RELATIONSHIP BETWEEN FUNCTIONAL ABILITY, COGNITVE RESERVE, PERSONALITY, AND EXECUTIVE FUNCTIOINING IN OLDER ADULTS

by

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ABSTRACT

Medical advances have dramatically increased the average life expectancy, and as a result the number of older adults (OAs) experiencing functional impairment is growing exponentially. To decrease the impact of functional impairment it is necessary to understand all factors that impact OAs ability to complete activities of daily living, functional ability (FA). Previous research has documented the association between several factors and OAs' FA; however, two factors that have yet to be comprehensively examined are Cognitive Reserve (CR) and personality. Overall a limited literature suggests CR is positively associated with FA, but it remains unclear if the magnitude of this relationship differs across the various ways to measure CR. It also has yet to be determined how CR is related to FA. Like CR, the relationship between personality and FA has been relatively ignored but preliminary evidence suggests two personality factors, Openness and Agreeableness, are positively associated with FA. Nonetheless, it also has yet to be determined how these personality factors are related to OAs' FA. It was hypothesized that the relationship between CR and personality factors with FA would be due to a separate but positively related psychological construct, executive functioning (EF). Thus, overall this project had four aims. The primary aim of this dissertation was to clarify the

relationship between CR and FA in community dwelling OAs. The second aim was to determine the impact of EF on the relationship between CR and FA. The third aim was to determine if previously documented relationships between personality factors and FA could be replicated. Finally, we aimed to understand how personality factors were related to FA. We found all CR proxies were positively related to FA, and that there were no significant differences between the various proxies and the magnitude of their relationship with FA. Mediation analyses revealed that the mechanism of action between CR and FA was EF. Despite null findings between Agreeableness and FA, the relationship between Openness and FA was replicated. Similar to CR, EF mediated its association with FA. Thus, future investigations should determine the effect on FA in OAs by improving EF.

INDEX WORDS: Older adults, Executive Functioning, Functional Ability, Cognitive Reserve, Personality

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M.A., University of Georgia, 2012

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2014

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August 2014

ACKNOWLEDGEMENTS

I would like to thank several individuals for the help in making this dissertation a reality. First, I want thank my fellow lab collaborator and friend, Cutter Lindbergh. Without his dedication, strong work ethic, and flexibility this project never would have been completed within the very tight timeframe and important deadlines would have been missed. Next, I want to thank my girlfriend, Kerrin George, for her numerous edits, suggestions, and enduring support throughout. I would also like to thank my major professor, Steve Miller. His constant guidance, expertise, and encouragement helped make this dissertation and my doctoral degree possible. Lastly, I want to thank my brother, sister, dad and mom. Specifically, I thank my brother for being someone I look up too, my sister for leading the pack, my dad for his professional expertise and helping me move forward professionally and personally, and my mom for being a never-ending source of inspiration and love.

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CHAPTER 1
INTRODUCTION and LITERATURE REVIEW

Functional ability (FA) refers to one's ability to carry out activities of daily living (ADLs). ADLs are separated into complex and simple ADLs. Instrumental activities of daily living (IADLs) demand greater use of cognition, are considered more complex, and have greater cognitive demand. IADLs involve activities such as laundry, cooking, managing finances, and housekeeping. Basic activities of daily living (BADLs) are inherently simpler and include bathing, dressing, toileting, eating, dressing, and grooming (Marcotte, Scott, Kamat, & Heaton, 2010)

Declines in FA often result in functional impairment and are associated with a number of different populations and conditions, including: severe mental illness (Hays, Steffens, Flint, Bosworth & George, 2001), human immunodeficiency virus (Fleishman & Stephen, 1998), epilepsy (Lehrner et al., 1999), and dementia (Marcotte et al., 2010). The highest prevalence of decline in FA is found in older adults (OAs; Freedman & Martin, 1998). This is likely a result of the unprecedented growth of older adults due to advances in medicine and public health. In 2040, OAs ($\geq$ 65) are expected to account for fourteen percent of the world's population (Kinsella & Wan, 2008). Even though medicine has successfully prolonged the life of OAs, decreasing functional impairment in OAs has not been as fruitful.

OAs with functional impairment are at increased risk for a host of life altering problems including: car accidents (Lloyd et al., 2001), to falls (van Doorn et al., 2003; Fuller, 2000), to malnutrition (Wolf-Klein & Silverstone, 1994), and even drowning (Rowe & Bennett, 2003). Functional impairment not only impacts the individual, but also significant others, family, and

close friends who often assist the individual with completing ADLs. Caregivers experience increased rates of depression (Joling et al., 2012), mortality (Schulz & Beach, 1999), and significant financial burden (Langa et al., 2001). The impact of functional impairment further impacts the aggregate population. The impact of functional impairment is most experienced by society because of substantially increased medical care costs. For example, in community dwelling OAs, each BADLs and IADLs impairment increases health care costs by 1,541 and 714 dollars, respectively (Hill, Fillit, Thomas, & Chang, 2006). To keep up with the constant advances in medical research, much more empirical research is needed to understand factors that impact FA.

Measuring FA

FA is typically assessed in clinical settings through questionnaires. Two types of questionnaires exist for measuring FA, self and collateral report. Questionnaires are frequently administered given the ease and efficiency of administration, but the convenience of these measures comes with a cost. On self-report measures, OAs with Alzheimer's disease (AD) frequently over-estimate ability and underreport problems with ADLs (DeBettignies, Mahurin, & Pirozzolo, 1990). Contrary to one's intuition, this lack of self-awareness is not limited to AD, but also present in OAs who have cognitive difficulties greater than expected for age but intact FA, defined as mild cognitive impairment (MCI; Albert et al., 2011;Tabert et al., 2002), and independently living community dwelling OAs (Mitchell & Miller, 2008a).

Collateral-report measures are an alternative to self-report and are suggested to be more accurate for measuring FA in OAs than self-reports (Kiyak, Terib & Borson, 1994), but they are not without problems. Collateral-reports are found to both over-estimate and underestimate FA

as compared to their performance of ADLs in OAs with cognitive impairment (Doble, Fisk, & Rockwood, 1999). However, Magaziner, Zimmerman, Gruber-Baldini, Hebel, and Fox (1997) indicated collaterals overall tend to over-report functional problems, as opposed to under reporting. Over-reporting is positively associated with the amount of caregiver burden and distress (Razani et al., 2007; Zanetti, Frisoni, Rozzini, Bianchetti, & Trabucchi, 1998). Inaccuracies of collateral report could also be due to amount of time spent with the OAs. For example, Ready, Ott, and Grace (2004) found that collaterals that lived with OAs were more accurate reporters. Additionally, these authors found that the type of relationship influences accuracy in collateral reports, such that spouses were more accurate than any other relationship type. However, other investigations have not found the same effects of time or type of relationship (Farias, Mungas, & Jagust, 2005).

Type of FA reported is also suggested to impact the accuracy of collateral report. Zanetti, Geroldi, Frisoni, Bianchetti, and Trabucchi (1999) compared FA as measured by performance-based instruments and collateral report. Collateral reports are most associated with the performance-based measure when simple ADLs are rated. Collateral reports were less associated with the performance-based measure of IADLs.

An alternative to questionnaires that is likely more objective and accurate is performance-based measures (Zanetti et al., 1999). Work in our laboratory has found performance-based measures to be more related to cognitive ability than self-reported FA (Mitchell & Miller, 2008a). Additionally, compared to self-reports, performance-based measures of FA are able to detect a greater level of problems with ADLs in OAs with and without cognitive impairment (Karagiozis, Gray, Sacco, Shapiro, & Kawas, 1998; Kempen, Steverink, Ormel, & Deeg, 1996).

By categorizing ADLs on different domains, accuracy and reliability is also said to increase on performance-based methods (Sherman & Rueben, 1998).

Performance-based measures have a substantial amount of face validity given they directly assess tasks OAs complete on a routine basis in an analogue setting (Myers, Holliday, Harvey, & Hutchinson, 1993). Performance-based measures are less subject to ceiling and floor effects (Sherman & Reuben, 1998) and are more reliable in OAs with some cognitive impairment (Hoeymans, Wouters, Feskens, van den Bos, & Kromhout, 1997). Despite their considerable advantages, performance-based measures are not without critique.

Performance-based measures of FA require more time to administer compared to questionnaires. They are also considered more cumbersome given the amount of stimuli typically needed for administration, and they require a trained assessor to administer these instruments. The inconveniences of additional time, trained examiners, and an atypical amount of test materials have limited the use of performance-based measures in clinical settings. Additionally, it could be argued that the ADLs assessed by the performance-based method are not essential or part of their routine necessary for independent living. In general it can be concluded that performance-based measures are relatively narrow in the assessment of FA, whereas self and collateral report are more general. There is not a consensus as to which method is a "gold-standard," however performance-based measures may be a more accurate representation of FA in community dwelling OAs (Zanetti et al., 1999).

Relationship between Normal Aging and FA

There are a number of factors associated with FA in the inevitable, gradual progression that increases the likelihood of disease and death, aging (Harman, 1981). There is no single

factor that causes aging, as it is the result of a complex multifactorial process (Weinert & Timiras, 2003). Normal aging OAs have age-associated diseases and medical conditions representative of typical aging (Smith & Ivnick, 2003). In contrast, pathological aging refers to OAs who experience atypical aging and have diseases and conditions not frequently experienced by normal OAs. Factors associated with OAs' FA can be categorized as sensory, physical, cognitive, and personality.

Intact sensory functions are necessary for FA. Normal biological aging processes alter sensory systems and impact OAs' vision, audition, olfaction, and vestibular sense (Lord & George, 2003; Woodruff-Pak, 1997). Vision changes in aging are typically experienced as far-sightedness or presbyopia, the inability to focus on close up objects. Overall decreased visual acuity (Branch, Horowitz & Carr, 1989), greater sensitivity to glares, color discrimination, decreased vision in low light conditions, and slowed visual scanning and processing also occur in OAs. Poor vision is associated with worse FA (West et al., 2000). Moreover, hearing loss, or presbycusis, generally occurs in OAs, and it more frequently affects males (Cruickshanks et al., 1988). Changes in audition are also experienced in OAs as difficulty discriminating between high frequency sounds as well as detection and localization of auditory stimuli (Ross, Fujioka, Tremblay, & Picton, 2007). Decreased vestibular sense is also decreased in OAs, which can increase the result of falls (Sturnieks, George, & Lord, 2008).

There are a host of physical changes in OAs. Typical physical changes include sarcopenia, decrease of muscle mass and strength, decreased bone density, and arteriosclerosis and atherosclerosis (Evans & Campbell, 1993; Lakatta, 2003). Physical changes in muscle and skeletal systems negatively impact FA (Janssen, Heymsfield, and Ross, 2002; Lee, 2000). These

physical changes are important given their association with OAs' FA. Cress & Meyer (2003) found age related muscle mass loss is associated with decreased ADLs. Leg power is also related to FA, and Petrella, Miller and Cress (2004) found leg power predicted OAs' independence. Leg power was also positively related to FA. A large epidemiological study found that OAs with decreased physical performance were more likely to experience functional dependence. Analyses also revealed increased likelihood of functional dependence as a result of low physical performance was independent of cognitive ability (Gill, Williams, Richardson, & Tinetti, 1996). A review of 66 studies further supports the important of physical functioning on OAs' FA (Paterson & Warbuton, 2010). Greater physical activity was associated with significantly reduced risk of FA limitations. Increased participation in exercise was associated with increased mobility and greater improvement in FA.

Even though it is necessary to attend to physical and sensory declines in normal aging, these changes can be remediated and do not substantially impact OAs' FA if addressed adequately. For example, individuals who obtained hip surgery had significantly improved FA (Rissannen, Aro, Sintonen, Slatis, & Paavolainen, 1996). Additionally, assistive devices are found to remediate physical limitations in OAs and, as a result, increase FA (Freedman, Agree, Martin, & Cornman, 2006). As a result, OAs have greater FA and are less dependent on others for personal care (Freedman et al., 2006). Appollonio, Carabelle, Frattola, and Trabucchi (1996) found that OAs without corrective devices (i.e., glasses & hearing aids) are less able to perform IADLs. However, IADLs ability increased in OAs with compromised sensory functioning when corrective devices were utilized. Likely due to technological improvement of these devices, FA in OAs is increased with the use of assistive and corrective devices.

FA and Cognition

A less remediable change associated with aging is cognitive decline. In normal aging, the most pronounced cognitive changes are processing speed, memory, and executive functioning (EF; Christensen, 2001). Processing speed measures one's ability to efficiently process and act upon information. Compared to their younger counterparts, OAs have slower processing speed (Cavanaugh & Blanchard-Fields, 2006) and, as a result, require greater time to complete activities. However, despite the extra time required, slowed processing speed does not necessarily affect OAs' FA. For example, a neuropsychological battery was administered to community dwelling OAs and processing speed measures were not found to be predictive of FA (Burton, Strauss, Hultsch, & Hunter, 2006).

The most common cognitive complaint in OAs is memory. Memory is the ability to encode, store, and retrieve information (Tulving, 1984). Frequently, OAs report difficulty remembering names, finding words in conversation, and misplacing items (e.g., keys). Even though these subjective memory complaints often are not indicative of an incipient stage of a neurodegenerative diseases (i.e., AD), empirical evidence does suggest OAs' memory performances are worse than younger adults (Chalfonte, & Johnson, 1996).

There are several different types of memory, including implicit, procedural, semantic and episodic. Personally experienced past events, episodic memory (Tulving, 1972), is usually the most affected type of memory in normal aging. Neuropsychological measures of episodic memory assess an individuals' ability to learn, recall, and recognize information, utilizing free and cued recall and recognition paradigms. On measures of memory, OAs recall less information, provide more intrusions and repetitions, and select more foils (Zacks, Hasher, & Li,

2000). The decline in memory in OAs is likely not due to ineffective storage but, rather, compromised encoding and retrieval processes given when learning strategies and retrieval cues are provided, performance differences are drastically decreased (Balota, Dolan, & Duchek, 2000).

Some evidence suggests that memory decline in OAs is predictive of decreases in ADLs. For example, data from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study found performance on a list-learning task to be predictive of IADLs functioning (Gross, Rebok, Unverzagt, Willis, & Brandt, 2012). However, evidence is mixed. Some studies have not found memory to be related to ADLs in community dwelling OAs (Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000). Memory was also not related to FA in OAs with AD or mild cognitive vascular impairment (Cahn-Weiner, Ready, & Malloy, 2003; Stephens et al., 2005). Another study of community dwelling OAs with probable Alzheimer's disease (AD) found memory was not related to FA (Monaci & Morris, 2012).

Inconsistent results could be due to the fact memory process more associated with Executive Functioning (EF) are predictive of ADLs, whereas those less associated with EF are not related to FA. Schmitter-Edgecombe, Woo, and Greeley (2009) compared several different types of memory (i.e., content & non-content) and their association with collateral report of ADLs in OAs with and without MCI. Content memory was assessed with traditional neuropsychological measures of memory such as list-learning tasks, which require the learning of a list of words. Non-content memory instruments included measures of temporal order, source, and prospective memory, which are reliant upon intact frontal lobes and associated with EF. Non-content memory measures were more associated with one's ability to successfully

complete IADLs, and predictive of FA over and above content memory. Furthermore, content memory measures were not related to collateral report of ADL (Schmitter-Edgecombe et al., 2009).

FA and Executive Functioning

Unlike other cognitive domains, EF has been consistently reported to be predictive of FA in OAs (Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002; Cahn-Weiner et al., 2000; Cahn-Weiner, Boyle, & Malloy, 2002; Jefferson, Paul, Ozonoff, & Cohen, 2006; Lewis & Miller, 2007; Martyr & Clare, 2012; Mitchell and Miller, 2008a, 2008b; Pereira, Yassuda, Oliveira, Forlenza, & 2008; Royall, Chiodo, & Polk, 2000; Schmitter-Edgecombe et al., 2011). EF even has been found to partially mediate the relationship between other cognitive domains such as visuospatial ability, memory, and FA (O'Bryant et al., 2011; Royall, Palmer, Chiodo, & Polk, 2005). The relationship between EF and FA is most apparent in healthy OAs. However, even in samples where OAs have greater than expected cognitive impairment for age and have functional impairment, EF is strongly associated with one's ability to carry out ADLs (Martyr & Clare, 2012; Pereira et al., 2008). General cognitive ability measured by the Mini-Mental State Examination (MMSE) is not associated with FA in independent OAs when age is controlled. However, while controlling for age, EF predicted ability to complete IADLs (Royall et al., 2000). Cahn-Weiner et al. (2000) administered a neuropsychological battery measuring various cognitive domains including: memory, visuospatial, motor, and EF to 27 community-dwelling OAs. ADLs in this investigation were measured with a performance-based measure of FA. Step-wise regression indicated EF accounted for 14% of the total variance, and was the only significant cognitive predictor of FA.

