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Home-based Cognitive Monitoring: The Role of Personality and Predictors of Adherence and Satisfaction

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Home-based Cognitive Monitoring: The Role of Personality and Predictors of Adherence and Satisfaction

by

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DEDICATION

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ABSTRACT

Over the last several decades, a growing awareness of the benefits of regular screening for common health conditions, such as cancer and cardiovascular diseases, has paved the way for preventative screenings to become routine in medical settings. Given that cognitive impairment is frequently reported as the number one worry of older adults, home-based cognitive monitoring may be an innovative solution that allows middle aged and older adults to take an active role in monitoring an important aspect of their health. Although several home-based cognitive monitoring programs have been validated for use in clinical and home-based settings, the Cogstate Brief Battery (CBB) may be the leading candidate based on its brevity, reliability, and lack of practice effects. Although home-based monitoring via the CBB tends to be well-received by participants, it remains unclear how participant characteristics such as personality traits may affect their performance over time. In addition, the factors related to participants' adherence and satisfaction with regular cognitive monitoring have yet to be examined.

Addressing these unknowns are important, as they can help determine what to expect in terms of participant performance, adherence, and satisfaction, if home-based cognitive monitoring was implemented on a population-wide level in the future. This study examined how personality traits influenced cognitive performance over time on the CBB and explored participant adherence and satisfaction with regular cognitive monitoring over 60 months, using quantitative and qualitative data from a sample of cognitively healthy older adults recruited from communities in central Florida (N=158).

Statistical analyses of the quantitative data using mixed effects models showed that personality traits were associated with performance on the CBB; in particular, higher conscientiousness was related to more accurate performance at baseline and improvements in speed over time. In addition, higher openness was associated with less accurate performance at baseline and slower, yet more accurate performance over time. In general, participants' performance was relatively stable over time and fluctuations in performance occurred mostly in the first year of the study. Intraindividual variability also decreased over time, with significant decreases in variability occurring in participants who were higher in conscientiousness and openness.

Mixed methods analyses of the data also suggested that participants liked their overall experience with the CBB, exhibited good study adherence over time, and were able to complete their monthly assessments with a high degree of independence. The themes that emerged from the qualitative analysis of participants' study feedback suggest that most participants liked that CBB was easy, convenient to use, and provided them with a way to challenge themselves. However, some participants disliked one task in particular and felt that the CBB eventually became repetitive.

The findings from both studies are useful for future applications of cognitive monitoring programs, as they would help improve the accuracy of conclusions drawn from participants' performance and could also lead to the development of strategies that encourage long-term participation among individuals whom low study adherence and satisfaction is likely.

CHAPTER ONE:

INTRODUCTION

Cognitive impairment is frequently reported as a major concern for older adults, but unfortunately many individuals do not receive a memory screening until they already have symptoms of MCI or dementia (Valdes, Sadeq, Harrison Bush, Morgan, & Andel, 2016). As a result, developing strategies for the early detection of cognitive impairment is a current objective of several public health agencies (Borson et al., 2013; Chodosh et al., 2004; Kaye et al., 2014; National Institute on Aging, 2016). Aside from enabling physicians to intervene the moment the earliest signs of cognitive decline become apparent, early detection is also important because it allows patients and caregivers to receive counseling during which they can discuss and understand the symptoms and disease progression, and make treatment plans and decisions, such as identifying health surrogates or creating advance directives (Chodosh et al., 2004). With limited treatment options for cognitive impairment, regular cognitive monitoring currently lacks a specific place. However, as treatments become available, the need for establishing viable methods of capturing early cognitive decline quickly and reliably is forecasted to grow rapidly.

Cognitive monitoring of middle aged and older adults that involves regular assessments may be one of the most promising methods of early detection, as it would provide insight about these individuals' cognitive functioning over time. Regular assessments would give physicians and researchers an advantage in identifying people who are most at risk for decline, since many cognitive monitoring assessments are able to detect the earliest signs of decline (i.e., slower speed of processing) before they are noticeably observable (Chodosh et al., 2004; Sano et al., 2013; Sano et al., 2010).

One of the most significant challenges associated with implementing a cognitive monitoring program involving repeated testing is developing a practical way for participants to complete their assessments. Although it may be possible to conduct routine assessments in a clinical or research setting with a modest sample of participants, this would become increasingly difficult with a larger sample of participants and a longitudinal follow-up with more frequent assessments. It may not be feasible to expect participants to be present at the study site at all of the designated testing intervals (e.g., monthly, quarterly, semi-annually, annually), since participants might be out of town (Valdes et al., 2016) or unable to travel on their own (Mundt, Kinoshita, Hsu, Yesavage, & Greist, 2007; Rentz et al., 2016). Because of these logistical issues, researchers have sought to find a more feasible approach for regular cognitive monitoring. Given the current widespread access to phone and internet and the fact that older adults are becoming increasingly tech-savvy, with nearly 70% of adults age 65 and older regularly using the internet (Pew Research Center, 2017), one possible alternative gaining interest among researchers and participants alike is remote home-based cognitive monitoring (Mundt et al., 2007; Rentz, 2016; Rentz et al., 2016; Sano et al., 2013; Sano et al., 2010; Valdes et al., 2016).

Home-Based Cognitive Monitoring

Home-based cognitive monitoring is an innovative approach that allows individuals to take an active role in monitoring their cognitive health by independently completing phone- or internet-based cognitive assessments without having to leave home (Mundt et al., 2007; Rentz, 2016; Rentz et al., 2016; Sano et al., 2013; Sano et al., 2010; Valdes et al., 2016). These assessments are able to provide data that is equally reliable and valid as data collected from in-person neuropsychological tests (Cromer et al., 2015; Lim et al., 2012; Lim et al., 2013; Maruff et al., 2013; Maruff et al., 2009; Valdes et al., 2016). One such cognitive monitoring program, the Cogstate Brief Battery (CBB) may be one of the leading candidates for future large-scale implementation. The CBB is a computer-based, online cognitive screening tool consisting of four tasks that assess psychomotor function, attention, working memory, and visual learning (Lim et al., 2012; Maruff et al., 2013). According to Lim et al. (2012), regular cognitive monitoring via the CBB could provide insight into the cognitive changes occurring in the earliest stages of dementia. When patients in the pre-clinical stages of dementia completed the CBB, significant impairments were observed on the tasks that measured working memory and visual learning (Lim et al., 2012). These impairments in CBB performance have also been linked to subjective cognitive complaints, decreased ADLs, and amyloid buildup (Lim et al., 2012).

Participants seem receptive to participating in home-based cognitive monitoring programs (Castanho et al., 2016; Mundt et al., 2007), with Mundt et al. (2007) reporting a 96% compliance rate in their interactive voice response technology study, and Sano et al. (2013) reporting a 90% retention rate in their home-based internet study, despite some small initial dropout. Home-based cognitive monitoring also appears to be more convenient for participants and researchers alike, especially when an introductory training session is included in the study design. Although such training sessions lengthen study startup time, they prove useful as participants who received training prior to beginning a cognitive monitoring program required less help over the duration of the study (Sano et al., 2013; Sano et al., 2010; Valdes et al., 2016).

From a practical standpoint, regular home-based assessment may offer a potential strategy for conducting large-scale and long term cognitive monitoring research. As technology continues advancing to improve patient care and “e-medicine” increases in popularity, it will become progressively more feasible to assess and monitor cognitive performance in large groups of people, particularly patients in remote areas or those unable to travel to clinics, hospitals, or research centers (Rentz et al., 2016). Since some home-based cognitive assessment programs are often designed specifically for repeated assessments, this would enable more frequent assessment of cognitive change (Rentz, 2016; Rentz et al., 2016) and the ability to follow patient cohorts longitudinally (Sano et al., 2013; Sano et al., 2010). Given the accumulating evidence that home-based cognitive monitoring is feasible in terms of logistics and participant interest, the present time is ideal to continue investigating factors that may influence individuals’ performance, adherence, and satisfaction over time.

New Contributions

This study contributes to the current research on early detection efforts in several ways. While some previous cognitive monitoring studies have followed older adults over time, many of these studies are shorter in duration or have longer periods of time between assessments. In the current study, participants completed assessments on a monthly basis for up to five years (*M*=20, *SD*=15), providing an uninterrupted view of their cognitive performance over time. To our knowledge, this study is also the first to examine how personality traits affect longitudinal performance in a cognitive monitoring program.

In addition, participant satisfaction and adherence have been studied mostly in clinical trials among patients and their caregivers thus far. These factors are also important to consider in cognitive monitoring studies, which require participants' continued engagement over time. In the present study, we used a mixed methods design to analyze quantitative data on participant adherence and satisfaction, as well as qualitative data to further understand their experiences with study participation.

Organization

This dissertation is organized into two papers. The first study quantitatively investigates whether personality traits affect cognitive performance, or changes in cognitive performance over time on the CBB. The second study examines participant adherence and satisfaction with using the CBB using both quantitative and qualitative data. The concluding chapter discusses the overall findings and limitations, and future research directions based on the studies.

CHAPTER TWO:

STUDY #1: PERSONALITY AND PERFORMANCE ON THE COGSTATE BRIEF BATTERY

Introduction

The study of personality – defined as the individual differences between people in their patterns of thinking, feeling, and behaving – currently has many implications in both biological and psychological functioning over the lifespan (John & Srivastava, 1999; McAdams & Pals, 2006; Srivastava, John, Gosling, & Potter, 2003). The Big Five Taxonomy (Goldberg, 1990) classifies personality into five distinct categories, known as dispositional traits, which are long-lasting and stable patterns of behavior caused by internal forces (John & Srivastava, 1999). Traits inform us about an individual's overall interactions with the social world, such as how they act, feel, and think about other people, ideas, and events (McAdams & Pals, 2006). The five traits consistently used to classify and study personality are openness (the tendency to seek out novel, intellectual experiences and to be creative and imaginative), conscientiousness (the degree to which an individual is methodical, self-disciplined, motivated to achieve goals, and has the ability to plan ahead), extraversion (a measure of excitement-seeking and sociability), agreeableness (the degree to which one is altruistic, cooperative, helpful, and trustworthy), and neuroticism (the tendency to experience difficulties with stress management and impulse control, anxiety, distress, and other negative emotions) (McAdams & Pals, 2006).

These traits can successfully predict behavior over time, as well as in different situations (Archer et al., 2009; Duberstein et al., 2011; John & Srivastava, 1999; Luchetti, Terracciano, Stephan, & Sutin, 2016; McCrae & Costa, 1999; Srivastava et al., 2003). One of the more recent applications of personality is its inclusion as a risk factor associated with cognitive decline. An increasing number of experts agree that personality may significantly contribute to cognition, and the changes in cognition that are observed longitudinally in both normal and abnormal aging, and merits inclusion in models that seek to explain the etiology of cognitive decline (Bogg & Roberts, 2013).

Personality Traits and Cognition

It is believed that individuals' existing personality traits influence cognition through behavioral and physiological pathways (Cipriani, Borin, Del Debbio, & Di Fiorino, 2015; Hock et al., 2014). In terms of behavior, personality influences the size and quality of one's social network, the level of cognitive activity they regularly engage in, and the way they react and cope with stressful events (Cipriani et al., 2015; Johansson et al., 2014). Physiologically, some individual traits as well as combinations of traits are associated with deleterious changes in brain regions that are responsible for memory and cognitive function (Boyle et al., 2010; Duberstein et al., 2011; Hock et al., 2014). Much of the current literature on personality traits and cognition focuses on conscientiousness and neuroticism, due to their robust associations with cognitive decline.

Conscientiousness

Out of the five personality dimensions, conscientiousness is considered to be the strongest protective factor against cognitive decline (Bogg & Roberts, 2013; Chapman et al., 2012; Cipriani et al., 2015; Duberstein et al., 2011; Hock et al., 2014; Luchetti et al., 2016). Aside from being associated with general health-promoting behaviors and longevity, numerous studies have concluded that conscientiousness is associated with a reduced risk of the cognitive deficits commonly observed in neurodegenerative diseases like dementia (Bogg & Roberts, 2013; Chapman et al., 2012; Cipriani et al., 2015; Duberstein et al., 2011). Although the pathway between conscientiousness and better cognitive functioning is not fully understood (Bogg & Roberts, 2013), many researchers hypothesize that conscientious individuals fare better because they remain goal-oriented and keep up with life responsibilities as they age, which helps them maintain their cognitive reserve (Chapman et al., 2012; Duberstein et al., 2011).

Neuroticism

While conscientiousness is an important protective factor, neuroticism is widely considered a substantial risk factor for cognitive decline and dementia (Archer et al., 2009; Bogg & Roberts, 2013; Boyle et al., 2010; Chapman et al., 2012). Neuroticism is related to faster and more substantial rates of cognitive decline, as well as younger ages of onset of neurodegenerative diseases (Chapman et al., 2012; Cipriani et al., 2015; Crowe, Andel, Pedersen, Fratiglioni, & Gatz, 2006). Several possible explanations for the relationship between neuroticism and cognitive decline exist. Neuroticism has been linked to several brain changes that are characteristic of dementia, including the presence of inflammatory markers (e.g., c-reactive protein and interleukin 6), hippocampal damage, and neurofibrillary tangles (Bogg & Roberts, 2013; Hock et al., 2014; Johansson et al., 2014). This suggests that neuroticism and cognitive decline may share some common biological mechanisms (Hock et al., 2014).

Other Traits

There is an increasing amount of evidence supporting the idea that openness may also be a protective factor against cognitive decline, although not to the same degree as conscientiousness (Chapman et al., 2012; Duberstein et al., 2011; Terracciano et al., 2014). Individuals who are higher in openness are likely to continue participating in cognitively stimulating and novel activities as they age, and this pattern of lifelong cognitive engagement places them at a lower risk for cognitive decline (Duberstein et al., 2011; Terracciano et al., 2014).

The relationships between cognition and agreeableness and extraversion are less clear. Although agreeableness tends to increase as people age (John & Srivastava, 1999; McAdams & Pals, 2006), few significant findings relating to cognition have emerged aside from one meta-analysis in which agreeableness was associated with a reduced risk of cognitive decline (Terracciano et al., 2014). The findings for extraversion are varied and include a correlation with worsening cognition over time (Chapman et al., 2012), a younger age at dementia onset (Archer et al., 2009), yet also a reduced risk for cognitive decline (Duberstein et al., 2011), or no significant benefit or risk at all (Terracciano et al., 2014). These inconclusive findings are surprising, given the fact that extraversion is characterized by better social support, which is considered a protective factor against cognitive decline.

Personality Traits and Cognitive Assessment

Aside from being substantial protective and risk factors for cognitive decline, personality traits are also associated with performance on cognitive assessments (e.g., Bogg & Roberts, 2013; Hock et al., 2014; Luchetti et al., 2016; Terracciano et al., 2014).

They often account for significant portions of variances between individuals' performance on cognitive tasks (Booth, Schinka, Brown, Mortimer, & Borenstein, 2006). For example, results from the Baltimore Epidemiologic Catchment Study indicated that conscientiousness was associated with improvements in Mini-Mental State Examination (MMSE) and immediate word recall scores over time, while neuroticism was associated with a decline in MMSE scores over time (Hock et al., 2014). Similar findings were observed in the Ginkgo Evaluation of Memory Study, in which conscientious participants experienced the slowest rates of cognitive decline over the seven-year study period, as measured by the modified Mini-Mental State Examination (3MSE). Despite the fact that they were experiencing cognitive decline, these participants still performed better on the 3MSE compared to others. Neurotic participants, however, experienced the steepest rates of cognitive decline on the 3MSE, with neuroticism accounting for a larger effect on 3MSE score than APOE genotype (Chapman et al., 2012). These observations highlight the importance of considering personality traits' influences on cognitive assessment. Although they have been studied extensively in relation to traditional cognitive tests, it remains unknown how personality traits would affect performance on home-based regular cognitive monitoring programs. A failure to account for personality traits' potential influences can lead to inaccurate conclusions being drawn from cognitive monitoring assessments, which may hinder future efforts to implement cognitive monitoring programs on a wider level.

