PERSONALITY TRAITS AND SUBJECTIVE MEMORY COMPLAINTS: DOES EXECUTIVE FUNCTION HAVE AN EXPLANATORY ROLE?

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Abstract

Personality Traits and Subjective Memory Complaints: Does Executive Function Have an Explanatory Role?

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Subjective memory complaints (SMC) are common among healthy older adults and are associated with negative affect, the Big Five Personality traits, and objective memory decline. Research from geriatric psychiatry, cognitive aging, and personality neuroscience converge on age-related changes in executive function as a third variable that explains the relationship among the same constructs. The present study used confirmatory factor analysis (CFA) and structural equation modeling (SEM) to test whether executive functioning explains the relationship between SMC and the Big Five. A multiple regression model found that the Big Five were not significant predictors of SMC while controlling for executive function (EF). The single criterion EF model found that executive completely accounted for the shared variance between retrospective memory complaints (RMC) and prospective memory complaints (PMC) and each of the Big Five Factors. Lastly, mediation analyses of the effect of executive function on the relationship between each of the Big Five factors and RMC and PMC found that executive function fully mediated the relationship of all of the Big Five and RMC except for openness. Taken together, the models suggest that executive function has a common causal relationship between the Big Five and SMC. The paper concludes with a discussion of methodological topics including multicollinearity and monomethod covariance inflation that threaten the validity of the current study's findings.

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Introduction

Subjective memory complaints (SMC) are prevalent among healthy, community-dwelling older adults, but standardized assessment and operationalization of SMC are absent from the cognitive aging literature (Abdulrab & Heun, 2008; Mark & Stiskoorn, 2013). Studies measuring SMC differ in their use of dichotomous or graded responding, temporal frame of reference, and the number of items used (i.e., single item versus multiple items) (Abulrab & Heun, 2008). The operationalization of SMC varies across studies. Some of the factors contributing to this variability include the inconsistent equating of SMC with subjective memory decline and inconsistency in the specificity or generality of the SMC elicited (Abulrab & Heun, 2008).

By result, SMC refer to self-reported evaluations of changes in memory ability, but substantial heterogeneity in their measurement exists beyond this generality. Prevalence estimates for SMC subsequently are variable. SMC were prevalent in 39% of healthy older adults in the Swedish Twin Registry, 40% of the participants in the Spanish NEDICES study, and 89.5% of the healthy older adults enrolled in the Sydney Memory and Aging Study (Benito-Leon et al., 2010; Caracciolo et al., 2012; Slavin et al, 2010). In a review of the SMC literature, Mark and Stitskoorn (2013) concluded that prevalence estimates typically fall within 22-56% of the community dwelling elderly population.

Despite the prevalence of SMC among older adults, the construct validity of SMC remains contentious due to a) the reliable association of SMC with negative affect and personality variables and b) the unreliable association of SMC with objective measures of memory. These concerns regarding the validity of SMC are particularly important to the diagnosis of Mild Cognitive Impairment (MCI), for which SMC are a core diagnostic feature (Mitchell, 2008; Winblad et al., 2004). Thus, a better understanding of the causes and correlates of SMC is needed to inform the clinical meaningfulness and the diagnostic accuracy of instruments assessing memory complaints.

The Association of SMC with Depression, Anxiety, and Negative Affect

SMC have been reliably associated with measures of depression and negative affect. For example, one study of healthy older adults over a 2.5-year period found that SMC were related to anxiety and depression, but not objective measures of cognition (Weaver Cargin, Collie, Masters, & Maruff, 2008). Other studies have replicated the association of concurrent depressive symptoms and SMC (e.g., Blazer, Hays, Fillenbaum, & Gold, 1997; Jorm et al. 2004; Sohrabi et al., 2009; Zandi, 2004). Similarly, other studies have found that subjects indicating SMC were significantly more likely to have a history of mood or anxiety disorder (Bartley et al., 2011). In a population study of community dwelling Australian older adults, it was found that past/present mental-health service use (*OR*: 1.8 [1.2-2.9]), history of anxiety disorder in the last 12 months (*OR*: 1.9 [1.1-3.1]), lifetime history of affective disorder (*OR*: 1.5 [1.0-2.2]), and lifetime history of alcohol use disorder (*OR*: 1.5 [1.1-2.0]) predicted self-reported memory decline over a five year period (Mewton, Sachdev, Anderson, Sunderland, & Andrews, 2014). Thus, SMC are consistently associated concurrent mood and anxiety disorders and past history of psychopathology

Depression is of significant clinical importance to cognitively normal older adults as it has been found to be a risk factor for cognitive decline and a prodrome for Alzheimer's disease (Brommelhoff et al., 2009). Depression in the context of SMC does not bar this possibility, especially given that incident SMC have been found to be a risk factor for cognitive decline and dementia (*HR*: 1.8) (Luck et al., 2015; Schofield, Jacobs, Marder, Sano, & Stern, 1997). However, the high prevalence of SMC relative to depression in older adults and the affective complexity of SMC complicate the consideration of SMC as an indicator of nascent neurodegenerative disease. The prevalence of major depression and clinically significant symptomatology is between1–4% and 8–16% respectively and is lower than the prevalence of SMC among healthy older adults (Blazer, 2003). The National Comorbidity Survey Replication study found that the 12-month anxiety disorder prevalence rates for adults 55 years-old and older was approximately 12%; falling short of that of SMC as well (Byers, Yaffe, Covinsky, Friedman, & Bruce, 2010). Thus, in addition to symptoms of depression and anxiety, other constructs related to negative affect, emotion regulation, and individual differences have been tested for their association with SMC.

Taylor, Miller, and Tinklenberg (1992) found that SMC were not significantly correlated with objective measures of memory over a four-year period, but were related to memory self-efficacy beliefs. Other constructs significantly associated with SMC cross-sectionally and longitudinally include health-related quality of life, external locus of control, self-esteem, self-focused attention, ruminative style, and, sense of mastery (Chin, et al., 2014; Comij, Deeg, Dik, & Twisk, 2002; Jorm et al., 2004; Sims et al., 2011; Sohrabi et al., 2009). There are no explicit theories regarding how negative affect and SMC are causally related. With respect to the association of depression and SMC, researchers have generally speculated that SMC are extensions of the negatively biased and distorted thoughts about oneself and one's abilities that are characteristic of depression (Bolla, Lindgren, Bonaccorsy, & Bleecker, 1991; Hertzog & Pearman, 2013; Weaver Cargin *et al.* 2008). Given the number of constructs related to SMC, it is unlikely that this cognitivist explanation of the association of negative affect and SMC is complete. This is more likely given the findings from the individual differences literature that has examined the associations between the Big Five personality traits and SMC.

SMC and the Big Five Personality Traits

Among the Big Five personality dimensions, the associations of neuroticism and conscientiousness with SMC have been most widely studied (Hertzog & Pearman, 2014). For example, in a cross-sectional study of adults ages 45 to 94, both decreased neuroticism (β = -0.19) and increased conscientiousness (β = 0.32) were significant predictors of decreased SMC (Pearman & Storandt, 2004; see also, Pearman & Storandt, 2005). With regard to prospective memory complaints (PMC), or complaints about being able remember plans for intended actions, a cross-sectional study of older adults found that conscientiousness, but not neuroticism, was a significant predictor of decreased PMC (Uttl & Kibreab, 2011). The association between SMC and neuroticism has been observed longitudinally while the association between SMC and conscientiousness has not been observed as consistently (Lane & Zelinski, 2003; Pearman, Gerstorf, & Hertzog, 2014). Importantly, in the longitudinal study by Pearman and colleages (2014), neuroticism remained a significant predictor of SMC even when controlling for depression, suggesting that trait variables related to negative affect might contribute unique variance above and beyond state variables of depression. In addition to neuroticism and conscientiousness, openness and extraversion have been associated with SMC. (Ausen, Edman, Almkvist, & Bogdanovic, 2009; Jorm et al., 2004; Slavin et al., 2010; Vestberg, Passat, Risberg, &Elfgren, 2007). For example, one cross-sectional study of 125 healthy older adults found that memory complaints measured by the Prospective and Retrospective Memory Questionnaire (PRMQ) were associated with increased neuroticism, decreased conscientiousness, and decreased extraversion (Steinberg et al., 2013). This study did not differentiate effects for retrospective memory complaints (RMC) and PMC. In a longitudinal study, Luchetti and colleagues (2015) found that lower ratings of neuroticism and agreeableness and higher ratings of extraversion, openness, and conscientious predicted fewer self-reported memory decline over a 4-year follow-up period. In sum, neuroticism, conscientiousness, openness, and extraversion have been shown to be the most consistent personality traits associated with SMC.

