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Insight into Memory and Functional Abilities in Individuals with Amnestic Mild Cognitive Impairment

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Abstract

Objective: Accurate insight into one's abilities facilitates engagement in rehabilitation and implementation of compensatory strategies. In this study, self-awareness, self-monitoring, and a new self-updating construct of insight were examined in amnestic mild cognitive impairment (aMCI).

Method: Individuals with aMCI and healthy older adults (HOAs) completed a list-learning task in a laboratory setting, and a naturalistic task of everyday functioning in a campus apartment along with other standardized neuropsychological tests. Participants made predictions about performance on the memory and functional tasks prior to task experience (self-awareness), immediately after task experience (self-monitoring), and after a delay (self-updating).

Results: Individuals with aMCI performed more poorly than HOAs on the memory task and other neuropsychological tests but not the functional task. For both the memory and functional task, performance predictions and prediction accuracy measures revealed that the aMCI group exhibited intact self-awareness, self-monitoring and self-updating. Prediction accuracy measures showed some association with an executive composite but not a memory composite.

Discussion: Participants with aMCI demonstrated intact self-awareness, self-monitoring, and self-updating for a memory and functional task despite exhibiting poorer performance on neurocognitive tests compared to HOAs. These findings suggest that, even as memory in aMCI degrades, executive abilities may help sustain insight into difficulties, enabling adoption of cognitive strategies to support difficulties.

Keywords

metamemory; self-awareness; self-monitoring; self-updating; performance discrepancy paradigm

Introduction

Having insight into one's memory and functional abilities allows an individual to assess their strengths and limitations when approaching a task, plan their behavior accordingly, and update knowledge of their abilities based on experience. Understanding the degree of insight that individuals with cognitive impairment have into their abilities is important, as accurate

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insight promotes engagement in rehabilitation and implementation of compensatory strategies. Insight is commonly comprised of two components: self-awareness and self-monitoring. *Self-awareness* relates to declarative knowledge an individual has about their abilities, such as how impairment may affect performance on a task (Fleming, Strong, & Ashton, 1995). *Self-monitoring* involves using task experience to track one's abilities (Toglia & Kirk, 2000), at least temporarily. Recent models of insight (see Morris & Mograbi, 2013) suggest the influence of a third component reflecting the consolidation of information learned through task-experience into long-term memory, which allows for updating of self-awareness, a construct we refer to as *self-updating*.

Prior research has shown that individuals with dementia due to Alzheimer's disease (AD) may lose insight into how their disease affects their ability to remember information (Morris & Hannesdottir, 2004) or complete everyday activities (Martyr et al., 2012). Little is known, however, about the degree of decreased insight in individuals with amnestic mild cognitive impairment (aMCI), a state of cognitive impairment often seen as prodromal to dementia due to AD given the early decline in episodic memory abilities (Petersen et al., 2001). This study aims to add to the sparse existing literature on insight in aMCI by assessing self-awareness, self-monitoring, and the self-updating constructs of insight in individuals with aMCI.

Current findings regarding self-awareness and self-monitoring in individuals with MCI are mixed (e.g., Collie, Maruff, & Currie, 2002; Seelye, Schmitter-Edgecombe, & Flores). This discrepancy may be due to the heterogeneity of the MCI diagnosis itself (aMCI vs. non-aMCI), or the lack of a "gold standard" for measuring insight. Three common methods for measuring insight include clinical ratings, patient-informant discrepancy, and performance discrepancy.

Clinical ratings involve a clinician interviewing the patient to determine level of self-awareness for deficits. Patient-informant discrepancy involves comparing a self-report of abilities (e.g., managing finances) to an informant's report of an individual's abilities on a parallel form. Both methods can provide an overall assessment about a person's beliefs about their illness status or memory abilities, but these beliefs may be independent from awareness of specific deficits (Morris & Mograbi, 2013; Sunderaraman & Cosentino, 2017). These methods have been described as "offline" assessments of self-awareness, as they measure awareness of abilities in distal proximity to any specific task (Bunnell, Baken, & Richards-War, 1999). Offline assessments have typically found impaired self-awareness of abilities in individuals with MCI (Collie et al., 2002; Galeone, Pappalarado, Chieffi, Iavarone, & Carlomagno, 2011; Vogel 2004).

The third most common method for measuring insight, performance discrepancy, allows for the assessment of both self-awareness and self-monitoring abilities. Performance discrepancy is commonly defined as an "online" assessment, as it measures an individual's insight into specific abilities in close proximity to a related task (Bunnell et al., 1999; Kennedy & Nawrocki, 2003). Individuals are asked to make predictions about their performance on a specific task, and then are asked to perform the task. Both their prediction and the discrepancy between their pre-experience prediction and their actual performance

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provides a measure of self-awareness. After experience with the task, individuals are also asked how they think they would perform on a similar task after a delay, or asked how they think they just performed. These new predictions allow for the measurement of self-monitoring – how an individual uses task experience to update or change predictions. Results using the performance discrepancy paradigm to measure insight have been mixed, finding intact self-awareness (Seelye et al., 2010), intact self-monitoring (Akhtar, Moulin, & Bowie, 2006; Ansell & Buck, 2006; Seelye et al., 2010) and reduced self-awareness and self-monitoring (Galeone et al., 2011) in individuals with MCI.