Aims

The current study investigated two aims:

Aim 1: Is there a relationship between personality traits and performance on monthly cognitive assessments?

Hypothesis: Based on existing findings, we predicted that there would be a relationship between personality traits and performance on monthly cognitive assessments. Specifically, we expected that higher conscientiousness would be related to better cognitive performance, and higher neuroticism would be related to poorer cognitive performance.

Aim 2: Are personality traits related to longitudinal changes in performance on monthly cognitive assessments, over a period of up to 60 months?

Hypothesis: We expected that personality traits would be related to longitudinal changes in performance over time, with participants higher in conscientiousness and participants higher in neuroticism continuing to outperform and underperform as compared to their counterparts, respectively. We also predicted that performance would remain relatively stable over time, with personality traits having little to no effect on longitudinal performance.

Method

Participants

Participants included 158 cognitively healthy older adults, age 55 years and older, who were enrolled in an ongoing, prospective cohort study examining home-based monthly memory monitoring using the Cogstate Brief Battery (CBB). Participants were recruited through community memory screening events at the University of South Florida Health Byrd Alzheimer's Institute, as well as from retirement communities in the central Florida area. The study was in compliance with the ethical standards of the

Committee on Human Experimentation of the University of South Florida and was approved by the Institutional Review Board (Pro00012918).

At the time of data extraction, 218 participants had been screened for participation in the monthly memory monitoring program. One hundred and fifty-eight eligible participants were enrolled and completed the CBB once a month, for up to 60 months (M=20 months, SD=15 months). Participants also completed the 44-item Big-Five Inventory (BFI). See Table 1 for participant demographics and Figure 1 for details regarding study eligibility and enrollment.

Procedure

All interested participants completed a baseline assessment where information about their sociodemographic and health characteristics was collected. To determine initial eligibility, participants were screened for existing cognitive impairment using the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005). Those with MoCA scores of at least 25 (indicating the absence of cognitive impairment), who had not been diagnosed with mild cognitive impairment or any type of dementia, were considered eligible for the study. Participants were not excluded based on any previous history of head injury, cardiovascular disease, cancer, vision or hearing loss, their educational or occupational history, or their medication use. All eligible participants then completed the 15-item Geriatric Depression Scale Short Form (GDS; Sheikh & Yesavage, 1986) and the 44-item Big Five Inventory (BFI; John & Srivastava, 1999). See Figure 2 for a visual representation of the study procedure.

Next, participants received individual training from a member of our research team on how to use the CBB. Participants first completed a practice assessment with the researcher, who would explain the objective of each of the CBB's four tasks before the participant attempted each task. Once they finished the practice assessment, participants were given a five-minute break, during which they reviewed the CBB task instructions with the researcher and were encouraged to ask questions. After the break, they independently completed their first month's assessment. Finally, they were given an opportunity to ask any additional questions about using the CBB and were sent home with instructions on how to troubleshoot common issues and our contact information in case they needed further assistance. Over the course of the study, participants received a monthly email that contained a link to the CBB and were instructed to complete their assessment at their convenience within one week.

Measures

*Cogstate Brief Battery (CBB)***.** The CBB is a computer-based cognitive screening tool that has previously been used in a clinician/researcher-supervised manner with cognitively normal older adults, as well as patients with mild cognitive impairment and clinically diagnosed dementia (Lim et al., 2012; Lim et al., 2013; Maruff et al., 2013; Maruff et al., 2009). The battery takes approximately 15 minutes to complete and consists of four tasks designed to assess psychomotor function, attention, working memory, and visual learning. Each task utilizes stimuli in the form of playing cards, and stimuli characteristics (e.g., color, suit) are manipulated based on the requirements of each task. The *Detection Task* is a simple reaction time task that measures psychomotor function and speed of processing. The *Identification Task* is a choice reaction time task that measures visual attention and vigilance. The *One Card Learning Task* is a measure of visual learning and memory. The *One-Back Task* is a measure of attention and working memory. Before each task appears onscreen, participants are instructed to “Go as fast as you can and try not to make any mistakes.” The Detection and Identification tasks measure speed as the standardized average reaction time for correct responses, while the One Card Learning and One Back tasks measure accuracy as the standardized measures of correct responses over total responses (Maruff et al., 2013; Maruff et al., 2009). These tasks are considered to be the CBB’s primary measures of interest. The CBB also measures accuracy for the Detection and Identification tasks, and speed for the One Card Learning and One Back tasks; these are known as the CBB’s secondary measures of interest. One strength of the Cogstate Brief Battery is that it was designed specifically for repeated administrations; it can be taken repeatedly without significant practice effects (Maruff et al., 2013) or ceiling effects (Lim et al., 2012; Lim et al., 2013). Additionally, Lim et al. (2012) reported that the Cogstate Brief Battery tasks have high test-retest reliability (r >.70) and show stability over repeated administrations with cognitively normal older adults, as well as those with mild cognitive impairment and dementia (Lim et al., 2012; Lim et al., 2013; Maruff et al., 2013).

Geriatric Depression Scale Short Form (GDS). The 15-item, short form of the GDS is a measure of depressive symptoms and takes about five to seven minutes to complete (Sheikh & Yesavage, 1986). Participants are asked to respond yes or no to the items (e.g., “Do you feel happy most of the time?”; “Do you feel full of energy?”) based on how they have felt over the previous week. The GDS has demonstrated good reliability and validity in assessing depressive symptoms in older adults and can differentiate between depressed and non-depressed older adults (r=.84; Sheikh &

Yesavage, 1986). The total possible score is 15, with a score of five or above indicating the possibility of clinical depression.

BFI. The BFI is a brief, multidimensional scale that measures the Big Five personality dimensions: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (John & Srivastava, 1999). This scale consists of 44 items and takes approximately five to ten minutes to complete. Items on the BFI (e.g., "I see myself as someone who is talkative,"; "I see myself as someone who is a reliable worker") are scored using a five-point Likert scale, with higher scores indicating a stronger association with that personality dimension. The BFI has good test-retest reliability, with a Cronbach's alpha of .72. To analyze the BFI, a composite score is computed for each personality dimension from the corresponding items that assess each dimension (Warr, Bartram, & Brown, 2005). The BFI composite scores were used to determine if specific personality domains affected task performance.

Statistical Analyses

Statistical analyses were performed using SAS® 9.4 Software, (SAS Institute Inc., Cary, NC). Mixed effects models in SAS (SAS Institute, Cary, NC) using procedure MIXED (Littell, Milliken, Stroup, Woldinger, & Schabenbarger, 2007) were used to examine associations between personality traits and performance on the four CBB tasks (Detection, Identification, One Card Learning, and One Back). Mixed effects models are statistical models that account for both fixed and random effects (i.e., differences in performance across participants), and can retain participants with missing data. This feature was particularly important in the current study, because mixed effects models allowed us to retain all 158 participants in the analyses, despite the fact that the number of completed assessments was different across participants.

In our analyses, we reported a baseline score for cognitive performance (intercept), an overall rate of change (time; measured by months in the study), an estimate for the association between the predictor variable (i.e., personality trait score), and the time x predictor interaction. The interaction shows the difference in the rate of change in performance, when the predictor value increases by one SD (i.e., one higher point in personality trait score). See Figure 3 for model specification equations. Performance on the CBB tasks was measured by speed and accuracy; for speed, lower scores indicate better performance and for accuracy, higher scores indicate better performance. All mixed effect models controlled for the following covariates: age, gender, and years of education.

We accounted for fluctuations in performance by using a coefficient of variation, which was calculated as the participant's standard deviation divided by the participant's mean score over the course of the study (Cook, 1977). Then, we used correlations and regressions to assess whether there were any associations between personality traits and coefficient of variation.

In addition, we measured fluctuations in performance over time using studentized residual scores obtained from the mixed effects models examining personality and performance. Studentized residuals measure the distance between the expected and observed score for each individual at each session (Tian, 2005). To test whether intraindividual variability in performance changed over time in the study, we entered the absolute value of the studentized residual at each session as the outcome of a separate mixed effects model with time and personality traits as the only predictors.

Prior research suggests that practice effects are evident between the first and second assessments of the CBB, but not during subsequent assessments (Collie, Maruff, Darby, & McStephen, 2003). Therefore, data from the participant's practice session were not used in the analyses, however, data from all subsequent sessions were included. The outcomes were standardized as *t*-scores (*M*=50, *SD*= 10) and all covariates were converted to *z*-scores prior to the analyses to allow for direct comparisons between the results for each personality trait.

Results

Sample Characteristics

The 158 participants enrolled in the study were on average 74.59 years of age (SD=7.87 years), mostly female (n=109), married (70.5%), had completed on average 16 years of education (SD=2.19) or approximately a Bachelor's degree, had an average MoCA score of 26.91 (SD=1.69), and reported less than one depressive symptom in the past week (M=.98, SD=1.45). Compared to normative personality trait data, our sample at baseline scored slightly higher than average in openness, conscientiousness, extraversion, and agreeableness, and slightly lower than average neuroticism.

Performance on the Cogstate Brief Battery

Aim 1. *Is there a relationship between personality traits and performance on monthly cognitive assessments?*

CBB Primary Measures. Personality traits were assessed in relation to performance on all four primary CBB tasks using mixed effects models (see Table 2).

The results indicated that openness was significantly related to less accurate performance on the One Back task indicating that, at first measurement, participants higher in openness by one SD performed less accurately by about one-tenth of a SD (estimate= -0.92, p=.04). Conscientiousness was significantly related to more accurate performance on the One Back task (estimate=0.99, p=.03), such that participants who were higher in conscientiousness by one SD performed more accurately by one-tenth of a SD. There were no further significant associations between personality traits and performance on the primary measures.

CBB Secondary Measures. Similar findings were observed for openness and conscientiousness on one of the CBB secondary measures, Identification accuracy. Openness was related to less accurate performance on the Identification task (estimate= -1.15, p=.01), while conscientiousness was significantly related to more accurate performance on the Identification (estimate=0.96, p=.04). These results indicated that at baseline, participants higher by one SD in openness performed less accurately by one-tenth of a SD, while participants higher in conscientiousness performed more accurately by one-tenth of a SD. No other significant associations between personality traits and performance on the other secondary measures were observed.

Aim 2. *Are personality traits related to longitudinal changes in performance on monthly cognitive assessments, over a period of up to 60 months?*

CBB Primary Measures. Next, personality traits and performance on the CBB were examined longitudinally. In addition to being associated with less accurate performance on the Identification task at baseline, higher openness was also related to slower performance over time on the Identification task (estimate=0.04, $p<.01$). This estimate indicated that scoring one SD higher in openness was related to slower performance by 0.04 SD per measurement occasion (month). Therefore, after multiplying the estimate of 0.04 by 60 months, assuming identical baseline performance, a participant with one SD higher openness would perform about 2.4 SD slower than their counterpart with one SD lower openness at 60 months (Figure 4a).

Despite performing less accurately on the One Back task at baseline, participants who were higher in openness eventually improved on this task and performed with significantly more accuracy over time (estimate=0.03, $p=.02$). This estimate indicates that one extra SD in openness was related to a 0.03 increase in One Back accuracy per month, which would result in an overall score 1.8 SD better at the end of 60 months (Figure 4b).

Higher conscientiousness was also related to a significant improvement in speed on the Detection task (estimate=-0.04, $p=.03$) over time, meaning that an extra SD in conscientiousness was related to a 0.04 improvement in Detection speed per month, which would result in an overall score 2.4 SD better over 60 months (Figure 4c).

CBB Secondary Measures. Personality traits were not significantly associated with performance over time on any of the CBB secondary measures.

Variability in Performance

Variability in participants' overall performance was first examined visually. See Figure 5 for three randomly selected participants' individual performance as well as mean performance for the four primary CBB tasks over the first year of the study. Variability was then measured using the coefficient of variation. The coefficient of variation indicated that on average, scores varied from the mean value by 7% for Detection, 5% for Identification, 1% for One Card Learning speed, and 2% for One Back speed, 8% for One Card Learning accuracy, and 16% for One Back accuracy.

We found that conscientiousness was significantly correlated with the coefficient of variation for Identification speed (r=.18, p=.04), and extraversion and neuroticism were both correlated with the coefficient of variation for One Card Learning speed (r=.21, p=.02 and r=-.18, p=.04 respectively). No other personality traits were significantly correlated to the coefficients. See Table 3 for all correlations between personality traits and coefficient of variations.

In subsequent analyses using regressions, we found that openness was significantly associated with the coefficient of variation for One Card Learning accuracy (β=.008, p=.04) and One Back accuracy (β=.014, p=.03), while extraversion (β=.002, p=.02) and neuroticism (β=-.003, p=.03) were associated with the coefficient of variation for One Card Learning speed. Conscientiousness and agreeableness were not related to the coefficient of variation for any of the CBB tasks.

Intraindividual Variability

To measure intraindividual variability, the absolute value of studentized residual scores were obtained from the mixed effects models examining personality traits and performance, and were used as the outcome variable in additional mixed effects models. In models with time as the only predictor, the estimates indicated decreasing intraindividual variability that was significant for nearly all of the CBB primary measures, including Detection speed (estimate=-.009, p<.01), Identification speed (estimate=-.003, p<.01), and One Back accuracy (estimate=-.004, p<.01). While intraindividual variability also decreased for One Card Learning accuracy, it was not statistically significant (p=.06). Intraindividual variability also decreased significantly for all of the CBB secondary measures: Detection accuracy (estimate=-.005, p<.01), Identification accuracy (estimate=-.007, p<.01), One Card Learning speed (estimate=-.007, p<.01), and One Back speed (estimate=-.005, p<.01).

When personality traits were added as predictors (see Table 4), one significant finding emerged for the CBB primary measures. Although variability seemed to decrease in general, participants higher in neuroticism showed greater variability in Detection speed overall (intercept=.899, estimate=.102, p=.05). Personality traits were not associated with variability in any of the other CBB primary measures.

For the CBB secondary measures, participants higher in openness showed significantly less variability over time in Detection accuracy (intercept=.736, estimate=-.005, p=.05). Participants higher in conscientiousness also showed less variability overall in Detection accuracy (intercept=.743, estimate=-.199, p=.01) as well as Identification accuracy (intercept=.936, estimate=-.112, p=.03). However, participants higher in extraversion showed greater variability in One Card Learning speed overall (intercept=.866, estimate=.136, p=.04). Personality traits were not associated with any variability in One Back speed.

Discussion

The present study examined whether there was a relationship between older adults' personality traits and their performance on monthly cognitive assessments, at baseline and over a period of five years. Our hypothesis for Aim 1 was partially supported; we found a significant relationship between higher conscientiousness and better performance, such that higher conscientiousness was related to more accurate performance on the One Back task. This finding is similar to those in previous studies that examined the effects of personality on traditional neuropsychological tests. For instance, Hock et al. (2014) concluded that higher conscientiousness was associated with improvements in MMSE scores and word recall. Many researchers also believe that higher conscientiousness serves a buffer against the cognitive deficits that are characteristic of dementia (e.g., Bogg & Roberts, 2013; Chapman et al., 2012; Cipriani et al., 2015; Duberstein et al., 2011). This may provide support for our finding that more conscientious participants performed better on the One Back task, since One Back accuracy is considered to be one of the CBB's primary measures of interest for dementia screening. In addition, participants who were more conscientious also performed with greater accuracy on the Identification task. Although Identification accuracy is considered a secondary measure of interest on the CBB, this finding nonetheless provides further support that conscientiousness contributes positively to cognitive performance on both traditional neuropsychological tests and computerized cognitive monitoring assessments alike.