SMC and Neuropsychological Measures of Memory

Associations between SMC and neuropsychological measures of memory are inconsistently observed. When associations between SMC and objective memory performance are observed, the effects are often small-to-moderate in size (Hertzog & Pearman, 2013). A recent meta-analysis found a small ($r = 0.062$, *S.E.* = 0.014), but reliably non-zero effect size for the association between SMC and objective measures of memory ability (Crumley, Stetler, & Horhota, 2014). In a two-year follow-up study of community dwelling older adults, objective memory performance accounted for 3% of the variance in SMC whereas ratings of psychological distress accounted for 20% of the variance in SMC (Smith, Petersen, Ivnik, Malec & Tangalos, 1996). In an 8-year longitudinal study using structural equation modeling (SEM), concurrent SMC were predicted by past SMC and were predictive of future objective memory performance. However, the most robust association with SMC was concurrent negative affect (Jorm, Christensen, Korten, Jacomb, & Henderson, 2001). The association between SMC and objective measures of memory may be attenuated or obscured by the particular memory complaint elicited by measures of SMC. Amariglio and colleagues (2011) found that indications of specific SMC such as perceived inability to memorize a short grocery list, rather than indications of general subjective memory decline, were linearly associated with increasing odds-ratios for impaired performance on objective measures of delayed recall, confrontation naming, and semantic fluency. Thus, the present body of literature suggests that SMC are related to objective measures of memory. It is likely that given the small-to-moderate effect size of the association between

SMC and objective memory measures, observed associations will be sensitive to study sample size, whether study design is cross-sectional or longitudinal, the specificity of the SMC queried on SMC measures, and the instrument used to measure objective memory.

SMC and their Neuroimaging Correlates

Recent research on the neuroimaging of SMC has provided an important indicator of the construct validity of SMC. Erk and colleagues (2011) found that although older adults with SMC did not perform worse than older adults without SMC on a battery of neuropsychological tests, the older adults with SMC demonstrated right hippocampal hypoactivation and hyperactivation in the right dorsolateral prefrontal cortex (DLPFC) relative to control participants. The hyperactivation of the DLPFC relative to the hypoactivation of the hippocampus was interpreted as compensatory activation to sustain effective encoding (Erk et al., 2011). It should be noted that Erk and colleagues (2011) did not report what instrument or questions were asked of the subjects to elicit knowledge of SMC. This research is consistent with another study of older adults that demonstrated an association between cognitive complaints and hyperactivation of the left DLPFC during memory encoding (Rodda, Dannhauser, Cutinha, Shergill, & Walker, 2009). In a study comparing hippocampal and whole brain volumes of healthy older adults, healthy adults with SMC, and adults with Mild Cognitive Impairment (MCI), adults with MCI and healthy adults with SMC demonstrated significantly reduced brain grey matter volumes relative to controls across all hippocampal and frontal regions except the left middle frontal gyrus and the right inferior frontal gyrus. For these two regions, the SMC group and healthy control group had significantly larger cortical volumes relative to the subjects with MCI (Saykin et al., 2006). Using resting-state functional connectivity MRI, Wang and colleagues (2013) found that right hippocampal connectivity for healthy older adults with SMC was intermediate between that of healthy older adults without cognitive complaints and participants with MCI. The association between SMC and the neuroimaging of memory functioning has been demonstrated in non-elderly populations as well. One study of a sample of middle-aged adults with cardiovascular disease found that SMC were associated with hypoactivation in the right frontal/middle gyrus and the left frontal gyrus during a 2-back task (Haley, Eagan, Gonzales, Biney, & Cooper, 2011). In sum, the imaging research reviewed suggests SMC are associated with a distributed network of neural structures that are implicated in controlled, effortful encoding and sustained attention (Haley et al., 2011). Furthermore, the association of SMC with frontal and medial temporal regions and the less reliable association of SMC with neuropsychological measures of memory may indicate that SMC may be manifestations of subtle, within-subject memory decline that neuropsychological tests may lack the sensitivity to detect (Verhaegen, Martin, & Sedek, 2012).

Executive Functioning as a Potential Third Variable

Existing research on SMC has yet to account for the potential role of third variables. In particular, there may be age-related dysfunction in non-memory systems that may mediate the relationship between negative affect and SMC. Furthermore, although SMC have face validity as indicators of memory dysfunction, there is no a priori reason to presuppose they are solely indicative of memory dysfunction.[1] The association of SMC with DLPFC volumes also suggests that SMC may indicate changes across distributed cortical networks (Rodda et al., 2009). Thus, SMC may be the downstream product of a cascade of dysregulated cognitive and affective processes. As will be reviewed in the following sections, research on depression, anxiety, the Big Five personality domains, and age-related memory dysfunction in older adults converge on, and parallel, age-related decrements in executive functioning. Currently, there are a limited number of studies that have investigated the relationship between executive function and SMC. In one

[1] David Johnson, Ph.D. is credited for this point.

study, Potter and Hartman (2006) found that poorer response inhibition was associated with increased SMC after controlling for objective memory performance, age, depression, and anxiety. In another cross-sectional study, better executive function, as measured by fewer errors on the Groton Maze Learning Task, predicted fewer SMC (Steinberg et al., 2013). Thus, preliminary studies support the contention of the present study that better executive functioning is related to fewer SMC.

Age-related changes in executive functioning and their neuroimaging correlates.

Lifespan cognition is characterized by differential trajectories of cognitive development and decline (Salthouse, 2004). Crystallized intelligence and its requisite processes, such as access to knowledge, increase rapidly from childhood to adulthood and continues to increase at a reduced rate into old age. Fluid intelligence, which has also been conceptualized as fluid mechanics, executive function, or cognitive control, peaks during early-to-middle adulthood and steadily declines into old age (Baltes, 1997; Craik & Bialystok, 2006). Similarly, performance on measures of executive function shows an inverted U-shaped relationship with respect to age (Jurado & Roselli, 2006; Zelazo, Craik, & Booth, 2004).

Studies have demonstrated the relationships between age-related executive function deficits and prefrontal cortex volume changes. Gunning-Dixon and Raz (2003) showed that perseverative errors on the Wisconsin Card Sorting task were associated with reduced prefrontal cortex volumes and white-matter hyperintensities. Other studies have documented similar associations between frontal brain volumes and measures of executive function (Brickman, Habeck, Zarahn, Flynn, & Stern, 2007; Elderkin-Thompson, et al., 2008; Zimmerman et al., 2006). In sum, age-related decline in executive function is an established trajectory of lifespan cognition and has been associated with reductions in cortical volume and cerebrovascular function in the prefrontal cortex.

The association of depression and anxiety and executive function in older adults.

In a recent meta-analysis, Snyder (2013) demonstrated that depressed adults were impaired on measures of inhibition, shifting, updating, verbal working memory, visuospatial working memory, planning, verbal fluency, processing speed, and vocabulary relative to healthy controls (range of effect sizes: d = 0.32–0.97). Depression among older adults is also associated with significantly more impairment in episodic memory and executive function compared to non-depressed older adults and depressed younger adults (Rapp *et al*., 2005; Thomas, Gallagher, Robinson, Porter, & Young, 2009). Given that prefrontal and anterior cingulate hypoactivation characterizes the functional neuroimaging of major depression and that decrements in prefrontal gray matter volumes characterize decrements in executive functioning, it is likely that many of the cognitive changes observed in older depressed adults may be attributable to executive dysfunction (Crocco, Castro, & Lowenstein, 2010; Raz & Rodrigue, 2006; Snyder, 2013).

Beyond late-life depression, anxiety and dysphoria, may be implicated in the association between depression and SMC and executive function. This is a likely possibility given that estimates of the prevalence of comorbid anxiety and depressive disorders in older adults is high, ranging from 23–47.5% (Devanand, 2002; Lenze et al., 2000; Lenze et al., 2001). It is likely that estimates of late-life depression with comorbid subthreshold anxiety exceeds these estimates. In their review, Bryant, Jackson, and Ames (2008) found that approximately 1.2-15% of the community dwelling older adult population had at least one diagnosable anxiety disorder and that 15-52.3% had clinically significant anxiety symptoms. The high prevalence of anxiety symptoms and their comorbidity with late-life depression has led some researchers to conclude that a subthreshold anxious-depressive syndrome may be a useful diagnosis for older adults and that the distinction between generalized anxiety disorder (GAD) and major depressive disorder (MDD) might be untenable (Flint, 2005). In addition, late-life depression and late-life anxiety share risk factors. A 9-year prospective study of mood disorder free older adults found that high neuroticism at baseline was a risk factor for anxiety, depression, and comorbid anxiety and depression (Vink et al., 2009). Importantly, as with older adults with depression, older adults with symptoms of anxiety demonstrate deficits in facets of executive functioning and memory (Beaudreau, & O'Hara, 2008; Beaudreau & O'Hara, 2009; Mantella et al., 2007; Yochim, Mueller, & Segal, 2013). For example, Mantella and colleagues (2013) found that patients with GAD and patients with MDD performed worse relative to healthy older adult controls on Trails B, and Short and Long Delayed Recall on the CVLT. However, performance on these neuropsychological tests did not differ between the two patient groups. Late-life anxiety is hypothesized to have a bi-directional relationship with executive functioning. Age-related decrements in cognitive control might lead to difficulty shifting attention from threat-related information while anxiety may contribute to difficulties sustaining goal oriented behavior (Beaudreau, MacKay-Brandt, & Reynolds, 2013). In sum, late-life anxiety and depression are both associated with executive dysfunction. It is possible that this association may be influenced by individual difference constructs including emotion regulation, neuroticism, low extraversion, or other personality variables.