This preliminary study established the importance of EF in its association with FA, yet it remained unclear as to what measures of EF predicted FA. Cahn-Weiner et al. (2002) compared several standard measures of EF in their ability to predict FA, and found that only one EF measure independently contributed to the prediction of performance-based FA, Trail Making Test-Part B (TMT-B). However, when IADLs were measured from caregiver report, TMT-B, and the Controlled Oral Word Fluency Test (COWAT) predicted FA.

Mitchell and Miller (2008b) also examined the prediction of FA by various EF measures. Specifically, with 45 OAs between 65 and 92, Mitchell and Miller compared the Delis-Kaplan EF system tests in their prediction of observed FA on a performance-based measure. Similar to Cahn-Weiner et al. (2002), only Trail Making Test-4, which is the Delis-Kaplan version of TMT-B, independently accounted for OAs' FA, although, the EF measures all together accounted for 26% of the variance while controlling for education and depression. Bell-McGinty et al. (2002) administered a battery of EF measures to 50 community dwelling, clinic referred and assisted living OAs. The battery included the TMT-B, COWAT, the Wisconsin Card Sorting Test (WCST), and two additional non-traditional EF instruments. FA was measured with an objective measure of IADLs (i.e., Independent Living Scales). After controlling for age, education and gender, only the Trail Making Test-Part B and WCST were significant in predicting IADLs ability.

Another study from our laboratory also examined the association between different components of EF and FA in 60 community dwelling and assisted living OAs (Lewis & Miller, 2007). Although all measures of EF were related to FA on a performance-based measure, only one component predicted FA. Planning, and not working memory, verbal fluency, or flexibility

significantly predicted FA, accounting for 14% of the variance. Jefferson et al. (2006) also compared the association of multiple EF elements with FA. However, different than Lewis and Miller (2007), this investigation had 72 community dwelling participants with documented cardiovascular disease. Additionally FA was measured through caregiver report of ADL questionnaire. The single significant predictor of IADLs was inhibition. Step-wise regression indicated working memory, verbal fluency, cognitive flexibility and sequencing, and planning and nonverbal generation were not predictive of IADLs ability.

Variability in findings across studies comparing the relationship of EF measures and FA is likely due to several reasons. One reason there are differences in results between studies may be due to how FA is measured. Mitchell and Miller (2008a) found a difference in the strength of the relationship between EF and FA as measured by self-report and a performance-based instrument. The relationship between EF and the performance-based instrument was stronger than between EF and self-report.

Measuring Executive Functioning

An alternative reason for the variability observed in the relationship is the lack of an agreed upon operational definition of EF. To date, there has yet to be a consensus in the scientific literature as to what constitutes EF. As a result the operational definition is extremely variable across sources (Barkley, 2012). Lezak, Howieson, Bigler, and Tranel (2012) indicated EF is the ability to behave in an adaptive manner to novel situations and are necessary for appropriate, effective and socially responsible behavior. According to Barkely (2012) one of the most popular definitions of EF comes from Welsh and Pennington (1988). They suggested EF is the ability to maintain set to attain a future goal, and includes the ability to inhibit irrelevant

information, planning and accurately encoding task relevant information in memory (Welsh & Pennington, 1988). Latent variable analyses suggest set shifting, information updating and monitoring, and inhibition underlies performance on commonly used EF measures (Miyake et al., 2000). Despite this lack of agreement, in general EF can be thought of as an umbrella term that refers to "higher-level" cognitive functions that facilitate purposeful goal-directed behavior by directing "lower-level" functions (Alvarez & Emory, 2006; Stuss & Benson, 1986; Stuss & Levine, 2002). EF facilitates the ability to complete purposive behaviors and function adaptively in various environments, and is particularly evident in novel situations (Lezak et al., 2012).

Frequently, neuropsychologists use the terms "executive" and "frontal" interchangeably (Baddeley, Della Salla, Gray, Papagno, & Spinnler, 1997; Stuss & Levine, 2002). This reflects efforts to understand the prefrontal cortex (Barkely, 2012), which Pribram (1973) termed as the "executive brain." Even though there is evidence to support the notion that EF is reliant on the frontal lobes, research suggests other areas, cortical and sub-cortical, are needed for EF (Alvarez & Emory, 2006; Jurado & Rosselli, 2007; Stuss & Benson, 1986; Stuss & Levine, 2002). Thus, it can be concluded that EF is sensitive to frontal lobe damage but not specific to frontal lobe damage (Alvarez & Emory, 2006; Jurado & Rosselli, 2007; Stuss & Benson, 1986; Stuss & Levine, 2002).

Inherent to the lack of an operational definition of EF is the complicated and difficult task for valid measurement (Jurado & Rosselli, 2007). There are a variety of different measures used by neuropsychologists to measure EF. According to one of the largest surveys of test usage by neuropsychologists, Rabin, Barr, and Burton (2005) determined the five most common used EF measures were: the Wisconsin Card Sorting Test, Rey–Osterrieth Complex Figure Task,

Halstead Category Test, the Trail Making Test and the Controlled Oral Word Association Test. These tests and the majority of other EF measures used were developed prior to the 1950s (Delis, Kaplan & Kramer, 2001). Since then there has been a substantial amount of research and the understanding of brain-behavior relationships, EF and the frontal lobes in particular. Despite the clinical of utility of these measures, they have not evolved and benefitted from the large amount of research and understanding of EF and the brain (Shunk, Davis, & Dean, 2006).

A more recently developed battery of EF tests that incorporates knowledge accrued from empirical research over the last 50 years is the Delis-Kaplan Executive System (D-KEFS; Delis et al., 2001). The D-KEFS is a battery of nine separate tasks that utilizes the process approach and was designed to isolate cognitive skills necessary for EF successful performance (Shunk et al., 2006). The D-KEFS is less subject to ceiling and floor effects and able to detect very mild EF difficulties (Strauss, Sherman & Spreen, 2006). The use of a process approach in determining multiple scores is another significant benefit of the D-KEFS given the single-score method in EF is likely measuring several different cognitive abilities (Delis et al., 2001).

Personality

Despite the fact that it has a substantial impact on lifespan longevity (Caspi, Roberts, & Shiner, 2005), and alterations are potentially indicative of the prodromal stages of dementia and functional decline (Copeland et al., 2003), personality's association with FA in OAs has been relatively ignored. There are several different models that have conceptualized personality and one of the most researched and validated is the Five-Factor Model (Costa-McCrae, 1992). The origins of the Five-Factor Model originated from analyses of existing personality measures including Cattell's 16 personality factor questionnaire but was refined with the lexical analyses

work originally completed by Allport and Odbert (John & Srivastava, 1999; Livesley, 2001; McCrae & John, 1992).

Unlike other models of personality, the Five-Factor Model suggests personality has a biological origin (Livesley, 2001) and is a universal personality system that allows for the understanding of people and how they operate (McCrae & Costa, 2008). The Five-Factor Model is a hierarchical organization of personality traits across dimensions (McCrae & Costa, 2008; McCrae & John, 1992). The five factors are Neuroticism, Extraversion, Conscientiousness, Agreeableness, and Openness; each of which is comprised of six facets (Costa & McCrae, 1992; McCrae & Costa, 2010).

Neuroticism is the general tendency to experience negative affective states such as fear, sadness, embarrassment, anger, guilt and disgust (McCrae & Costa, 1987). Proneness to negative affective states is the "core" of this domain, and facets are anxiety, angry hostility, depression, self-consciousness, impulsiveness and vulnerability (Costa & McCrae, 1992; McCrae & Costa, 2010). Someone who is outgoing, expressive, energetic, and dominant would be considered high on Extraversion (Caspi, Roberts, & Shiner, 2005). The central features of Extraversion are the tendency to experience frequent positive moods, enjoy social attention, and sensitivity to potential rewards (Caspi et al., 2005). The facets of Extraversion are warmth, gregariousness, assertiveness, activity, excitement-seeking, and positive emotions (Costa & McCrae, 1992; McCrae & Costa, 2010). The basis of behavioral and cognitive control is captured by Conscientiousness (Watson, Clark, & Harkness, 1994; Caspi et al., 2005); which is made up of six facets -- competence, order, dutifulness, achievement striving, self-discipline and deliberation. A conscientious individual is strong willed, capable, determined, punctual, reliable

and is strongly associated with lifetime achievements (Costa & McCrae, 1992; McCrae & Costa, 2010). Agreeable individuals tend to use their feelings in reasoning, are trusting and tender-minded, sympathetic and helpful (McCrae & Costa, 1989). The factor is made up from these facets: trust, straightforwardness, altruism, compliance, modesty and tender-mindedness (Costa & McCrae, 1992; McCrae & Costa, 2010). Openness to experience (i.e., Openness) is the last factor in the Five-Factor Model (John & Srivastava, 1999). This factor is designed to measure the aspects of which an individual is open to fantasy, aesthetics, feelings, actions, ideas and values (Costa & McCrae, 1992; McCrae & Costa, 2010).

FA and Personality

Although the empirical literature on the relationship between FA and personality is rather limited, there is preliminary evidence that suggests there is an association, which is dependent on how IADLs are measured. Specifically, existing research has supported that only Openness and Agreeableness have been found to be related to and predictive of the performance of IADLs (Gregory, Nettelbeck, & Wilson, 2010; Suchy, Williams, Kraybill, Franchow, & Butner, 2010); whereas, results suggest Openness is not related to self-reported IADLs (Suchy et al., 2010). With 70 community dwelling OAs, Gregory, Nettelbeck, and Wilson (2010) showed that Openness was positively associated with performance of IADLs ($r = .235$). Suchy, Williams, Kraybill, Franchow, and Butner (2010) examined all five personality factors and found that Agreeableness and Openness were predictive of IADLs performance. In their sample of 65 community dwelling OAs, Suchy et al. (2010) found Openness and Agreeableness were negatively related to IADLs performance errors ($r = -.256$ & $-.285$).

Similar to performance-based measurement, there have only been two investigations that have examined the association between personality and self-reported IADLs. Evidence suggests Neuroticism is positively related to self-reported problems with IADLs (Chapman et al., 2007; Suchy et al., 2010). By contrast, greater Conscientiousness is associated with less self-reported IADLs dysfunction (Chapman et al., 2007; Suchy et al., 2010). Additionally, there is inconsistent evidence for Extraversion and Agreeableness with self-reported problems with IADLs, as Chapman et al. (2007) found both to be negatively related and Suchy et al. (2010) reported both were not associated. In contrast, consistent evidence suggests Openness is not related to self-reported FA.

Despite the preliminary insight these studies provide, it remains unclear as to how or why specific personality factors are related to performance-based IADLs. However, as suggested by Suchy et al. (2010) the association between personality factors and self-report may be due to individual differences in perception of ability, while personality and performance-based IADLs may be due to a specific cognitive function. We suggest this is executive functioning (EF).

Performance-based IADLs are consistently predicted by EF (Bell-McGinty et al., 2002; Cahn-Weiner et al., 2002; Cahn-Weiner et al., 2000; Mitchell & Miller, 2008a, 2008b; Schmitter-Edgecombe et al., 2011). In addition to being related to IADLs, EF has also shown to be related to personality factors. Schretlen, van der Huslt, Pearlson, and Gordon (2010) found Neuroticism was negatively related to EF, whereas Openness was positively related to EF in 335 middle aged adults and OAs. Similarly, Williams, Suchy, and Kraybill (2010) found Neuroticism was negatively associated with EF, and Openness and Agreeableness were positively correlated with EF. Booth, Schinka, Brown, Mortimer, and Bornstein (2006) also found Openness was

positively related to EF, but Neuroticism was inconsistently related to separate measures of EF in a sample of 398 community dwelling OAs. These authors also found Extraversion, Conscientiousness, and Agreeableness were positively related to EF performance. An additional study of 178 community dwelling OAs found that the only personality factor related to EF was Openness (Ayotte, Potter, Williams, Steffens, & Bosworth, 2009). Thus, there appears to be a relationship between EF and personality factors, but its relationship with the five factors is variable. However, there is consistent evidence that Openness is positively associated with EF.

Cognitive Reserve

The construct of reserve comes from clinical observation whereby brain damage is not linearly associated with clinical symptoms (Stern, 2002). For example, an OA may have significant AD neuropathology but present clinically normal, that is, without functional or cognitive impairment (Stern, 2006). The construct of reserve is very recent, and likely because of this there is variability in operational definitions of reserve. However, definitions of reserve can be categorized under two different but not mutually exclusive models, passive and active (Stern, 2002, 2006, 2009).

An example of a passive reserve model is brain reserve. This model suggests the mitigating factor between clinical manifestation and brain damage or pathology is brain reserve. Brain reserve can be defined as brain size, number and density of neurons at the end of adolescence, number of cognitive strategies, or volume of healthy neural tissue at any time (Mortimer, 1997; Satz, 1993). Brain reserve can be thought of as a mediator between brain pathology or damage and clinical symptoms. It can either be protective or a vulnerability factor, and it varies between individuals on a continuum between high and low. Individuals with high

brain reserve have ‘further to fall’ and greater resistance to change (Schofield, 1999); whereas individuals with less brain reserve are more vulnerable to exhibiting the clinical expression of brain damage or pathology (Stern, 2002). Those with large brain sizes, high brain reserve, have later onset clinical symptoms and are less likely to have AD (Schofield, 1999).

Although Mortimer (1997) conceptualizes number of cognitive strategies as a type of brain reserve, Stern (2002, 2006, 2009) suggests this is not a component of brain reserve. Cognitive strategies would be categorized under an active model using this categorization method. Active models are theoretically distinct from passive models, given the brain actively copes with brain damage or pathology (Stern, 2002).

The most prevalent active model of reserve is cognitive reserve (CR; Stern, 2002, 2009). As an active model, CR suggests individuals deal with brain damage and pathology by engaging in alternative cognitive strategies or compensatory strategies (Stern, 2002). CR emphasizes the method an individual copes with brain dysfunction, and it does not assume there is a fixed threshold when clinical symptoms will manifest (Stern, 2009).

CR is similar to brain reserve in that it assumes the brain controls cognitive functioning (Stern, 2009) and implements CR in two different ways, neural reserve and neural compensation (Stern et al., 2005). Neural reserve suggests there are differences across individuals with respect to efficiency, capacity, and flexibility in brain networks or cognitive strategies in cognition before insult or disease. Therefore, one with greater efficiency, capacity, and/or flexibility is in a better position to actively cope with brain dysfunction. Neural compensation refers to the ability to maintain or improve performance by using brain structures or networks not typically used by

individuals with healthy brains (Stern, 2005, 2009). Similar to neural reserve, there are inter-individual differences in the ability to implement neural compensation.

In contrast to passive models of reserve, active models such as CR suggest that the brain actively attempts to cope with brain damage by using pre-existing cognitive processes and/or by enlisting compensatory processes (Stern, 2002). Although two patients might have the same amount of brain reserve capacity, the patient with more CR may tolerate a larger lesion than the other patient before clinical impairment is apparent. Thus, an active model does not assume that there is some fixed cutoff or threshold at which functional impairment will occur. Rather it focuses on the processes that allow individuals to sustain brain damage and maintain function.

There are a number of findings that support CR as a psychological construct. A longitudinal study of approximately 600 community dwelling OAs found individuals with less CR were two times as likely to develop dementia (Stern et al., 1994). Not only is low CR a risk factor, but given CR operates on a continuum, high CR is protective such that OAs with greater CR have a significantly lowered incidence of dementia (Valenzuela & Sachdez, 2006).

The impact of CR is not limited to pathological aging and dementia, but is also related to normal age related cognitive decline in OAs (Stern, 2009). With 136 English speaking OAs from diverse backgrounds, Manly, Touradji, Tang, and Stern (2003) reported high CR was protective against memory decline after accounting for age and education. Data from the Baltimore cohort of the Epidemiologic Catchment Area study also found that individuals with greater CR had less cognitive decline (Lykestos, Chen, & Anthony, 1999).

In normal aging the impact of CR is also related to FA. Individuals with greater CR are much more likely to maintain ADLs and their ability to live independently (Snowdon, Ostwald,

& Kane, 1989). Altogether, this suggests the effects of CR are not limited to pathological aging but also occur in normal aging affecting both cognition and FA.