Contrary to our hypothesis, neuroticism was not significantly related to performance on any of the CBB's primary or secondary measures as we had anticipated, given the substantial amount of literature that links higher neuroticism to poorer cognitive functioning (Archer et al., 2009; Chapman et al., 2012; Cipriani et al., 2015; Crowe et al., 2006). Higher neuroticism has often been linked to neurological changes that are characteristic of dementia (i.e., the presence of neurofibrillary tangles) as well as poorer performance on traditional neuropsychological tests (Chapman, Hampson, & Clarkin, 2014; Hock et al., 2014). One possible explanation for our non-findings could be that participants who are higher in neuroticism may perform differently on traditional versus computer-based cognitive tests. Completing a cognitive monitoring monthly assessment from home may be perceived as less threatening by participants who are higher in neuroticism, compared to completing a test in an unfamiliar clinical setting with a tester present. In addition, our sample scored lower than average in neuroticism compared to age norms, which may have also contributed to our non-findings.

Although we did not hypothesize that we would find any significant associations between openness and performance, the results indicated that participants who were higher in openness performed less accurately on the Identification and One Back tasks at baseline. This finding was also unexpected, since openness is usually thought to be a protective factor against cognitive decline, because individuals who are higher in openness are more likely to remain cognitively engaged as they age (Chapman et al., 2014; Duberstein et al., 2011; Terracciano et al., 2014).

Our hypothesis for Aim 2 was partially supported; as expected, higher conscientiousness was related to improvements in speed on the Detection task over time. Similarly, improvements in test performance over time among highly conscientious participants have been observed in other longitudinal studies (Chapman et al., 2014; Hock et al., 2014). We hypothesize that the improvement in speed observed in our study could be explained by the fact that participants higher in conscientiousness would be more likely to follow the instructions provided to them prior to starting each CBB task, which reminded them to “go as fast as you can and try not to make any mistakes.”

Similar to our non-findings for neuroticism in Aim 1, we also did not find any significant associations between neuroticism and performance over time in Aim 2.

We did not hypothesize that there would be a significant relationship between openness and performance over time, however, two findings emerged for openness and the CBB primary measures. Our results indicated that higher openness was associated with slower performance over time on the Identification task, as well as more accurate performance over time on the One Back task. This discrepancy is interesting, especially considering that the Identification task is less demanding than the One Back task, and should be investigated further in future studies. No significant findings were observed for any of the CBB secondary measures over time.

When measuring variability in overall task performance, the coefficient of variation was small for all tasks, ranging from 1% for One Card Learning speed to 16% for One Back accuracy, suggesting that participants' performance was relatively stable over time. When comparing the coefficient of variation for the first year of the study with all five years, we found that fluctuations in performance were limited mostly to the first year of the study.

Intraindividual variability, as measured by the absolute value of studentized residuals, showed decreasing variability over time for all tasks, with the exception of One Card Learning accuracy. When intraindividual variability was measured with personality traits, higher neuroticism and extraversion were associated with greater variability, while higher openness and conscientiousness were related to less variability. This finding is noteworthy given the substantial amount of literature that establishes greater intraindividual variability in accuracy and reaction time scores as a marker for incipient cognitive decline, mild cognitive impairment, and AD (Bielak, Hultsch, Strauss, Macdonald, & Hunter, 2010; Christ, Combrinck, & Thomas, 2018; MacDonald, Hultsch, & Dixon, 2003). In addition, our findings on intraindividual variability extend to the literature on personality and cognition. Decreasing intraindividual variability was related to higher openness and conscientiousness, which are consistently related to a lower risk for cognitive decline (Chapman et al., 2014; Cipriani et al., 2015; Duberstein et al., 2011; Luchetti et al., 2016), while increasing intraindividual variability was related to higher neuroticism and extraversion, which are considered to be significant and moderate risk factors, respectively, for cognitive decline (Archer et al., 2009; Chapman et al., 2014; Crowe et al., 2006; Hock et al., 2014)

The present study has some limitations that should be addressed. First, our sample of mostly white, well-educated older adults is not representative of the older adult population, and our findings may not generalize to more diverse groups of older adults. Next, our sample was considered to be cognitively healthy (MoCA ≥25), and as a result, our findings may not extend to individuals who are experiencing various levels of cognitive decline. Finally, it is possible that having participants complete assessments using the same four tasks on a monthly basis for five years reintroduced practice effects, and could have affected participants' performance. Future studies could use different intervals between assessments (e.g., monthly, quarterly, semi-annually) to determine whether monthly testing may be too frequent, and which interval may offer a better solution.

Despite these limitations, this study makes a significant contribution to the existing research on cognitive monitoring. To our knowledge, it is the first study in which participants completed regular cognitive monitoring assessments independently on a monthly basis for five years, and the first study to examine how personality traits affect cognitive performance specifically on computerized cognitive monitoring assessments.

Overall, we found that personality traits have some influence on participants' performance on monthly cognitive monitoring. Higher openness may relate to slower and less accurate performance at baseline, but eventually result in more accurate performance over time. Higher conscientiousness may indicate more accurate performance at baseline, as well as faster performance over time. In general, participants' performance was relatively stable, and intraindividual variability decreased over time. However, higher openness and conscientiousness were related to significantly less variability over time, while higher extraversion and neuroticism were associated with greater variability over time. These trends in performance may not necessarily be indicators of cognitive decline; instead, they reflect the influence of participants' existing personality characteristics on their cognitive performance. An awareness of how personality traits may affect performance in cognitive monitoring programs is important, particularly if cognitive monitoring programs are to be used as a screening or diagnostic tool for the early detection of cognitive decline. Accounting for personality traits may reduce the number of false positives and false negatives that may occur when screening for potentially clinically significant cognitive decline.

Table 1. *Participant Demographics.*

Background Characteristics	***M* (%)**	***SD***	**Range**
Age	74.5	7.9	60.0 – 94.0
Female	68.9%	-	
Caucasian	98.1%	-	
Completed college degree	66.0%	-	
Married	72.3%	-	
MoCA	26.9	1.8	20.0 – 30.0
GDS	2.1	1.6	1.0 – 8.0
Openness trait	3.8	0.5	2.5 – 5.0
Conscientiousness trait	4.2	0.6	1.9 – 5.0
Extraversion trait	3.5	0.8	1.8 – 5.0
Agreeableness trait	4.2	0.5	2.9 – 5.0
Neuroticism trait	2.3	0.7	1.0 – 4.0

Note. MoCA = Montreal Cognitive Assessment. GDS = Geriatric Depression Scale.

Table 2. *Mixed Effects Models of Performance on Detection, Identification, One Card Learning, and One Card Learning Tasks.*

Variables	Intercept		Time		Predictor		Time x Predictor	
	Estimate	***p***	**Estimate**	***p***	**Estimate**	***p***	**Estimate**	***p***
Detection speed								
Openness	52.282	<.01	-0.117	<.01	-0.381	.63	0.006	.75
Conscientiousness	52.239	<.01	-0.116	<.01	0.412	.61	-0.044	.03*
Extraversion	52.222	<.01	-0.116	<.01	-0.475	.54	0.037	.06
Agreeableness	52.240	<.01	-0.117	<.01	1.187	.14	0.007	.73
Neuroticism	52.246	<.01	-0.117	<.01	0.261	.74	-0.011	.59
Detection accuracy								
Openness	49.321	<.01	0.041	<.01	-0.356	.41	0.018	.21
Conscientiousness	49.292	<.01	0.041	<.01	0.798	.07	-0.013	.36
Extraversion	49.289	<.01	0.041	<.01	-0.366	.39	0.016	.27
Agreeableness	49.305	<.01	0.041	<.01	-0.634	.14	0.016	.27
Neuroticism	49.303	<.01	0.041	<.01	0.328	.43	-0.020	.15
Identification speed								
Openness	50.197	<.01	-0.004	.79	-0.167	.82	0.042	<.01*

Table 2 (Continued).

Conscientiousness	50.226	<.01	-0.004	.80	-0.570	.45	-0.025	.08
Extraversion	50.220	<.01	-0.004	.79	0.022	.98	0.012	.39
Agreeableness	50.208	<.01	-0.004	.81	0.598	.43	0.005	.72
Neuroticism	50.211	<.01	-0.003	.81	0.195	.79	0.017	.26
Identification accuracy								
Openness	48.831	<.01	0.077	<.01	-1.150	.01*	0.017	.22
Conscientiousness	48.703	<.01	0.078	<.01	0.956	.04*	-0.009	.49
Extraversion	48.703	<.01	0.079	<.01	0.022	.96	-0.013	.34
Agreeableness	48.716	<.01	0.078	<.01	-0.002	.99	-0.009	.51
Neuroticism	48.714	<.01	0.078	<.01	0.466	.30	-0.007	.59
One Card Learning speed								
Openness	53.543	<.01	-0.191	<.01	0.525	.50	0.032	.26
Conscientiousness	53.591	<.01	-0.188	<.01	1.051	.18	-0.013	.69
Extraversion	53.669	<.01	-0.188	<.01	0.779	.31	0.031	.30
Agreeableness	53.603	<.01	-0.189	<.01	0.948	.23	0.025	.44
Neuroticism	53.609	<.01	-0.189	<.01	-0.843	.26	-0.042	.19
One Card Learning accuracy								
Openness	44.378	<.01	0.287	<.01	-0.437	.42	0.015	.31
Conscientiousness	44.345	<.01	0.286	<.01	0.128	.82	0.003	.84

Table 2 (Continued).

Extraversion	44.300	<.01	0.286	<.01	-0.731	.17	-0.006	.69
Agreeableness	44.349	<.01	0.286	<.01	-0.308	.58	-0.004	.80
Neuroticism	44.349	<.01	0.286	<.01	-0.423	.43	-0.008	.61
One Back speed								
Openness	53.348	<.01	-0.181	<.01	0.243	.75	0.002	.92
Conscientiousness	53.377	<.01	-0.181	<.01	0.128	.87	-0.027	.08
Extraversion	53.434	<.01	-0.182	<.01	0.835	.26	-0.003	.84
Agreeableness	53.372	<.01	-0.181	<.01	0.819	.29	-0.007	.67
Neuroticism	53.374	<.01	-0.181	<.01	-0.377	.61	0.012	.46
One Back accuracy								
Openness	47.981	<.01	0.112	<.01	-0.920	.04*	0.027	.02*
Conscientiousness	47.899	<.01	0.112	<.01	0.986	.03*	-0.011	.20
Extraversion	47.905	<.01	0.112	<.01	0.104	.81	-0.011	.35
Agreeableness	47.911	<.01	0.112	<.01	-0.152	.74	-0.004	.74
Neuroticism	47.909	<.01	0.112	<.01	-0.412	.34	0.004	.74

Table 3. *Correlations between Personality Traits and Coefficient of Variation.*

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1. Openness	1	-	-	-	-	-	-	-	-	-	-
2. Conscientiousness	**.18**	1	-	-	-	-	-	-	-	-	-
3. Extraversion	.14	.15	1	-	-	-	-	-	-	-	-
4. Agreeableness	.15	**.24**	**.21**	1	-	-	-	-	-	-	-
5. Neuroticism	**-.23**	**-.24**	**-.20**	**-.42**	1	-	-	-	-	-	-
6. COV Detection speed	.17	.07	.01	-.06	-.01	1	-	-	-	-	-
7.COV Identification speed	.15	**.18**	.07	.10	-.14	**.73**	1	-	-	-	-
8. COV One Card Learning speed	.14	.14	**.21**	.10	-.18	.03	**.42**	1	-	-	-
9. COV One Card Learning accuracy	.15	-.05	.15	.08	-.04	-.04	.04	**.34**	1	-	-
10. COV One Back speed	.13	.15	.16	.05	-.16	**.34**	**.59**	**.69**	**.30**	1	-
11. COV One Back accuracy	.13	.01	-.02	.14	.05	.14	**.20**	.01	**.47**	-02	1

Note. COV = Coefficient of variation. Bold indicates *p*<.05.

Table 4. *Mixed Effects Models of Absolute Values of Studentized Residuals.*

Variables	Intercept		Time		Predictor		Time x Predictor	
	Estimate	*p*	Estimate	*p*	Estimate	*p*	Estimate	*p*
Detection speed								
Openness	0.900	<.01	-0.009	<.01	-0.042	.54	0.001	.60
Conscientiousness	0.899	<.01	-0.009	<.01	-0.009	.88	-0.002	.30
Extraversion	0.902	<.01	-0.009	<.01	0.027	.56	0.001	.79
Agreeableness	0.898	<.01	-0.009	<.01	-0.080	.26	0.003	.24
Neuroticism	0.899	<.01	-0.009	<.01	0.102	.05*	-0.003	.06
Detection accuracy								
Openness	0.737	<.01	-0.004	<.01	0.116	.16	-0.005	.05*
Conscientiousness	0.742	<.01	-0.004	<.01	-0.199	<.01*	0.004	.11
Extraversion	0.741	<.01	-0.004	<.01	0.029	.61	-0.002	.32
Agreeableness	0.740	<.01	-0.004	<.01	0.121	.15	-0.003	.28
Neuroticism	0.740	<.01	-0.004	<.01	-0.053	.40	0.003	.15
Identification speed								
Openness	0.787	<.01	-0.002	.01	0.019	.73	0.001	.96
Conscientiousness	0.791	<.01	-0.003	.01	-0.079	.10	0.001	.55
Extraversion	0.794	<.01	-0.003	<.01	0.061	.10	-0.001	.60

Table 4 (Continued).

Agreeableness	0.790	<.01	-0.003	.01	-0.060	.29	0.002	.22
Neuroticism	0.790	<.01	-0.003	.01	-0.011	.79	0.001	.38
Identification accuracy								
Openness	0.927	<.01	-0.007	<.01	0.098	.10	0.001	.87
Conscientiousness	0.936	<.01	-0.007	<.01	-0.112	.03*	0.001	.53
Extraversion	0.935	<.01	-0.007	<.01	-0.024	.56	0.001	.32
Agreeableness	0.935	<.01	-0.007	<.01	-0.020	.76	0.003	.20
Neuroticism	0.935	<.01	-0.007	<.01	-0.049	.30	-0.001	.80
One Card Learning speed								
Openness	0.851	<.01	-0.008	<.01	0.094	.34	-0.002	.52
Conscientiousness	0.855	<.01	-0.008	<.01	0.116	.18	-0.002	.30
Extraversion	0.866	<.01	-0.010	<.01	0.136	.04*	-0.001	.38
Agreeableness	0.855	<.01	-0.008	<.01	0.139	.18	-0.002	.48
Neuroticism	0.855	<.01	-0.008	<.01	-0.131	.09	0.003	.13
One Card Learning accuracy								
Openness	0.794	<.01	-0.001	.07	0.064	.13	-0.001	.35
Conscientiousness	0.797	<.01	-0.001	.05	0.020	.60	-0.001	.37
Extraversion	0.800	<.01	-0.001	.04	0.044	.13	-0.001	.55
Agreeableness	0.797	<.01	-0.001	.05	0.032	.47	-0.001	.88

Table 4 (Continued).