The association of the Big Five personality traits and executive function.

The relationship between personality and cognitive ability is likely bidirectional. However, studies have hypothesized and have found that personality predicts executive functioning in adulthood and late-life (Curtis, Windsor, & Soubelet, 2015). In a sample of 2,317 adults ages 18-96, Soubelet and Salthouse (2011) found that higher levels of openness and lower levels of extraversion predicted better fluid intelligence and crystallized intelligence and that the magnitudes and patterns of these associations were comparable across age groups. In another large lifespan sample (*N* – 4,790), one study found that decreased neuroticism, increased extraversion, and increased openness predicted better category fluency performance (Sutin, et al., 2011). Sutin and colleagues (2011) also found that increased conscientiousness predicted better category fluency, but only for subjects with lower education. In another study, lower levels of neuroticism and higher levels of openness and agreeableness predicted better performance on measures of executive function including the trail making test, design fluency, letter fluency, and color-word inhibition (Williams, Suchy, & Kraybill, 2010). Booth and colleagues (2004) found that conscientiousness was the only predictor of performance on the Stroop color-word tasks and that neuroticism was the only predictor of performance on the Trails B. However, conscientiousness and neuroticism accounted for marginal amounts of variance on these tasks (2.6% and 5.7% respectively). In a cross-sectional study of young adults, a composite score of updating/monitoring was significantly associated with increased neuroticism while updating/monitoring and a cognitive flexibility composite score were associated with increased openness. No other associations between executive function composite scores and personality domains were observed (Murdock, Oddi, & Bridgett, 2013). In sum, preliminary research suggests that decreased neuroticism and increased openness are associated with better executive function in late-life. Extraversion has also been associated with executive function in late-life, but the direction of this association is inconsistent between studies.

Although the Big Five traits predict executive function in adulthood and late-life, the pathways by which each trait influences executive function likely differs. Conscientiousness might buffer older adults from decrements in executive function because conscientious older adults may be more likely to exercise and engage in health behaviors and thus sustain brain health (Wilson, Schneider, Arnold, Bienia, & Bennett, 2007; Curtis et al., 2015). Individuals higher in openness may be disposed to pursuing cognitively stimulating or creative activities that might have a buffering effect on cognitive decline (DeYoung, Peterson, & Higgins, 2005; Sharp, Reynolds, Pedersen, & Gatz, 2010). Neuroticism might affect executive function bidirectionally through neuroticism's relationship to rumination, depression, anxiety, and anger proneness (Kotov, Gamez, Schimdt, & Watson, 2010; Williams, Suchy, & Rau, 2009). Individuals low in extraversion, or who are more introverted, might be more inclined toward intellectual or analytical activities and thus reap cognitive benefits over time (Soubelet & Salthouse, 2010).

Neuropsychological research into the relationship between the Big Five and executive functioning is complemented by recent theorization and neuroscientific research. General domains that have face valid associations with executive function likely subserve the Big Five personality domains. Conscientiousness refers to individual abilities that underlie conscious goal pursuit. Neuroticism refers to the facets of individual differences that underlie emotional reactivity, ability to cognitively reappraise threatening information, and tendencies to experience negative emotion. Although these traits are distinct, they may be commonly served by a general capacity for intentional behavior and/or self-regulation (Williams, Suchy, & Rau, 2009). This relationship may be reflected in the robust associations of both conscientiousness and neuroticism with the Effortful Control factor on the Adult Temperament Questionnaire (ATQ) (Evans & Rothbart, 2007; Willliams et al., 2009). Integration of the Big Five with executive function can be further articulated by broadening the conceptualization of executive function from a 'cold' cognitive depiction to include the social, emotional, and motivational aspects of executive functioning that are compromised in patients with frontal lobe lesions (Barkley, 2012). Thus, individual differences among older adults in extraversion, openness, and agreeableness might reflect underlying executive capacities that facilitate sociality, curiosity, and warmth/empathy (Williams et al., 2009). A recent neuroimaging study has confirmed the possible role of common executive contributions to the Big Five traits themselves. Using a large sample (*N* = 249) of brain-injured Vietnam Veterans and healthy controls, it was found that higher neuroticism and lower conscientiousness were both associated with decreased DLPFC volumes (BA 9) (Forbes et al., 2014). Patients with focal injuries to the DLPFC had significantly higher levels of neuroticism, lower levels of conscientiousness, and poorer performance on measures of executive function than patients with non-DLPFC traumatic brain injury and healthy controls, thus confirming the importance of the DLPFC toward regulating negative affect and subserving goal oriented behavior (Forbes et al., 2014). From this study, it is apparent that despite being psychometrically distinct, neuroticism and conscientiousness are subserved by common pre-frontal regions (Forbes et al., 2014). Thus, it is possible that measures of executive function could explain variance shared by neuroticism and conscientiousness and potentially other of the Big Five traits as well.

The association of age-related changes in memory functioning with executive function and its neuroimaging correlates.

Regardless of the facet of memory functioning assessed, cognitive aging research has demonstrated reliable age-related memory declines. Researchers have found robust age-related decrements in episodic memory with particular deficits in recollection while recognition abilities remain relatively intact (Hoyer & Wingfield, 2006). Other memory processes have demonstrated age-related vulnerabilities. Metamemory processes are involved in the regulation and monitoring of memory processes involved in learning. Research has demonstrated that neurological patients with frontal lobe damage exhibit deficient memory control and monitoring (Pannu & Kaszniak, 2005). Studies of metamemory and executive function have also shown that older adults do not conform their study time and rehearsal to increasing task demands to the same extent that younger adults do (Dunlosky & Connor, 1997; Souchay, Insigrini, Clarys, Taconnat, & Eustache, 2004). Souchay and colleagues (2004) demonstrated that indices of study time and rehearsal adjustment were associated with performance on the Wisconsin Card Sorting Task among older and younger adults. The extent of controlled, relative to automatic, processing demands and contextual or environmental cues have all been hypothesized to affect memory performance in older adults as well (Balota, Dolan, & Duchek, 2000; Zacks, Hasher, & Li, 2000). Importantly, given that everyday tasks are "ill-structured" and are defined by environments with more task-irrelevant contextual cues, the memory demands of everyday life may tax the executive functioning of older adults more than neuropsychological tests do (Gilbert, Zamenpoulos, Alexiou, & Johnson, 2010, p. 79). In sum, age-related declines in executive functioning are likely associated with age-related declines across multiple facets of memory functioning.

Research has shown that changes in executive functioning and its associated neural structures are associated with age-related decrements in memory functioning (Baudouin, Clarys, Vanneste, & Isingrini, 2009; Hedden & Gabrieli, 2004). Although functional changes may vary across prefrontal regions with respect to whether they represent focal dysfunction (i.e. underactivation), compensation (i.e. overactivation), increased neural noise, or dedifferentiation (i.e. activation of non-target cortical regions), they are consistently found in the same prefrontal regions that subserve executive functioning (Rajah & D'Esposito, 2005). Age-related declines in executive function have been found to contribute to declines in the strategic use of mnemonic strategies for encoding and deficits in strategic, guided retrieval. Source memory also appears to dependent on executive functioning among older adults (Buckner, 2004). For example, deficits in the strategic use of mnemonic strategies to facilitate encoding in healthy older adults have been observed and have been associated with reduced activation in the left ventral prefrontal cortex (VPFC) (Buckner, 2004; Logan, Sanders, Snyder, Morris, & Buckner, 2002). Research suggests that the VPFC is implicated in various subfunctions of executive functioning and self-regulation including subvocal articulatory rehearsal and response inhibition (Banfield, McRae, Hunte, & Heatherton, 2004; Raye, Johnson, Mitchell, Greene, & Johnson, 2007). In their study of the functional anatomy of the component processes of memory in a sample of young adults, Wheeler and Buckner (2003) found that stimuli that were presented less frequently, and thus required more cognitive control to recall, evoked greater responses in BA 45/47 and 44 of the left prefrontal cortex. In addition, executive control processes in distinct regions of the prefrontal cortex have been demonstrated to be associated with cortical activation in distinct regions of the prefrontal cortex while participants in engaged in a source memory task (Dobbins et al., 2002). Thus, neuroimaging research suggests that the prefrontal cortex is also associated with facets of memory functioning, which demonstrate decline with age in-step with the age-related vulnerability of the prefrontal cortex.