FA and Cognitive Reserve

The relationship between CR and FA in OAs has not been explicitly examined. However, likely a result from how CR is measured, these variables are collected as demographic and/or ancillary measures in investigations examining FA. CR is measured indirectly through different proxies, such as socioeconomic status (SES; i.e., income or occupational attainment), education, intelligence (IQ), and premorbid IQ, which are all used as proxy measures of CR (Manly, Schupf, Tang, & Stern, 2005; Stern, 2006, 2009). There is not a consensus as to what measure of CR is most accurate for different populations in literature, but for OAs with and without cognitive impairment, researchers have measured CR by education, occupation, premorbid IQ, and a composite derived from multiple proxies (Corral, Rodriguez, Amenedo, Sanchez & Diaz, 2006; Stern et al., 2005; Solé-Padullés et al., 2009; Tucker-Drob, Johnson, & Jones, 2009; Tuokko, Garrett, Mcdowell, Silverberg, & Kristajansson, 2003).

IQ occurring before disease or injury is called premorbid IQ, and it is a valid measure of CR (Alexander et al., 1997). Premorbid IQ can be computed in a variety of different ways. One way is the use of demographic factors such as age, race, and sex (Barona, Reynolds, & Chastain, 1984). However, the use of demographic factors alone has been criticized, suggesting they are most accurate for individuals with average IQ and inaccurate for individuals with significantly below or above average IQs (Groth-Marnat, 2009). Measures of oral reading, such as the Wide Range Achievement Test reading subtest (WRAT; Wilkinson, 1993) and Wechsler Test of Adult Reading (WTAR; Wechsler, 2001), are an additional and possibly more accurate ways to

measure premorbid IQ. Oral reading is an over learned skill that is generally well preserved with brain injury and disease (Johnstone, Callahan, Kapila, & Bouman, 1996; Orme, Johnstone, Hanks, & Novak, 2004).

In a sample of French OAs, an oral reading measure was found to be protective of FA decline (Artero, Touchon, & Ritchie, 2001). Similarly, in a large sample of OAs with AD, Starr and Loine (2008) found an oral reading measure to be protective against FA decline. In contrast, Plehn, Marcopulos, and McLain (2004) reported premorbid IQ was not related to a self-report measure of IADLs in normal OAs. However, the non-significant correlation ($r = -.108$) suggested functional impairment increased as premorbid IQ decreased, and the measure of premorbid IQ was not an oral reading measure but instead a test of defining various vocabulary words (i.e., WAIS Vocabulary). The relationship between premorbid IQ and FA is equivocal, and more research is necessary to better understand this association.

SES is also regarded as an accurate proxy of CR, and it is typically measured through occupation and amount of income (Stern, 2002, 2006). There are a variety of ways to classify occupation when examining CR. However, typically occupations are first categorized based on different countries' (i.e., United States, France, Brazil) census classification methods and subsequently divided according to complexity level (Baldivia, Andrade, & Bueno, 2008). Blue-collar workers (i.e., "unskilled" workers) are much more likely to have difficulties completing ADLs compared to "skilled" and white-collar workers (Parker, Thorslund, & Lundberg, 1994). The authors also found "skilled" workers to be more likely to exhibit ADL limitations; while, white-collar workers did not have an increased risk in exhibiting FA problems. Compared to OAs who were white-collar workers, agricultural and trade workers were much more likely to

have FA limitations (Li, Wu, & Wen, 2000). These findings are consistent with the finding that manual work is associated with increased risk for dementia (Qiu et al., 2003), whereas "more complex" occupations are associated with better prognosis (Whalley, Deary, Appleton, & Starr, 2004).

Another SES proxy of CR is income. Typically income level is determined through questionnaires that ask about total household income during the past year (Lee, Buring, Cook, & Grodstein, 2007). In a large sample of Danish OAs, low levels of income were associated with functional decline in women but not men (Avlund et al., 2004). Data from approximately 32,000 OAs in the US, the national health interview survey, also indicated level of income impacts FA as Coustasse et al. (2008) found ability to complete ADLs was related to OAs' income. Those with an income of less than 20,000 dollars were at an increased risk for having ADL disability. Additionally, income was found to be related to IADLs ability in Finnish males (Laukkanen, Kauppinen, Eraand, & Heikkinen, 1993), but not predictive of ADL difficulties. Correlations suggested more income was associated with greater FA in these OAs. These epidemiological investigations are over-inclusive and broad in nature, and as a result it is difficult to discern the makeup of the OAs in these studies. However, from the reported performance on measures of global cognitive functioning in these investigations it appears that the samples contained a variety of OAs with variable levels of cognitive status (i.e., normal, MCI, AD).

Education is arguably the most frequently used measure of CR and can be operationalized several different ways, but almost always is a continuous variable in studies examining FA. Some investigations have not found education to be related to FA (Lewis & Miller, 2007; Kraybill & Suchy, 2011; Suchy et al., 2010; Schmitter-Edgecombe, Parsey, &

Cook, 2011) while others have (Barberger-Gateau, Fabrigoule, Rouch, Letenneur, & Dartigues, 1999; Bickel & Kurz, 2009; Burton et al., 2006; Cahn-Weiner et al., 2000; Mitchell & Miller, 2008b; Plehn et al., 2004; Van der Elst, Van Boxtel, Van Vreukelen, & Jolles, 2008; Zunzunegui, Nunez, Durban, Garcia de Yebenes, & Otero, 2006). Schmitter-Edgecombe et al. (2011) reported education was not related to several measures of FA across 88 normal OAs with a mean education level of approximately 17 years. Years of education were additionally not found to be related to FA as measured by a performance-based instrument in well-educated predominately Caucasian sample of 60 OAs (Lewis & Miller, 2007). Albeit not significant, the correlation between education and FA problems was negative ($r = -.135$), suggesting functional impairment increased as educational history decreased.

In a sample of 75 cognitively normal Caucasian OAs, Suchy et al. (2010) also did not find education was related to FA. However, similarly the non-significant correlations in this investigation suggested that less education may be associated with worse FA on self-report and an objective measure. A separate study by the same research laboratory reported a non-significant correlation between education and FA difficulties in community dwelling OAs. Again this non-significant correlation suggested less education may be associated with worse FA ($r = - .066$; Kraybill & Suchy, 2011). There was also not a relationship between years of education and IADLs performance in three separate domains in a sample of OAs with variable years of education (Diehl et al., 1995).

Although at baseline education was not related to FA, data collected in a prospective aging study found OAs with less education had more FA difficulties over time (Van der Elst et al., 2008). In a sample of 89 normal OAs, MCI, and mild AD there was a positive relationship

between scores on a performance-based instrument and education ($r = 0.36$, $p<0.001$; Pereira et al., 2008). Bickel and Kurz (2009) examined 442 Roman Catholic sisters of Notre Dame of Bavaria, Germany with and without varying degrees of dementia. Analyses indicated education was associated with FA. Participants with less education had more difficulty in completing ADLs. Another European epidemiological study found less education was associated with more ADL disability and greater functional limitations (Zunzunegui et al., 2006).

Education has more specifically been linked to IADLs in OAs. Plehn et al. (2004) found years of education were negatively correlated with self-reported IADL difficulties, in a sample of 133 healthy OAs. Inconsistent findings between FA and education could be associated with ADL domain measured. Barberger-Gateau et al. (1999) examined OAs' ability to complete four different IADLs: telephone use, ability to travel, medication management, and finances. Education was dichotomized as little or no education and completion of higher education. In this large sample, of 1,792 non-demented French OAs, higher education was protective against FA decline in telephone use and finances. However, education was not related to medication use, and was inversely associated with transportation, such that greater education was associated with increased risk for transportation use difficulties.

Education's predictive ability of current FA has been investigated in several studies. Cahn-Weiner et al. (2000) found education to be related to collateral rating of IADL ability, but not predictive. In contrast, Mitchell and Miller (2008b) reported education predicted community dwelling OAs' FA; accounting for 17% of the variance. Burton et al. (2006) and Plehn et al. (2004) also found education predictive of IADL performance while accounting for age in community dwelling non-demented OAs. Despite some inconsistency, education is reported to

be the most related proxy of CR in OAs to FA. There are null findings between education and FA, but in the majority of these cases the expected direction was found such that there was a positive relationship; greater education was associated with increased FA and less education with decreased FA (Lewis & Miller, 2007; Kraybill & Suchy, 2011; Schmitter-Edgecombe et al., 2011; Suchy et al., 2010).

In contrast to education, there is a relative paucity of studies examining how the other frequently used proxies of CR relate to FA. The relationship between premorbid IQ and FA is not certain, but the majority of results suggest this measure of CR is positively related to FA (Artero et al., 2001; Starr & Loine, 2008). Moreover, the one investigation without a significant finding between premorbid IQ and FA was in the expected positive direction, greater premorbid IQ was associated with greater FA. Additionally, measures of SES, occupation and income, are also positively related to FA. "Unskilled" or low occupation OAs are much more likely to have ADL difficulties (Li et al., 2000; Parker et al., 1994). Less income is associated with decreased FA, whereas more income was associated with greater FA in these OAs (Avlund et al., 2004; Coustasse et al., 2008; Laukkanen et al., 1993).

Thus, while the relationship between CR and FA is somewhat variable, it can be concluded that CR is positively related to FA. More CR is protective and associated with greater FA although specific questions remain unanswered. To date there has yet to be an investigation that has examined the different components of CR as they relate and predict FA in OAs. Despite the clinical utility of understanding the relationship between different proxies of CR and FA, almost all CR proxies are indicative of past accomplishments for OAs. While understanding how they impact FA is useful, in order to develop new and improve existing intervention techniques

and prevention models the process by which CR is related to FA needs to be understood. A possible mechanism of action is EF.

EF is consistently found to be positively related as well as predictive of CR (Bell-McGinty et al., 2002; Cahn-Weiner et al., 2000; Cahn-Weiner, Boyle, & Malloy, 2002; Jefferson, Paul, Ozonoff, & Cohen, 2006; Lewis & Miller, 2007; Martyr & Clare, 2012; Mitchell and Miller, 2008a, 2008b; Mitchell, Shaughnessy, Shirk, Yang, & Atri, 2012; Pereira et al., 2008; Roldan-Tapia, Garcia, Canovas, & Leon, 2012; Royall, Chiodo, & Polk, 2000; Siedlecki et al., 2009). Specifically, confirmatory analyses completed by Mitchell et al. (2012), found correlations between EF and a CR composite (i.e., education and premorbid IQ) were .431 and .433 in cognitively intact and cognitively impaired OAs (i.e., MCI & AD). Another study that used education and premorbid IQ as a composite measure of CR found it to be highly correlated, .77 and .78, with EF in different samples of cognitively intact OAs (Siedlecki et al., 2009). Additionally, with a composite measure of CR that included years of education, occupation, and premorbid IQ, Roldan-Tapia et al. (2012) found CR to be positively predictive of EF. Even when CR is limited to one proxy, such as education, as it increases in normal adults so does EF (Barry, Bates, & Labouvie, 2008; Boone, Ghaffarian, Lesser, Hill-Gutierrez, & Berman, 1993; Fine, Delis, Holdnack, 2011; Ruff, Light, & Evans, 1987; Ruff, Light, Parker, & Levin, 1996; Obonsawin, Crawford, Page, Chalmers, Low, & Marsh, 1999; Tombaugh, 2004). This finding is replicated when the sample is specific to OAs (Brooks, Iverson, Lanting, Horton, & Reynolds, 2012; Chan, Lam, Wong, & Chiu, 2003).

Aims

The primary aim of this study was to clarify the relationship between CR and FA in community dwelling OAs. The different proxies that were investigated with FA were premorbid IQ, occupation, income, and education. A performance-based measure of FA (i.e., DAFS-R) was used given its sensitivity and accuracy in assessing OAs' FA (Karagiozis et al., 1998; Kempen et al., 1996; Sherman & Reuben, 1998).

It was hypothesized that all proxies of CR would be positively related to FA given the majority of evidence (Artero et al., 2001; Avlund et al., 2004; Barberger-Gateau et al., 1999; Bickel & Kurz, 2009; Burton et al., 2006; Cahn-Weiner et al., 2000; Coustasse et al., 2008; Laukkanen et al., 1993; Li et al., 2000; Mitchell & Miller, 2008b; Parker et al., 1994; Plehn et al., 2004; Starr & Loine, 2008; Van der Elst et al., 2008; Zunzunegui et al., 2006). In terms of prediction it was hypothesized that premorbid IQ would account for the most variance in FA; however, whether there would be incremental validity by any of CR proxies was unclear. Moreover, the mechanism of action between CR and FA is unclear, but it may be due to a positively related variable, EF. Thus, the second aim of this study was to determine if EF mediated the relationship between CR and FA in community dwelling OAs. It was hypothesized that EF would mediate this relationship. A composite score of EF was determined from several D-KEFS measures given its ability to detect very mild EF difficulties (Strauss et al., 2006).

The third aim of this investigation was to determine if previously documented relationships between personality factors and performance based IADLs could be replicated. It was hypothesized that Agreeableness and Openness would be positively related to and predict IADLs performance. The fourth aim of this study was to understand how personality factors may be related to the performance of IADLs. We hypothesized that EF would mediate the

relationship between the personality factors of the Five-Factor Model and IADLs. To fully understand the association between personality and IADLs, we explored the facets of the personality factors that were predictive of IADLs and hypothesized that EF would mediate the relationship between each personality facet and IADLs.

CHAPTER 2

METHODS

Participants

Power Analysis. To ensure adequate power a power analysis was completed. First, the effect size was determined from previous research that reported the associations between CR and FA. Studies that examined functional impairment were not included given the metric differences between functional impairment and FA. Additionally, results from epidemiological studies were not included given the inherent methodological differences for the proposed investigation. Only the results from empirical investigations with a community sample of non-demented OAs measuring FA via performance-based method were used for determining the effect size.

After results meeting the specified criteria were identified, the effect size was determined through several steps. Two cross sectional empirical investigations of community dwelling, independent older adults were identified; both of which were conducted within our laboratory. Mitchell & Miller (2008b) reported a Pearson product correlation between education and FA of .431. Unpublished data acquired as part of Puente (2012) indicated the relationship between a premorbid IQ measure (i.e., WTAR) and FA was .472. The mean of these Pearson product correlations is .452.

Applying the equation detailed by Cohen (1992), this correlation was than transformed into Cohen's f^2, the ratio of explained variance and error variance (R^2/1- R^2), which serves as the effect size measure. Cohen's f^2 was then inputted into G*Power 3.1.3 (Faul, Erdfelder,

Buchner, & Lang, 2007). Following Faul, Erdfelder, Buchner, and Lang (2009), a power analysis was completed for a multiple regression fixed model for detecting R^2 deviation from zero. The specifications included 4 predictors (Premorbid IQ, Occupation, Income and Education), $\alpha = .05$ level, Cohen's $f^2 = .256$ (i.e., medium effect size, Cohen, 1988), and power = .80. To achieve sufficient power this analysis suggested 64 participants were required.

Recruitment

In total, 65 participants were recruited and completed the investigated. In order to reach that number, 120 participants from the surrounding Athens were contacted regarding participation. Specifically, announcements and information was distributed at two different independent living communities for OAs, and previous lab participants who consented to be contacted about future studies were contacted about provided with information about this investigation. Participants were excluded if they not interested, were <65 or >85, had inadequate sensory and/or motor abilities for paper pencil testing, a history of substance dependence within the past five years, self-reported neurological disorder, functionally dependent, or if performance on MMSE was ≤ 20. Upon completion, all were given a gift bag, valued at approximately $15 dollars, which had UGA goods, including: a notepad or notebook, sticker, UGA drinking glass, and writing utensil. Additionally all participants received $20 dollars, and had a chance to win up to $100 dollars depending on their dice roll and response to a specific item on an ancillary task.

Measures

Cognitive Reserve. For this investigation there were four measures of CR: premorbid IQ, occupation, income and education. The Wechsler Test of Adult Reading (WTAR) was used to

measure premorbid IQ (Wechsler, 2001). The WTAR is a 50-item word reading test that estimates intelligence either by performance on the WTAR alone or with incorporating participants' performance with demographic variables (i.e., age, gender, education, and ethnicity). To determine their word reading ability, adults read irregular words of increasing phonological complexity and decreasing familiarity out of context until they receive 12 consecutive incorrect scores. Compared to other measures of premorbid ability, it is indicated to be a more accurate predictor of premorbid IQ (Ball et al., 2007).