Use of the performance discrepancy paradigm in individuals with cognitive impairment has led to some interesting findings. For example, studies have shown that even for individuals with dementia due to AD, self-monitoring may remain intact, while self-awareness is impaired (Ansell & Buck, 2006; Duke, Seltzer, Seltzer, & Vasterling, 2002; Moulin, Perfect, and Jones, 2000; Schmitter-Edgecombe & Seelye, 2011). In other words, individuals with AD initially demonstrated poor accuracy when predicting their task performance. However, after gaining experience with the task, they were able to use task experience to increase the accuracy of their performance predictions. Akhtar et al. (2006) found similar results in individuals with MCI. In a study investigated the impact of experience over a longer delay, Stewart and colleagues (2010) found that prediction accuracy in individuals with dementia due to AD was initially poor, increased after task experience, maintained after 20 minutes, but then returned to baseline after one hour. These findings suggest that insight gained through task-experience may be short-lived, and the ability to report on temporally proximal events eventually decays. This hypothesis is supported by Morris and Mograbi (2013) who suggested that impaired insight is a failure to *consolidate* information learned through experience, leading to an inability to *update* self-awareness. The ability to consolidate information learned through task experience to update self-awareness in individuals with dementia due to AD may be limited, based on findings from Stewart et al. (2010), but this ability in individuals with aMCI has yet to be investigated.

It is important to note that performance discrepancy paradigms have typically measured insight in relation to memory abilities, most often utilizing a list-learning task (see Hertzog, Dixon, & Hultsch, 1990; Pearman & Trujillo, 2013; Schmitter-Edgecombe & Seelye, 2011; Seelye et al., 2010). However, it is now known that individuals with MCI also experience subtle difficulties completing complex everyday tasks (Ciro et al., 2015; Petersen et al., 2014; Schmitter-Edgecombe & Parsey, 2014), known as instrumental activities of daily living (IADLs; e.g., cooking, managing finances). Assessing self-awareness and self-monitoring abilities related to everyday functioning may provide a more ecologically valid assessment of insight and its effect on the everyday lives of individuals with aMCI. The few studies that have assessed insight into functional abilities in individuals with MCI have used offline assessments, including clinical ratings (Okonkwo et al., 2009) and patient-informant discrepancy ratings (Farias et al., 2006; Tabert et al., 2002), and found mixed results.

In this study, individuals with aMCI and healthy older adults (HOAs) completed a laboratory list-learning memory task and a naturalistic task of everyday functioning in a campus apartment (i.e., the Day Out Task [DOT], Schmitter-Edgecombe, McAlister, & Weakley, 2012). To evaluate components of insight, participants made predictions about their

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performances prior to the tasks, and after gaining experience with the tasks. We expected that individuals with aMCI would perform more poorly than the HOAs on the memory and functional tasks. Based on prior work (Collie et al., 2002; Galeone et al., 2011; Stewart et al., 2010; Vogel et al., 2004), we hypothesized that (a) individuals with aMCI would have poorer self-awareness of their memory and functional abilities compared to HOAs; (b) individuals with aMCI and HOAs would be able to use task experience to improve prediction accuracy in the short term and exhibit intact self-monitoring for both the memory and functional task; and (c) information learned through task experience would not consolidate for individuals with aMCI, while changes consistent with self-updating would be seen in HOAs.

A secondary aim of the study was to examine cognitive correlates related to insight. Findings have been inconsistent regarding the relationship between insight and cognitive abilities. Available work suggests that executive functioning (Perrotin, Belleville, & Isingrini, 2007; Seelye et al., 2007), and memory processes (Suchy, Kraybill, & Franchow, 2011) play a role in impaired insight. For example, Hannesdottir and Morris (2007) proposed that deficits in executive functioning underlie impaired insight, while deficits in memory processes (i.e., encoding) maintain the impairment. Meanwhile, Perrotin et al. (2007) proposed that self-monitoring may be related to executive functioning, and that individuals with cognitive impairment may use executive functioning to compensate for deteriorating memory abilities. Based on these arguments, we hypothesized that decreased self-awareness and self-updating would be related to deficits in memory processes (i.e., encoding), while decreased self-monitoring would be related to deficits in executive functioning.

Method

Participants

The current study was part of a larger study investigating IADLs in community-dwelling middle-aged and older adults. Participants (aged 50+) were recruited from the community between 2013 and 2017 via advertisements, health fairs, physician referrals, and previous participation in former studies. Participants were screened via phone for significant cognitive impairment using the Telephone Interview for Cognitive status (TICS) to rule out participants who would be unable to complete the assessment (i.e., TICS $\leq$ 20). Exclusionary criteria for this study also included a history of head trauma with period of loss of consciousness, current or recent psychoactive substance abuse, history of cerebrovascular accident, and other known causes of cognitive dysfunction (i.e., epilepsy, multiple sclerosis). If participants were missing data necessary for the study analyses (i.e., prediction data, performance data, neuropsychological data), they were also excluded from this study. From a sample of 43 individuals who met criteria for aMCI, 26 individuals with aMCI had data available for this study. The participants with aMCI were matched by age and education to 26 healthy older adults (HOAs) from a sample of 175 possible HOAs. All participants gave written consent to participate. Participants were given pre-paid parking passes and individuals from outside the immediate area received an additional $50 travel

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reimbursement. For compensation of their time, all participants were given a report of their cognitive performance following completion of testing.