Goals of the Present Study

Based upon the reviewed literature above, the overarching hypothesis of the present study is that executive function accounts for the relationship between the Big Five personality traits and SMC in addition to variance shared among the Big Five traits themselves. Each of the three models tested conveys related, but distinct hypotheses that further explicate the relationships among SMC, the Big Five, and executive function. Hypothesis A, tested by model A (Figure 1), posited that when accounting for executive function, the predictive power of the Big Five factors, particularly neuroticism, conscientiousness, openness, and extraversion, on SMC would be non-significant or significantly attenuated. Hypothesis B, tested by Model B (Figure 2), was that executive function would account for the shared variance between the Big Five, in particular with respect to neuroticism, conscientiousness, extraversion, and openness. Because the present project used cross-sectional data, the regression paths of the Big Five and SMC on the DEX in Model B will approximately equal the covariances of these latent variables with the DEX in the measurement model. In addition, the regression paths of SMC on the Big Five in the Multiple Regression model will be approximately equivalent to the covariances between the Big Five and SMC in Model B because both models represent the relationship of the Big Five and SMC after partialing out the effect of executive function. Thus, the parameters of interest in Model B were the covariances among the Big Five, which represented the shared variance among the personality traits after accounting for the contribution of executive function. Lastly hypothesis C, tested by model C (Figure 3), was that executive function mediated the relationship between the Big Five factors and SMC. Because of the paucity of research on the associations of SMC and PMC with executive function and the Big Five, separate hypotheses for these constructs are not warranted.

Method

Participants and Data Collection

Participants were older adults from the alumni participant registry at the Landon Center on Aging at the University of Kansas Medical Center. The data for this project was collected during the summer, 2010 as part of the pilot study for the Many Dimensions of Aging study (MDA). Potential participants were contacted by telephone and were mailed the survey if consent was obtained. Participants completed five in-home surveys in total and were paid $5 per survey. Returned surveys were read electronically using optical character recognition software. Items in the survey were grouped according to the measure they were originally from to facilitate the maintenance of cognitive set. The number of response options and the quality of the responses (e.g. how often vs. how much do you agree) was limited to reduce the response heterogeneity across scales.

The MDA survey was comprised of 562 items from existing measures of self-regulation, self-reported cognitive complaints, self-reported health practices, self-reported physical and emotional functioning, and new items devised by the Neuropsychology and Aging Laboratory. Due to the large number of scales and items included in the MDA, items that were deemed redundant, irrelevant to the research aims of the MDA, poorly written, and not applicable to older adults were excluded. A subset of these measures was used for the present study.

Measures

The Prospective and Retrospective Memory Questionnaire (PRMQ). The PRMQ was developed to assess the relative frequencies of self-reported prospective and retrospective memory failures in cognitively normal older adults and older adults with Alzheimer's disease (Smith, Della Sala, Logie & Maylor, 2000). Retrospective memory refers to remembering information learned in the past whereas prospective memory refers to remembering to do something in the future, or an intention (Kvavilashvili et al., 2009). The PRMQ is comprised of 16 items that are rated on a 5-point Likert scale ranging from “very often” to “never.” The PRMQ has demonstrated adequate internal consistency for the total, Prospective, and Retrospective memory scales (α = 0.89, 0.84, and 0.80 respectively) (Crawford, Smith, Maylor, Della Salla, & Logie, 2003). Factor analytic studies of the PRMQ demonstrated that the best-fitting model for the PRMQ was comprised of a general memory factor and individual factors for prospective and retrospective memory (Crawford *et al*., 2003; Crawford, Henry, Ward, & Blake, 2006). Eight of the 16 items of the PRMQ were retained for the MDA. Five items from the retrospective memory scale and three items from the prospective memory scale were included. The eight items that were selected from the PRMQ were chosen because they were deemed the most applicable to the daily experiences of healthy older adults. Consistent with the structure of the original scale, the RMC and PMC scales will be modeled separately as latent variables.

The Dysexecutive Questionnaire (DEX). The DEX is a self-report measure of 20 common symptoms of executive dysfunction. It is included in the Behavioral Assessment of Dysexecutive Syndrome (BADS) test battery (Burgess, Alderman, Wilson, Evans & Emslie, 1996; Burgess, Wilson, Evans, Emslie & Alderman, 1998). Each item is scored on a scale ranging from “never” to “very often. “

No consistent factor structure of the DEX has been found. The manual for the BADS cites an exploratory factory analysis (EFA) that yielded a three-factor solution (“Behavior,” “Cognition,” “Emotion”). However, the cited solution only included 16 of the 20 items of the DEX (Wilson, Alderman, Burgess, Emslie, & Evans, 1996). Other studies using EFA have yielded five-factor solutions (Amieva, Phillips, Della Sala, 2003; Chan, 2001). Using a sample of healthy young adults, Chan (2001) obtained a five-factor solution with factors labeled as, “inhibition,” “intentionality,” "knowing-doing dissociation,” “in-resistance,” and “social regulation.” The 5-factor solution obtained by Amieva and colleagues (2003) used a very small sample ($N = 20$) of healthy older adults. They labeled their factors, “intentionality/ability to take initiative,“ ”coping with interfering events,” “euphoria/perseveration,” “confabulation,” and, “planning/thinking ahead.” However, the interpretability of this solution is questionable given the cross-loadings of 20% of the items. One EFA study using a large sample of young adults found a four-factor solution. The factors were labeled, "inhibition," "intention," "social regulation," and "abstract problem solving" (Mooney, Walmsley, & McFarland, 2006). One study using a Rasch analysis of a large sample of patients with acquired brain injury found that the DEX was multidimensional and thus required subscales. This analysis concluded that three items failed to discriminate between different thresholds of ability. The authors proposed a three-factor model comprised of factors labeled, "executive cognition," "behavioral-emotional self-regulation," and "metacognition" (Simblett & Bateman, 2011). There is one study of the DEX that has used confirmatory factor analysis. This study found that the best fitting and most parsimonious model was a one-factor model (Gerstorf, Siedlecki, Tucker-Drob, & Salthouse, 2008). Given the paucity of CFA studies of the DEX, a sub-goal of the present project was to test the comparative fit of the different factor structures proposed in the literature.

The Big-Five Inventory (BFI). The BFI is a 44-item measure of the Big Five personality traits. The BFI has five scales, Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism (Benet-Martinez & John, 1998; John & Srivastava, 1999). Although the BFI is psychometrically valid, CFAs of the Five-Factor model using the BFI have fit poorly (Chiorri, Marsh, Ubbiali, & Donati, 2015). Poor fit likely resulted from the overly stringent assumptions of CFA that an item load on one factor only (i.e. univocality, or the assumption of the independent clusters model) (Marsh et al., 2010). For large inventories approaching 50 items, satisfactory model fit is highly unlikely given aggregated item-related incremental error (Marsh, Morin, Parker, & Kaur, 2014). Consistent with this research, replications of the Five-Factor model at the item-level in early analyses for the present study resulted in poor fit (χ^2 (595) = 2721.98, RMSEA = 0.09 [0.08-0.10], CFI = 0.68, TLI = 0.65).

Facet level composites of the Big Five subscales comprised the indicators of the Big Five latent variables for the present study. Soto and John (2009) derived ten facets from the original 44-item scale. Facets were derived by testing each item's convergent validity with the facets of the NEO-PI-R and then grouping items based upon common patters of BFI item-NEO-PI-R facet correlations. Facets were then evaluated for their reliability and discriminant validity in two samples (Soto & John, 2009). The BFI facets are widely used to score the BFI and have also been used in CFA and SEM studies (e.g. Nye, Allemand, Gosling, Potter, & Roberts, 2015). The use of facets, as opposed to item level indicators, was appropriate because the analytical emphasis in the present study was on the structural relationships between latent variables as opposed to characteristics of item functioning.