Neuroticism	0.797	<.01	-0.001	.05	-0.005	.89	0.001	.94
One Back speed								
Openness	0.853	<.01	-0.005	<.01	-0.009	.81	0.001	.94
Conscientiousness	0.853	<.01	-0.004	<.01	-0.026	.45	0.002	.21
Extraversion	0.856	<.01	-0.005	<.01	0.047	.09	0.001	.44
Agreeableness	0.852	<.01	-0.004	<.01	0.034	.41	0.001	.67
Neuroticism	0.853	<.01	-0.004	<.01	-0.026	.40	-0.001	.88
One Back accuracy								
Openness	0.870	<.01	-0.004	<.01	0.050	.24	-0.002	.33
Conscientiousness	0.872	<.01	-0.004	<.01	-0.036	.33	-0.001	.49
Extraversion	0.873	<.01	-0.004	<.01	0.013	.67	0.001	.48
Agreeableness	0.871	<.01	-0.004	<.01	0.027	.56	0.001	.48
Neuroticism	0.872	<.01	-0.004	<.01	-0.031	.36	0.001	.59

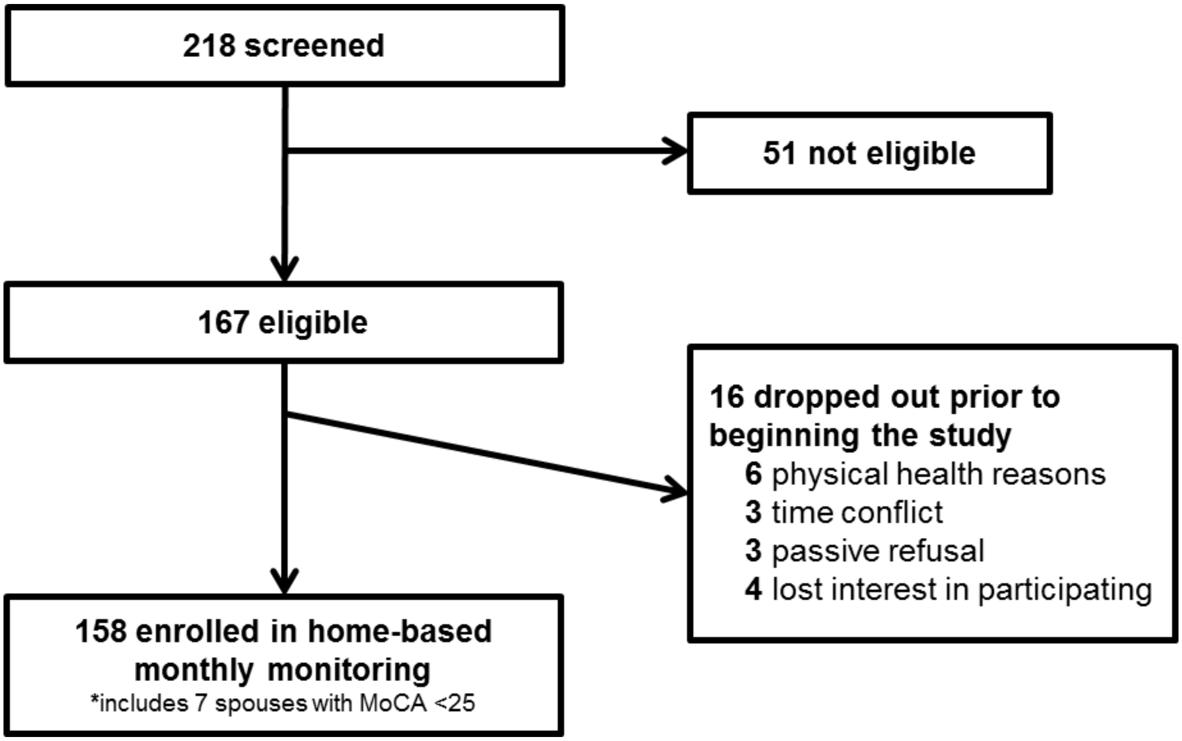

Figure 1. *Sample Eligibility and Enrollment.*

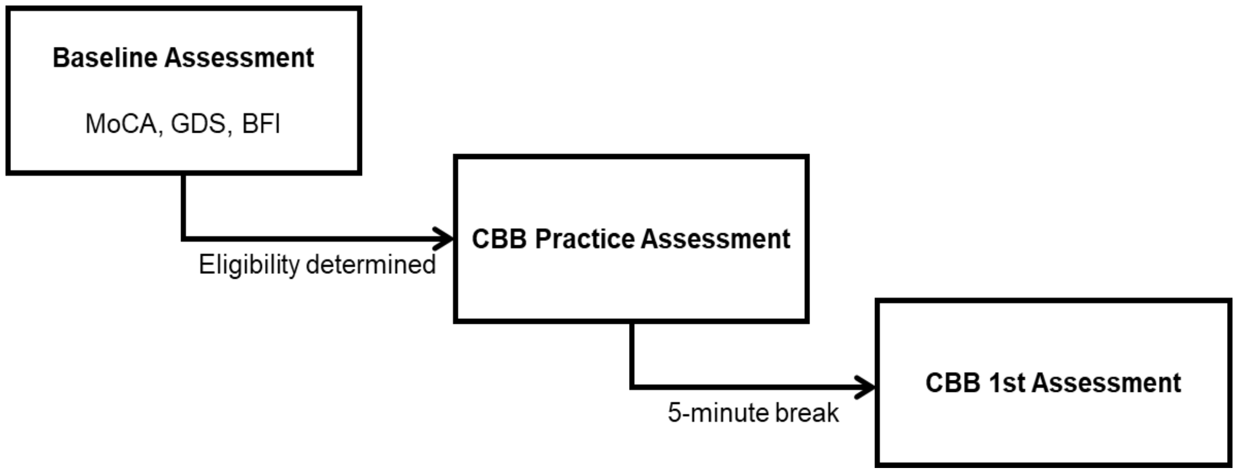

Figure 2. *Study Procedure.*

Level 1 Equation

$Y_{task} = \pi_{0i} + \pi_{1i} * Time_{ti} + e_{ti}$

Level 2 Equations

$\pi_{0i} = \beta_{00} + \beta_{01} * Trait_i + r_{0i}$

$\pi_{1i} = \beta_{10} + \beta_{11} * Trait_i + r_{1i}$

Combined Model

$Y_{task} = \beta_{00} + \beta_{01} * Trait_i + \beta_{10} * Time_{ti} + \beta_{11} * Trait_i * Time_{ti} + r_{0i} + r_{1i} * Time_{ti} + e_{ti}$

Figure 3. *Model Specification Equations.*

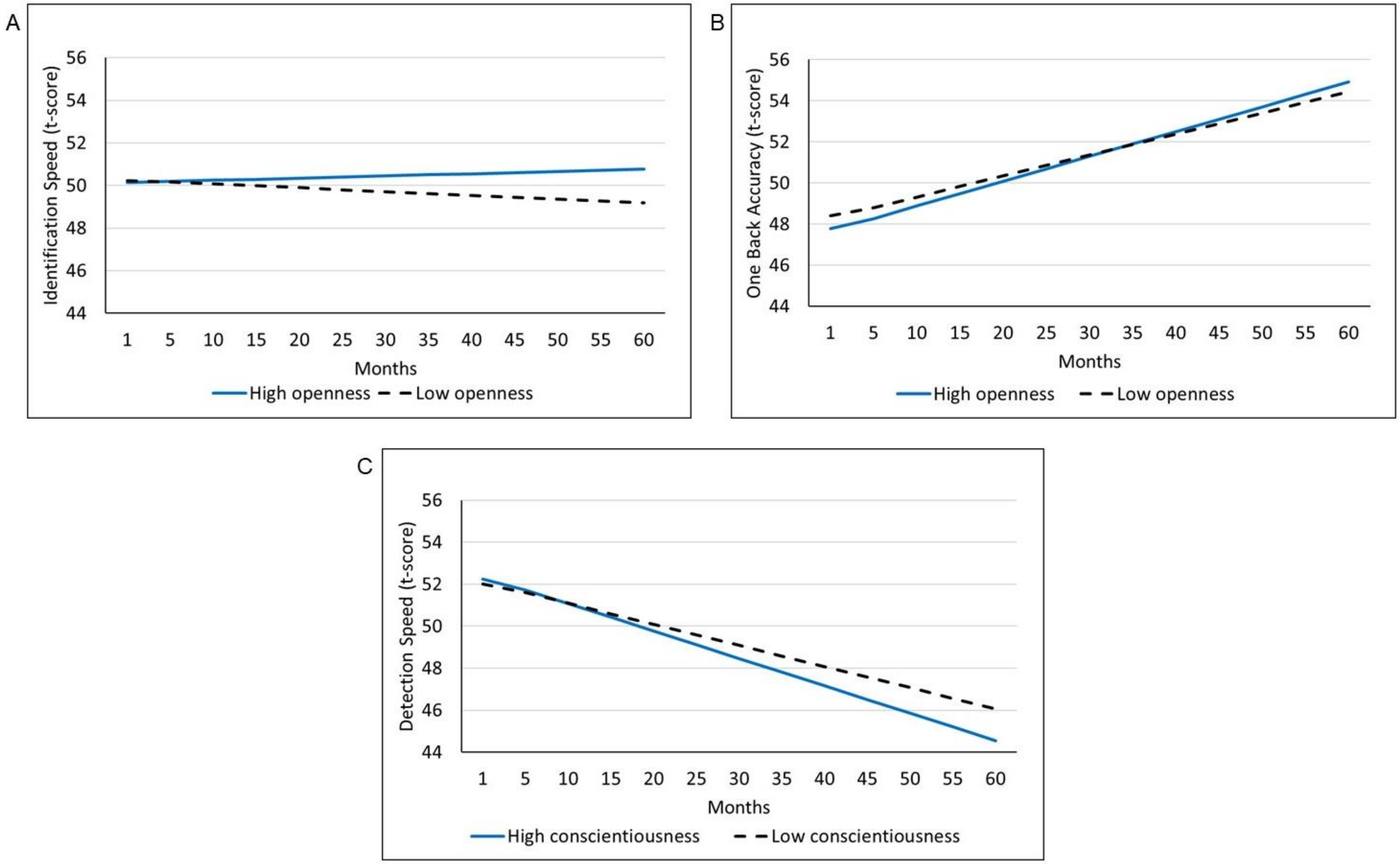

Figure 4. *Mean Performance over Time on the Detection, Identification, and One Back Tasks.*

Note. Personality traits were classified as high or low based on the intercept values; high levels of a trait corresponded to 1 SD above the intercept, whereas low levels corresponded to 1 SD below the intercept.

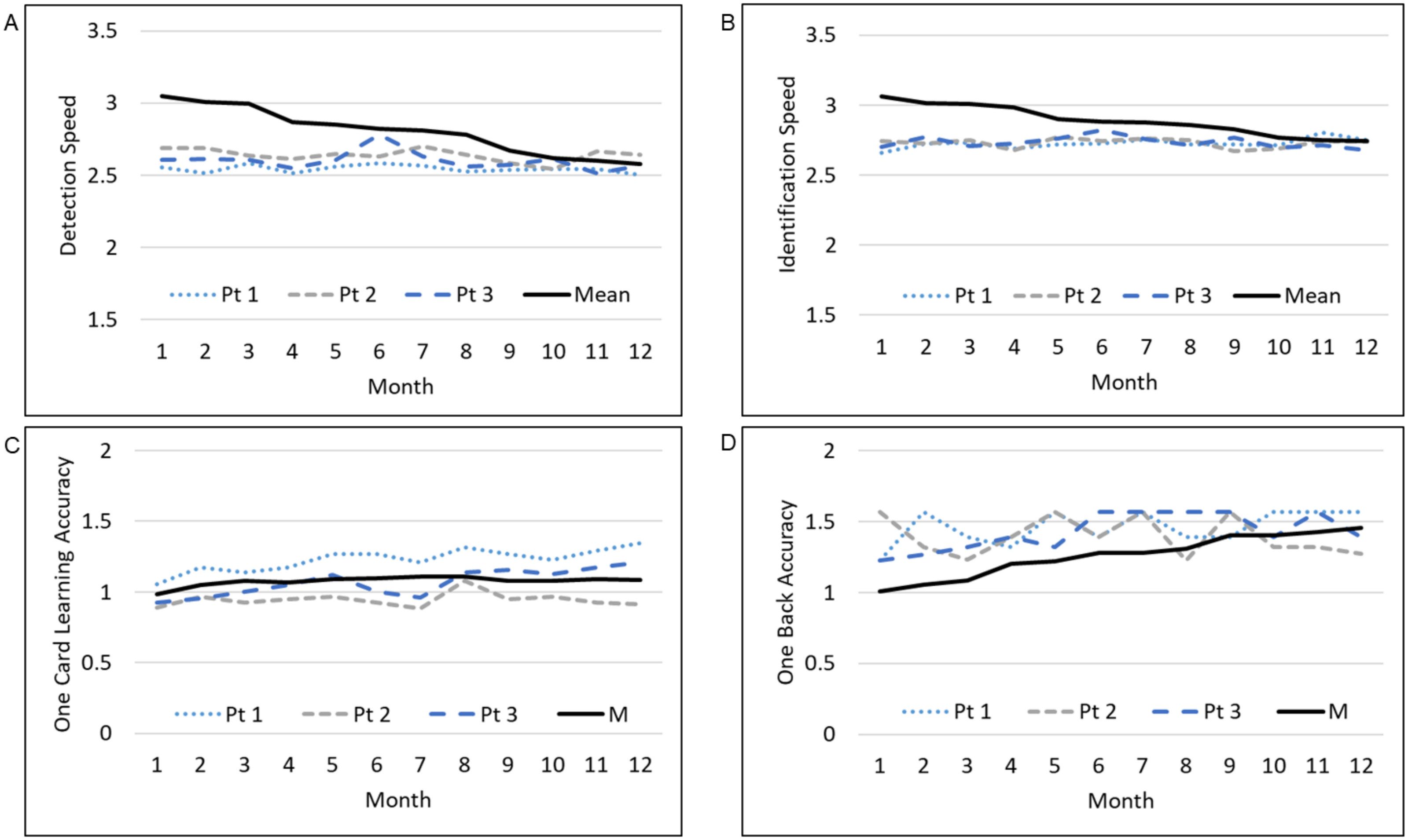

Figure 5. *One-Year Change in Mean Performance.*

Note. Mean task performance is graphed in comparison to individual performance of three randomly selected participants.

CHAPTER THREE:

STUDY #2: PREDICTORS OF ADHERENCE AND SATISFACTION WITH HOME-BASED COGNITIVE MONITORING PROGRAMS

Introduction

Regular, computerized cognitive monitoring among older adults is a promising method for the early detection of cognitive decline. Currently, most studies that involve cognitive monitoring are completed in lab settings with researcher or clinician supervision (e.g., Cromer et al., 2015; Lim, Ellis, et al., 2013; Lim, Jaeger, et al., 2013). However, there is a growing interest in self-administered cognitive monitoring programs as older adults are becoming increasingly tech-savvy. While preliminary studies have concluded that most participants are able to complete cognitive monitoring assessments independently (Rentz, 2016; Rentz et al., 2016; Sano et al., 2013; Sano et al., 2010; Valdes et al., 2016), few have extensively examined the predictors of participants' adherence and satisfaction with cognitive monitoring, or their self-reported experiences with participating in these programs. This is an especially relevant issue to address with regular cognitive monitoring programs, since they require continued participation over long follow-up periods.