To determine diagnostic status, after all testing was complete two independent neuropsychologists reviewed performance on the neuropsychological tests, participant and informant interviews, and medical records when available. Determination of aMCI was based on Peterson (2004) criteria, and included (a) self-report or knowledgeable informant report of subjective cognitive impairment for 6 or more months, (b) objective cognitive impairment in the memory domain, taking into account intraindividual variability and clinical judgment; observed scores fell 1.5 standard deviations below appropriate norms on average, (c) non-fulfillment of the Diagnostic and Statistical Manual of Mental Disorders for Major Neurocognitive Disorder (DSM-5; American Psychiatric Association, 2013), and (d) absence of severe depression (T-score < 64) as measured by the Patient Reported Outcomes Measurement Information System (PROMIS; Reeve et al., 2007). The sample included participants with both single-domain ($n = 14$) and multi-domain ($n = 12$) aMCI. Inclusion criteria for HOAs included (a) no self or informant report of significant cognitive changes, (b) lack of objective cognitive impairment, and (c) absence of severe depression.

Materials

Neuropsychological and functional assessment.—Participants made predictions (pre-experience, post-experience, and future predictions) about their performances on the following memory and functional tasks.

Memory Test—The Memory Assessment Scale (MAS; Williams, 1991) includes an auditory verbal list-learning and memory task. Participants are presented with 12 words, consisting of four semantic categories (countries, colors, birds, and cities), at a rate of one word per second. The list of words is presented over six trials, or until the participant recalls all 12 words in a single trial. Following a delay of approximately 30 minutes, participants are told to recall the 12 words from memory. Scores for list recall can range from 0 – 12 words.

Functional Task—The Day Out Task (DOT; Schmitter-Edgecombe, McAlister, & Weakley, 2012) is a naturalistic task that asks individuals to multi-task and interweave tasks (e.g., collecting change, gathering items for a recipe) in a naturalistic environment (i.e., campus apartment), to assess everyday functional abilities. The DOT was designed to be sensitive to functional changes characteristic of aMCI, allowing for examination of the frequency of different error types (e.g., inefficiency, substitutions). Examiners asked participants to imagine they were planning for “a day out”, where they would meet a friend at a museum at 10:00 AM, and then later travel to that friend’s house for dinner. Examiners observed participants while they planned, organized, and implemented the eight different subtasks required to prepare for this day out. These subtasks included gathering change, taking medication, planning a bus route, preparing a heating pad, choosing a magazine, locating and gathering items for a recipe, and packing all items in a picnic basket. The completion of these tasks were recorded and later reviewed and scored for errors by video coders. Each subtask was assigned a number score. A score of “1” indicated that a subtask

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was completed accurately and efficiently. A score of “2” indicated that a task was completed, but in an inefficient manner. A score of “3” indicated that a task was incomplete or inaccurate. A score of “4” indicated the task was not initiated. For further detail regarding the DOT, see Schmitter-Edgecombe, McAlister, and Weakly, 2012). These scores were then transformed (a score of 1 became 4, a score of 2 became 3, etc.) to mirror the information given to participants when they made predictions about their performances. The minimum score a participant can receive on the DOT is an “8”, with the highest possible score being a “32”. A perfect score (32) on the DOT means that an individual completed the various tasks in an efficient manner and committed no errors, indicating the ability to simultaneously track, organize, and implement various subgoals individuals may encounter in everyday life.

Neuropsychological tests: correlational analyses.

Verbal Memory Composite.: The Memory Assessment Scale (MAS; Williams, 1991) includes a Verbal Memory Summary Scale, with a mean of 100 and a standard deviation of 15. This measure was used as the verbal memory composite and is comprised of the following MAS subtests: List Recall and Immediate Prose Recall subtests.

Executive Memory Composite.: The mean of the standard scores (mean = 10, standard deviation = 3) from four of the derived scaled scores from the Delis-Kaplan Executive Functioning System subtests were combined to create the executive functioning composite. These included Category Switching, Letter Fluency, Color-Word Interference Inhibition, and Design Fluency Composite.

Procedure

Participants completed a battery of standardized and experimental neuropsychological and functional assessments over two, three-hour testing sessions, held one-week apart. All assessments were scored after completion of the second testing session.