Covariates. All latent variables were regressed on age, education, and a 10-item physical functioning composite variable from the SF-36 (Ware & Sherbourne, 1992). A measure of physical functioning was included in the present study because physical functioning has been found to be a predictor of SMC and related to negative affect in late-life (Jorm et al., 2004; Stewart et al., 2001). Items from this subscale ascertain the extent of physical limitation across multiple activities including carrying groceries, kneeling, and other behaviors. The effect of sex was assessed separately using invariance testing on the measurement model. Models were determined to be invariant if each nested model had a ΔCFI ≥ 0.01 and a ΔRMSEA value that fell within the less restrictive model's RMSEA 90% confidence interval. For the comparison of the strong model and strong-plus latent-means-model, a non-significant chi-square difference test indicated invariance of the latent means (Cheung & Rensvold, 2002).

Data Analysis

This study used confirmatory factor analysis (CFA) and structural equation modeling (SEM) to model the associations among the latent variables of interest. Analyses were conducted in RStudio, V. 0.99 using the Latent Variable Analysis (lavaan) package (Rosseel, 2012). The present analysis used maximum likelihood (ML) and robust maximum likelihood (MLR) estimators, which corrects for deviations from multivariate normality. Although the variables used are ordinal, the treatment of them as continuous was justified by their having five or more levels. Even under conditions of non-symmetrically distributed thresholds, biases in estimation using ML does not exceed 10% for categorical variables with five or more levels (Rhemtulla, Brosseau-Liard, & Savalei, 2012). Model fit was assessed using RMSEA, CFI, and TLI. Nested model comparisons were assessed using the χ^2 difference test with the Satorra-Bentler scaled chi-square correction (Little, 2013; Satorra, 2000). Non-nested models will be compared using the Akaike Information Criteria (AIC) and the Bayesian Information Criteria (BIC).

The use of regression and mediation in this study required the use of different estimators and different techniques for parameter estimation. The regression models used the MLR estimator. For the Mediation model, direct paths (*c*') and indirect effects (*ab*) were estimated using a bootstrapping procedure (5,000 draws) with the maximum likelihood (ML) estimator (Hayes, 2009). This approach obviated the limited power of the joint significance method and the necessity of normally distributed parameters of the Sobel test (Hayes, 2009). Bootstrapping procedures treat the observed sample as a sample of a theoretical population. Thus, *m* draws of a subset of the observed sample are made with replacement and the parameters of interest are calculated from each subsample. Ninety-five percent confidence intervals for *a* and *b* are then calculated and determine the significance of the indirect effect (Hays, 2009).

Rates of missing data were small to moderate (5-24%) in the current sample. Missing data were handled using full-information maximum likelihood estimation (FIML). In addition, all variables were scaled using percent of maximum possible (POMP) scoring in order to circumvent estimation problems (i.e. heterogeneity of variances and restricted ranges) posed by the use of Likert-scales with differing numbers of levels. Thus, all item values were constrained to 0-1, inclusive.

Results

Table 1 displays the characteristics of the current sample, the internal consistencies of the scales and measures used, and the distribution of indicator skew and kurtosis. The sample was well educated and comprised a wide range of ages (63-98). The internal consistencies of the modified PRMQ scales were acceptable and comparable to those obtained in other validation studies of the PRMQ (Crawford et al., 2003). The internal consistencies for all other measures and scales were also acceptable. Internal consistencies for the Big Five factor facets were lower than the factor scale internal consistencies with the exception of the aesthetics facet and the openness scale. The internal consistencies for the Big Five facets occupied a large range (α_{Dep} = 0.60 [0.44-0.72] - $\alpha_{anxiety}$ = 0.82 [0.76-0.86]). The facets represent a low-to-moderate level of internal consistency, likely due to the relatively low number of items that comprised each facet. Summary values for all variables other than age, sex, and education were bounded between 0 and 1. The present sample indicated low levels of physical limitation, low levels of neuroticism, few retrospective (RMC) and prospective (PMC) memory complaints, and few dysexecutive behaviors. Consistent with previous research, this sample of older adults had comparable ratings of RMC and PMC (Eschen, Martin, Gasser, & Kliegel, 2009). On average, participants considered themselves to be agreeable and conscientious, while ratings of self-reported openness and extraversion were more moderate. Skewness and kurtosis values for the scales and facets used indicated substantial deviations from univariate normality. In particular, the kurtosis values reflect limited response variability. The DEX exhibited the most limited response variability, with the mean proportion of participants indicating the two lowest levels of symptom endorsement equaling 74.8% with a standard deviation of 8.2%. Both the facets and total subscales of agreeableness and conscientiousness items also exhibited limited variability in responding. This indicated that participants rated themselves generally at the ceiling of agreeableness and conscientiousness.

The bivariate correlation matrix demonstrates robust relationships between the DEX and the Big Five facets and SMC (see Table 3). Consistent with existing research and theorizing on the association of executive function and the Big Five, increased ratings of executive dysfunction on the DEX was positively related to negative affect, negatively related to goal-oriented behavior, negatively related to mental flexibility, and negatively related to prosociality. Remarkably, the DEX was as correlated with the depression facet ($r = 0.62$, $p < 0.05$) of neuroticism as the anxiety facet of neuroticism ($r = 0.61$, $p < 0.05$). A similar pattern was also present with respect to the correlation of the DEX with the active facet of extraversion ($r = -0.50$, $p < 0.05$) and the correlation of the assertiveness facet of extraversion with the active facet of extraversion ($r = 0.40$, $p < 0.05$). The DEX correlated more strongly with both RMC and PMC than any of the Big Five facets or covariates. Consistent with previous research on SMC and the Five Factor model, the facets most consistently correlated with SMC belonged to neuroticism, conscientiousness, and extraversion. Both RMC and PMC were associated with increased neuroticism, decreased conscientiousness, and introversion (low extraversion). The directions of these associations also replicated the findings of other studies (e.g., Ausen et al., 2009; Pearman

& Storandt, 2004; Slavin et al., 2010; Uttl & Kibreab, 2011). The facets with the largest correlations with any of the RMC or PMC items were the depression facet of the neuroticism subscale ($r_{RMC4} = 0.4$, $p < 0.05$), the self-discipline facet of the conscientiousness subscale ($r_{RMC1} = 0.44$, $p < 0.05$), and the active facet of the extraversion subscale ($r_{RMC1} = 0.45$ $p < 0.05$). There was no appreciable difference in the pattern of correlations between SMC and PMC and the other variables presented in the correlation matrix. With regard to the covariates, education was positively related to the Openness facets. Age was significantly correlated with increased physical limitation ($r = 0.39$, $p < 0.05$), poorer self-discipline ($r = -0.19$, $p < 0.05$), poorer trait activeness ($r = -0.24$, $p < 0.05$), increased RMC, increased DEX total score. Consistent with previous research, increase physical limitation was significantly correlated with both increasing SMC, increased, neuroticism and decreased levels of conscientiousness and extraversion (Chapman, Duberstein, & Lyness, 2006; Jorm et al., 2004; Stewart et al., 2001). Sex (not listed in table) was not significantly correlated with any variables.

CFA was used to replicate and assess the acceptability of all proposed factor structures for the DEX. The results indicated that all previously reported factor structures were unsatisfactory and/or resulted in poor model fit (see Table 2). In the present sample, four out of five factor structures yielded poor model fit (Amieva et al., 2003; Chan, 2001; Simblett & Bateman, 2011; Wilson, et al., 1996). Although model fit could be improved for these models using modification indices, all proposed structures had significant problems with model specification as indicated by the frequency of factor covariances approaching one. The structure proposed by Amieva and colleagues (2003) had seven out of ten covariances greater than 0.80, and two out of seven greater than 1.0. The structure proposed by Chan (2001) had four out of ten covariances greater than 0.80, with two out of ten greater than 0.90. The covariances in the structures proposed by Simblett and Bateman (2011) and Wilson and colleagues (1996) were all greater than 0.90. Although the structure proposed by Mooney and colleagues fit well, five out of the six factor covariances were greater than 0.80 and three out of 6 were greater than 0.90. The highly collinear factors as well as the variation in the items used in each proposed factor structure significantly limited the utility of using any of these proposed factor structures in subsequent analyses.