The second measure of CR was occupation, which was coded using substantive complexity scores developed by Roos and Treiman (1980). Substantive complexity scores were derived for 1970 census occupation categories through factor analysis of 46 worker trait and function aggregate scores that were presented in the fourth edition of the Dictionary of Occupational Titles (U.S. Department of Labor, 1977). Items that loaded strongly, $\geq$.5, onto the substantive complexity factor, and $\leq$ .3 onto another factor were retained. Eight items were retained: complexity of function in relation to data, general educational development, specific vocational preparation, intelligence, verbal aptitude, numerical aptitude, abstract and creative versus routine and concrete activities, and low temperament for repetitive or continuous processes. Subsequently, these items were standardized and transformed to a score between 0 – 10, where 0 represents the lowest complexity and 10 represents the highest. Homemakers (n =3) were excluded given a complexity rating for this category was not provided (Roos & Treiman, 1980). Except with homemakers, there were no cases where an individual's occupation was not included in the occupational categories.

The third measure of CR for this study was income level. Following previously documented procedures (Lee et al., 2007), during the semi-structured interview participants were asked "What was your total household income during the past year?" The fourth and final measure of CR for this study was education. The number of formal years of education was the measure for education following the procedures outlined by Siedlecki et al. (2009), whereby 20 is the highest level, representing a doctoral degree.

Personality. Personality was measured with the Revised NEO Personality Inventory self-report (NEO-PI-R; McCrae & Costa, 2010). The NEO-PI-R is 240-item measure appropriate for variety individuals, and takes approximately 40 minutes for the participants to complete. There are five major dimensional factors, which are made up of 6 8-item facet scales. The psychometric properties have improved with this version. Test-retest reliability ranges from .91 to .93 over a one-week period and .78 to .85 over a 10-year period. The NEO-PI-R is also reported to have adequate construct validity, which is supported by reported convergent and discriminant validity results (McCrae & Costa, 2010).

Executive Functioning. EF was measured by a composite score derived from the performance on four EF tasks from the Delis-Kaplan Executive System (D-KEFS): the Trail Making Test condition 4 (TMT-4), Tower Test, Verbal Fluency and Design Fluency. A composite score of EF was used instead of performance on a single measure given there is no "gold" standard measure of EF (Delis et al., 2001). Additionally, there has not been a measure that has consistently been associated with FA in OAs. Rather EF as a construct in general has been consistently associated with FA. Out of the nine possible instruments in the DKEFS, the TMT-4, Tower Test, Verbal Fluency and Design fluency were used to derive the composite

measure given the reported internal consistency found in an EF composite using these measures in a previous study from our laboratory (Mitchell & Miller, 2008a).

The TMT-4 is a number-letter sequencing task, requiring alternation between number and letters in numerical and alphabetical order (e.g, 1-A-2-B-3-C and so on until reaching the end). This measure is similar to the Trails B Test developed for the Army Individual Test Battery (1944). While there are many cognitive abilities necessary to perform well on this measure, in general TMT-4 involves planning and the ability to maintain task goals. The TMT-4 has been shown to have adequate reliability in adults 50 – 89 (Delis et al., 2001).

The D-KEFS Tower Test was administered to all OAs participants. This measure is an extension of the Tower of London and Tower of Hanoi. The Tower Test requires examinees to arrange various sized disks on three wooden pegs to match the displayed picture. The pegs are arranged in various starting formats, and the test requires the examinee rearrange the pegs to match the picture by using the fewest moves as possible. While completing the task the examinee is not permitted to place a larger disk on top of a smaller disk and can only move on disk at a time, which emphasizes planning. The Tower Test increases in difficulty with each item. There are a number of different scores that are provided based on test performance, however the most informative variable used for this measure is the Total Achievement scaled score.

Purposive action is a core component of EF (Lezak et al., 2012), which involves the ability to initiate and generate responses (Sbordone, 2000). D-KEFS measures that require one to generate responses are the Verbal Fluency and Design Fluency tests. To comprehensively measure verbal fluency, the D-KEFS Verbal Fluency measure has three conditions, but only the first condition was used for the current study. The first condition can be considered a measure of

letter fluency and requires the examinee to generate as many words that begin with a particular letter (i.e., F, A, S) for one minute. In doing so they are not allowed to use the names of people or places, or numbers. Additionally, they are not allowed to use the same word with different ending, such as fast, faster and fastest. This test is very similar to an earlier measure of verbal fluency, the Controlled Oral Word Association Test (Benton & Hamsher, 1976). Total correct number of words was used to determine participants' performance.

The fourth and final measure of EF that was administered was Design Fluency. Similar to Verbal Fluency, there are three conditions. In condition one, the individuals were required to generate as many designs as possible by connecting four lines between four or more dots in a square that has 10 dots. Each line should touch at least another line at a dot, and the design should not be repeated. The generated design does not have to be able to be named (e.g., square). In the second condition, the examinee has to complete the same exercise, except the square it is completed in now has five empty and five filled dots. The individual has to generate as many different designs following the aforementioned rules but only connecting lines between the empty dots. The third and final condition also has five empty and five filled dots within a single square. This condition requires the participant to switch between empty and filled dots when generating designs. The Design Fluency Test of D-KEFS is similar too and developed from the Ruff Figural Fluency Test (Ruff, 1988). The score for Design Fluency was derived from total correct designs from all conditions.

Functional Ability. The measure of FA used to examine the aims of the current study was a performance-based measure, the Direct Assessment of Functional Status–Revised (DAFS-R; Loewenstein & Bates, 1989). A performance-based measure was chosen to be used over

questionnaires given greater accuracy (Myers et al., 1993), reliability (Hoeymans et al., 1997), and larger ceiling and basals (Sherman & Reuben, 1998). On the DAFS-R, an examiner compares examinees' FA in 10 different domains including: time orientation, communication, financial skills, grocery shopping, dressing and grooming, eating, driving, meal preparation, providing demographic information, and taking a telephone message. These 10 scales combine to determine overall functional ability but can be separated to examine IADLs and simple ADLs independently. The IADLs domains include: communication, financial skills, grocery shopping, driving, meal preparation, and taking a telephone message. The DAFS-R is well validated and found to be reliable. Specifically, it has test-retest reliability across subscales ranging from .55 to .91 (Loewenstein & Bates, 1989). The total administration time is approximately 45 minutes.

Procedures

This study was a cross sectional design and required approximately three and a half hours of each participant's time. Before the research protocol was initiated, participants consented and were subsequently administered the MMSE. All participants scored above the cutoff (20), and therefore no participants were excluded based on a low mental status (i.e., MMSE). Following informed consent and MMSE, participants underwent a semi-structured examiner administered interview that determined the participant's longest held occupation, level of income, and amount of formal education. The participant then completed questionnaires regarding: personality (i.e., NEO-PI-R), depressive symptomology (i.e., GDS), impulsivity (i.e. UPPS), their medical diagnoses/conditions, medications and family history of disease (i.e., demographics questionnaire), and FA (i.e., OARS).

Subsequently, participants were administered the performance based measure of FA (i.e., DAFS-R), cognitive measures of executive functioning (i.e., D-KEFS), and premorbid IQ (i.e., WTAR). Additional measures collected but not related to this study's aims included a comprehensive screening measure of cognitive functioning (i.e., RBANS) and discounting measures (i.e., PDT & DDT). The administration of functional, cognitive and discounting measures was counterbalanced across all participants to prevent fatigue effects. Additionally, measures were randomized within the cognitive and discounting counterbalanced block to prevent order effects. As stated, the discounting measures, impulsivity self-report, and comprehensive screening measure of cognitive functioning were ancillary measures and used for a separate investigation. All procedures were completed either at the OAs' respective independent living facility or in the University of Georgia Neuropsychological and Memory Assessment Laboratory.

Data Analysis

To test the hypothesis that all CR proxies would be positively related, Pearson product correlations were completed. Hierarchical multiple regression analyses were then completed to determine if proxies were also predictive. Subsequently, mediation analyses were completed. Given three participants were homemakers and unable to be assigned a substantive complexity score, mediation analyses consisted of 62 participants. A composite score of CR was then used for mediation analyses to determine if the mechanism of action between CR and FA is EF. To obtain a composite score for CR, each proxy was first converted into z-scores. The z-scores for each proxy were then summed and averaged. Similar to EF, the CR composite was internally consistent (Cronbach's $\alpha = .825$). For the mediation analyses we followed the procedures outlined by Baron and Kenny (1986).

In step one, the EF composite was regressed onto the CR composite, path a. In step two FA was regressed onto CR, path c. Third, EF was added in step 2 of the second regression, path b, and was evaluated to determine if EF significantly predicted FA above and beyond CR. Complete or partial mediation was determined by evaluating if path c was no longer significant or still significant but reduced. Additionally, to further support mediation, a Sobel's test (1982) was completed to determine if indirect effect of CR (i.e., the IV) on FA (i.e., the DV) via EF (i.e., Mediator) was significantly different from zero (Preacher & Hayes, 2004).

To test the hypotheses that Openness and Agreeableness are positively related with IADLs, Pearson product bivariate correlations and a hierarchical regression analysis was completed. Given invalid self-reports four participants were excluded (n = 61).

Subsequently, mediation analyses were completed to determine if EF mediated the relationship between personality and IADLs. After controlling for age and overall cognitive ability (i.e., MMSE) Openness and not Agreeableness predicted IADLs. Thus, mediation analyses were only completed for Openness following Baron and Kenny (1986). First EF composite was regressed onto Openness (path a). Then, IADLs was regressed onto Openness (path c). Third, EF was added in step 2 of the second regression, path b, and was evaluated to determine if EF significantly predicted IADLs above and beyond Openness. Complete or partial mediation was determined by evaluating if path c was no longer significant or still significant but reduced. To further support mediation, a Sobel's test (1982) was completed to examine if the change in the regression coefficient between the IV and DV after accounting for the mediator was significantly different from zero (Preacher & Hayes, 2004).

CHAPTER 3

RELATIONSHIP BETWEEN COGNTIVE RESERVE AND FUNCTIONAL ABILITY IS MEDIATED BY EXECUTIVE FUNCTIONING IN OLDER ADULTS

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Abstract

Overall, a limited literature suggests cognitive reserve (CR) is positively associated with functional ability (FA); however, this relationship has yet to be comprehensively investigated. This investigation aimed to explicate this relationship. We hypothesized that executive functioning (EF) would mediate this relationship. All measures of CR were positively related to and predictive of FA. Although the highest zero order correlation was between income and FA ($r = .417$), education accounted for the greatest amount of variance in FA after controlling for age and overall cognitive ability, 8.3%. Complete mediation was found between CR and FA via an internally consistent D-KEFS composite score (Cronbach's $\alpha = .795$); suggesting EF mediates the relationship between CR and FA, such that as CR increases so does EF, which is in turn related to improvements in FA.

Largely due to medical advances, the world's life expectancy has dramatically increased. In fact, it is expected that by 2060, the average life expectancy in some countries will be 100 years of age. However, "Is a longer life a better life?" (Kinsella & Wan, 2009, p. 51). Not surprisingly, the highest prevalence of declines of functional ability (FA), the ability to carry out activities of daily living (ADLs), is found in older adults (OAs) (Freedman & Martin, 1998). Therefore, it is vital to understand the factors that impact OAs' FA in order to improve current intervention techniques and prevention models, and help maintain or improve their FA.

Although research has documented numerous factors that impact FA, such as sensory functioning (West et al., 2000), physical ability (Janssen, Heymsfield, and Ross, 2002; Lee, 2000; Petrella, Miller & Cress, 2004), and cognitive functioning (Gross, Rebok, Unverzagt, Willis, & Brandt, 2012; Schmitter-Edgecombe, Woo, & Greeley, 2009), other factors that impact FA have yet to be fully elucidated. One such factor garnering much attention recently is Cognitive Reserve (CR). CR is a clinical construct that explains the non-linear relationship between neuropathology and clinical symptoms (Stern, 2002). Individual differences in innate intelligence or lifetime experiences, such as education and occupation, suggest CR operates on a continuum. Those with greater CR have a later onset of clinical symptoms and are less likely to be diagnosed with dementia (Qiu et al., 2003; Stern et al., 1994), whereas those with less CR are at greater risk (Scarmeas & Stern, 2003). Similarly, OAs with less CR have greater FA difficulties (Bickel & Kurz, 2009; Coustasse, Bae, Arvidson, Singh, & Treviño, 2009; Parker, Thorslund, & Lundberg, 1994) and are at greater risk for exhibiting FA impairment in the future (Artero, Touchon, & Ritchie, 2001; Avlund, Damsgaard, & Osler, 2004; Barberger-Gateau,

Fabrigoule, Rouch, Letenneur, & Dartigues, 1999; Laukkanen, Kauppinen, Eraand, & Heikkinen, 1993; Li, Wu, & Wen, 2000; Pereira, Yassuda, Oliveira, Forlenza, & 2008; Van der Elst, Van Boxtel, Van Vreukelen, & Jolles, 2008; Zunzunegui, Nunez, Durban, Garcia de Yebenes, & Otero, 2006). Specific to community dwelling OAs, a few investigations have found CR is predictive of FA (Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002; Burton, Strauss, Hultsch, & Hunter, 2006; Mitchell & Miller, 2008a; Plehn, Marcopulos, & McLain; 2004), although, there has yet to be an investigation that compares different measures of CR and their associations with FA.

Measures of CR are variables representative of lifetime experiences or innate intelligence, such as premorbid IQ, occupational attainment, income, and education (Stern, 2009). Premorbid IQ has generally been found to be protective of FA in OAs (Artero et al., 2001; Starr & Loine, 2008). However, there have been some exceptions (e.g., Plehn et al., 2004). OAs who have occupations associated with greater complexity and skill are less likely to have difficulties with ADLs (Li et al., 2000; Parker et al., 1994). Level of income is also positively associated with FA, as investigations have found when income decreases the risk for ADLs impairment increases (Avlund et al., 2004; Coustasse et al., 2009); whereas, when income increases so does FA (Laukkanen et al., 1993). One of the most commonly used measures of CR, education (Stern, 2009), has been found to be positively related to and predictive of FA in OAs (Barberger-Gateau et al., 1999; Bell-McGinty et al., 2002; Bickel & Kurz, 2009; Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000; Mitchell & Miller, 2008a; Van der Elst et al., 2008; Zunzunegui et al., 2006). Even after controlling for age, education has been found to be predictive of FA in community dwelling OAs (Burton et al., 2006; Plehn et al., 2004). However,

this has not always been found (e.g., Diehl, Willis & Schaie, 1995; Lewis & Miller, 2007; Kraybill & Suchy, 2011; Suchy Kraybill, & Franchow, 2010; Schmitter-Edgecombe, Parsey, & Cook, 2011). When reviewed, many of these studies in fact suggest their non-significant findings are in the expected direction. Thus, overall there appears to be a positive relationship between CR and FA.

Although CR is not fixed (Stern, 2009), most proxies including the ones evaluated here are indicative of past accomplishments for OAs. Therefore, understanding the process by which CR is related to FA will facilitate improving current interventions and the development of future programs to help OAs maintain FA and decrease functional decline. One potential mechanism of action is executive functioning (EF) as it is found to be positively related to CR, (Mitchell, Shaughnessy, Shirk, Yang, & Atri, 2012; Roldan-Tapia, Garcia, Canovas, & Leon, 2012; Siedlecki et al., 2009) and predictive of FA (Bell-McGinty et al., 2002; Cahn-Weiner et al., 2000; Cahn-Weiner, Boyle, & Malloy, 2002; Jefferson, Paul, Ozonoff, & Cohen, 2006; Lewis & Miller, 2007; Mitchell and Miller, 2008a, 2008b; Pereira et al., 2008; Royall, Chiodo, & Polk, 2000). In general, EF is thought to be a "higher-level" cognitive construct that facilitates purposeful goal-directed behavior by managing "lower-level" cognitive functions (Alvarez & Emory, 2006; Stuss & Benson, 1986; Stuss & Levine, 2002). It is necessary for appropriate, effective, and socially responsible behavior, as well as, adaptive behaviors in novel situations (Lezak, Howieson, Bigler, & Tranel, 2012). In normal OAs, EF accounts for more variance in the ability to perform ADLs than any other cognitive ability, including general cognitive ability (Cahn-Weiner et al., 2000). It also has been found to mediate the relationship between other

cognitive domains such as visuospatial ability and memory with FA (O'Bryant et al., 2011; Royall, Palmer, Chiodo, & Polk, 2005).