The first testing session was held in a laboratory and included the evaluation of insight into memory. Participants completed some neuropsychological tasks before being provided with a description of the verbal learning and memory task. To avoid use of mid-point anchoring as a strategy, participants received an age-normed anchor (see Connor, Dunlosky, & Hertzog, 1997; Hertzog & Dixon, 1994) and were asked to predict how many of 12-words they thought they would recall after hearing the word list one-time as well as after six repetitions. Next, they were asked to predict how many of 12 words they thought they would retain after a 30-minute delay, which served as the pre-experience memory prediction measure (pre-experience prediction). After the list-learning subtest was administered, giving participants experience with the task, participants again predicted how they thought they would perform after a 30-minute delay (post-experience prediction). Approximately 40 minutes after completing the delayed recall subtask, participants made hypothetical predictions about how they might perform on a similar (same task description provided) memory task in the future (future-experience predictions).

The second testing session included an evaluation of insight into functional abilities, and was conducted in a university apartment. Participants were given a description of an

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upcoming task that would be used to assess their everyday functioning (i.e., DOT). They were then asked to make predictions about how they might perform on the task (pre-experience prediction), using age-normed anchors. After participants completed a number of functional and mobility tasks, the DOT was administered. Following DOT administration, participants predicted how they just performed on the task (post-experience prediction). Approximately 40 minutes after completing the DOT, participants made a hypothetical prediction about how they might perform on a similar task (same task description provided) in the future (future prediction).

Data analyses

Analyses were conducted using Statistical Package for the Social Sciences (SPSS) version 26. *T*-tests and chi square analyses were used to confirm successful matching of the groups on demographic variables. *T*-tests were used to examine for group differences in *performance* on the memory and functional tasks. Although *predictions* alone are a measure of an individual's insight into their abilities, evaluating *accuracy* of the predictions (i.e., signed and absolute difference scores) can provide additional information. That is, signed difference scores (predicted performance – actual performance) allowed for assessment of the direction (over- or under-estimation) of accuracy. Scores above 0 indicate overestimation, while scores below 0 indicate underestimation and a score of 0 would reflect perfect accuracy. Whereas, absolute difference scores allowed for examination of overall accuracy of prediction such that over and under predictions within a group cannot cancel each other out. The further an absolute difference score is from 0, the worse the accuracy of the prediction.

T-tests were used to assess for group differences in *self-awareness* using pre-experience predictions and accuracy scores on the memory and functional tasks. *Self-monitoring* was examined by comparing predictions and the accuracy of predictions made prior to and following task experience using group (aMCI, HOA) by time of prediction (pre-experience, post-experience) mixed model analyses of variance (ANOVAs). Of note, the examination of self-monitoring was not directly parallel between the two tasks. The memory task measured self-monitoring by asking for a second prediction of delayed recall performance after the participant had gained experience with the list-learning task, whereas participants predicted how well they thought they just performed for the functional task. This difference was necessary to avoid participants simply counting the number of words they had just recalled if asked to provide a post-prediction for the memory task. To evaluate *self-updating* (i.e., whether a change in prediction accuracy is maintained across a time delay), we used a group (aMCI, HOA) by time of prediction (pre-experience, future-prediction) mixed model ANOVA. A p-value of .05 was used for all analyses and effect sizes are presented.

Correlations were also conducted between pre-experience, post-experience and future-prediction absolute accuracy scores to look at the relationship between the insight measures for both the memory and functional task using the full sample. Absolute accuracy scores were used in the correlations so that deviation of predictions from actual performance rather than actual direction of participant predictions could be captured. Exploratory correlation analyses were conducted separately for each group to examine the relationship between the

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prediction accuracy scores (absolute) and the composite measures of memory and executive functioning. Given the exploratory nature of the correlations and the small sample size, we used $p < .05$ for significance rather than setting a more conservative p-value. All significant correlations were moderate in size (i.e., $r > .40$).

Results

Verbal Memory Abilities

Demographics—As seen in Table 1, analyses revealed no group differences in age, $t(50) = -.10$, $p = .92$, $d = 0.03$, education, $t(50) = -.50$, $p = .62$, $d = 0.14$, or sex, $X^2(1, N = 52) = 0.00$, $p = 1.00$. An estimate of premorbid ability, as assessed with the Wechsler Test of Adult Reading (Wechsler, 2002), similarly revealed no group difference, $t(50) = .34$, $p = .40$, $d = 0.24$, with both groups performing in the High Average range. As expected, the aMCI group performed in the Low Average range and more poorly than HOAs on the verbal memory composite, $t(50) = 8.61$, $p < .001$, $d = 2.39$. Although scoring within the Average range or normal limits, the aMCI group also performed more poorly than the HOAs on the executive functioning composite, $t(50) = 3.54$, $p = .001$, $d = 0.98$ (see Table 1) and on a global cognitive screener (TICS), $t(50) = 3.88$, $p < .001$, $d = 1.07$.

Memory performance—See Table 2 for the verbal memory performance, predictions and prediction accuracy data, including means and standard deviations as a function of group. A *t*-test revealed that the aMCI group ($M = 9.00$) recalled significantly fewer words after a long delay than HOAs ($M = 11.42$), $t(50) = 5.29$, $p < .001$, $d = 1.46$ (see Table 2).

Self-awareness.

Pre-experience predictions.: Consistent with the performance data, the individuals with aMCI predicted that their delayed recall performance ($M = 4.54$) would be poorer than that of the HOAs ($M = 6.07$), $t(50) = 2.32$, $p < .05$, $d = 0.68$ (see Table 2).