These results are similar to one study that found that the fit and model specification for existing factor structures of the DEX were unsatisfactory for subsequent use in structural models (Gerstorf et al. 2008). In step with Gerstorf and colleagues (2008), a single factor solution with three parcels was specified for the subsequent analyses. A single-factor model was appropriate given the high degree of ambiguity in the factor structure of the DEX. Parceling was appropriate in this scenario because a single-factor structure precluded the risk of obscuring model misfit that parceling poses (Little, Cunningham, Shahar, & Widaman, 2002). A parceling approach previously used for the DEX was applied (D. Gerstorf, personal communication, April 10, 2015; Gerstorf et al., 2015). Using this parceling scheme, model fit was marginally acceptable (χ^2 (167) = 291.49, RMSEA = 0.08 [0.06-0.09], CFI = 0.91, TLI = 0.88) (Table 3). Additionally, parameter estimates for the DEX in subsequent analyses resulted in a Heywood case and inflated standard errors, indicating problems with model specification (Rindskopf, 1984). This model also produced a negative residual variance for the self-discipline facet, likely due to the large correlation between the two conscientiousness facets. This negative residual variance was constrained to be greater than zero. Because a single-factor structure was specified for the DEX, a CFA model with the DEX specified by a single composite indicator was tested in order to determine if performance of the model could be improved relative to the model with parcels. The single-indicator DEX model resulted in the resolution of the Heywood case for the DEX, less inflated standard errors, and a more parsimonious model (χ^2 (131) = 205.56, RMSEA = 0.07 [0.05 0.08], CFI = 0.93, TLI = 0.91). However, the Heywood case for the self-discipline facet persisted. The single-indicator DEX model was used in subsequent structural analyses. The single-indicator DEX measurement model was invariant for sex for factor loadings, intercepts, and latent means (see, Table 4). Standardized factor loadings for the measurement model showed that all indicators loaded adequately on their target factors (see Table 5). The standardized covariances between many of the Big Five factors were larger than would be anticipated given previous research on the Five Factor model of personality (e.g. McCrae & Costa, 1987). For example, the covariance between openness and extraversion (*r* = 0.82) and agreeableness and neuroticism (*r* --0.76) far exceeded the same covariances estimated by the multimethod-multitrait CFA in the initial BFI validation study (*r* = 0.25 and *r* = -0.37, respectively) (John & Srivastava, 1999). The Big Five covariances obtained in the present model are likely inflated due to the confounding of construct covariance with common method variance, the attenuation of error variance due to the use of facet indicators, and the constraining of all factor cross-loadings to zero, which is implicit in CFA (Lance, Dawson, Birkelbach, & Hoffman, 2010; Little et al., 2002; Marsh et al., 2010). The measurement model achieved invariance of factor loadings, intercepts, and latent means for sex (see Table 4).

The structural models demonstrated that the DEX accounted for significant variance in RMC and PMC over and above the Big Five personality factors. The full Multiple Regression model fit the sample variance-covariance matrix well (χ^2 (182) = 230.86, RMSEA = 0.07 [0.05-0.08], CFI = 0.95, TLI = 0.93) (see Table 4). While modeled simultaneously with the DEX, none of the Big Five factors significantly predicted RMC or PMC, while the DEX was robustly associated with the SMC variables. The non-significant Big Five factors were constrained to zero in the trimmed model, resulting in no significant loss of fit from the full model ($\Delta\chi^2$ (10) = 10.52, p = 0.40). In the trimmed Multiple Regression model (see Figure 4), the DEX positively predicted both RMC (β = 0.72, $p < 0.01$) and PMC (β = 0.47, $p < 0.01$), indicating that increased self-reported dysexecutive behavior was robustly associated with increased PMC and RMC. Of the covariates, increased physical limitation was significantly associated with decreased agreeableness, decreased conscientiousness, decreased openness, increased neuroticism, and robustly predicted decreased extraversion (β = -0.56, $p < 0.01$). Age marginally predicted more self-reported executive dysfunction (β = 0.11, p = 0.06). Increased education predicted increased levels of openness (β = 0.26, p = 0.01). Neither age nor education significantly predicted any of the Big Five latent variables. None of the covariates predicted RMC or PMC. In all reported analyses (see Table 4), all non-significant covariance paths were constrained to zero to increase model parsimony.

As can be seen by comparing the estimated covariances of the measurement model and the results of the Multiple Regression model (see Figures 4 and 5) with the parameter estimates of Single Criterion EF Model (Model B), the Single EF Criterion model and the other tested models were partially equivalent (see Table 6). With regard to the parameters of interest for the Single Criterion Model, the DEX substantially attenuated the covariance between neuroticism and conscientiousness (r = -0.27, $p < 0.01$) relative to the same covariance estimated in the measurement model (r = -0.62, $p <0.01$). Partialing out the effect of the DEX also resulted in attenuated covariances between conscientiousness and extraversion (r = 0.34, p = 0.01) and non-significant covariances between conscientiousness and openness, conscientiousness and agreeableness, agreeableness and extraversion, and agreeableness and openness (see Figure 2).

The non-significant latent variable covariances for the Single EF Criterion model were constrained to zero and did not result in a loss of model fit relative to the full single EF Criterion Model ($\Delta\chi^2$ (14) = 10.14, p = 0.75). Lastly, the comparison of the trimmed multiple regression and single Criterion EF model revealed that the Single EF Criterion model fit was more parsimonious than the multiple regression model while having equivalent fit ($\Delta\chi^2$ (4) = 3.57, p = 0.47).

A single mediation model was used to test simultaneously the hypothesis that the DEX mediated the relationship between the Big Five factors and SMC and PMC (see Figure 1). Results of the omnibus mediation model resulted in extremely wide confidence intervals, indicating significant uncertainty in parameter estimation. The imprecision of the estimates may have been due to the number of regression parameters being estimated relative to the sample size.[2] In order obtain more precise parameter estimates, the omnibus mediation model was decomposed into five separate mediation models for each Big Five factor. It should be noted that testing separate mediation models is not equivalent to testing the omnibus model. Individual mediation models cannot test overall indirect effects (i.e. across all Big Five factors); they cannot shed light on the conditional predictive relationships of the independent and dependent variables; and, the resulting decomposed models inevitably suffer from omitted variable biases (Preacher & Hayes, 2008).

Table 7 contains the parameter estimates for the Big Five mediation models. Table 7 is also accompanied Figures 6 through 9 which depict model results. To compensate for the potentially increased Type I error rate due to the number of separate mediation models estimated, a 99% confidence interval was used instead of a 95% confidence interval to test parameter

[2] Mauricio Garnier, M.A. is credited with this point.

significance.[3] *P*-values for the listed parameters were omitted from Table 7 because they assume a multivariate-normal distribution that the product of coefficients ($a*b$) was unlikely to conform to (Preacher & Hayes, 2008). Standard errors of the parameters were omitted from Table 7 because they were inflated. Non-consideration of the parameter standard errors was valid because parameter standard errors can be biased without affecting the estimation of *a* and *b* parameters; however, biased standard errors indicate problems with model specification (Preacher & Hayes, 2008). It is possible that the source of model misspecification was due to multicollinearity observed among the latent variables and/or the indicators (Lei & Wu, 2007).

For the analysis of indirect effects, both *a* and *b* paths must be statistically significant for a valid test of mediation (Mathieu & Taylor, 2006). Thus, it was concluded that there was no evidence of indirect effects for the Neuroticism-PMC model, the Conscientiousness-PMC model, the Extraversion-PMC model, the Openness-PMC model, and the Openness-RMC model due to non-significant *a* and *b* paths (see Table 7).

With regard to Neuroticism (Figure 6) , the DEX fully mediated the relationship between Neuroticism and RMC as indicated by the significant product term and non-significant direct effect relative to the total effect, (*c*) (B_{a*b} = 0.77 [0.12-1.60]), $B_{c'}$ = -0.13 [-0.91-0.83]). The significance of this effect was also made clear in the change in RMC variance accounted for by the direct total effect model (*c*) versus the mediation model ($\Delta R^2 = 0.26$). The DEX fully mediated the relationship between Conscientiousness (Figure 7) and RMC (B_{a*b} = -0.54 [-0.93 -0.27], $B_{c'}$ = -0.20 [-0.63-0.15], $\Delta R^2 = 0.26$), the relationship between Extraversion (Figure 8) and RMC (B_{a*b} = -0.50 [-1.22 -0.30], $B_{c'}$ = -0.22 [-0.11-0.55], $\Delta R^2 = 0.19$), and the relationship between Agreeableness (Figure 9) and RMC (B_{a*b} = -0.73 [-2.76 -0.34], $B_{c'}$ = -0.36 [-0.12-1.73], $\Delta R^2 = 0.46$). For the Agreeableness-RMC mediation model, it should be noted that the total

[3] Mauricio Garnier, M.A. is credited with this point.

effect (B_{total} = -0.37 [-0.87 -0.08]) might have been non-significant due to the potentially small contribution of the direct effect. Agreeableness predicted RMC weakly (R^2 = 0.10). With respect to the Agreeableness-PMC model, the absence of a significant direct path of PMC on Agreeableness (B = -0.19 (0.13), p = *n.s.*) changed the meaning of this model, in that a mediation model without a significant *c* path is only a test of indirect effects because there is no effect to mediate (Mathieu & Taylor, 2006; Preacher & Hayes, 2004). The indirect effect (*a***b*) of agreeableness and the DEX on RMC was statically significant, demonstrating that the DEX exerted an indirect effect on PMC (B_{a*b} = -0.73 [-2.76- -0.34], $\Delta R^{2\,=}$= 0.22).