Using a composite measure of CR that included years of education, occupation, and premorbid IQ, previous research found CR to be positively predictive of various measures of EF, including verbal fluency and Trail-Making Test B (Roldan-Tapia et al., 2012). Confirmatory factor analyses have also been used to understand the relationship between CR and EF. One investigation found that a latent variable of CR composed of education and a measure of premorbid IQ was positively related to EF in cognitively intact and cognitively impaired OAs (i.e., MCI & AD) (correlations = .431 and .433, respectively; Mitchell et al., 2012). Another study found that years of education and two measures of premorbid IQ loaded onto the latent variable of CR in two different samples of cognitively intact OAs, which was highly correlated with EF in both samples (.77 and .78, respectively; Siedlecki et al., 2009). Further support for the relationship between EF and CR comes from traditional neuropsychological studies that report as education increases so does EF (Barry, Bates, & Labouvie, 2008; Boone, Ghaffarian, Lesser, Hill-Gutierrez, & Berman, 1993; Fine, Delis, Holdnack, 2011; Ruff, Light, & Evans, 1987; Ruff, Light, Parker, & Levin, 1996; Obonsawin, Crawford, Page, Chalmers, Low, & Marsh, 1999; Tombaugh, 2004), even when analyses are specific to OAs (Brooks, Iverson, Lanting, Horton, & Reynolds, 2012; Chan, Lam, Wong, & Chiu, 2003).

Given the literature cited above, there were two aims for this investigation. First we aimed to explicate the relationship between CR and FA. We hypothesized all CR proxies: premorbid IQ, occupational complexity, current income and education, would be positively related to FA as measured by a performance-based measure given the majority of evidence

(Artero et al., 2001; Avlund et al., 2004; Barberger-Gateau et al., 1999; Bickel & Kurz, 2009; Burton et al., 2006; Cahn-Weiner et al., 2000; Coustasse et al., 2008; Laukkanen et al., 1993; Li et al., 2000; Mitchell & Miller, 2008b; Parker et al., 1994; Plehn et al., 2004; Starr & Loine, 2008; Van der Elst et al., 2008; Zunzunegui et al., 2006). A performance-based measure of FA (i.e., DAFS-R) was used given its sensitivity and accuracy in assessing OAs' FA (Karagiozis et al., 1998; Kempen et al., 1996; Sherman & Reuben, 1998). In terms of prediction it was hypothesized that premorbid IQ would account for the most variance in FA; however, whether there would be incremental validity by any of CR proxies was unclear. The second aim was to unravel the mechanism of action between CR and FA. We hypothesized EF as an explanatory mechanism. Specifically, we hypothesized that an EF composite score would fully mediate the relationship between a composite score of CR and performance-based FA.

Method

Participants

Sixty-five independent community dwelling OAs were recruited from the local community of Athens, GA and provided with a small monetary compensation for their time. Potential participants were included if they were between the ages of 65-85 without self-reported history of substance dependence within the past five years, self-reported literacy, without gross sensory impairment, without self-reported neurological disorder, able to live independently, and if performance on the Mini-Mental State Examination (MMSE) was greater than 20. A cutoff of 20 was used given findings from Bedard et al. (2003) suggest scores on the MMSE below 20 are associated with possibly invalid self-reports. Descriptive statistics for age, gender, depressive symptomology, overall general cognitive ability, number of medical diagnoses and medical

prescriptions are presented in Table 3.1 (n = 65). Although age was negatively related to FA (r = -.216, p = .042), and overall cognitive ability was positively related to FA (r = .684, p < .001), gender (r = .077, p = .544), depressive symptomology (r = -.138, p = .136), number of medical diagnoses (r = .071, p =.286) or medical prescriptions (r = .123, p = .167) were not significantly associated with FA.

Measures

Cognitive Reserve. For this investigation there were four proposed measures of CR (i.e., CR proxies): premorbid IQ, occupation, income and education. The Wechsler Test of Adult Reading (WTAR) was used to measure premorbid IQ (Wechsler, 2001). The WTAR is a 50-item word reading test that estimates intelligence either by performance on the WTAR alone or with incorporating participants' performance with demographic variables (i.e., age, gender, education, and ethnicity). To determine their word reading ability, adults are required to read irregular words of increasing difficulty until they receive 12 consecutive incorrect scores. Compared to other measures of premorbid ability, it is a more accurate predictor of premorbid IQ (Ball et al., 2007). The raw number of correct words out of 50 without demographic adjustment was used to determine the premorbid IQ score.

The second measure of CR was occupation, which was coded using substantive complexity scores developed by Roos and Treiman (1980). Substantive complexity scores were derived for 1970 census occupational categories through factor analysis of 46 worker trait and function aggregate scores that were presented in the fourth edition of the Dictionary of Occupational Titles (U.S. Department of Labor, 1977). Items that loaded strongly, $\geq$.5, onto the substantive complexity factor, and $\leq$.3 onto another factor were retained. Eight items were

retained: complexity of function in relation to data, general educational development, specific vocational preparation, intelligence, verbal aptitude, numerical aptitude, abstract and creative versus routine and concrete activities, and low temperament for repetitive or continuous processes. Subsequently, these items were standardized and transformed to a score between 0 – 10, where 0 represents the lowest complexity and 10 represents the highest. Homemakers (n =3) were excluded given complexity ratings for this category was not provided (Roos & Treiman, 1980). There were no cases where an individual's occupation was not included in the occupational categories provided by Roos and Treiman (1980).

Income was the third measure of cognitive reserve and determined during the semi-structured interview, and was based on the procedures of Lee, Buring, Cook, and Grodstein (2007) where participants were asked "What was your total household income during the past year?" The fourth and final measure of CR proposed for this study was education. Following the procedures of Siedlecki et al. (2009), number of formal years was used, with 20 the highest level representing a doctoral degree, 18 for a master's degree, 16 for a bachelor's degree, 14 for an associate's degree, and 12 for a high school degree or GED. Additionally, each year of formal education was counted as a formal year of education, regardless if it was or wasn't a degree granting year. For example, a high school graduate who completed a year of college would have 13 years of education. The maximum number of years of education was limited to 20.

Executive Functioning. EF was measured by a composite score derived from the performance on four EF tasks from the Delis-Kaplan Executive System (D-KEFS). A composite score of EF was used given there is no "gold" standard measure of EF (Delis, Kaplan & Kramer, 2001). Additionally, there has not been a single EF measure that has consistently been

associated with FA in OAs. Out of the nine possible instruments in the DKEFS, the TMT-4, Tower Test, Verbal Fluency and Design fluency were selected apriori to derive the composite measure given the reported internal consistency (Cronbach's $\alpha = .753$) found in an EF composite using these measures in a previous study with OAs (Mitchell & Miller, 2008b).

The TMT-4 is a number-letter sequencing task, requiring the individual to alternate between number and letters in numerical and alphabetical order (e.g., 1-A-2-B-3-C and so on until reaching the end). This measure is similar to the Trails B Test developed for the Army Individual Test Battery (1944). While there are many cognitive abilities necessary to perform well on this measure, in general TMT-4 involves planning and the ability to maintain task goals. The TMT-4 has been shown to have adequate reliability in adults 50 – 89 (Delis et al., 2001).

The first condition of the D-KEFS Verbal Fluency is based on the Controlled Oral Word Association Test (Benton & Hamsher, 1976) and can be considered a measure of letter fluency. During this condition the examinee generates as many words that begin with a particular letter (i.e., F, A, S) for one minute that are not names of people or places, numbers, or the same word with different ending (e.g., fast, faster and fastest). Total number of words correct was used to determine participants' performance.

The third measure of EF administered was Design Fluency, which is similar to the Ruff Figural Fluency Test (Ruff, 1988). There are three conditions, which require participants to generate different unique designs as quickly as they can within 60s while abiding by a specific set of rules. In condition one; participants generate as many designs as possible by connecting four lines between five dots in a square. In condition two, the examinee completes the same exercise, except the square now has five empty and five filled dots. They are required to make

their designs by only connecting lines between the filled dots. Condition three also has five empty and five filled dots within a single square. However, this condition requires the participant to switch between empty and filled dots when generating designs. The score for Design Fluency was the sum of correct designs across conditions.

The D-KEFS Tower Test is an extension of the Tower of London (Shallice, 1982) and Tower of Hanoi (Borys, Spitz, & Dorans, 1982), and requires examinees to arrange various sized disks on three wooden pegs to match the displayed picture. The pegs are arranged in various starting formats, and the test requires the examinee to rearrange the pegs to match pictures of increasing difficulty by using the fewest moves as possible while not placing a larger disk on top of a smaller disk and only moving one disk at a time. The total achievement scaled score was used to reflect performance on the Tower.

Functional Ability. FA was measured with a performance-based measure, the Direct Assessment of Functional Status–Revised (DAFS-R; Loewenstein & Bates, 1989). A performance-based measure was chosen over questionnaires given the higher level of accuracy (Myers et al., 1993), reliability (Hoeymans et al., 1997), and decreased sensitivity to ceiling and floor effects (Sherman & Reuben, 1998). The DAFS-R examines FA in 10 different domains: time orientation, communication, financial skills, grocery shopping, dressing and grooming, eating, driving, meal preparation, providing demographic information, and taking a telephone message. These 10 scales combine to determine overall functional ability on a scale of 0 - 137 but can be separated to examine IADLs and simple ADLs independently (e.g., Mitchell & Miller, 2008a). The IADLs domains include: communication, financial skills, grocery shopping, driving, meal preparation, and taking a telephone message. The DAFS-R is well validated and

found to be reliable. Specifically, it has test-retest reliability across subscales ranging from .55 to .91 (Loewenstein & Bates, 1989).

Procedures

The university institutional review board first approved all procedures completed in this investigation. Following informed consent participants were administered the MMSE and a semi-structured interview, which determined participants longest held occupation, level of income, and years of formal education. The participants then completed the Geriatric Depression Scale (GDS; Yesavage et al., 1983), and a demographic questionnaire regarding their medical diagnoses/conditions, medications and family history of disease. Three additional measures that were used for an ancillary study were also completed. Subsequently, participants were administered the performance based measure of FA (DAFS-R), cognitive measures of executive functioning (D-KEFS), and premorbid IQ (WTAR). The administration of the functional and cognitive measures was counterbalanced across all participants to minimize any order effects.

Analyses

Descriptive statistics for CR, EF, and FA are summarized in Table 3.2. Performance on the four separate D-KEFS measures was used to create a composite score. Consistent with Mitchell and Miller (2008b) this composite score was found to be internally consistent (Cronbach's $\alpha = .795$).

To test the hypothesis that all CR proxies would be positively related, Pearson product bivariate correlations were completed (Table 3.3) followed by multiple regression analyses (Table 3.4). Subsequently, mediation analyses were conducted using a composite score of CR to determine if the mechanism of action between CR and FA was EF. To obtain the composite

score for CR, each proxy was converted into z-scores then summed and averaged. Similar to EF, the CR composite was internally consistent (Cronbach's $\alpha = .825$). For the mediation analyses we followed the procedures outlined by Baron and Kenny (1986).

Results

Assumptions for hierarchal regression analyses were checked using procedures specified by Cohen, Cohen, West and Aiken (2002) and were met. Zero-order bivariate correlations (Table 3.3) between CR proxies and FA ranged between .338 and .417 and were all significant at $p < .01$. To determine if there were differences, a Steiger (1980) Z test was completed between all correlations of the CR proxies and FA. There were no differences between the WTAR and occupational complexity ($Z = -0.230$, $p = .818$), WTAR and income ($Z = -0.466$, $p = .641$), WTAR and education ($Z = -0.167$, $p = .867$), occupational complexity and income ($Z = -0.504$, $p = .614$), occupational complexity and education ($Z = 0.34$, $p = .853$), or income and education ($Z = 0.318$, $p = .750$).

Age ($r = -.216$, $p = .042$) and overall cognitive ability (i.e., MMSE; $r = .684$, $p < .001$) were significantly related to FA and, therefore, controlled in each of 4 independent hierarchical multiple regression analyses by entering them in the first step of each analysis. As expected, these variables were predictive of FA (adjusted $R^2 = .457$), F (2, 62) = 27.916, $p < .001$. WTAR performance was then entered as the second step in the first analysis and significantly increased the variance accounted for in FA ($\Delta R^2 = .063$), ΔF (1, 61) = 8.25, $p < .01$ (Table 3.4). Following these same procedures, occupational complexity ($\Delta R^2 = .078$; ΔF (1, 58) = 10.059, $p < .01$), income ($\Delta R^2 = .081$; ΔF (1, 61) = 11.113, $p < .01$) and education ($\Delta R^2 = .083$; ΔF (1, 61) = 11.384, $p < .01$) all accounted for variance in FA above and beyond age and overall cognitive

ability. To determine if one CR proxy could predict variance above and beyond the others, a simultaneous regression analysis was completed. The overall regression model was significant (adjusted $R^2 = .163$), F (4, 57) = 3.971, $p < .05$; however, no one CR proxy accounted for a significant amount of variance independently: WTAR ($p = .420$), Income ($p = .080$), occupational complexity ($p = .635$), and education ($p = .517$).

The four conditions were met for mediation (Baron & Kenny, 1986). First, the EF composite was regressed onto the CR composite, path a (Figure 3.1). CR accounted for a significant amount of variance in the EF composite (adjusted $R^2 = .375$), F (1, 60) = 37.620, $p < .001$. Second, FA was regressed onto CR in step 1, path c, (adjusted $R^2 = .186$), F (1, 60) = 14.97, $p < .001$. Third, EF was added in step 2 of the second regression, path b, and EF significantly predicted FA above and beyond CR ($\Delta R^2 = .171$), ΔF (1, 59) = 16.002, $p < .001$. The relationship between CR and FA, path c, was no longer significant ($p = .368$; $\Delta\beta = -.327$) which supports the fourth condition and suggests complete mediation. To further support mediation, a Sobel's test (1982) was completed to examine if the indirect effect of CR (i.e., the IV) on FA (i.e., the DV) via EF (i.e., Mediator) was significantly different from zero. The indirect effect of CR on FA was significant, $Z = 3.35$, $p < .001$, which supports mediation and suggests the change in the regression coefficient between the IV and DV after accounting for the mediator was significantly different from zero (Preacher & Hayes, 2004).

Discussion

Overall, the extant literature suggests CR is positively related to FA in OAs, such that those with greater CR are better able to complete ADLs and less likely to experience functional decline and impairment (Artero et al., 2001; Avlund et al., 2004; Barberger-Gateau et al., 1999;

Bell-McGinty et al., 2002; Bickel & Kurz, 2009; Cahn-Weiner et al., 2000; Coustasse et al., 2009; Laukkanen et al., 1993; Li et al., 2000; Mitchell & Miller, 2008a Parker et al., 1994; Starr & Loine, 2008; Van der Elst et al., 2008; Zunzunegui et al., 2006). However to date, different proxies of CR and their relationships with FA in community dwelling OAs have not been examined in a single comprehensive study. First, the association between FA and four commonly used measures of CR: premorbid IQ, occupation, income and education, were compared; subsequently, we examined if the mechanism of action for this relationship was EF.

Premorbid IQ has been shown to be protective of FA in OAs (Artero et al., 2001; Starr & Lonie, 2008). Similar to these findings, our analyses indicate a positive association between premorbid IQ and FA (Table 3.3). Li et al. (2000) and Parker et al. (2004) found OAs who had a lifetime occupation with greater complexity were less likely to have difficulties with ADLs, which is consistent with the positive relationship ($r = .338$, $p < .01$) found between occupation complexity and FA in our study. Pearson product correlations (Table 3.3) also support the conclusion that as income increases so does FA in OAs (Laukkanen et al., 1993). Consistent with previous findings (Barberger-Gateau et al., 1999; Bell-McGinty et al., 2002; Bickel & Kurz, 2009; Cahn-Weiner et al., 2000; Mitchell & Miller, 2008a; Van der Elst et al., 2008; Zunzunegui et al., 2006), the final measure of CR, education, was also positively related to FA ($r = .370$, $p < .01$). Across all proxies, income had the highest bivariate correlation ($r = .417$); however, all correlations were of moderate magnitude (Cohen, 1988) and there were not significant differences between any of the correlations.