Pre-experience prediction accuracy.: Pre-experience prediction accuracy further revealed no significant group differences in the accuracy of memory predictions as measured by the absolute score, $t(50) = .54$, $p = .59$, $d = 0.15$, and the signed difference, $t(50) = -1.08$, $p = .29$, $d = 0.30$, which showed an underestimation from true performance (see Table 2).

Self-monitoring

Predictions.: A group (aMCI, HOA) by time of prediction (pre-experience, post-experience) mixed model ANOVA was used to examine participant’s ability to self-monitor. After gaining experience with the task, individuals with aMCI predicted that they would recall fewer words than HOAs, $F(1, 50) = 15.04$, $p < .001$, $n_p^2 = .23$. There was no interaction involving group, $F = .13$. As can be seen in Table 2, both groups predicted that they would recall more words after they had gained experience with the list-learning task, $F(1, 50) = 7.53$, $p = .008$, $n_p^2 = .13$.

Prediction accuracy.: The 2 (group) X 2 (time) mixed model ANOVA on the prediction accuracy data using absolute difference scores similarly revealed more accurate memory

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predictions following task experience (*M* = 3.79) compared to prior to experience (*M* = 5.25), $F(1, 50) = 13.54$, $p = .001$, $n_p^2 = .21$. There was no main effect of group, $F = .95$, or interaction involving group, $F = .08$. The mixed model ANOVA using signed difference scores revealed that participants underestimated their expected memory performance less after task experience (*M* = −3.71) compared to prior to experience (*M* = −4.90), $F(1, 50) = 7.53$, $p = .008$, $n_p^2 = .13$. Again, there was no main effect of group, $F = 1.53$, or significant interaction, $F = .13$. These findings indicate that, similar to HOAs, the aMCI group was able to successfully self-monitor their memory abilities, updating memory knowledge based on task experience.

Self-updating

Predictions.: A group (aMCI, HOA) by time of prediction (pre-experience, future-experience) mixed model ANOVA was used to examine participant's ability to self-update. Both groups predicted they would recall more words when making future predictions compared to pre-experience predictions, $F(1, 50) = 9.56$, $p = .003$, $n_p^2 = .16$ (see Table 2). Individuals with aMCI predicted that they would recall fewer words than the HOA group, $F(1, 50) = 11.77$, $p =.001$, $n_p^2 = .19$, and there was no interaction, $F = 2.38$.

Prediction accuracy.: The 2 x 2 ANOVA on prediction accuracy data using absolute difference scores revealed that more accurate predictions were made about future memory performance (*M* = 3.60) compared to pre-experience predictions (*M* = 5.25), $F(1, 50) = 15.01$, $p < .001$, $n_p^2 = .23$. There was no significant main effect of group or interaction, *Fs* < 1.00. Analysis using signed difference scores revealed that the underestimation of memory performance when making pre-experience predictions (*M* = −4.90) was significantly improved for the future predictions (*M* = −3.46), $F(1, 50) = 9.56$, $p = .003$, $n_p^2 = .16$ (see Table 2). There was no main effect of group, $F = 1.04$, or interaction involving group, $F = .29$. These findings indicate that both groups were successful in longer-term consolidation of memory task information learned through experience.

Correlations—Correlations conducted on the full sample to examine for relationships among the insight measures revealed an association between the post- and future-experience absolute prediction accuracy scores ($r = .41$, $p = .002$), suggesting a significant positive relationship between self-monitoring and self-updating abilities. No significant relationships emerged between the pre-experience and post-experience ($r = .18$) or future-experience ($r = .20$) absolute accuracy scores.

Exploratory correlations examining the relationship between the absolute accuracy measures and the executive and memory composites revealed no significant relationships for either group (see Table 3).

Analysis of Functional Abilities

Performance—See Table 4 for the functional task performance, predictions and prediction accuracy data, including means and standard deviations as a function of group. A *t*-test revealed no statistically significant differences in performance on the functional task (i.e.,

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DOT) between the aMCI ($M = 25.84$) and HOA ($M = 27.27$) groups, $t(50) = 1.43$, $p = .16$ $d = 0.39$ (see Table 6).

Self-awareness

Predictions.: Consistent with actual DOT performance, there were no statistically significant group differences in functional performance predictions for the aMCI ($M = 26.62$) and HOA ($M = 27.73$) groups, $t(50) = 1.38$, $p = .17$, $d = 0.38$ (see Table 6).

Prediction accuracy.: There were also no group differences in absolute prediction accuracy, $t(50) = -.63$, $p = .54$, $d = 0.22$, or signed prediction accuracy, $t(50) = -.28$, $p = .78$, $d = 0.10$., which showed an overestimation from true performance. This suggests intact self-awareness of functional abilities by the aMCI group.

Self-monitoring

Predictions.: Self-monitoring of functional abilities was examined using a group (aMCI, HOA) by time of prediction (pre-experience, post-experience) mixed model ANOVA. This analysis revealed that participants predicted significantly lower performance on the functional task after experience with the task ($M = 25.63$, $SD = 6.15$) compared to prior to task experience ($M = 27.19$, $SD = 2.84$), $F(1, 50) = 4.52$, $p = .04$, $n_p^2 = .08$. There was no significant main effect of group or interaction, $Fs < 1.53$.