Factors Affecting Study Adherence and Satisfaction

Most in-depth studies that have examined participant adherence are interventions that involve medication or exercise (e.g., Krousel-Wood et al., 2011, Conn et al., 2009), however, their findings are still applicable to cognitive monitoring studies. Several of these have concluded that it remains challenging to encourage study adherence among participants – especially over extended periods of time – despite compelling evidence for the health benefits associated with adhering to their prescribed intervention. In a large sample of patients with hypertension who were participating in the Cohort Study of Medication Adherence among Older Adults (CoSMO), only 52% had high adherence to their antihypertensive medication regimen. Poor study adherence among the CoSMO sample was associated with depressive symptoms, higher perceived stress, and the occurrence of a stressful life event. However, patients who were female and married exhibited better adherence rates (Krousel-Wood et al., 2011). Better adherence outcomes among females and individuals with social support have also been observed in a meta-analysis on medication adherence (Conn et al., 2009) and a systematic review on exercise participation among older adults (Koeneman, Verheijden, Chinapaw, & Hopman-Rock, 2011), respectively.

The technological requirements of a study and their associated problems can also affect adherence and dropout. Sano et al. (2013) found that across all three arms of their Home-Based Assessment Study, the highest dropout rate (17%) was observed in the arm that was the most technologically demanding for participants. They reported that participants' reasons for dropout usually included the inconvenience of the computer equipment and challenges with using technology.

In addition to their associations with cognitive performance, personality traits also affect how successfully an individual adheres to a study (Ozer & Benet-Martinez, 2006). The combination of low neuroticism, high conscientiousness, and high openness to experience is typical among people who enjoy volunteering in research studies (Lonnqvist et al., 2007) and is associated with better study adherence over time (Duberstein et al., 2011). Conversely, Hock et al. (2014) reported that participants who dropped out between waves of the Epidemiologic Catchment Area longitudinal study were significantly higher in neuroticism, and lower in both openness and conscientiousness, as compared to the participants who remained enrolled.

Finally, physical and cognitive health may also affect study adherence. Health problems and concerns about worsening health were cited as the most common reasons that participants withdrew from the one-year Cogstate pilot study (Valdes et al., 2016). Similarly, Mundt et al. (2007) reported that in their 20-week home-based study, completion rates were 100% for cognitively normal participants, 99.2% for participants with MCI, and 87.3% for participants with dementia, which suggests that cognitive status can affect study adherence.

Participants' Feedback about Study Experience

Similar to study adherence, participant satisfaction is another crucial component of longitudinal studies, especially those designed to document changes related to aging and cognition. Currently, most findings on older adults' satisfaction with research participation are based on clinical trials and patient samples (Karlawish, Casarett, Klocinski, & Sankar, 2001; Karlawish, Casarett, & James, 2002; Molinuevo et al., 2016). Patients and caregivers reported that their primary motivations for enrolling in clinical trials include the potential therapeutic benefits of the trial and the possibility of helping others (Avent et al., 2013; Hubbard, Downs, & Tester, 2003; Karlawish et al., 2001; Karlawish et al., 2002). However, little is known about the perspectives of cognitively healthy older adults who participate in research that can contribute to our understanding of the aging process (e.g., cognitive monitoring), but do not necessarily experience any immediate benefits from such participation.

Most studies that involve cognitive monitoring programs have not extensively focused on older adults' experiences with participation. Participant feedback can provide valuable information about their experience with research participation, including the factors that motivated them to participate, whether they were satisfied with the study, and what they gained from participation (Sano et al., 2018). Understanding how to retain participants and provide them with a positive study experience are concerns that are especially relevant to home-based cognitive monitoring studies, as they require continued self-motivated participation over lengthy follow-up periods.

Despite the challenges of encouraging long-term participation in research studies and the limited research on adherence and dropout in studies involving unsupervised cognitive assessment, the majority of older adults seem to be interested in programs that screen for early signs of cognitive impairment. A recent study conducted in several European countries and the United States found that 70% of older adults were interested in a program that could potentially screen for cognitive impairment (Wikler, Blendon, & Benson, 2013). In order to make recommendations for ways to keep participants engaged in long-term cognitive monitoring, and for the development of strategies that target individuals with low study adherence in order to encourage their long-term participation, there is a need to identify the participant characteristics that are related to adherence, dropout, and satisfaction with regular cognitive monitoring. In addition, participants' self-reported feedback about their experiences with participating in a long-term study can provide insight on how to improve study adherence and satisfaction and reduce study dropout.

Aims

The current study investigated three aims:

Aim 1: How well do cognitively healthy older adults adhere to a long-term study of regular cognitive monitoring?

> Hypothesis: Based on existing findings regarding older adults' interest in participating in programs that screen for early signs of cognitive impairment, we expected that participants would exhibit good adherence despite needing occasional reminders to complete their monthly assessments.

Aim 2: What demographic (age, gender, race, marital status) and health characteristics (personality traits, mental and physical health conditions, cognitive status) are related to study adherence and dropout, and satisfaction with study participation?

> Hypothesis: We predicted that participants who were younger, had greater social support, were higher in conscientiousness and openness to experience, and were in better health would adhere better compared to other participants.

Aim 3: What are cognitively healthy older adults' self-reported experiences with study participation, including their likes and dislikes, and suggestions for study improvement?

> Objective: Explore participants' qualitative feedback about study participation.

Method

Participants

Participants included 158 cognitively healthy older adults, age 55 years and older, who were enrolled in an ongoing, prospective cohort study examining home-based monthly memory monitoring. Participants were recruited through community memory screening events at the University of South Florida Health Byrd Alzheimer's Institute, as well as from retirement communities in the central Florida area. The study was in compliance with the ethical standards of the Committee on Human Experimentation of the University of South Florida and was approved by the Institutional Review Board (Pro00012918).

Procedure

As described in Study #1, participants first completed an in-person training session, during which they 1) completed a practice assessment with a researcher present and available to answer any questions and 2) completed their first month's assessment independently. Then they were given an opportunity to ask any additional questions about using the CBB and were sent home with instructions on how to troubleshoot common issues and our contact information in case they needed further assistance. Over the next 11 months, participants received a monthly email that contained a link to the CBB and were instructed to complete their assessment at their convenience within one week.

As part of the study's initial goal of assessing the feasibility of home-based cognitive monitoring (Valdes et al., 2016), participants completed an annual interview via phone following one year of monthly assessments. They were asked Likert-scale survey questions about using the CBB and their overall experience with participating in the study, including ease of access, issues with technical difficulties, and test content. In addition, they were asked open-ended questions about their likes, dislikes, and suggestions for study improvement. See Appendix 1 for a list of all questions that were included in the annual interview.

At the end of the interview, participants were also given the option to continue participating in the study indefinitely. If they chose to continue, the annual interviews that were administered in subsequent study years no longer included questions about their study experience, but were replaced by a health survey. If at any time a participant wished to withdraw from the study, they were asked an open-ended question about their reason(s) for withdrawal.

Mixed Methods Analysis

This study used a convergent mixed methods approach to integrate quantitative and qualitative data (Creswell, Klassen, Plano Clark, & Smith, 2011; Creswell & Plano Clark, 2017). Because study adherence and satisfaction are subjective and may vary considerably across participants, the exploratory value of the quantitative data can be limited without considering participants' self-reported qualitative feedback. Quantitative and qualitative data were collected concurrently during each year of the study as participants completed monthly assessments, and continued to be collected as participants remained actively enrolled in the study.

Quantitative Data Collection

Quantitative data were collected as participants completed each monthly assessment. Research assistants checked Datapoint, Cogstate's data management website, on a weekly basis to determine whether participants had completed their assessments on time, and would record assessment completion dates for each participant. If a participant did not complete their monthly assessment within a week of receiving their email, a research assistant would make a reminder phone call and resend their monthly email if the participant did not answer the phone or if the participant requested their email to be resent. This reminder procedure was repeated for two weeks; if a participant failed to complete a monthly session within five days of their third reminder phone call and email, the session was coded as skipped. Quantitative data were also collected following each participant's completion of twelve monthly assessments during annual phone interviews.

Quantitative Measures and Analysis

Study Adherence and Dropout. Quantitative measures that were used to collect data on study adherence included the number of: 1) days participants needed to complete their assessments; 2) phone and email reminders needed per monthly assessment; 3) assessments that were completed late; 4) assessments that were skipped; and 5) assessments that were completed prior to study dropout, if applicable. In addition, we calculated an overall successful adherence score. Based on data from our pilot study (Valdes et al., 2016) and a similar telephone-based monitoring study (Mundt et al., 2007), we operationalized successful adherence as skipping no more than two monthly assessments per year. Study dropout was analyzed using binary variables that categorized participants into groups based on whether or not they dropped out during the first year of the study and at any point throughout the study. Linear regressions, *t*-tests, and correlations were used to analyze data on study adherence, while logistic regressions and Chi-square tests were used to examine study dropout.

Study Satisfaction. Quantitative questions included in the annual interview were used to analyze participants' satisfaction with study participation. Participants were asked to answer scaled questions about their experience with completing the monthly assessments (i.e., "Overall, how would you rate your experience using the Cogstate program – very satisfied, satisfied, neither, dissatisfied, or very dissatisfied?") as well as yes/no questions (e.g., "Did you experience any technical problems?" "Was the program too time consuming?"). Logistic regressions and Chi-square tests were also used to examine study satisfaction.

Qualitative Data Collection

Qualitative data were collected at multiple points throughout the study. First, data were collected from all participants as they completed their monthly assessments. Anytime a participant did not complete their monthly assessment within a week of receiving their email, the research assistant making the reminder phone call would follow a script that prompted the participant to provide the reason(s) that prevented them from completing their assessment on time, and would record the reason(s) provided. Similar procedures were followed if a problem occurred that prevented a participant from completing an assessment altogether. In the event that a participant wished to withdraw from the study, they were encouraged to share their reason(s) for withdrawal, which were also recorded. Second, qualitative data were collected during the annual interviews from the open-ended questions about participants' likes, dislikes, and suggestions for improvement.

Phone calls between the research team and participants were not audio recorded. However, members of the research team transcribed all phone conversations verbatim in password-protected databases. Participants were informed at the beginning of the study that the content of their phone conversations with the research team would be transcribed and were reminded of this at the beginning of the annual interviews.

Qualitative Measures and Analysis

Study Adherence and Dropout. Qualitative items that were used to analyze study adherence and dropout included participants' reasons for 1) delayed assessments; 2) skipped assessments, and 3) if applicable, why they no longer wished to continue participating in the study.

Study Satisfaction. Participants' feedback about study satisfaction was collected through the open-ended questions about their likes, dislikes, and suggestions. A content analysis approach, a method of data interpretation with the goal of identifying recurring themes in the data (Pope, Ziebland, & Mays, 2000), was used to analyze participant responses. Simple counts (Driscoll, Appiah-Yeboah, Salib, & Rupert, 2007) were used to determine how frequently themes occurred, both in the total sample and among specific subgroups of the sample based on participant demographics including age, sex, education, cognitive status, and personality traits. Chi-square tests were used to determine whether there were any significant differences by group for each theme.

A list of a-priori codes was developed by the study coordinator (NS) and two undergraduate research assistants (BV and SB). These codes were based on the content of the open-ended questions, codes used in a similar study that explored participant feedback about computer-based cognitive assessments (Gamaldo et al., 2018), and common reasons for study non-adherence and dropout (e.g., forgetting, busy, health problems). The study coordinator (NS) and research assistants (BV and SB) coded all of the responses using Atlas.ti Version 7 computer software (Berlin, Scientific Software Development, 2015). A total of 660 quotes were collected from the four open-ended questions from the first annual interview, as well as study dropout reasons. According to our coding scheme, each participant quote was assigned only one code. To establish inter-rater reliability, the first 10 responses from each question were coded together (NS, BV, and SB). All of the remaining responses were then coded independently by each of the three coders. With only 31 coding disagreements, our inter-rater reliability was at 95%. An iterative consensus approach was used to reconcile any coding differences. All coding disagreements were discussed by NS, BV, and SB with two additional research assistants (DB and SC) until a consensus was reached on the appropriate coding.

Results

Sample Characteristics

The 158 participants were on average 74.59 years of age (*SD*=7.87 years), mostly female (n=109), White (98.0%), married (70.5%), had completed on average 16 years of education (*SD*=2.19) or approximately a Bachelor's degree, had an average MoCA score of 26.91 (*SD*=1.69), and reported less than one depressive symptom in the past week (*M*=.98, *SD*=1.45). Compared to normative personality trait data, our sample at baseline scored slightly higher than average in openness, conscientiousness, extraversion, and agreeableness, and slightly lower than average neuroticism.

Study Adherence

Aim 1. *How well do cognitively healthy older adults adhere to a long-term study of regular cognitive monitoring?*

On average, participants completed their monthly assessment within 4.02 days (*SD*=2.87) of receiving their pre-programmed monthly email, with minor fluctuations across study years. Participants needed three reminder calls (about one call every four months) and two reminder emails (about one email every six months) per year, and completed two late assessments per year and skipped one assessment per year. The three most common reasons why participants completed their assessments late or skipped them were: traveling (31%), computer problems (20%), and being busy (17%). Overall, 95% of participants met our criteria for successful study adherence, skipping no more than two monthly assessments per year. They also participated in the study with a high degree of independence, with approximately 50% of the sample needing only one reminder call and email per year. See Table 5 for all measures of study adherence.

Aim 2. *What demographic and health characteristics are related to study adherence and dropout, and satisfaction with study participation?*

Study adherence and dropout were next examined in relation to demographic and health characteristics. Age, sex, education, or race were not significantly correlated to any measures of adherence, including the number of days it took to complete monthly assessments or the number of late and skipped assessments, and were not significant predictors of study dropout over time. However, marital status was significantly related to the number of days needed to complete the monthly assessments, $t(143)=2.60$, $p=.01$. This indicated that participants who were married needed fewer days to complete their monthly assessments (*M*=3.67, *SD*=2.46) than participants who were not married (*M*=5.08, *SD*=3.71). Marital status was also significantly related to study dropout. Unmarried participants were more likely to withdraw from the study during the first year (X^2 (1)=12.40, *p*<.001) and also at any time during the study (X^2 (1)=4.21, *p*=.04).

Personality traits were also significantly correlated with study adherence. Participants who were more conscientious completed their monthly assessments sooner (r=-.21, p=.01), while those who were more agreeable (r=.185, p=.02) and extraverted (r=.18, p=.04) took longer. In addition, conscientiousness and extraversion were able to predict study adherence and dropout. In linear and logistic regressions adjusted for age, sex, and education, higher conscientiousness significantly predicted fewer days needed to complete monthly assessments (*β*=-0.21, *p*=.01) and lower extraversion significantly predicted study dropout over time (*β*=-0.16, *p*=.05). Openness or neuroticism were not related to any measures of study adherence or dropout. See Table 6 for correlations between participant characteristics and study adherence.

Most measures of cognitive and physical health, including MoCA, GDS, PSQI, and PSS were not significantly related to adherence or dropout, with the exception of the SMQ, which measured subjective memory complaints. The number of subjective memory complaints reported by participants was positively correlated with the number of skipped assessments (*r*=.37, *p*=.04). A greater number of subjective memory complaints also predicted more skipped monthly assessments (*β*=0.41, *p*=.01) in a regression adjusted for age, sex, and education.

Performance on the four primary CBB tasks at baseline was also related to study adherence and dropout. The number of days needed for study completion was significantly correlated to Detection (*r*=.24, *p*=.01) and Identification speed (*r*=.20, *p*=.02), which indicated that participants who performed slower on these tasks required more time to complete their monthly assessment. Slower speed on the Detection task also significantly predicted days to completion (β=0.41, *p*=.01), even after adjusting for age, sex, and education.

