment Scale; BADS = Behavioral Assessment of the Dysexecutive Syndrome; KI = Knowledgeable Informant; IADL = Instrumental Activities of Daily Living.

[#] Lower score represents better performance.

* $p < .05$;

** $p < .005$