Discussion

The overarching hypothesis of the present study was that executive function accounts for the relationship between SMC and the Big Five personality traits and for variance shared among the Big Five traits themselves. Across all three models, the DEX accounted for variance in SMC above and beyond the Big Five and explained the variance shared by the Big Five factors. Hypothesis A (see Figure 1) posited that the while holding executive functioning constant, the effect of the Big Five on SMC would be significantly attenuated. Model A confirmed this hypothesis and demonstrated that while holding executive functioning constant, none of the Big Five factors significantly predicted RMC or PMC. The full attenuation of the effect of personality on SMC in the present multiple regression model differs from the results of previous studies. Using multiple regression, Potter and Hartman (2006) found that higher scores on the Geriatric Depression Scale (GDS), Beck Anxiety Inventory (BAI) and longer reaction times on the Stroop-Color task simultaneously predicted increasing SMC. Although the GDS and BAI are not identical to neuroticism, this study suggests that neuropsychological measures of executive function do not account for variance over and above that of negative affect (Potter & Hartman, 2006). In the multiple regression analysis by Steinberg and colleagues (2013), conscientiousness and neuroticism remained significant predictors of SMC with the inclusion of their measure of executive function. However, these differences might also reflect methodological differences between multiple regression and structural equation modeling, which accounts for error variance.

There were also important discrepancies in the Multiple Regression model with regard to the predictive relationships observed between physical limitation and SMC in the present study and in the literature. Contrary to previous studies, physical limitation did not predict SMC (e.g. Bassett & Folstein, 1993; Jorm et al., 2004; Stewart et al., 2001). The observation of a significant association of physical limitation with the DEX and not SMC might be attributable to differential reliability of the two constructs due to the different number of items (20 vs. 8, respectively) comprised by each factor. The observed association of increased physical limitation with increased, neuroticism and decreased conscientiousness, extraversion, and openness and is consistent with existing research on self-reported physical health and the Big Five (Duberstein et al., et al., 2003; Löckenhoff, Sutin, Ferrucci, & Costa Jr., 2008).

Hypothesis B posited that the DEX would explain variance shared by the Big Five Personality traits. The results of the Single Criterion EF model confirmed this hypothesis. Consistent with theoretical work positing a common effortful control component of neuroticism and conscientiousness and neuroimaging research supporting this hypothesis, the DEX significantly attenuated the relationship between conscientiousness and neuroticism ($r = -0.27$, $p < 0.01$) relative to the measurement model ($r = -0.62$, $p < 0.01$) (Forbes et al., 2015; Williams et al., 2009). Other pairs of correlations were attenuated as result of the regressions of the Big Five on the DEX, including the correlations of neuroticism with extraversion, openness, and agreeableness, the correlations of conscientiousness with extraversion and openness, and the correlations of agreeableness with extraversion and openness.

Research on young adults has found a positive association of extraversion with activation of the medial orbitofrontal cortex (OFC), a negative association between neuroticism and activity in the dorsomedial PFC, a positive association between conscientiousness and activity in lateral PFC, a positive association between agreeableness and activation in the cingulate cortex, and a positive association between openness and activations in the DLPFC (DeYoung, et al., 2010; DeYoung et al., 2005). Given that both executive function and the Big Five personality traits likely represent activity in distributed systems in the prefrontal and orbitofrontal cortices, it is possible that the observed attenuations of the correlations between the Big Five latent variables could be due to common executive function, or frontal system, variance being explained.

However, an exception to this hypothesis was the unexpectedly robust correlation between openness and extraversion, which was unchanged across models ($r = 0.82$, $p < 0.01$). This value could reflect an atypically strong, positive relationship between extraversion and openness in this sample of older adults. It is more likely that this correlation is indicative of misspecification of the Big Five model. The present study made no modifications to the Big Five structure because there were no indications of substantive model misfit in the modification indices nor indications of localized strain in the correlation matrix for the model standardized residuals. In addition, a conservative approach to model confirmation was taken in order to maximize model generalizability across studies and literatures that have used the Big Five. However, drastic changes to the Big Five model using multiple cross-loadings, eliminating indicators, or relaxing the assumption of item univocality have been necessary in studies of the Big Five to achieve satisfactory model fit (Chiorri et al., 2015; Small, Hertzog, Hultsch, &

Dixon, 2003). Researchers using the Big Five Model and CFA/SEM will have to continue to reconcile model fit with fidelity to the classic Big Five model of personality.

Hypothesis C posited that executive function mediates the association of SMC with the Big Five personality traits. Model C (Figure 3) partially confirmed this hypothesis. Mediation analyses showed that the DEX fully mediated the relationship between RMC and Neuroticism, Conscientiousness, Agreeableness, and Extraversion. With respect to Agreeableness, the DEX was shown to have an indirect influence on PMC, but did not mediate the relationship due to the non-significant *c* path. These findings confirm the hypothesis that personality influences executive function, which thereby influences RMC beyond the effect of personality on RMC. The lack of any mediation effects of the DEX on the Big Five and PMC and only one indirect effect for the effect of the DEX on PMC was unexpected, as both neuropsychological measures of inhibition and shifting have been found to predict both PMC and RMC subscales of the PRMQ (Eschen et al., 2009). The differential pattern of mediation effects between the RMC and PMC might be attributable to the low reliability of PMC due to it being comprised of only three items.

Despite the data being cross-sectional, the models, taken together, demonstrated that both RMC and PMC are personologically complex and not simply a consequence of negative affect. Increasing SMC was associated with increased neuroticism, decreased conscientiousness, decreased extraversion, or increased introversion, decreased openness, and decreased agreeableness. The complexity of SMC is compounded by the fact the Big Five traits are themselves multifaceted. Neuroticism can imply sensitivity to punishment, hypervigilance, anxiety, or irritability; conscientiousness can imply goal-directedness, self-discipline, or organization; extraversion can imply reward sensitivity and predisposition to approach behavior;

openness can imply intellectual engagement, creativity/imagination, aesthetic/artistic inclination; and, agreeableness can imply prosociality, compassion, and empathy (DeYoung, 2010). Thus, analyses of SMC at the facet level of the Big Five would be instructive in determining more precisely the personality characteristic of each of the Big Five that is associated with SMC. The models also corroborated current research in personality neuroscience that has demonstrated that the Big Five likely share common variance associated facets of executive function such as inhibition and planning. In sum, the present study demonstrated that executive function plays an important role in explaining the relationship between the Big Five and SMC and the relationship between the Big Five traits themselves.

Limitations

A core assumption of the present study is that the DEX is a useful and valid measure of executive function. Consistent with Gerstorf and colleagues (2013), a one-factor model was the best fitting and most parsimonious representation of the DEX. Although the constituent elements of executive function and the factor structure that represent them are not currently agreed upon, most factor structures, if not all, are not unitary (e.g., Jurado & Rosselli, 2007; Miyake & Friedman, 2012). Thus, it is not apparent how the DEX and neuropsychological measures of executive function relate structurally. Furthermore, the use of the DEX as a single indicator in the present study is suboptimal because it obscures the multifaceted nature of executive function and the meaning of the relationship of the DEX with the other latent variables of interest in this study. Lastly, and most problematic, the validity of the DEX as measure of executive function in healthy older adults is unclear. Gerstorf and colleagues (2013) observed that younger adults indicated more executive dysfunction than healthy older adults on the DEX and that the DEX was unrelated to laboratory measures of executive function, but related to measures of negative affect. Similarly, other studies have failed to demonstrate the construct validity for the DEX. Rather, findings from other studies suggest that the DEX may be more strongly related to negative affect than executive function (Munshi, Hayes, Iwata, Lee, & Weinger, 2012; Sanders & Schmitter-Edgecombe, 2012). However, there is some evidence to suggest the construct validity of the DEX in older adults. One study of a small sample of older adults ($N = 17$) found that poorer performance on a difficult Left-Right tapping task, ostensibly requiring executive control, was correlated with increasing dysexcutive behaviors on the DEX (Bangert, Reuter-Lorenz, Walsh, Schachter, & Seidler, 2010). Thus, current research has not substantiated the DEX as a measure of executive function in older adults. Thus, the results of the present study must be interpreted cautiously and must be replicated using neuropsychological measures of executive function.