Prediction accuracy.: The mixed model ANOVA using absolute difference scores revealed no significant main effects, $Fs < 2.35$, or an interaction, $F < 1$. In contrast, consistent with a change in the prediction data, analyses using the signed difference scores revealed a significant change from overestimation of performance prior to task experience ($M = 0.64$) to an underestimation of performance after experience with the task ($M = -0.93$), $F(1, 50) = 4.52$, $p = .04$, $n_p^2 = .08$.

Self-updating

Predictions.: The analyses evaluating changes in participant's predictions between pre-experience and future predictions revealed no significant main effect of time of prediction, $F(1, 50) = 3.16$, $p = .08$, $n_p^2 = .06$, or group, $F < 1$. There was also no significant interaction, $F < 1$.

Prediction accuracy.: Prediction accuracy data using absolute difference scores revealed no main effect of time of prediction, $F < 1$, or group, $F < 1$. Although there were no overall main effects, there was a crossover interaction, $F(1, 50) = 4.14$, $p = .04$, $n_p^2 = .08$. The effect of group on prediction accuracy varied depending on time of prediction. The HOAs exhibited numerically better prediction accuracy compared to the aMCI group for pre-experience predictions ($M = 3.08$ and 3.57, respectively) but not for future predictions ($M = 4.00$ and 2.69, respectively). The mixed model ANOVA using signed difference scores revealed a similar pattern to the prediction analysis (all *ns*).

Correlations—Similar to the memory data, there was a significant relationship between the post- and future-experience absolute prediction measures ($r = .70$, $p < .001$) for the

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combined groups. Significant relationships also emerged between pre-experience and the post-experience ($r = .46$, $p = .001$) and future experience ($r = .41$, $p = .002$) absolute accuracy scores.

As can be seen in Table 3, for the aMCI group the executive composite measure correlated with the post-experience absolute accuracy score ($r = -.41$, $p = .04$). No other correlations reached significance for the aMCI group. For the HOA groups, correlations emerged between the executive functioning composite and the pre- ($r = -.54$, $p = .007$), post- ($r = -.45$, $p = .03$) and future-experience ($r = -.43$, $p = .04$) absolute accuracy score. No significant correlations emerged with the memory composite (see Table 3).

Discussion

The current study used a performance discrepancy paradigm to assess differences in constructs of insight (self-awareness, self-monitoring, self-updating) between HOAs and individuals with aMCI for both a functional and verbal memory task. This work adds to the sparse literature related to insight in individuals with aMCI, provides preliminary data regarding insight into functional abilities, and examines whether the ability to “update” one’s knowledge about one’s own abilities is related or distinct from other constructs of insight such as self-awareness and self-monitoring.

As expected, given the diagnosis of aMCI, individuals with aMCI exhibited significantly poorer memory recall than HOAs after a 30-minute delay. The finding that individuals with aMCI and HOAs did not differ in their performance on the Day Out Task (DOT) contrasts with a prior larger sample size DOT study ($n = 38$ MCI; $n = 38$ HOA; Schmitter-Edgecombe et al., 2012), and with other studies that have found individuals with MCI to exhibit greater difficulty performing functional tasks than HOAs (e.g., Okonkwo et al., 2009). Of interest for this study, however, is whether aMCI participants were able to accurately predict their performances.

Self-awareness is related to declarative knowledge a person has about their own abilities, such as how cognitive changes may affect performance (Fleming et al., 1995). Contrary to our hypothesis, individuals with aMCI exhibited intact self-awareness for their performances on both the functional and memory tasks. Consistent with the finding of no performance difference on the DOT, there were no differences between the two groups in their pre-experience predictions, or the absolute or signed accuracy of those predictions. Furthermore, even when given an age-normed anchor, individuals with aMCI predicted they would recall fewer words than HOAs on the memory task, demonstrating awareness of poorer performance compared to the average older adult. Consistent with this, there were also no differences between the aMCI and HOAs in their memory prediction accuracy scores, with both groups underestimating their true performance.

Prior research regarding self-awareness in individuals with MCI has been mixed, finding both intact (Seelye et al., 2010) and impaired (Collie et el., 2002; Galeone et al., 2011; Vogel et al., 2004) self-awareness. This may be related to several factors, including the MCI population being studied, use of age-normed anchors, and methods of assessment. Studies

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finding reduced self-awareness in individuals with MCI used different methodology from that of the current study, including self-report (Collie et al., 2002; Tabert et al., 2002; Vogel et al., 2004), patient-informant discrepancy (Galeone et al., 2011; Vogel et al., 2004), clinical interview (Vogel et al., 2004) and signed difference scores without age-normed anchors (Galeone et al., 2011). The current study findings were consistent with Seelye et al. (2010) who also used an online performance-discrepancy paradigm, but without age-normed anchors, providing support that the prior results were not merely due to the use of a mid-point anchoring strategy. Unlike clinical interviews, self-reports, and patient-informant discrepancy, performance-discrepancy paradigms may yield different results because participants are predicting performance on a well-defined, specific task in close proximity to the task.