Identification speed was related to dropout at any time during the study, *t*(147)=-2.35, *p*=.02, meaning that participants who dropped out of the study performed significantly more slower on the Identification task at baseline (*M*=2.77, *SD*=.11) than participants who continued participating (*M*=2.73, *SD*=.07). One Card Learning accuracy was also related to dropout at any time during the study, *t*(147)=2.62, *p*=.01, as well as dropout specifically during the first year, *t*(147)=2.73, *p*=.01. Participants who dropped out of the study performed less accurately on the One Card Learning task (*M*=0.89, *SD*=.09) compared to those who remained in the study (*M*=0.96, *SD*=.11).

Study Satisfaction

Of the 158 participants enrolled in the study, 123 completed the first annual interview which contained questions related to participants' satisfaction with study participation. On average, these participants were 77 years of age (SD=7.5 years), mostly female (67.5%), Caucasian (99.2%), college educated (68.3%), and married (76.4%). There were no significant differences between participants who completed the annual interview and those who did not in terms of demographics, MoCA score, GDS score, or personality trait scores. See Table 7 for participant demographics by annual interview completion status.

In general, participants reported positive experiences with study participation. Eighty-seven percent (n=107) said they were either ‘satisfied’ or ‘very satisfied’ with their overall experience in the study, and over 94% reported that the monthly assessments were easy to access, had clear instructions, and were easy to see. Eighty-four percent (n=103) of participants indicated they would like to continue completing the monthly assessments. Of the 20 participants who chose not to continue participating in the study, the three most common reasons were that they felt the monthly assessments were: boring or repetitive (25%), were too busy (20%), or disliked cards and card games (20%).

Out of all the participant demographic characteristics and measures of health, only age was significantly related to satisfaction with study participation. When asked about their satisfaction with the study overall, participants who felt satisfied were younger (M=76.3, SD=7.5) than participants who did not feel satisfied (M=80.7, SD=7.5). This finding remained significant even after adjusting for sex, education, and participants’ frequency of computer usage and familiarity with computers.

When asked whether they experienced any problems with the study, approximately 27% of participants reported that they did. The most common problem was that several participants received an error message from the CBB website after completing their assessment stating that their data had not been successfully uploaded. After participants called to report the issue, research assistants checked whether their data was received. In all reported cases, the data was received successfully and participants were advised to disregard the error message. The next common problem was that computer glitches sometimes caused the CBB to momentarily freeze during a participant's assessment, followed by participants using an internet browser that was incompatible with the CBB. Participants also reported that typically these problems were solved within a day and had little effect on their satisfaction with participation. See Table 8 for complete descriptive results about study satisfaction.

Qualitative Results

Themes for Study Likes, Dislikes, and Suggestions

Aim 3. *What are cognitively healthy older adults' self-reported experiences with study participation, including their likes and dislikes, and suggestions for study improvement?*

All themes for each of the four open-ended questions from the annual interview are listed in Table 9 with some exemplar quotes from participants. They are discussed by question in the following sections.

Question 1: "What are some things you liked about the Cogstate program?"

The most common themes that emerged for the first question in rank-order were: 1) easy, 2) helping others or helping with research, 3) challenging, 4) everything, and 5) convenient. For the first theme, many participants liked that the CBB was easy to use. One participant (female, age ≥77) stated, "It was easy to use and fairly easy to do the tasks.", while another (male, age ≥77) commented that it was easy even though they were not very familiar with computers, "It was easy to do, even though I'm not extremely confident with computers, it was something I looked forward to."

In the second theme, participants liked that they were contributing to research and that their participation in the study could potentially help others in the future. One participant (female, age <77) stated, “I liked that taking the test was helping with the research.”, while another (female, age <77) said, “I liked the idea of helping people out, maybe they will learn something that will help others.”

The third theme, challenging, had several responses where participants said they enjoyed that the monthly assessments provided them with a way to challenge themselves, as one male (age <77) explained, “I like that it challenged me and I could tell my brain was having to work hard.” For the fourth theme, some participants stated that they liked everything about the study, such as a female (age <77) who said, “I liked everything about the way the program was done and I'm looking forward to the next part.”

The fifth theme, convenient, was related to participants’ ability to complete their monthly assessment from home at any time within a week of receiving their email. One participant (male, age <77) said, “It was convenient because you could do it whenever and I never felt pressured to complete it.”

Question 2: “What were some things you did not like about the Cogstate program?”

Question 3: “What was the most difficult part of the Cogstate program?”

For the second and third questions, the emerging themes overlapped considerably. As a result, they were combined into a total of four themes: 1) task 3, 2) nothing, 3) compatibility, and 4) dislikes cards. In the first theme, 19% of participants (n=23) disliked the One Card Learning task and 80% participants (n=98) felt that it was the most difficult part of the study, as one female (age ≥77) stated, “Task 3 [One Card

Learning] was most difficult. I felt like I could never get better at it." In the One Card Learning task, participants are shown randomly selected playing cards, one at a time, and are asked to indicate whether that particular card has appeared before in the task. The task continues until the participant makes 42 complete responses, or reaches the maximum time limit (three minutes) allowed for the task (Maruff et al., 2009). Out of the four CBB tasks, the One Card Learning task requires the most time and effort to complete. While many participants did not like that it was more difficult compared to the other tasks, as evidenced by the following quote from a female (age <77): "One of the tasks is much harder than the others, that was a bit strange.", some mentioned that they appreciated the challenge it presented. For example, one participant (female, age ≥77) said, "'Have you seen the card before?' was hard, but actually challenging and fun."

In the second theme, 54% of participants (n=67) responded that they could not think of anything they disliked about the CBB and 8% (n=10) did not think that one specific task was more difficult than the others. For the third theme, participants disliked that the CBB was only compatible with computers and certain internet browsers. A female (age <77) said, "It would be more convenient if I could do it on a tablet or smart phone." and a male (age ≥77) said, "[I disliked] that I had to change browsers for the program." In the fourth theme, others disliked that the CBB tasks used only playing cards as stimuli, as one female (age <77) stated, "I never liked card games so I wish there was something else to do the study with."

Question 4: "What suggestions do you have to improve the Cogstate program?"

The most common themes were 1) nothing, 2) wanted feedback, 3) change cards, 4) more tasks, and 5) compatibility. In the first theme, many participants were satisfied with the CBB and did not have any suggestions for its improvement. The following participant's (female, age <77) response is representative of most of the quotes: "None, I think it's great the way it was." The second theme, wanted feedback, suggests that many participants were interested in receiving feedback on their performance. One female (age <77) said, "I would like a score at the end, like to show me each month how I did, and how I compared to others."

In the third theme, change cards, many participants expressed that they wanted the CBB to have more options for stimuli other than playing cards, as evidenced by the following quotes from a male (age ≥77), "Give people the choice of what they want to use instead of cards, like cars or animals." and a female (age ≥77), "More variety instead of cards. Maybe something I'm more familiar with, like people."

The fourth theme, more tasks, had several responses indicating that participants wanted the assessment to be longer, and in some cases, more challenging. One female (age <77) said, "It wasn't very long, so I think it could've used another task." and a male (age <77) suggested, "Maybe a more challenging task besides the third one could be included, since there were three easy ones."

Participants' suggestions in the fifth theme were related to their dislikes regarding the CBB's compatibility issues. One participant (female, age ≥77) stated, "I would like if we didn't have to use a computer, it would be better if I could do it on my iPad." and another (male, age ≥77) said, "Make it work with Google Chrome."

Themes for Likes, Dislikes, and Suggestions by Group

Themes were also separated by groups to determine whether there were any differences based on age (<77 or ≥77), sex (male or female), education (college educated or non-college educated), cognitive status (MoCA ≤25 or MoCA >25), and personality traits (high or low; all BFI traits). See Table 10 for themes separated by age, sex, education, and cognitive status, and Table 11 for themes separated by personality traits. Chi-square analyses indicated two statistically significant differences when themes were separated by group. There were differences between participants who were lower and higher in agreeableness regarding what they liked ($p=.02$), and differences between males and females about what they disliked ($p=.01$). More agreeable participants were more likely than less agreeable participants to report that they liked everything about the study especially that it was convenient, easy, and provided them with a way to help others. Compared to males, females were more likely to say that their dislikes included Task 3 and compatibility problems with the CBB.

Themes for Study Dropout Reasons

Of the 158 participants who enrolled in the study, 89% (n=140) completed all 12 assessments. When asked whether they would like to continue participating in the study, 100 participants decided to continue, and the remaining 40 decided to conclude their participation after completing the required 12 assessments. Following the first year of the study, an average of 88% of participants who continued into subsequent years of the study completed all 12 assessments. See Figure 6 for study withdrawal information by year.

Over the five-year study period, several themes emerged for participants' reasons for study withdrawal. The most common themes that occurred across years in the study were: 1) computer, 2) lost interest, 3) passive refusal, and 4) spouse/family health.

The first theme included any computer related issues that participants experienced that led to study withdrawal, including problems they encountered with their own computers or compatibility issues that occurred with the CBB. For example, several participants withdrew from the study because the internet browser of their choice was not compatible with the CBB, and they were not willing to switch to a compatible browser. One female participant stated, “I know I can put another one [browser] on, but I am not going to do that.” Some participants withdrew because they felt they were “not computer savvy enough” to troubleshoot technical difficulties they encountered with their computers, such as installing routine system updates, and others withdrew as a result of replacing their computer with a tablet, since the CBB is not yet touchscreen-compatible.

The second theme, lost interest, occurred primarily during the second year of the study and accounted for five of the thirteen withdrawals that year. The following quote from one male participant is representative of most responses in this theme: “[I’m] just not interested anymore.” Many participants added that they felt they had contributed sufficiently to the study and “got what they wanted out of it [participating]”. The third theme, passive refusal, was coded according to the original study protocol, which stated that a participant would be considered a passive refusal if they did not complete three consecutive monthly assessments and could not be contacted via phone after three attempts.

In the fourth theme, spouse/family health, participants cited health concerns affecting their spouse or family as their primary reason for withdrawing from the study. Some participants said that their increased caregiving responsibilities did not leave them with much free time for additional activities, such as participating in the study. For example, one female participant said that “health issues with my 96-year-old mother have changed my schedule and I am no longer able to continue.” In addition, some participants wanted to withdraw from the study because they “did not feel in the right mind to participate anymore” as a result of the stress brought on by their spouse or family member’s new or worsening health-related problem. One female participant shared that she “had been very busy and stressed out lately due to her husband being moved out of assisted living and into a nursing home and would like to withdraw from the study.”

Discussion

The present study examined study adherence and satisfaction among cognitively healthy older adults enrolled in an online, monthly cognitive monitoring program for up to five years. Our hypothesis for Aim 1 was supported; most participants (95%) met our established criteria for overall successful adherence. They also reported positive experiences with the study and felt that their monthly assessments were relatively easy to access, understand, and complete. These findings are similar to recent studies which concluded that older adults can successfully complete cognitive monitoring assessments independently (Rentz et al., 2016; Sano et al., 2010; Valdes et al., 2016), and further suggest that home-based cognitive monitoring may indeed be a feasible option for detecting potential cognitive changes among older adults.

Our hypothesis for Aim 2 was partially supported. Study adherence was not significantly related to age, openness to experience, or most measures of cognitive and physical health. However, we found significant differences in adherence based on participants' marital status, conscientiousness, agreeableness, extraversion, subjective memory, and baseline CBB performance. Participants who were married exhibited better study adherence (i.e., needing fewer days to complete monthly assessments) and were less likely to withdraw from the study, comparted to participants who were not married. These findings, which have been reported previously in studies about medication adherence and exercise intervention participation (Conn et al., 2009; Koeneman et al., 2011; Krousel-Wood et al., 2011), suggest that being married, or having a higher level of social support, can contribute to better study adherence over time. Qualitative feedback from our participants also supports this finding, since many participants shared that they often talked with their spouse about participating in the study and some were even reminded by their spouse to complete their monthly assessments. For example, one married couple said that participating was "fun because I was doing it and so was my husband" and "was nice because I could talk to my wife about it."

Based on these findings, we conducted post-hoc exploratory analyses on participants who were married couples. Of the 115 participants who were married, 40% (n=46) were married to another participant, with a total of 23 couples in the study. We found that couples in the study were significantly less likely to drop out during the first year of the study (X^2 (1)=5.41, p=.02). In fact, none of the couples dropped out during the first year of the study, while eight participants who were married to a non-participant did. Although not statistically significant, further analyses showed that compared to other married participants, couples completed their monthly assessments a day sooner, had fewer late and skipped assessments, and required fewer reminder phone calls and emails. Based on these findings, a potential strategy for reducing study dropout may be to enroll a participant's spouse or other loved one in the study too.

It was not surprising that conscientious participants completed their monthly assessments sooner than other participants, since conscientiousness is related to being reliable, responsible, and punctual (Bogg & Roberts, 2013) and is associated with research participation (Lonnqvist et al., 2007). However, our findings that participants higher in agreeableness and extraversion took longer to complete their monthly assessments were unexpected. Based on participants' reasons for completing their assessments late, we speculate that participants who are more agreeable and more extraverted might be busier due to a greater number of social commitments that they prioritized ahead of study participation.

Study adherence was also associated with SMQ score and baseline performance on the CBB. A greater number of subjective memory complaints predicted more skipped assessments, which likely occurred as a result of participants forgetting to complete their monthly assessment. Participants who performed slower and less accurately on the CBB at baseline needed significantly more days to complete their monthly assessments and were more likely to withdraw from the study. Together, these findings suggest that participants with more subjective memory complaints and poorer performance on objective measures of cognition are at a greater risk for study non-adherence and dropout, despite the fact that they might be the individuals who could benefit the most from study participation. Strategies to improve study adherence among these participants could be developed to encourage them to participate regularly, such as more detailed or frequent reminders about completing their monthly assessments.

The themes that were identified in participants' answers to the open-ended questions highlighted their likes and dislikes of cognitive monitoring using the CBB. Participants appreciated that the CBB tasks were fairly easy, but still provided them with a way to challenge themselves. Some participants compared the CBB to a computer game and even said they looked forward to completing it each month. In addition, participants liked being able to complete the CBB from home at their convenience.

Participants' primary concerns were related to the One Card Learning task. 80% of participants stated that it was the most difficult part of the study, and many commented that they felt it was disproportionately more difficult than the other tasks. However, several participants said that although they disliked the One Card Learning task, they still enjoyed the challenge that it presented them and were motivated to "beat their score from last month." Interestingly, participants' performance on the One Card Learning task showed small yet significant improvements over time (Sadeq, Valdes, Harrison Bush, & Andel, 2018), suggesting that a challenging task may have actually motivated participants to put extra effort into their monthly assessments. While most participants did not report any additional dislikes, some thought that the CBB was too repetitive and disliked that it used only playing cards as task stimuli.

Consistent with findings from clinical trials and dementia prevention studies (Avent et al., 2013; Hubbard, Downs, & Tester, 2003; Sano et al., 2018), many participants were motivated by altruism and liked that their participation provided them with a way to contribute to research and could potentially help others. As suggested by Sano et al. (2018), recruitment materials for studies involving healthy older adults could highlight the fact that their participation could help advance gerontological research and potentially be beneficial to others.

When asked about suggestions for study improvement, 54% of participants said they were completely satisfied with the study. However, several participants suggested that the study could be improved if they were provided with individualized feedback about their performance. The desire to receive feedback is not uncommon among research participants; in fact, 87% of older adults surveyed about the creation of participant registries for longitudinal study recruitment said that their willingness to enroll would substantially increase if they would be receiving personalized results from cognitive tests (Grill, Holbrook, Pierce, Hoang, & Gillen, 2017). In addition, Sano et al. (2018) suggested that not providing feedback about participants' cognitive performance could potentially cause to them to assume a negative perception about their performance, as opposed to the idea that "no news is good news."