In addition, all proxies were positively predictive of FA (Table 3.4); this supports Schofield's (1999) perspective of reserve, such that those with greater reserve have "further to

fall," and OAs with less CR have a much greater likelihood of exhibiting decreased FA. Therefore, clinicians should be mindful in evaluating OAs with low CR, as the threshold for them exhibiting functional impairment not due to physical or sensory impairments is much smaller. This is of particular importance given functional impairment is one of the distinguishing factors for differentiating normal aging from dementia (American Psychiatric Association, 2004; World Health Organization, 1992). In fact, this may in part explain why individuals with decreased CR have increased risk for dementia (Scarmeas & Stern, 2003) and exhibit functional impairment in the future (Artero et al., 2001; Avlund et al., 2004; Barberger-Gateau et al., 1999; Laukkanen et al., 1993; Li et al., 2000; Pereira et al., 2008; Van der Elst et al., 2008; Zunzunegui et al., 2006). Even though premorbid IQ has been found to be more protective against functional decline in OAs than education (Starr & Loine, 2008) cross sectional results suggest premorbid IQ does not account for the greatest amount of variance.

In contrast to our hypothesis, when viewed independently education and not premorbid IQ accounted for the greatest amount of variance in FA above and beyond age and overall cognitive ability ($\Delta R^2 = .083$). However, the difference in the amount of variance accounted for between premorbid IQ and education was only 2% (Table 3.4) and the range of R^2 change values for all proxies fell between the amount of variance accounted for in FA by premorbid IQ and education, 6.3% – 8.3% (Table 3.4). Finally, when simultaneous regression analysis was completed evaluating all CR proxies in the same model, none stood out over the others, suggesting each accounts for a similar amount of variance in FA and represent a similar construct.

Thus, these regression results add to the current literature by demonstrating four commonly used measures of CR are positively related and predictive of FA in community dwelling OAs, and no one proxy is more predictive of FA above and beyond the others. Thus, in addition to other factors like cognitive performance (Mitchell and Miller, 2008a), clinicians could obtain a general idea about their FA based on scores from any of the CR measures, such that low scores on any proxy would suggest decreased FA.

Even though CR may not be fixed, it can be thought of as innate intelligence and/or reflective of one's lifetime experiences and is, therefore, less remediable for OAs. Thus, after establishing the positive relationship between all proxies and FA, it was necessary to examine the process by which CR impacts FA so current interventions can be refined and new ones can be developed to help OAs maintain FA. Our hypothesis that EF would mediate the relationship between CR and FA was supported; suggesting that increases in CR predicts higher EF, which in turn positively predicts FA (Figure 3.1). Therefore, in an attempt to maintain FA and prevent functional decline, OAs could complete intervention programs that improve EF (e.g., Basak, Boot, Voss, & Kramar, 2008; Bherer et al., 2005; Carlson et al., 2008; Colcombe & Kramer, 2003; Dahlin, Nyber, Backman, & Neely, 2008). While it would be expected that there would be some measurable benefit to FA when EF is improved, to our knowledge this has not been investigated and should be the focus of future research. In fact, we have found only one investigation that has examined functional outcomes following a cognitive training intervention. Willis et al. (2006) showed training in reasoning not only improved performance on reasoning measures but also decreased self-reported FA decline at 5-year follow up. Furthermore, interventions improve EF through a variety of different methods, including direct cognitive

training with EF tasks (Bherer et al., 2005; Dahlin et al., 2008), strategy based video games (Basak et al., 2008), community based activity programs (Carlson et al., 2008), and aerobic fitness training (Colcombe & Kramer, 2003). These methods should not only be compared to determine their impact on various measures of EF, but should also be examined in relation to FA in order to develop the most effective intervention.

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Table 3.1
Demographics

Variable	
Age	76.1 (6.1; 65-85)
Gender (M, FM)	(14, 51)
GDS	4.9 (4.9; 0-26)
MMSE	27.3 (1.7; 23-30)
Diagnoses	2.0 (1.6; 0-7)
Prescriptions	2.9 (2.8; 0-13)

GDS = Geriatric Depression Scale;
MMSE = Mini-mental State Examination
Values are mean & (SD; range)

Table 3.2
Descriptive statistics for Cognitive Reserve, Executive Functioning, and Functional Ability

	Minimum	Maximum	Mean	SD
Cognitive Reserve				
WTAR	13.00	50.00	36.42	9.5
Occupational Complexity	0.8	8.40	5.6	1.7
Income	6,900	170,000	43,947.7	37,088.7
Education	9.0	20.0	15.6	2.9
Composite Score	-2.03	1.60	-.0038	.81
Executive Functioning				
TMT-4	1.0	15.0	8.23	4.3
Verbal Fluency	3.0	19.0	10.4	3.6
Design Fluency	4.0	19.0	11.1	3.6
Tower Test	2.0	16.0	9.5	3.2
Composite Score	3.0	14.75	9.8	2.9
Functional Ability				
DAFS-R total score	91	134	119.0	9.2

WTAR= Wechsler Test of Adult Reading; TMT-4 = Delis-Kaplan Executive Function System Trail Making Test condition 4; DAFS-R = the Direct Assessment of Functional Status–Revised; CR composite are Z-scores with mean of 0 and *SD* of 1. Occupational complexity are between 0 – 10. WTAR, income, education, and DAFS-R are raw scores. WTAR scores have a minimum of 0 and maximum of 50. DAFS-R raw scores have a minimum of 0 and maximum of 137. Executive Functioning measures are scaled scores with mean of 10, and *SD* of 3.

Table 3.3
Bivariate correlations between Cognitive Reserve proxies and Functional Ability

	Functional Ability	WTAR	Occupational Complexity	Income
WTAR	.343*	--	--	--
Occupational Complexity	.338*	.490*	--	--
Income	.417*	.438*	.537*	--
Education	.370*	.617*	.565*	.540*

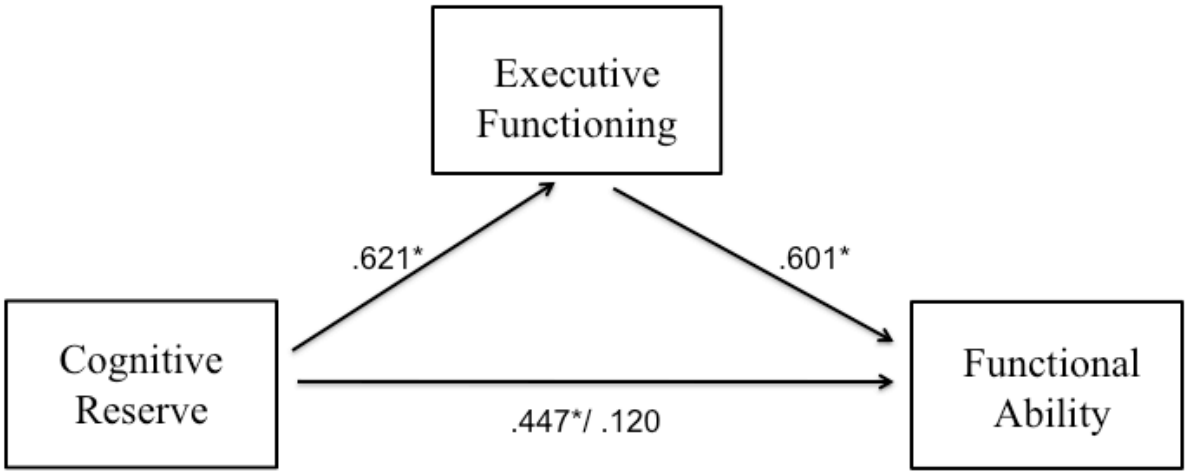
WTAR = Wechsler Test of Adult Reading
* = $p < .01$

Table 3.4
Hierarchical multiple regression analysis for prediction of Functional Ability by Cognitive Reserve proxies after controlling for age and overall cognitive ability (i.e., MMSE).

Model	Variable	B	*T*	p value	R^2 change	*F* change	df
1	WTAR	.253	2.872	.006	.063	8.250	1, 61
2	Occupational Complexity	.293	3.172	.002	.078	10.059	1, 58
3	Income	.291	3.334	.001	.081	11.113	1, 61
4	Education	.275	3.374	.001	.083	11.384	1, 61

Model 1: $R = .732$; $R^2 = .537$; adjusted $R^2 = .514$; *SE* of est. = 6.399; $F (3, 61) = 23.537$, $p < .001$; Model 2: $R = .743$; $R^2 = .552$; adjusted $R^2 = .529$; *SE* of est. = 6.129; $F (3, 58) = 23.800$, $p < .001$; Model 3: $R = .745$; $R^2 = .555$; adjusted $R^2 = .533$; *SE* of est. = 6.271; $F (3, 61) = 25.351$, $p < .001$; Model 4 $R = .746$; $R^2 = .557$; adjusted $R^2 = .535$; *SE* of est. = 6.259; $F (3, 61) = 39.172$, $p < .001$

Figure 3.1



*Mediation model of Cognitive Reserve – Functional Ability via Executive Functioning. Numbers are standardized beta coefficients, and after the backslash indicates the standardized coefficient after the inclusion of the mediator. * = p < .001*

CHAPTER 4

PERSONALITY'S ASSOCIATION WITH IADLS IN COMMUNITY DWELLING OLDER ADULTS

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Abstract

Extant research has established several predictors of functional ability (FA) in older adults (OAs), but one factor that has been relatively ignored is personality. Preliminary evidence suggests Openness and Agreeableness are associated with instrumental activities of daily living (IADLs). However, a question that still remains is *how* personality is related to IADLs. We aimed to replicate the relationships between personality and IADLs, and determine how personality factors predict performance of IADLs, which we hypothesized was due to executive functioning (EF). The relationship between personality and IADLs was replicated for Openness but not Agreeableness with a performance based measure. In addition to replication, we extend the current literature by showing that EF is how personality is related to performance of IADLs. The relationship between the only factor that predicted IADLs, Openness, was mediated by EF. While mediation results would support this perspective, future research should determine if interventions that increase OAs' EF in turn increase or attenuate decline IADLs over time.

The world's population is aging with life expectancy increasing globally and by 2017 there will be a greater number of older adults (OAs; ≥ 65) than children under age five for the first time in history (Kinsella & Wan, 2008). While medical advances have increased human lifespan, functional impairment in humans as we age persists. Compromised functional ability not only impacts the individual, but caregivers experience increased rates of depression (Joling et al., 2012), mortality (Schulz & Beach, 1999) and significant financial burden (Langa et al., 2001). Moreover, each activities of daily living (ADLs) impairment in community dwelling older adults increases health care costs by $1,541 (Hill, Fillit, Thomas & Chang, 2006). To decrease the prevalence of functional impairment and its significant impact, development of prevention and intervention techniques is vital. In order to effectively develop these methods it is first necessary to fully understand all factors that impact functional ability (FA). Personality affects our lives every day, but its impact on FA has yet to be fully understood.

FA in community dwelling OAs

FA is separated into complex, or instrumental ADLs (IADLs), and simple or basic ADLs (BADLs). IADLs involve activities such as laundry, cooking, managing finances, housekeeping, and transportation. BADLs include bathing, grooming, dressing, eating, and toileting (Marcotte, Scott, Kamat, & Heaton, 2010). In independently living community dwelling OAs BADLs are almost always intact and inability to complete BADLs as a result of compromised cognition typically does not occur until dementia (Mioshi et al., 2007). In contrast, IADLs are quite variable in community dwelling OAs and found to be related to cognitive ability (Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002; Cahn-Weiner, Boyle, & Malloy, 2002; Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000; Gross, Rebok, Unverzagt, Willis, & Brandt, 2012;

Mitchell & Miller, 2008a, 2008b; Schmitter-Edgecombe et al., 2011; Schmitter-Edgecombe, Woo, & Greeley, 2009), sensory functioning (West et al., 2000), and physical ability (Janssen, Heymsfield, and Ross, 2002; Lee, 2000; Petrella, Miller & Cress, 2004).

Still, existing research has not yet comprehensively established all factors that impact or are related to FA. In particular, personality's association with FA in OAs has been relatively ignored. Exploring this relationship is critical, as personality has been shown to have a substantial impact on lifespan longevity (Caspi, Roberts, & Shiner, 2005), and alterations in personality have been argued to represent the prodromal stages of dementia and functional decline (Copeland et al., 2003).

Personality and IADLs

Personality can be defined as consistencies in behavior, forms of experience, thinking, perceiving, and feeling (Livesley, 2001). Several different models exist for conceptualizing personality, but one of the most prevalent, researched, and validated is the Five-Factor Model (Costa & McCrae, 1992). The Five-Factor Model is a universal personality system that provides a framework as to how people operate, and it suggests personality exists on five dimensional factors: 1) Neuroticism, or the general tendency to experience negative affect, such as sadness and embarrassment; 2) Extraversion, or the tendency to experience positive moods, enjoy social attention, and have sensitivity to positive rewards; 3) Openness to Experience (i.e., Openness), or how imaginative, curious and willing to reexamine traditional values as opposed to rigid, concrete and narrow minded; 4) Agreeableness, or how trustworthy, straightforward, modest, compliant, tender-minded, and altruistic one tends to be; and, 5) Conscientiousness, or the

foundation for behavioral and cognitive control, which facilitates one to be strong willed, capable, and reliable (Caspi et al., 2005; Costa & McCrae, 1992; McCrae & Costa, 2010).

Preliminary data suggests that the relationship between personality and IADLs is dependent on whether IADLs are measured with performance-based or self-report measures. Specifically, existing research has supported that only Openness and Agreeableness have been found to be related to and predictive of the performance of IADLs, such that increases in these personality factors are associated with better performance of IADLs (Gregory, Nettelbeck, & Wilson, 2010; Suchy, Williams, Kraybill, Franchow, & Butner, 2010). In contrast, data indicates Openness is not related to self-reported IADLs. However, Neuroticism has been shown to be negatively related to self-reported IADLs, whereas Conscientiousness and Extraversion have been reported to be positively associated with self-reported IADLs (Chapman et al., 2007; Suchy et al., 2010). These disparate findings are not surprising given the established distinctions between these different measures of IADLs.

In comparison to self-report questionnaires, performance based measures are more objective (Zanetti, Geroldi, Frisoni, Bianchetti, & Trabucchi, 1999), have a substantial amount of face validity (Myers, Holliday, Harvey, & Hutchinson, 1993), are more sensitive to functional limitations in OAs with and without cognitive impairment (Karagiozis, Gray, Sacco, Shapiro, & Kawas, 1998; Kempen, Steverink, Ormel, & Deeg, 1996), and are more related to cognition (Mitchell & Miller, 2008a). Additionally, while self-reports provide clinicians with an understanding of how OAs perceive their functioning in the real-world environment, community dwelling OAs are found to overestimate ability and underreport ADL dysfunction (Mitchell &

Miller, 2008a). Thus, the most accurate representation of the relationship between personality and IADLs is likely found when a performance-based instrument is used.

Despite the preliminary evidence that suggest Openness and Agreeableness are related to performance-based IADLs, it remains unclear how they are related. Suchy et al. (2010) suggested the association between personality factors and performance-based IADLs may be due to specific cognitive function. We examine this hypothesis by exploring the role of executive functioning (EF) in explaining this relationship.

The Mediating role of Executive Functioning

EF is considered a "higher-level" cognitive ability that aids purposeful goal-directed behavior through the management of "lower-level" cognitive functions (Alvarez & Emory, 2006; Stuss & Benson, 1986; Stuss & Levine, 2002). EF is consistently found to be predictive of performance-based IADLs in community dwelling OAs (Bell-McGinty et al., 2002; Cahn-Weiner et al., 2002; Cahn-Weiner et al., 2000; Mitchell & Miller, 2008a, 2008b; Schmitter-Edgecombe et al., 2011). Additionally, when compared to other cognitive domains (e.g., memory, visuospatial, and motor processes), EF accounts for the greatest proportion of variance in IADLs (Cahn-Weiner et al., 2000) and has been found to mediate the relationship between some other cognitive domains (e.g., visuospatial ability and memory) with FA in OAs (O'Bryant et al., 2011; Royall, Palmer, Chiodo, & Polk, 2005).

EF is not only found to be significantly related to IADLs, but has also been shown to be related to Agreeableness and Openness; however, in contrast to Openness, the relationship between EF and Agreeableness is inconsistent. Two separate investigations found Openness was positively related and Agreeableness was not associated with EF in OAs (Booth, Schinka,

Brown, Mortimer, & Bornstein, 2006; Schretlen, van der Huslt, Pearlson, & Gordon, 2010). Nonetheless, Williams, Suchy, and Kraybill (2010) found Openness and Agreeableness to be positively correlated with EF in community dwelling OAs.