Self-monitoring involves using task experience to track one's abilities and judge one's performance (Agnew & Morris, 1998; Toglia & Kirk, 2000). As hypothesized, individuals with aMCI were able to use task experience to adjust their perceptions about their abilities to perform both memory and functional tasks. Consistent with past research (Akhtar et all., 2006; Seelye et al, 2010), both the aMCI and HOA groups successfully used task experience, adjusting their memory predictions upward, resulting in more accurate memory predictions following experience with the task. For the functional task, both groups appeared to find the task more difficult than they originally believed it to be. That is, both groups adjusted their predictions about their functional abilities downward immediately following task experience. Given that participants were not given feedback about their performance, these findings suggest that both individuals with aMCI and HOAs encoded information about task success and failure, which they then used to adjust their performance predictions in the correct direction.

Does the ability to update insight proximal to the task consolidate and change predictions about later performance on similar tasks? If an individual has difficulty updating their concept of the self, one would expect an increasingly dissociated relationship between someone's degree of self-awareness and their actual abilities. In our sample, individuals with aMCI had intact self-awareness, and therefore, not surprisingly, also exhibited intact self-updating.

For the memory task, similar to HOAs, individuals with aMCI improved the accuracy (underestimated less) of initial pre-experience predictions when making similar predictions about performance on a future task. This shows that information learned from task experience (accurate self-monitoring) was retained over a delay (approximately 40 minutes) and changed perception of abilities. For the functional task, there was an effect of time of prediction on prediction accuracy that differed between the groups for the absolute accuracy score only. HOAs exhibited more accurate prediction accuracy than individuals with aMCI when making pre-experience predictions, while individuals with aMCI were more accurate than HOAs when making predictions about future performance. Findings by Shaked et al. (2019) suggest that greater metacognitive ability in individuals with MCI may be related to greater concern about abilities and this may explain the aMCI group's positive shift in accuracy when predicting future performance in the current study, compared to HOAs.

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In the current study, post-experience and future-experience prediction accuracy scores were significantly correlated for both the memory and functional tasks. Associations between these scores and pre-experience accuracy (self-awareness) were not significant for the memory task and smaller in magnitude for the functional task. The pattern of correlations suggests that information learned about task success and failure during the tasks was related to an updated self-concept that appeared to differ from pre-experience beliefs about the self.

Prior literature has suggested that executive dysfunction leads to impaired insight, and deficits in encoding maintain the impairment (Hannesdottir & Morris, 2007; Perrotin et al., 2007). In the current study, participants with memory impairment (i.e., aMCI) demonstrated levels of insight that were similar to those of HOAs. Consistent with this finding, correlational analyses conducted separately for each group revealed that memory ability was not significantly related to the accuracy of an individual's predictions about their memory or functional performance. In contrast, for the functional task, better executive functioning was associated with better accuracy of predictions made both prior to (pre) and following (post, future) experience with the task for the HOAs, and with post-experience prediction accuracy for the aMCI group. Although further research is needed, these findings suggest that executive functioning abilities may support self-monitoring of skills for individuals with aMCI, thereby contributing to self-updating and self-awareness of limitations. However, examination of the association between the constructs of insight and cognitive domains was limited in this study to memory and executive functioning and some work proposes a "hub and spoke" model of insight that may be impacted by multiple cognitive domains (Morris and Mograbi, 2013; Tondelli et al., 2018).

Study limitations include a well-educated, predominately Caucasian sample and a small sample size. The DOT also provided limited environmental feedback to help individuals understand whether they met task demands; future studies could use functional tasks that provide more explicit feedback to support self-monitoring. Moreover, given the partially implicit nature of self-monitoring, further understanding participant's awareness of the self-monitoring process is important. Future work could examine whether participants have explicit knowledge of their change in predictions by asking about their pre-experience predictions after getting their post-experience predictions. Moreover, participants continued to engage in other cognitive and functional tasks during the time delay, which could have either improved performance through saliency or decreased performance through interference. A future study with greater control over tasks administered during the delay to eliminate this confound would be recommended. Furthermore, assessment of self-updating over a longer delay (i.e., 24 hours, one week), outside of engagement in other cognitive and functional tasks, or multiple time delays (e.g., 20 minutes, 1 hours) may improve understanding of the ability of individuals with aMCI to self-update and integrate performance information. In addition, studies directly comparing methodologies for gathering information about insight with comparisons to real-world functioning, may further understanding of insight in individuals with aMCI.