While our original study protocol did not include providing participants with any feedback, we later modified this during the third year of the study in response to participants' repeated requests for feedback on their performance. With the approval of the IRB and Cogstate LLC, we began sending annual progress reports that featured a color-coded line graph of the participant's performance on the four CBB tasks over the past year. These progress reports have been well-received by participants; many of them have expressed their appreciation with receiving information about their study performance.

Other suggestions for improving the study included modifications to the CBB, including more tasks as well as more variety in the tasks. Many participants felt that an intermediate-level task should be placed after the Identification task that would prepare them for the difficulty level of the subsequent One Card Learning task. Participants also felt that completing the same four tasks that utilized the same stimuli became monotonous. They suggested including a greater variety of tasks, as well as tasks that utilized other everyday objects aside from playing cards. While these suggestions are not entirely practical in that they require significant modifications to the existing CBB, they nonetheless offer valuable information for cognitive assessment programs that will be developed in the future or existing ones that can be modified.

Lastly, participants also suggested that the study could be improved if they were able to access the CBB on alternate platforms, such as tablets or smartphones, and through the internet browser of their choice. Given that approximately half of adults over the age of 65 own a smartphone or tablet (Pew Research Center, 2017), it is not surprising that participants would like the option of being able to complete their assessments on multiple devices. Despite the increases in technology adoption among older adults, it is interesting that many participants also suggested that the CBB should be compatible with the internet browser they regularly use. While some participants did not want the inconvenience of using an additional browser solely for the purpose of participating in the study, others were willing to do so, but were apprehensive about using a browser with which they were unfamiliar. This suggests that participants' comfort level and experience with computers are important factors to consider in computer-based studies with evolving technology.

Some of the most common reasons reported for study withdrawal among our participants – such as computer-related issues, loss of interest, and passive refusals –

were to be expected in a study that required long-term participation combined with the regular use of technology, and have been reported in previous studies (e.g., Mundt et al., 2007; Rentz et al., 2016; Sano et al., 2013; Sano et al., 2018). However, we did not expect that health issues affecting participants' spouse or family members would be a common reason for study withdrawal, particularly given the relatively low demand associated with study participation (15 minutes per month). Based on participant quotes, and the fact that they were motivated by altruism and helping others, we hypothesize that our participants have significant caregiving responsibilities for their spouse or family member that required them to limit additional activities they participated in.

This study does have some limitations which must be addressed. Our sample of predominately white, healthy, and educated older adults is not representative of the older adult population. Another limitation is that participants' feedback is specific to the CBB and therefore may not be generalizable to other cognitive monitoring programs. In addition, participant feedback was only collected following the first year of study participation, and it is possible that participants' likes, dislikes, and suggestions can change over time. Lastly, one aspect of our study design may have caused participants to overestimate the easiness of participation. Our participants were emailed a direct link to their monthly assessment that was preprogrammed with their participant identification number, and simply had to click the link to begin their assessment. While this method was feasible with our smaller sample, it would not be practical for large-scale implementation of cognitive monitoring; participants would most likely need to access the program's website independently and enter a username and password. These additional steps may be challenging for participants who are less experienced with using computers and the internet.

Despite these limitations, our study provides a significant contribution to the existing research on cognitive monitoring. To our knowledge, it is the first study to report on factors affecting participant adherence and satisfaction and extensively examine feedback from the perspective of cognitively healthy older adults in a cognitive monitoring study that spanned several years. Evaluating participants' feedback to understanding their likes and dislikes can help researchers and test developers provide participants with a positive and engaging study experience. It can also inform the development of strategies that facilitate long-term retention of participants and minimize study withdrawal, especially among those with the characteristics that were related to study non-adherence and dropout.

Table 5. *Study Adherence by Year.*

Variables	**Year 1**		**Year 2**		**Year 3**		**Year 4**		**Year 5**		**Total**	
	M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
Days to completion	3.98	2.93	3.72	2.91	3.54	2.59	3.63	2.71	3.78	2.91	4.02	2.87
Late assessments	2.17	2.14	2.21	2.14	2.20	2.14	2.65	2.39	1.59	2.12	6.76	7.22
Skipped assessments	0.37	0.89	0.63	1.03	0.84	1.34	1.07	1.41	0.59	1.09	2.01	2.70
Reminder calls	2.77	3.34	2.76	3.26	1.86	2.92	2.51	2.72	1.56	2.25	7.56	8.78
Reminder emails	1.49	1.92	1.57	2.41	1.16	2.08	1.75	2.38	1.05	1.68	4.49	5.96

Table 6. *Correlations between Participant Characteristics and Study Adherence.*

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1. Days to completion	1	-	-	-	-	-	-	-	-	-	-	-	
2. Late assessments	**.48**	1	-	-	-	-	-	-	-	-	-	-	
3. Skipped assessments	**.25**	**.68**	1	-	-	-	-	-	-	-	-	-	
4. Openness	.14	-.01	.04	1	-	-	-	-	-	-	-	-	
5. Conscientiousness	**-.21**	-.15	-.11	.10	1	-	-	-	-	-	-	-	
6. Extraversion	.04	**.19**	.12	**.26**	**.17**	1	-	-	-	-	-	-	
7. Agreeableness	**-.18**	.49	.11	**.17**	**.21**	**.24**	1	-	-	-	-	-	
8. Neuroticism	-.03	.07	-.03	**-.31**	**-.25**	**-.25**	**-.44**	1	-	-	-	-	
9. MoCA	.01	-.03	-.09	.06	.01	-.08	-.08	-.01	1	-	-	-	
10. GDS	.05	.05	.02	-.10	**-.17**	**-.29**	**-.23**	**.29**	-.01	1	-	-	
11. SMQ	.05	.25	**.37**	.21	-.32	-.24	.17	-.03	-.18	.19	1	-	
12. PSQI	-.06	.04	.14	.01	-.16	**-.41**	.13	.02	.04	.16	.10	1	
13. PSS	.16	.19	.02	.20	-.09	.01	.08	-.02	-.30	-.07	.08	-.02	1

Note. Bold indicates $p<.05$. MoCA = Montreal Cognitive Assessment. GDS = Geriatric Depression Scale. SMQ = Subjective Memory Questionnaire. PSQI = Pittsburgh Sleep Quality Inventory. PSS = Perceived Stress Scale.

Table 7. *Participant Demographics by Annual Interview Status.*

	Completed annual interview (n=123)		Did not complete annual interview (n=35)	
Background Characteristics	***M* (%)**	***SD***	***M* (%)**	***SD***
Age	76.9	7.5	75.2	9.1
Female	67.5%	-	74.3%	-
Caucasian	99.2%	-	94.3%	-
Completed college degree	68.3%	-	62.9%	-
Married	76.4%	-	60%	-
MoCA	26.8	1.7	27.2	1.8
GDS	0.8	1.4	1.0	1.5
Openness trait	3.8	0.5	3.8	0.6
Conscientiousness trait	4.2	0.6	4.1	0.6
Extraversion trait	3.5	0.8	3.5	0.8
Agreeableness trait	4.2	0.5	4.3	0.4
Neuroticism trait	2.3	0.7	2.2	0.7

Note. MoCA = Montreal Cognitive Assessment. GDS = Geriatric Depression Scale.

Table 8. *Study Satisfaction Responses.*

Questions	% Yes	% Easy[a]
How easy was the program to use overall?	-	98.4
How easy was it to access your monthly test?	-	97.5
How easy was it to understand the instructions for the four tasks?	-	100.0
How easy was it to see the details of the cards (color, suit, number)?	-	98.4
Would you be willing to continue to complete the monthly assessments in the future?	83.7	
Did you like hearing audio feedback for your responses?	87.7	-
Did you experience any technical problems with the program?	26.8	-
Was the program too time consuming?	3.3	-

[a]Items were answered on a scale of 1 to 4, where 1=very easy, 2= somewhat easy, 3=somewhat difficult, 4=very difficult

Table 9. *Themes and Participant Quotations from Annual Interview.*

Question 1. What are some things you liked about the Cogstate program?

Themes	Total Responses	Example Quotes
1. Easy	22	It was easy to use and fairly easy to do the tasks.
2. Helping others/research	22	I liked helping out, because the program can help others.
3. Challenging	14	It was a challenge and I liked that.
4. Everything	14	I liked everything about the way the program was done.
5. Convenient	12	I liked I could do it when it was convenient for me.

Question 2. What were some things you did not like about the Cogstate program?
Question 3. What was the most difficult part of the Cogstate program?

Themes	Total Responses	Example Quotes
1. Task 3	121[a]	I was really frustrated with Task 3.
2. Nothing	77[b]	There wasn't anything I disliked.
3. Compatibility	6	I could not use it on my iPad.
4. Dislikes Cards	6	I'm not a card player, not used to seeing cards.

Table 9 (Continued).

Question 4. What suggestions do you have to improve the Cogstate program?		
Themes	Total Responses	Example Quotes
1. Nothing	67	I can't think of any, I liked it just fine.
2. Wanted feedback	10	It would be nice to get some feedback.
3. Change cards	10	More variety in tasks other than cards.
4. More tasks	9	Tasks that are more challenging
5. Compatibility	8	Make it compatible with all browsers.

Note. Total Responses column reflects the number of participant quotes that were coded as each theme listed. Only one theme could be assigned to a participant quote.
[a]Of the 121 total quotes for "Task 3," 19% (n=23) were from Question 2 (dislikes) and 80% (n=98) were from Question 3 (most difficult).
[b]Of the 77 total quotes for "Nothing," 54% (n=67) were from Question 2 (dislikes) and 8% (n=10) were from Question 3 (most difficult).

Table 10. *Themes for Likes, Dislikes, and Suggestions by Covariates.*

	Age		Sex		Education		MoCA	
Themes for Likes	**<77 (n=63)**	**≥77 (n=60)**	**Male (n=40)**	**Female (n=83)**	**No college (n=39)**	**College (n=84)**	**≤25 (n=22)**	**>25 (n=101)**
Easy	**12** (19%)	**10** (17%)	**9** (23%)	**13** (16%)	**8** (21%)	**14** (17%)	**3** (14%)	**19** (19%)
Helping others/research	**10** (16%)	**13** (22%)	**6** (15%)	**17** (20%)	**7** (18%)	**16** (19%)	**4** (18%)	**19** (19%)
Challenging	**9** (14%)	**5** (8%)	**6** (15%)	**8** (10%)	**3** (8%)	**11** (13%)	**1** (5%)	**13** (13%)
Everything	**6** (10%)	**8** (13%)	**3** (8%)	**11** (13%)	**6** (15%)	**8** (10%)	**3** (14%)	**11** (11%)
Convenient	**5** (8%)	**7** (12%)	**5** (13%)	**7** (8%)	**6** (15%)	**6** (7%)	**5** (23%)	**7** (7%)
Themes for Dislikes								
Task 3	**7** (11%)	**16** (27%)	**2** (5%)	**21** (25%)	**7** (18%)	**16** (19%)	**2** (9%)	**21** (21%)
Nothing	**36** (57%)	**31** (52%)	**24** (60%)	**43** (52%)	**22** (56%)	**45** (54%)	**12** (55%)	**55** (54%)
Compatibility	**4** (6%)	**2** (3%)	**1** (3%)	**5** (6%)	**1** (3%)	**5** (6%)	**2** (9%)	**4** (4%)
Dislikes cards	**1** (2%)	**5** (8%)	**3** (8%)	**3** (4%)	**0**	**6** (7%)	**1** (5%)	**5** (5%)
Themes for Suggestions								
Nothing	**29** (46%)	**38** (63%)	**23** (58%)	**44** (53%)	**25** (64%)	**42** (50%)	**16** (73%)	**51** (50%)
Wanted feedback	**7** (11%)	**3** (5%)	**4** (10%)	**6** (7%)	**0**	**10** (12%)	**1** (5%)	**9** (9%)
Change cards	**4** (6%)	**6** (10%)	**2** (5%)	**8** (10%)	**1** (3%)	**9** (11%)	**0**	**10** (10%)
More tasks	**6** (10%)	**3** (5%)	**4** (10%)	**5** (6%)	**4** (10%)	**5** (6%)	**0**	**9** (9%)
Compatibility	**3** (5%)	**5** (8%)	**4** (10%)	**4** (5%)	**3** (8%)	**5** (6%)	**3** (14%)	**5** (5%)

Table 11. *Themes for Likes, Dislikes, and Suggestions by Personality Traits.*

	Openness		Conscientiousness		Extraversion		Agreeableness		Neuroticism	
Themes for Likes	**Low (n=59)**	**High (n=64)**	**Low (n=31)**	**High (n=92)**	**Low (n=35)**	**High (n=88)**	**Low (n=34)**	**High (n=89)**	**Low (n=101)**	**High (n=22)**
Easy	**10** (17%)	**12** (19%)	**6** (19%)	**16** (17%)	**5** (14%)	**17** (19%)	**3** (9%)	**19** (21%)	**20** (20%)	**2** (9%)
Helping others/research	**12** (20%)	**11** (17%)	**3** (10%)	**20** (22%)	**10** (29%)	**13** (15%)	**7** (21%)	**16** (18%)	**18** (18%)	**5** (23%)
Challenging	**5** (8%)	**9** (14%)	**6** (19%)	**8** (9%)	**4** (11%)	**10** (11%)	**7** (21%)	**7** (8%)	**10** (10%)	**4** (18%)
Everything	**5** (8%)	**9** (14%)	**2** (6%)	**12** (13%)	**3** (9%)	**11** (13%)	**2** (6%)	**12** (13%)	**12** (12%)	**2** (9%)
Convenient	**5** (8%)	**7** (11%)	**2** (6%)	**10** (11%)	**3** (9%)	**9** (10%)	**2** (6%)	**10** (11%)	**10** (10%)	**2** (9%)
Themes for Dislikes										
Task 3	**15** (25%)	**8** (13%)	**5** (16%)	**18** (20%)	**7** (20%)	**16** (18%)	**7** (21%)	**16** (18%)	**20** (20%)	**3** (14%)
Nothing	**30** (51%)	**37** (58%)	**20** (65%)	**47** (51%)	**24** (69%)	**43** (49%)	**17** (50%)	**50** (56%)	**51** (50%)	**16** (73%)
Compatibility	**2** (3%)	**4** (6%)	**1** (3%)	**5** (5%)	**3** (9%)	**3** (3%)	**1** (3%)	**5** (6%)	**5** (5%)	**1** (5%)
Dislikes cards	**2** (3%)	**4** (6%)	**0**	**6** (7%)	**0**	**6** (7%)	**2** (6%)	**4** (4%)	**6** (6%)	**0**
Themes for Suggestions										
Nothing	**30** (51%)	**38** (59%)	**19** (61%)	**48** (52%)	**17** (49%)	**50** (57%)	**18** (53%)	**50** (56%)	**54** (53%)	**13** (59%)
Wanted feedback	**6** (10%)	**4** (6%)	**2** (6%)	**8** (9%)	**3** (9%)	**7** (8%)	**4** (12%)	**6** (7%)	**7** (7%)	**3** (14%)
Change cards	**3** (5%)	**7** (11%)	**2** (6%)	**8** (9%)	**2** (6%)	**8** (9%)	**0**	**9** (10%)	**10** (10%)	**0**
More tasks	**8** (14%)	**1** (2%)	**2** (6%)	**7** (8%)	**3** (9%)	**6** (7%)	**3** (9%)	**6** (7%)	**8** (8%)	**1** (5%)
Compatibility	**3** (5%)	**5** (8%)	**2** (6%)	**6** (7%)	**4** (11%)	**4** (5%)	**2** (6%)	**6** (7%)	**6** (6%)	**2** (9%)