Study Aims and Hypotheses

The first aim of this study was to determine if previous relationships between personality factors and IADLs could be replicated. Based on previous evidence, it was hypothesized that only Agreeableness and Openness would be positively related to and predict IADLs on a performance-based measure. Secondly, we aimed to understand how personality factors would be related to the performance of IADLs, and hypothesized EF would mediate the relationship(s). To fully understand this association between personality and performance-based IADLs, we explored the facets of the personality factors that were predictive of IADLs.

Method

Participants

Sixty-five independent community dwelling OAs were recruited from the local community of Athens, GA and provided with a small monetary compensation for their time. Potential participants were included if they were between the ages of 65-85, without history of substance dependence within the past five years, self-reported literacy, without gross sensory impairment or self-reported neurological disorder, able to live independently, and performance on the Mini-Mental State Examination (MMSE) was greater than 20. A cutoff of 20 was used given the findings from Bedard et al. (2003) suggest scores on the MMSE below 20 are associated with possibly invalid self-reports. All personality questionnaires (i.e., NEO-PI-R) were checked for acquiescence, nay-saying, and random responding based on procedures

outlined by McCrae & Costa (2010). Four participants were excluded from final analyses given: random responding (N=2), acquiescence (N=1), and nay saying (N=1). Descriptive statistics for age, gender, depressive symptomology, overall general cognitive ability, number of medical diagnoses, and medical prescriptions are presented in Table 4.1 (n = 61). Although age was negatively related to FA (r = -.263, p = .02) and overall cognitive ability was positively related to IADLs (r= .631, p < .01), gender (r = .147, p = .13), depressive symptomology (r = -.171, p = .09), number of medical diagnoses (r = .076, p = .28) medical prescriptions (r = .018, p = .45) were not significantly associated with performance-based IADLs.

Measures

Personality. Personality was measured with the Revised NEO Personality Inventory self-report (NEO-PI-R; McCrae & Costa, 2010). The NEO-PI-R is 240-item measure appropriate for a variety of individuals, and takes approximately 40 minutes to complete. There are five major dimensional factors, which are each made up of 6 8-item facet scales. Test-retest reliability ranges from .91 to .93 over a one-week period and .78 to .85 over a 10-year period. The NEO-PI-R is reported to have adequate construct validity, which is supported by reported convergent and discriminant validity results (McCrae & Costa, 2010). Internal consistency is also adequate and our consistency values from this study were .86, .74, .66, .71, and .79 for Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness, respectively.

Executive Functioning. EF was measured by a composite score derived from performance on the four EF tasks from the Delis-Kaplan Executive System (D-KEFS): the D-KEFS Trail Making Test condition 4 (TMT-4), Verbal Fluency, Design Fluency, and the Tower Test. A composite score of EF was used instead of performance on a single measure given there is no

"gold" standard measure of EF (Delis, Kaplan & Kramer, 2001). Additionally, there has not been a measure that has consistently been associated with FA in OAs. Rather, EF as a construct in general has been consistently associated with FA. The four DKEFS subtests listed above were used to derive the composite measure given the reported internal consistency (Cronbach's α = .753) found in an EF composite using these measures in a previous study from our laboratory with OAs (Mitchell & Miller, 2008a).

Instrumental Activities of Daily Living. Performance-based IADLs were measured with the Direct Assessment of Functional Status–Revised (DAFS-R) (Loewenstein & Bates, 1989). The DAFS-R examines FA in 10 different domains: time orientation, communication, financial skills, grocery shopping, dressing and grooming, eating, driving, meal preparation, providing demographic information, and taking a telephone message. These 10 scales combine to determine overall functional ability on a scale of 0 - 137 and can be separated to examine IADLs (0 – 91) and BADLs (0 – 46) independently (e.g., Mitchell & Miller, 2008b). The domains that assess IADLs include: communication, driving, financial skills, grocery shopping, meal preparation, and taking a telephone message. The DAFS-R is well validated and found to be reliable. Specifically, it has test-retest reliability across subscales ranging from .55 to .91 (Loewenstein & Bates, 1989).

Additional measures. Participants additionally were given the MMSE as a screening device, completed a demographic questionnaire which included questions of medications, diagnoses, and family history of disease, and completed the Geriatric Depression Scale (GDS; Yesavage et al., 1983), and an additional questionnaire used for an ancillary study.

Procedures

All procedures were approved by the university institutional review board. Following informed consent, participants were administered an MMSE and, if eligible, completed all questionnaires (NEO-PI-R; GDS; demographics). Subsequently, participants were administered the DKEFS EF subtests and the DAFS-R. The administration of the functional and cognitive measures was counterbalanced across all participants to minimize any order effects.

Analyses

Descriptive statistics for the personality factors, DAFS-R, and D-KEFS composite are presented in Table 4.2. Consistent with Mitchell & Miller (2008a) this composite score was found to be internally consistent (Cronbach's $\alpha = .769$). To test if Agreeableness and Openness were positively related with IADLs, Pearson product correlations (Table 4.3) and a hierarchical regression was completed (Table 4.4). Subsequently, mediation analyses were then completed following the procedures outlined by Baron and Kenny (1986). Finally, Pearson product correlations and linear regressions were completed for facets of factors that significantly predicted FA (Table 4.5).

Results

Pearson product correlations indicated Openness and Neuroticism were related to performance-based IADLs, such that Openness was positively related whereas Neuroticism was negatively related to IADLs (Table 4.3). Hierarchical regression was used to examine our hypothesis that Openness and Agreeableness would predict performance-based IADLs. Given age ($r = -.263$, $p = .02$) and overall cognitive ability (i.e., MMSE; $r = .631$, $p < .01$) were significantly related to performance-based IADLs, it was necessary to control for these factors. In step one, age and overall cognitive ability were found to predict IADLs (adjusted $R^2 = .387$, *F*

(2, 58) = 19.965, p < .001). The variance in IADLs was largely due to overall cognitive ability, which significantly predicted IADLs (p < .001) while age did not (p > .05). In the second step, we added Agreeableness and Openness to the model (i.e., Model 2 in Table 4.4). Again, this model accounted for a significant amount of variance in performance of IADLs (adjusted R^2 = .409, F (4, 56) = .11.385, p < .001). Openness was a significant predictor of IADLs, (β = .200, t = 1.977, p = .05) but Agreeableness was not (β = -.049, t = -.446, p = .66; Table 4.4), partially supporting our hypothesis. Therefore, mediation analyses were only completed for Openness.

The four conditions were met for mediation (Baron & Kenny, 1986). First, the EF composite was regressed onto Openness (path a). Openness accounted for a significant amount of variance in EF (adjusted R^2 =.066, F (1, 59) = 5.248, p ≤ .05). Then, using hierarchical regression, we found that Openness predicted performance on IADLs in step 1 (path c; adjusted R^2 = .067, F (1, 59), p ≤ .05). In step 2, the composite EF score was added to the model (path b), and EF predicted IADLs above and beyond Openness (ΔR^2= .350, ΔF (1, 58) = 35.703, p ≤ .01). The relationship between Openness and IADLs (path c), was no longer significant (p = .290; Δβ= -.073) which suggests complete mediation. To further support mediation, a Sobel's test (1982) was completed to examine if the change in the regression coefficient between the IV and DV after accounting for the mediator was significantly different from zero (Preacher & Hayes, 2004). The change was significant, Z = 2.10, p ≤ .05, further supporting mediation.

Exploratory

Individual linear regressions were completed to explore the relationship between the facets of Openness and performance-based IADLs. These analyses indicated two of the six Openness facets, Fantasy and Values, were positively predictive of IADLs (Table 4.5). To

determine if these were related as a result of EF, mediation analyses for these two facets were completed. All four conditions were met for mediation (Baron & Kenny, 1986). Both Openness facets were positively related to IADLs via EF.

Discussion

As the global population ages the number of OAs requiring assistance to complete ADLs is also increasing (Kinsella & Wan, 2008). To develop more effective interventions understanding what impacts FA is vital. Unfortunately, while there are many factors that are associated with FA, the effect of personality on FA has been relatively ignored. Only, a few studies have examined this relationship; we aimed to replicate these findings and extend the literature by determining how personality is related to performance of IADLs.

The current study replicated previous research by supporting the relationship between Openness and performance-based IADLs. Openness was positively correlated with IADLs (Table 4.3) and predicted IADLs while controlling for age and overall cognitive ability (Table 4.4). This finding suggests that as active seeking and appreciation of experiences, Openness (McCrae & Costa, 2010), increases, so does performance-based IADLs in OAs. Post-hoc facet level analyses indicate the positive relationship between Openness and IADLs may be associated with two facets: Fantasy and Values (Table 4.5). Consistent with Gregory et al. (2010), this suggests having an active fantasy life and imagination and being open to reexamining social, political, and religious values are associated with greater IADLs. In contrast to Openness, the relationship between Agreeableness and performance-based IADLs was not replicated, as Agreeableness was not associated (Table 4.3) or predictive of IADLs (Table 4.4). This is not

surprising given that this personality factor was not related to our hypothesized mechanism of action, EF. Thus, Agreeableness may not be reliably related to performance-based IADLs.

According to Suchy et al. (2010), the association between personality factors and self-report is probably attributable to individual differences in perception, whereas personality and performance-based IADLs are likely related due to a specific cognitive function. Our hypothesis that personality factors are related to performance-based IADLs due to their association with EF was supported. EF mediated the relationship between performance-based IADLs and Openness. Subsequent post-hoc facet level analyses also indicated the relationships between the facets that predicted performance-based IADLs (i.e., fantasy and values) were also mediated by EF.

Taken together, our results support efforts to increase Openness in OAs as a way to maintain and potentially increase FA, perhaps through completion of time limited behavioral interventions that have been shown to increase Openness (e.g., Jackson, Hill, Payne, Roberts, & Stine-Morrow, 2012). Additionally, a more effective intervention might be one that not only increased Openness but also the mechanism that explains how it is related. Interventions that increase EF such as video games (Basak, Boot, Voss, & Kramar, 2008), community based activity programs (e.g., Carlson et al., 2008), aerobic fitness (Colcombe & Kramer, 2003), and direct cognitive training with EF tasks (Bherer et al., 2005; Dahlin, Nyber, Backman, & Neely, 2008) could be targeted to determine if they help maintain and even possibly increase IADLs. In support of this, a cognitive training program in reasoning, a related cognitive ability to EF, attenuated IADLs decline at 5-year follow up (Willis et al., 2006). However, there does not appear to be an investigation that has determined the impact on IADLs after EF is increased via a behavioral intervention, and should be the focus of future research.

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Table 4.1
Demographics

Variable	
Age	76.2 (6.2; 65-85)
Gender (M, FM)	(12, 49)
Education	15.7 (2.7; 10-20)
GDS	4.9 (5.0; 0-26)
MMSE	27.4 (1.7; 23-30)
Diagnoses	2.0 (1.6; 0-7)
Prescriptions	2.9 (2.9; 0-13)

GDS = Geriatric Depression Scale;
MMSE = Mini-mental State Examination
Values are mean & (SD; range)

Table 4.2
Descriptive statistics for Personality, Self-reported and Performance-based Functional Ability, and Executive Functioning

	Minimum	Maximum	Mean	SD
Personality				
Neuroticism	36	126	74.5	20.7
Extraversion	55	145	108.4	17.1
Openness	82	151	112.7	16.9
Agreeableness	94	161	133.0	13.8
Conscientiousness	68	154	118.5	17.0
Functional Ability				
DAFS-R TS	97	134	119.8	8.2
IADLs	54	88	75.7	7.0
BADLs	33	46	44.1	2.1
Executive Functioning				
Composite Score	3	14.8	10.0	2.8

OARS = Older American Resources and Services Activities of Daily Living Scale; TS = Total Score; IADLs = Instrumental Activities of Daily Living; BADLs = Basic Activities of Daily Living; DAFS-R = the Direct Assessment of Functional Status–Revised; Personality, OARS and DAFS-R are raw scores. Personality scores have a minimum of 0 and maximum of 192 for each dimensional factor. DAFS-R TS raw scores have a minimum of 0 and maximum of 137. DAFS-R IADLs raw scores have a minimum of 0 and maximum of 91. DAFS-R BADLs raw scores have a minimum of 0 and maximum of 46. OARS TS raw scores have a minimum of 0 and maximum of 29. OARS IADLs raw scores have a minimum of 0 and maximum of 14. OARS BADLs raw scores have a minimum of 0 and maximum of 14. Executive Functioning composite score is an average of four separate scaled scores with mean of 10, and *SD* of 3.

Table 4.3
Pearson product correlations between Personality factors and Performance-Based Functional Ability

	DAFS-R TS	DAFS-R IADLs	DAFS-R BADLs	EF
Neuroticism	-.24*	-.28*	-.02	-.120
Extraversion	.18	.19	.07	.036
Openness	.26*	.29*	.05	.286**
Agreeableness	-.16	-.17	-.03	-.204
Conscientiousness	.15	.15	.10	-.048

DAFS-R = the Direct Assessment of Functional Status–Revised; TS = Total Score; IADLs = Instrumental Activities of Daily Living; BADLs = Basic Activities of Daily Living; EF = Executive Functioning Composite Score
** = $p \leq .01$
* = $p \leq .05$

Table 4.4 Hierarchical multiple regression analysis for prediction of performance based IADLs

Model	Variable	β	*t*	p value	Correlations		
					Zero-Order	Partial	Semi-partial
1	Age	-.116	-.975	.33	-.263	-.127	-.099
	MMSE	2.463	5.760	< .01	.631	.603	.582
2	Age	-.061	-,470	.64	-.263	-.063	-.047
	MMSE	2.385	.422	< .01	.631	.603	.561
	Agreeableness	-.025	-.446	.66	-.174	-.059	-.044
	Openness	.083	1.977	.05	.287	.255	.196

Model 1: F (2, 58) = 19.965, $p \leq .001$; Model 2: F (4, 56) = .11.385, $p < .001$

Table 4.5
Linear regression analyses for prediction of IADLs by Openness facets

Model	Openness Facet	*R*	R^2	Adjusted R^2	*SE* of the estimate	β	*t*	p value
1	1: Fantasy	.281	.079	.063	6.773	.281	2.251	.03*
2	2: Aesthetics	.104	.011	-.006	7.019	.104	0.807	.42
3	3: Feelings	.224	.050	.034	6.879	.224	1.761	.08
4	4: Actions	.225	.050	.034	6.877	.225	1.771	.08
5	5: Ideas	.136	.019	.002	6.992	.136	1.056	.295
6	6: Values	.301	.091	.075	6.730	.301	2.425	.02*

Model 1: $F(1, 59) = 5.065$, $p \leq .05$; Model 2: $F(1, 59) = .423$, $p = .654$; Model 3: $F(1, 59) = 3.102$, $p = .083$; Model 4: $F(1, 59) = 3.138$, $p = .082$; Model 5: $F(1, 59) = 1.116$, $p = .295$; Model 6: $F(1, 59) = 5.883$, $p \leq .05$

CHAPTER 5

DISCUSSION

Although previous research has documented several predictors of functional ability (FA), two factors that have yet be comprehensively examined are Cognitive Reserve (CR) and personality. This project had four aims that overall sought to better understand the relationships of CR and personality with FA. The primary aim of this dissertation was to clarify the relationship between CR and FA in community dwelling OAs. The second aim was to determine the impact of executive functioning (EF) on the relationship between CR and FA. The third aim was to determine if previously documented relationships between personality factors and Instrumental Activities of Daily Living (IADLs) could be replicated. Finally, we aimed to understand how personality factors were related to IADLs.

Primary Aim

CR is a clinical construct that comes from the non-linear relationship between neuropathology and clinical symptoms (Stern, 2002). For example, it has been found that select individuals who meet pathologic criteria for Alzheimer's disease on autopsy are not cognitively impaired on formal testing (Ince, 2001; Katzman et al., 1989). Individual differences in innate intelligence or lifetime experiences explain the difference between amount of neuropathology and clinical symptoms, such that those with greater CR have more resilience to neuropathology as they often have later onset of clinical symptoms and are less likely to be diagnosed with dementia (Qiu et al., 2003; Stern et al., 1994); whereas, those with less CR have a greater risk for dementia (Scarmeas & Stern, 2003; Stern et al., 1994).