The data showed that for both memory and functional task abilities, when compared to HOAs, individuals with aMCI exhibited intact self-awareness, self-monitoring, and self-updating within a 40-minute time frame. As self-updating was conceptualized to represent an ability to encode and consolidate information about performance abilities (*self-update*), the demonstration of intact self-updating may explain why self-awareness remained intact. Importantly, insight was intact despite poorer performance of the aMCI compared to the HOA group on the memory test and on the memory and executive composite measures, though the executive composite measure remained within the Average range. Given that insight is typically assessed through clinical ratings and informant report in clinical settings, the findings remind clinicians that some individuals with aMCI can reliably self-report on their subjective concerns, and deviations from informant report may not necessarily represent impaired insight of the patient. The findings further support the idea that individuals with aMCI should be encouraged to participate in cognitive rehabilitation early, while insight is intact, as intact insight is related to better cognitive rehabilitation outcomes (Clare et al., 2004) and adoption of compensatory strategies (Schmitter-Edgecombe, Parsey, & Lamb, 2014). If individuals with aMCI are encouraged to trust their self-monitoring abilities, they may experience increased self-efficacy related to compensating for their cognitive decline.

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Table 1.

Demographic and Neuropsychological Testing Data

	aMCI (*n* = 26)		**HOA (*n* = 26)**		
	M	*SD*	*M*	*SD*	*d*
Age (in years)	68.81	9.41	68.54	9.27	0.03
Range	(52-88)		(52-85)		
Education (in years)	16.77	2.72	16.38	2.86	0.14
% female	69		69		
% White	100		92		
% Not Hispanic or Latino	100		100		
Premorbid Ability: WTAR	113.07	11.01	115.54	9.75	0.24
Global Cognitive Screener: TICS	32.81	3.89	36.23	2.27	1.07*
Verbal Memory Summary Score: MAS	84.77	9.77	106.42	8.31	2.39*
Executive Composite (SS): D-KEFS	10.41	2.38	12.50	1.85	0.98*

Note: aMCI = amnestic mild cognitive impairment, HOA = healthy older adult, WTAR = Weschler Test of Adult Reading; TICS = Telephone Interview of Cognitive Status; MAS = Memory Assessment Scale; D-KEFS: Delis-Kaplan Executive Function System; Executive Composite = mean of the following four scaled scores: Category Switching, Letter Fluency, Color-Word Interference Inhibition, and Design Fluency Composite.

* $p \leq .001$

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Table 2.

Memory Recall Performance, Predictions and Prediction Accuracy Scores

	aMCI (*n* = 26)		HOA (*n* = 26)	
	M	*SD*	*M*	*SD*
Memory Recall Performance	9.00	2.10	11.42	1.03
Predictions				
Pre-experience	4.54	2.17	6.07	2.30
Post-experience	5.58	1.98	7.42	2.08
Future-experienced	5.73	2.61	7.70	2.67
Prediction Accuracy (Absolute)				
Pre-experience	5.08	2.30	5.42	2.30
Post-experience	3.50	2.20	4.08	2.12
Future-experienced	3.42	2.53	3.77	2.57
Prediction Accuracy (Signed)				
Pre-experience	−4.46	3.37	−5.35	2.48
Post-experience	−3.42	2.32	−4.00	2.26
Future-experienced	−3.27	2.74	−3.65	2.53

Note: aMCI = amnestic mild cognitive impairment, HOA = healthy older adult. Prediction accuracy scores are difference scores between predicted and actual performance (e.g., signed difference scores: predicted performance – actual performance; absolute difference scores: |predicted performance – actual performance|).

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Table 3.

Correlations between Prediction Accuracy Scores (Absolute) and Executive and Memory Composite Measures as a Function of Group and Task

	Memory Task		Functional Task	
Prediction Accuracy	**Executive Composite**	**Memory Composite**	**Executive Composite**	**Memory Composite**
	Healthy Older Adults			
Pre-Experience Absolute Accuracy	−.23	−.17	−.54**	.03
Post-Experience Absolute Accuracy	−.20	−.08	−.49**	−.32
Future Experience Absolute Accuracy	− .14	−.18	−.48*	−.24
	aMCI			
Pre-Experience Absolute Accuracy	−.05	−.03	−.01	−.11
Post-Experience Absolute Accuracy	−.25	.31	−.41*	.24
Future Experience Absolute Accuracy	−.17	−.02	−.06	.26

Note: aMCI = amnestic mild cognitive impairment

* $p < .05$

** $p \leq .01$

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Table 4.

Functional (Day Out Task) Performance, Predictions and Prediction Accuracy Scores

	aMCI (*n* = 26)		**HOA (*n* = 26)**	
	M	*SD*	*M*	*SD*
Performance	25.84	3.29	27.27	3.85
Predictions				
Pre-experience	26.65	3.17	27.73	2.41
Post-experience	26.00	5.07	25.27	7.15
Future-experienced	26.23	3.19	26.50	4.55
Prediction Accuracy (Absolute)				
Pre-experience	3.58	3.18	3.08	2.56
Post-experience	3.92	3.26	4.38	5.05
Future-experienced	2.69	1.78	4.00	4.04
Prediction Accuracy (Signed)				
Pre-experience	0.81	4.77	0.46	4.02
Post-experience	0.15	5.16	−2.00	6.43
Future-experienced	0.38	3.25	−0.77	5.69

Note: aMCI = amnestic mild cognitive impairment, HOA = healthy older adult. Prediction accuracy scores are difference scores between predicted and actual performance (e.g., signed difference scores: predicted performance – actual performance; absolute difference scores: |predicted performance – actual performance|).