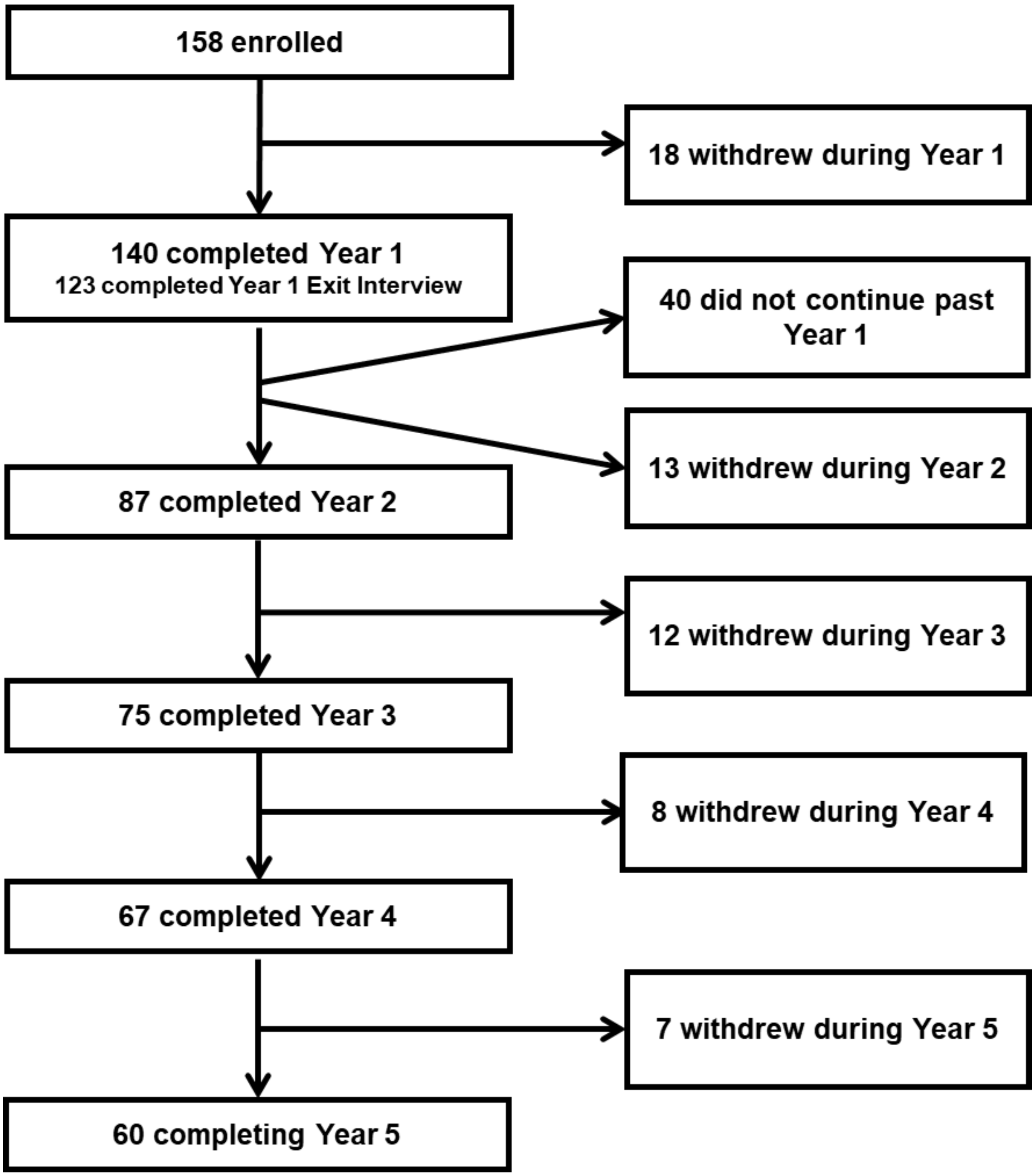

Figure 6. *Study Withdrawal by Year.*

CHAPTER FOUR:

CONCLUDING REMARKS

As treatment options for cognitive impairment among older adults become available in the future, the demand for instruments that can detect cognitive decline in its earliest stages among large groups of individuals will increase rapidly. Regular monitoring of cognition among healthy middle aged and older adults using computer-based programs is believed to be a feasible and effective method of early detection, since many cognitive monitoring programs enable clinicians to detect the initial signs of cognitive decline before they are noticeably observable (Chodosh et al., 2004; Sano et al., 2013; Sano et al., 2010). However, research on home-based cognitive monitoring is still a relatively new area. This dissertation consisted of two studies that contribute to the existing research on cognitive monitoring by examining how personality traits may affect individuals' performance, and their adherence and satisfaction with regular cognitive monitoring programs. The findings from each study are summarized in the following sections.

Study #1 used a sample of cognitively healthy older adults from central Florida (N=158) who completed monthly assessments using the CBB, a computer-based cognitive monitoring program. The primary goals of this study were to determine whether participants' personality traits affected their performance on the CBB, and to explore variability in performance as well as intraindividual variability. The results from mixed effects models indicated that openness and conscientiousness were significantly related to performance on the CBB primary measures. As expected, higher conscientiousness was associated with greater accuracy in baseline performance on the One Back task. Higher openness was related to less accurate performance on the One Back task at baseline, however, participants higher in openness later showed improvement on the One Back task over time. Despite their improvement in accuracy over time, participants higher in openness also showed slower performance on the Identification task over time. Personality traits were not significantly related to performance on any of the CBB's secondary measures.

We also used the coefficient of variation to examine variability in participants' overall performance and concluded that performance over time was relatively stable, and that any fluctuations took place mostly during the first year of the study. Finally, we tested whether personality traits were related to intraindividual variability, or relative deviation from the expected score at every measurement occasion. This longitudinal variable was assessed using the absolute value of studentized residuals. In general, intraindividual variability decreased over time for all CBB tasks. Higher openness and conscientiousness were related to significantly decreasing variability, but higher neuroticism and extraversion were related to increasing variability.

These results emphasize the need to take into consideration the role of personality traits when monitoring cognition, especially if any conclusions that are drawn from an individual's performance are used for diagnostic purposes. For instance, a participant who scores higher in openness may display less accurate performance on an accuracy task at baseline. However, this may not be indicative of true cognitive decline; this may simply be a pattern of performance characteristic of participants who are higher in openness. Our findings about intraindividual variability also contribute to the well-documented association between cognitive decline and greater intraindividual variability (Christ et al., 2018; Kalin et al., 2014), and suggest that personality traits may also affect intraindividual variability.

In Study #2, we used the same participant sample and examined adherence and satisfaction with participating in monthly cognitive monitoring. 95% of participants met our criteria for successful study adherence, skipping no more than two monthly assessments per year, and 50% needed only one reminder call and email per year. Most participants also reported positive experiences with the study and felt that the monthly assessments were relatively easy to access, understand, and complete.

Better study adherence was related to conscientiousness and being married, but agreeableness, extraversion, subjective memory complaints, and baseline CBB performance were related to worse study adherence, including more late and skipped assessments, and a higher likelihood of study dropout. These findings can be helpful for future studies by identifying the characteristics associated with individuals who may benefit most from strategies that promote better study adherence. Content analysis of the qualitative feedback collected during annual interviews with participants suggested that they liked that the CBB was easy and convenient, challenging, and that it provided them with a way of potentially helping others. While most participants said they did not have any major dislikes about the study, 19% said they disliked the One Card Learning task the most, and 80% felt that it was the most difficult part of the study. This was not surprising, considering that the One Card Learning task is the longest of the four CBB tasks and requires the most effort. Despite its difficulty, some participants said they actually enjoyed the challenge that the task provided them with. In addition, this task is crucial in order to reduce any bias due to a ceiling effect on the CBB, especially for the high performing participants. When asked about suggestions for study improvement, 54% of participants said they did not have any and were satisfied with the CBB just the way it was. Other participants mentioned that they wanted to receive feedback on their performance, such as an overall score at the end of each monthly assessment, while others wanted to have a choice of alternative forms of stimuli aside from the playing cards.

Limitations

There are several limitations from both studies that should be considered. First, our findings may not generalize to diverse groups of older adults, given that our sample was comprised of mostly white, healthy, and well-educated older adults. Second, our results are based only on the CBB, and it would be helpful to determine whether they can be replicated in cognitive monitoring programs other than the CBB. Third, the existing literature on the CBB states that practice effects only occur between the first and second assessments and not during any subsequent assessments (Collie et al., 2003; Lim et al., 2012; Lim et al., 2013; Maruff et al., 2013). However, it is possible that repeated monthly assessments over an extended amount of time may have reintroduced practice effects, which in turn, could potentially inflate participants' scores. Fourth, our relatively smaller sample size allowed us to send our participants an email containing a link to their monthly assessment, but this would not be feasible if cognitive monitoring was implemented on a wider level. Participants would probably need a username and password to access their assessments; this extra step may have a detrimental effect on study adherence and satisfaction, particularly among participants who are less comfortable with using computers or the internet. Finally, since our only measure of social support was participants' marital status, we were unable to determine whether other types of social support (e.g., another person in their household, a neighbor, or a friend enrolled in the study) also had a positive effect on adherence.

Future Research

The current studies can provide us with several avenues for future research. To our knowledge, this was the first study to examine the role of personality traits in cognitive monitoring; therefore, it is critical that these findings are replicated. Aside from simply replicating this study, it would also be beneficial for future studies to recruit more diverse groups of participants in terms of race/ethnicity, education, and personality trait scores, in order to determine whether our findings extend to a different sample of participants. Future studies could also examine whether our findings about personality and cognitive performance extend to cognitive monitoring programs other than the CBB.

In addition, studies using different intervals between assessments (e.g., monthly, quarterly, semi-annually) on the CBB could be used to help determine whether monthly testing may be too frequent and inadvertently cause practice effects, and if so, which interval may be a better option for repeated testing. Another area of research that could be expanded on, specifically with cognitive monitoring, is the use of intraindividual variability as a marker for cognitive decline. In our current study, the results indicated that greater intraindividual variability was significantly related to personality traits that have been linked to cognitive decline, while decreasing variability was related to traits that are considered protective factors against decline. Our findings suggest the possibility of an unexplored association between intraindividual variability, personality traits, and risk for cognitive decline. It would be interesting to investigate whether personality traits, especially those that are considered risk factors for cognitive decline, play any mediating or moderating roles between increasing intraindividual variability and a greater risk for cognitive decline.

Finally, a more comprehensive measure of social support that includes spouses/significant others, family, and friends could be used in future studies in order to determine how different levels of social support affect study adherence. Anecdotally, we knew that some of our participants had friends who were also enrolled in the study, but we did not have sufficient data to determine who these participants were. It would have been informative to compare whether friends and spouses affected adherence similarly, as this would have provided us with more specific information on the role of social support in studies that require participants to remember to complete a task within a given amount of time.

The findings from both studies in this dissertation, as well as the ideas for future research discussed, can be beneficial for any future uses of cognitive monitoring programs. Understanding how personality traits affect performance, and changes in performance, can enable researchers or clinicians to make more accurate conclusions about participants' performance. In addition, our findings on participant adherence and satisfaction can assist with the development of strategies that promote better study adherence and greater satisfaction with study participation. Together, these findings contribute to our overall knowledge about cognitive monitoring and suggest that it may be a well-received and effective method of early detection among middle aged and older adults.

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APPENDICIES

Appendix 1. Annual Interview

1. Overall, how would you rate your experience using the Cogstate program?
    a. Very satisfied
    b. Satisfied
    c. Neither satisfied or dissatisfied
    d. Dissatisfied
    e. Very dissatisfied

2. Would you be willing to continue to complete the monthly Cogstate program in the future?
    a. Yes
    b. No
        2a. If no, why not? (open-ended)

3. Do you think your brain health has improved since starting the Cogstate program?
    a. Yes
    b. No

4. Did you find participating in this study to be personally rewarding?
    a. Yes
    b. No

5. How helpful was the practice session with the research assistant?
    a. Very helpful
    b. Somewhat helpful
    c. Not helpful at all
        5a. If not very helpful, what could make the practice sessions more helpful? (open-ended)

6. Did you experience any technical problems with the program?
    a. Yes
    b. No
        6a. If yes, please explain. (open-ended)
        6b. If yes, approximately how many days did it take to resolve the problem? (open-ended)

7. How easy was it to access your monthly Cogstate testing sessions?
    a. Very easy
    b. Somewhat easy
    c. Somewhat difficult

d. Very difficult

7a. If not very easy, what would make the Cogstate program easier to access? (open-ended)

8. Would the Cogstate program be easier to access by entering a personal username and password on a specific website?

a. Yes
b. No

8a. If you had to enter a personal username and password, would you still be willing to continue using the Cogstate program? (open-ended)

9. How clear were the instructions for the four Cogstate tasks?

a. Very clear
b. Somewhat clear
c. Somewhat confusing
d. Very confusing

9a. If not very clear, what could make the instructions clearer or more helpful? (open-ended)

10. How easy was the Cogstate program to use?

a. Very easy
b. Somewhat easy
c. Somewhat difficult
d. Very difficult

11. What was the most difficult part of the program? (open-ended)

12. Did you like hearing audio feedback for responses?

a. Yes
b. No

13. How easy was it to see the details of the cards (color, suit, number) used in each of the Cogstate tasks?

a. Very easy
b. Somewhat easy
c. Somewhat difficult
d. Very difficult

13a. If difficult, what was difficult to see? (open-ended)
13b. If difficult, how could it be improved? (open-ended)

14. Was the program too time consuming?

   a. Yes, very time consuming
   b. Yes, a little time consuming
   c. No, not time consuming at all

      14a. If yes, what was the most time consuming? (open-ended)

15. What were some things you liked about the Cogstate program? (open-ended)

16. What were some things you did not like about the Cogstate program? (open-ended)

17. What suggestions do you have to improve the Cogstate program? (open-ended)

18. What suggestions would you have to help people take the test every month? (open-ended)

Appendix 2. IRB Approval Letter

USF
UNIVERSITY OF SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

7/12/2018

Aryn Harrison, Ph.D.
School of Aging Studies
4202 E. Fowler Ave.
MHC 1319
Tampa, FL 33620

RE: **Expedited Approval for Continuing Review**

IRB#: CR5_Pro00012918

Title: Computer-Based Assessment of Cognition in Community-Dwelling, Cognitively Normal Older Adults Using the CogState Brief Battery

Study Approval Period: 8/4/2018 to 8/4/2019

Dear Dr. Harrison:

On 7/11/2018, the Institutional Review Board (IRB) reviewed and **APPROVED** the above application and all documents contained within including those outlined below.

Approved Item(s):

Protocol Document(s):

Pro00012918_Study Protocol_Use of CogState in CNOAs_Version20_clean.docx

Consent/Assent Document(s)*:

Pro00012918_CogState in CNOAs_Informed Consent_Rev11_clean.doc.pdf

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab on the main study's workspace. Please note, these consent/assent document(s) are valid until they are amended and approved.

The IRB determined that your study qualified for expedited review based on federal expedited category number(s):

(4) Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for

marketing.

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with USF HRPP policies and procedures and as approved by the USF IRB. Any changes to the approved research must be submitted to the IRB for review and approval by an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) business days.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

Kristen Salomon, Ph.D., Chairperson
USF Institutional Review Board