CR operates on a continuum and is quantified through indirect proxies representative of lifetime experiences or innate intelligence, including income, occupational attainment, education, and premorbid IQ (Manly, Schupf, Tang, & Stern, 2005; Stern, 2006, 2009). These proxies have been shown to be related to FA. Specifically, when income decreases, the risk for FA impairment or limitations increase (Avlund, Damsgaard, & Osler, 2004; Coustasse, Bae, Arvidson, Singh, & Treviño, 2009). The literature examining occupations indicates a positive relationship between complexity of occupation and FA (Li, Wu, & Wen, 2000; Parker, Thorslund, Lundberg, 1994). Premorbid IQ has been found to be protective against FA decline (Artero, Touchon, & Ritchie, 2001; Starr & Loine, 2008). Arguably the most commonly used measure of CR, education, is also positively related to FA, such that OAs with less education are more likely have FA limitations (Bickel & Kurz, 2009; Zunzunegui, Nunez, Durban, Garcia de Yebenes, & Otero, 2006) and experience more FA difficulties over time (Van der Elst, Van Boxtel, Van Vreukelen, & Jolles, 2008). Although education has also been found to be predictive of FA in OAs (Burton, Strauss, Hultsch, & Hunter, 2006; Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000; Mitchell & Miller, 2008), some investigations have not found education to be related to or predictive of FA (Diehl, Willis, & Schaie,1995; Kraybill & Suchy, 2011; Lewis & Miller, 2007; Suchy, Williams, Kraybill, Franchow, & Butner, 2010; Schmitter-Edgecombe, Parsey, & Cook, 2011).

The primary aim of this project was to extend previous research by examining the different proxies of CR with FA in community dwelling OAs. The proxies that were investigated were premorbid IQ, occupation, income, and education. A performance based-measure of FA was used given its sensitivity and accuracy in assessing OAs' FA (Karagiozis et al., 1998;

Kempen et al., 1996; Sherman & Reuben, 1998). It was hypothesized that all proxies of CR would be positively related to FA (Artero et al., 2001; Avlund et al., 2004; Barberger-Gateau et al., 1999; Bickel & Kurz, 2009; Burton et al., 2006; Cahn-Weiner et al., 2000; Coustasse et al., 2008; Laukkanen et al., 1993; Li et al., 2000; Mitchell & Miller, 2008; Parker et al., 1994; Plehn et al., 2004; Starr & Loine, 2008; Van der Elst et al., 2008; Zunzunegui et al., 2006). In terms of prediction, it was hypothesized that premorbid IQ would account for more variance in FA than occupation, income, and education. Pearson product correlations supported that all proxies of CR were positively related to FA (Table 3.3). Additionally, hierarchical regressions indicated all proxies predicted FA above and beyond age and overall cognitive ability (Table 3.4). These results support the perspective that those with less CR have a greater likelihood of being diagnosed with dementia (Stern, 2002, 2006, 2009); such that community dwelling OAs with less CR have a much greater likelihood of exhibiting decreased FA and FA closer to the threshold of functional impairment. This perspective is also consistent with Schofield (1999), who suggested those with greater reserve have "further to fall." Therefore, those with less CR are by definition more likely to receive a diagnosis of dementia.

Given current results, clinicians should be mindful of the impact of CR on FA, as the threshold for OAs exhibiting functional impairment is relative to their CR. This is of particular interest given functional impairment is one of the distinguishing factors for differentiating normal aging from dementia (American Psychiatric Association, 2004; World Health Organization, 1992). Furthermore, this may in part explain why those with greater CR are less likely to be diagnosed with dementia (Qiu et al., 2003; Stern et al., 1994), whereas, those with less CR have a greater risk for dementia (Scarmeas & Stern, 2003; Stern et al., 1994) and more

likely to exhibit functional impairment in the future (Artero et al., 2001; Avlund et al., 2004; Barberger-Gateau et al., 1999; Laukkanen et al., 1993; Li et al., 2000; Pereira et al., 2008; Van der Elst et al., 2008; Zunzunegui et al., 2006).

In comparing the proxies of CR, education, not premorbid IQ, accounted for the greatest amount of variance in FA above and beyond age and overall cognitive ability ($\Delta R^2 = .083$). Overall, all CR proxies accounted for 6 – 8% of incremental variance (Table 3.4) when viewed independently, which suggests the different proxies all account for a similar amount of variance in FA. To determine if any of the proxies predicted FA over and above the others, simultaneous regression was completed. Results suggest no proxy of CR predicts FA above and beyond the other three proxies.

All together, these results add to the literature by showing four common proxies of CR are positively correlated and predictive of FA in community dwelling OAs. Additionally, while education appears to account for the most amount of variance (8.3%) after controlling for age and overall cognitive ability, no one proxy is more predictive above and beyond the others. Therefore, like cognitive performance (Mitchell & Miller, 2008), a general idea of community dwelling OAs could be obtained via any of the four CR proxies, such that low scores on any proxy would indicate a greater likelihood of decreased FA.

Secondary Aim

CR has been shown to be related and predictive of FA in OAs, but results are somewhat variable as some have found CR not to be related to FA. Thus, the secondary aim was to examine the impact of a moderator on the relationship between CR and FA. According to Baron and Kenny (1986), moderation is likely to occur when there is an unexpectedly inconsistent

relationship between a predictor and criterion; such that, a moderator affects the strength and direction between the predictor and criterion. Within a correlational framework, it is said to impact the zero-order correlation between the other two variables.

EF has been consistently linked to FA in OAs, and the inconsistent positive relationship between FA and CR may be due to EF. For example, OAs with low CR may not have decreased FA due to intact EF. It could also work in the opposite fashion such that OAs with high CR may not have high FA due to low EF. The relationship between CR and FA has yet to be studied while incorporating EF. Due to the variable relationship between CR and FA, it was hypothesized that EF would moderate this relationship. Using hierarchical regression (Baron & Kenny, 1986; Cohen, Cohen, West, & Aiken, 2002), we found that the joint effect of CR and EF did not predict FA ($\Delta R^2 = .009$, $p = .370$), failing to support our hypothesis.

Therefore, at this time the literature between CR and FA was reevaluated, focusing on the investigations with non-significant relationships. Plehn et al. (2004) found that premorbid IQ was not related to FA in OAs, but the non-significant correlation ($r = -.108$) suggested as functional impairment increased premorbid IQ decreased. Similarly, despite non-significance greater education was associated with greater FA ($r = .16$) and decreased functional errors ($r = -.16$; Schmitter-Edgecombe et al., 2011). In a separate study of well-educated predominately Caucasian OAs, Lewis and Miller (2007) also did not find education to be related to FA, but the non-significant correlation ($r = -.135$) suggested as functional impairment increased education decreased. Additionally, two separate cross sectional investigation of community dwelling OAs that did not find education to be related to FA had non-significant correlations in the same

direction, which suggested greater education was associated with greater FA (Diehl et al., 1995; Suchy et al., 2010).

Thus, when these non-significant findings are reviewed they are in the expected direction. Specifically, as education increases FA increases (Diehl et al., 1995; Schmitter-Edgecombe et al., 2011; Suchy et al., 2010), or as education and premorbid IQ increases FA limitations and difficulties decrease (Lewis & Miller, 2007; Plehn et al., 2004; Suchy et al., 2010). Overall there appears to be a positive relationship between CR and FA. Therefore, the inconsistent results may be due to limited power rather than the impact of EF as a moderator.

As a result, we explored alternative ways EF could be implicated in the relationship between CR and FA. Previous literature has shown that EF is positively related and predicted by CR (Bell-McGinty et al., 2002; Cahn-Weiner et al., 2000; Cahn-Weiner, Boyle, & Malloy, 2002; Jefferson, Paul, Ozonoff, & Cohen, 2006; Lewis & Miller, 2007; Martyr & Clare, 2012; Mitchell and Miller, 2008a, 2008b; Mitchell, Shaughnessy, Shirk, Yang, & Atri, 2012; Pereira et al., 2008; Roldan-Tapia, Garcia, Canovas, & Leon, 2012; Royall, Chiodo, & Polk, 2000; Siedlecki et al., 2009), and consistently predicts FA in OAs (Bell-McGinty et al., 2002; Cahn-Weiner et al., 2000; Cahn-Weiner, Boyle, & Malloy, 2002; Jefferson, Paul, Ozonoff, & Cohen, 2006; Lewis & Miller, 2007; Martyr & Clare, 2012; Mitchell and Miller, 2008a, 2008b; Pereira et al., 2008; Royall, Chiodo, & Polk, 2000). Thus, we hypothesized that EF would be the mechanism of action in the relationship between CR and FA.

Our results suggested increases in CR predict greater EF, which in turn predicts FA (Figure 3.1), supporting our hypothesis. Given the mediation results, to maintain and potentially increase FA, OAs should complete intervention programs that improve EF (Basak, Boot, Voss,

& Kramar, 2008; Bherer et al., 2005; Carlson et al., 2008; Colcombe & Kramer, 2003; Dahlin, Nyber, Backman, & Neely, 2008). However, while we would expect that increasing EF would improve FA, there has yet to be an investigation that examined this empirical question. Furthermore, EF can be improved in a variety of different mechanisms (e.g., community activity program, video game, training with EF tasks, and aerobic fitness). Therefore, different interventions that improve EF should measure and determine their impact on FA in OAs.

Tertiary Aim

Even though it significantly impacts lifespan longevity (Caspi, Roberts, & Shiner, 2005), and changes in late life could be indicative of the beginning stages of a neurodegenerative dementia and functional decline (Copeland et al., 2003), personality's relationship with FA in OAs has been largely overlooked. Personality can be thought of as regularities and consistencies in forms of behavior and experience (Livesley, 2001). There are several models of personality, but one of the most researched and validated is the Five-Factor Model (Costa-McCrae, 1992). The Five-Factor Model is a universal personality system that allows for the understanding of how people operate through five dimensional factors: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness (McCrae & Costa, 2010).

The third aim of this investigation was to explicate the relationship between personality factors and FA. Preliminary evidence from two separate investigations suggests there is a relationship between personality and FA. Gregory, Nettelbeck, and Wilson (2010) found Openness was positively correlated with performance-based FA ($r = .235$) with 70 community dwelling OAs. Suchy, Williams, Kraybill, Franchow, and Butner (2010) also found Openness was associated with FA, but additionally reported that Agreeableness was related to FA. Thus,

preliminary research suggests Openness and Agreeableness are related to FA, but how these factors may be related remains unclear. It is possible the relationship between personality factors and FA is due to EF given it is consistently found to be predictive of FA (Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002; Cahn-Weiner, Boyle, & Malloy, 2002; Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000; Mitchell & Miller, 2008a, 2008b; Schmitter-Edgecombe et al., 2011) and is positively related to both Agreeableness and Openness in OAs (Ayotte, Potter, Williams, Steffens, & Bosworth, 2009; Booth, Schinka, Brown, Mortimer, & Borenstein, 2006; Williams, Suchy & Kraybill, 2010).

It was hypothesized that Openness and Agreeableness would be positively correlated with and predictive of FA, and that EF would mediate the relationship between personality and FA. The hypothesis regarding Agreeableness was not supported, as it was not correlated or predictive of FA, and was also not related to EF. However, the hypotheses regarding Openness and FA were partially supported, as it was correlated ($r = .26$) and predictive of FA. Nonetheless, after controlling for age and overall cognitive ability (i.e., MMSE), Openness no longer predicted FA. These findings may be attributed to the attenuation of the relationship of Openness with FA by BADLs.

In independently living community dwelling OAs, BADLs are almost always intact, and the inability to complete BADLs as a result of compromised cognition typically does not occur until dementia (Mioshi et al., 2007). The variability in FA in community dwelling OAs is usually due to IADLs, which are found to be more related to EF as compared to BADLs (e.g., Bell-McGinty et al., 2002; Cahn-Weiner et al., 2002; Cahn-Weiner et al., 2000; Mitchell & Miller, 2008a, 2008b; Schmitter-Edgecombe et al., 2011). Consistent with this perspective, the

range of BADLs in our sample is restricted with a negative skew and suggests intact BADLs for the current sample of OAs. Thus, the current study supports that relationship between Openness and FA may be attenuated as a result of BADLs as the relationship between Openness and FA (r = .26) was less than Openness and IADLs (r = .29) but greater than Openness and BADLs (r = .05; Table 4.3).

Thus, it was necessary to adjust the third aim from understanding the relationship between personality and FA, to personality and IADLs. Furthermore, both previous investigations that documented the relationship between FA and personality (i.e. Gregory et al., 2010; Suchy et al., 2010) only measured IADLs, and not composite FA (i.e., both IADLs & BADLs). Therefore based on this perspective, we hypothesized Openness would predict IADLs after controlling for age and overall cognitive ability.

After controlling for age and overall cognitive ability, Openness predicted IADLs (Table 4.4). Thus, in order to preserve and potentially improve IADLs, community dwelling should complete interventions that increase Openness (Jackson, Hill, Payne, Roberts, & Stine-Morrow, 2012). However, there not evidence that suggests increasing Openness improves IADLs, and should be the focus of future research.

Although it was not the focus of this investigation, previous evidence suggests the relationship between personality and IADLs is dependent on measurement. Specifically, preliminary evidence suggests Neuroticism is negatively related, while Conscientiousness and Extraversion are positively related to self-reported IADLs (Chapman et al., 2007; Krueger, Wilson, Shah, Tang & Bennett, 2006; Suchy et al., 2010). In contrast, consistent evidence suggests Openness is not related to self-reported IADLs (Chapman et al., 2007; Suchy et al.,

2010). To determine if these findings can be replicated we administered the Older American Resources and Services Activities of Daily Living Scale (OARS; Duke University, 1978), and examined the relationship between personality factors and IADLs.

Given the previous evidence we expected that Neuroticism would be negatively related, and Conscientiousness and Extraversion would be positively related to self-reported IADLs. The relationship between Neuroticism, Extraversion, and Conscientiousness with IADLs was replicated. Neuroticism was associated with decreased self-reported IADLs; whereas, Conscientiousness and Extraversion were associated with greater self-reported IADLs. Taken together with the performance-based results, this data supports the perspective that the relationship between personality and IADLs is dependent on how FA is measured. We determined that the mechanism of action of relationship between personality and IADLs is EF (e.g., Quaternary aim); however, what remains unexamined is how personality factors are related to self-reported FA. It is plausible that the relationship between self-report FA and personality could be indicative of individual differences in perceptual, reporting style, and/or awareness. This will be looked into in a future manuscript.

Quaternary Aim

The final aim of this investigation was to determine how personality factors were related to IADLs. We expected the relationship between personality factors and performance-based IADLs would be accounted for by EF. Given Openness and not Agreeableness predicted IADLs after controlling for age and overall cognitive ability, mediation analyses were only completed for Openness.

Complete mediation of the relationship between Openness and IADLs by EF was found. Thus, as Openness is increased so do IADLs as a result of EF. Subsequent, Pearson product correlations and individual linear regressions revealed two of the six Openness facets, fantasy and values were positively related to IADLs (Table 4.5). Furthermore, as expected, additional mediation analyses revealed these Openness facets were related to IADLs via EF. Thus, consistent with Gregory et al. (2010), having an active fantasy life and imagination as well as being open to reexamination of social, political, and religious values are associated with greater IADLs.

Overall, mediation results suggest it would be more effective to target and improve EF given that is how Openness is related to IADLs. Despite the fact that evidence suggests several time limited behavioral programs can improve EF (e.g., Basak et al., 2008; Carlson et al., 2008; Colcombe & Kramer, 2003; Bherer et al., 2005), there is no evidence that suggests training in a program that improves EF also helps preserve FA. This should be the focus of future research.

Conclusion

Overall, this study examined the relationship of both CR and personality with FA. Both CR and personality were found to be related to and predictive of FA, suggesting that a clinician may be able to use this information to obtain a very rough estimate of OAs' FA. Specifically, OAs with greater CR and Openness are likely able to complete more ADLs independently than an individual with limited CR and Openness. Behavioral interventions during middle adulthood that increase CR and Openness may decrease functional decline and potentially preserve FA. However, even though CR and Openness may be able to be increased, both are relatively fixed at old age. Thus, improving and targeting the mechanism by how they are related to FA would

likely be more effective for OAs. Both CR and Openness were related to FA via EF, which highlights the importance of this higher order cognitive construct. Even though there have been several behavioral investigations that have been shown to improve EF, there has yet to be one study that determined their effect on FA after EF is increased. Furthermore, even if functional decline is attenuated or if FA is maintained or improved, the exact numerical benefit should be determined to develop the most efficacious intervention.

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