With respect to the models themselves, multicollinearity and shared method variance may have biased parameter estimates in the present study. Multicollinearity can bias parameters and standard errors, however limited total-observation-to-free-parameter ratios and/or poor indicator reliability must also be present to appreciably inflate the Type II error rate for regression paths (Grewal, Cote, & Baumgartner, 2004). In their simulation study, Grewal and colleagues (2004) found that when latent variable covariances were between 0.6-0.8, when indicator reliability was 0.7 or below, when R^2 was 0.25 or below, and when the observation-to-parameter ratio was 3:1 or lower, Type II error rates for regression paths could be between 50-80%. The multiple regression model in the current study had numerous large latent variable covariances (largest, $r = 0.85$), a small observation to indicator ratio (2.17), and indicator reliabilities ranging from $\alpha = 0.60$-0.81. Although the R^2 was greater than 0.25 for both PMC and RMC in the trimmed multiple regression model, there was an increased likelihood of Type II errors for the path coefficients of RMC and PMC on the Big Five given the other parameters. Consistent with Grewal and colleagues' (2004) simulation study, increased likelihood for Type II errors for regression paths was reflected in the inflated standard errors relative to the parameter estimates for all regression paths in the Multiple Regression model. Thus, it is highly likely that the robust multiple regression effect for the DEX observed in the multiple regression model is biased due to Type II error.

A related issue to model multicollinearity that likely affected all models is the confounding effect of common method variance. Although the inflationary effect on the covariance matrix of common method variance is attenuated by indicator unreliability (i.e. measurement error), one review of multitrait-multimethod CFA analyses estimated that method variance accounts for 18% of total model variance (Lance et al., 2010). In addition, the extent to which monomethod effects is problematic depends on whether the monomethod variance is shared between constructs or not (Lance et al., 2010). In the present study, independent, third/mediator variables, and dependent variables were monomethod, thus making disentangling the method effects from the hypothesized relations between the variables impossible. In addition, monomethod effects across constructs are additionally problematic in CFA/SEM because they inflate the covariances between indicators that belong to separate constructs, which can lead to inflated latent variable covariances (Grewal et al., 2004). Thus, the results of the regression analyses, particularly from the multiple regression model, should be interpreted cautiously given the increased likelihood of Type II errors for the Big Five factors due to the relatively low indicator reliabilities, latent variable multicollinearity, low observation-to-parameter ratio, and monomethod variance contamination.

An additional methodological limitation to the present study was its cross-sectional design. The use of cross-sectional data resulted in testing partially equivalent models and precluded a rigorous analysis of the temporal relationship among age-related changes in executive functioning, personality, and memory complaints. The cross-sectional data used in the present study also significantly limits the interpretability of the presented mediation analyses. Data with multiple time points of measurement is needed in order to establish temporal causation between the independent variable and the mediator and the mediator and the dependent variable (Frazier, Tix, & Barron, 2004; Mathieu & Taylor, 2006). Thus, the causal chain implied by the fully mediated models in the present study must be tempered by the inability to establish causality with the present data. Conclusions based on this study's mediation analyses are tentative until they can be replicated with longitudinal data.

A conceptual limitation of the present study, and the memory complaint literature in general, is that models of SMC typically only include biological, neuropsychological, and psychological variables. Memory complaints might be better accounted for by a more complex and nuanced model of causation. For example, Jylhä (2009) highlighted the importance of cultural context, social comparison, health expectations, personal health history, disease/illness knowledge, and individual differences in interoception in her model of subjective health evaluations. One study comparing geriatric nurses and childcare workers, matched for sociodemographic characteristics and dementia knowledge, found that geriatric nurses indicated higher levels of dementia worry than childcare workers (Kessler, Tempel, & Werner-Wahl, 2014). Although dementia worry is not synonymous with SMC, it suggests how social factors influence dementia worry, which could inform how older adults interpret subjective memory failures. In addition to new variables, SMC research should hypothesize alternative pathways of causation for SMC. For example, one study found that health variables such as increased respiratory illness, and personality variables such as, increased conscientiousness predicted decreased and increased effort in implementing memory compensation strategies, respectively (de Frias, Dixon, & Bäckman, 2003). Thus, SMC could represent the failure to sustain adequate effort in the implementation of memory compensation strategies due to illness, low conscientiousness, or myriad other factors.

Future Directions

Future research on executive function, the Big Five, and SMC should employ longitudinal designs to better understand the chain of causation among these variables. In addition, a multimethod-multrait approach, potentially using self-reported memory, proxy-ratings of memory complaints, and laboratory measures executive function could be employed to attenuate method variance and provide a more complex picture of SMC. Future research in this area should work to expand the causal model of SMC by incorporating novel variables such as Alzheimer's disease knowledge, use of memory compensation strategies, and normative expectations regarding aging and cognition. These innovations are necessary in order to inform appropriate clinical responses to healthy older adults with SMC.

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Tables

Table 1. Sample characteristics ($N = 180$)

	Summary Value	Cronbach's Alpha Point Estimate [95%CI]	Skewness	Kurtosis
Gender (% female)	50	-	-	-
Age, M (SD)	77.28 (7.00)	-	-	-
Education, M (SD)	16.27 (2.43)	-	-	-
Physical Limitation M (SD)	0.29 (0.27)	0.95 [0.94-0.96]	0.83	2.52
Neuroticism scale, M (SD)	0.27 (0.19)	0.84 [0.78-0.88]	-	-
N: Anxiety	0.29 (0.21)	0.82 [0.76-0.86]	0.49	2.40
N: Depression	0.22 (0.22)	0.60 [0.44-0.72]	1.12	3.87
Conscientiousness scale, M (SD)	0.79 (0.17)	0.84 [0.78-0.88]	-	-
C: Order	0.73 (0.24)	0.69 [0.54-0.79]	-0.85	2.89
C: Self-Discipline	0.81 (0.16)	0.76 [0.67-0.82]	-1.15	4.53
Openness scale, M (SD)	0.68 (0.16)	0.78 [0.72-0.83]	-	-
O: Aesthetics	0.65 (0.25)	0.81 [0.75-0.86]	-0.37	2.10
O: Ideas	0.69 (0.17)	0.77 [0.70-0.82]	-0.72	3.21
Extraversion scale, M (SD)	0.59 (0.20)	0.79 [0.73-0.84]	-	-
E: Assertiveness	0.53 (0.22)	0.78 [0.71-0.83]	0.11	2.28
E: Activity	0.65 (0.24)	0.77 [0.67-0.84]	-0.60	2.55
Agreeableness scale, M (SD)	0.82 (0.14)	0.79 [0.70-0.85]	-	-
A: Altruism	0.82 (0.15)	0.70 [0.57-0.79]	-1.28	4.81
A: Compliance	0.82 (0.16)	0.63 [0.48-0.73]	-1.00	3.74
Retrospective MC scale, M (SD)	0.29 (0.13)	0.83 [0.78-0.87]	0.56†	2.65††
Prospective MC scale, M (SD)	0.32 (0.17)	0.80 [0.73-0.85]	0.34†	2.10††
DEX scale, M (SD)	0.21 (0.13)	0.90 [0.86-0.92]	0.97	3.84

† Value represents mean skew of items comprising scale, RMC SD = 0.36, PMC SD = 0.27
†† Value represents mean kurtosis of items comprising scale, RMC SD = 0.64, PMC SD = 0.51

Table 2. Fit and model information for EFA solutions for the DEX

Study	χ^2	*df*	RMSEA 90% CI	CFI	TLI	Range of Covariances	Number of Factors	Items Excluded
Amieva, et al., 2003	252.946	154	0.06 0.046 0.073	0.895	0.871	0.724 – 1.008	5	-
Chan, 2001	211.298	126	0.061 0.047 0.076	0.886	0.861	-0.704 – 0.982	5	6, 10
Mooney et al., 2006	198.012	144	0.046 0.029 0.061	0.934	0.922	0.669 – 0.928	4	-
Simblett & Bateman, 2011	219.056	116	0.07 0.056 0.084	0.863	0.839	0.924 – 1.021	3	6
Wilson et al., 1996.	147.708	86	0.063 0.045 0.080	0.885	0.86	0.950 – 1.081	3	1, 4, 10, 17

Table 3 Correlation matrix for variables included in SEM analyses

				Neuroticism		Conscientiousness		Agreeableness		Openenss		Extraversion		Retrospective MC					Prospective MC			
	Age	Edu.	Phys. Lim.	Dep.	Anx.	Order	Self-Disc.	Altru.	Compli.	Aesth	Ideas	Assert	Active	RMC1	RMC2	RMC3	RMC4	RMC5	PMC1	PMC2	PMC3	DEXtotal
Age	1																					
Edu.	-0.07	1																				
Phys.Lim.	**0.29**	0	1																			
N.Dep.	0.08	0.02	**0.32**	1																		
N.Anx.	0.1	-0.1	**0.3**	**0.61**	1																	
C.Order	-0.1	-0.11	**-0.19**	**-0.37**	**-0.31**	1																
C.Self-Disc.	**-0.19**	0.01	**-0.41**	**-0.52**	**-0.47**	**0.73**	1															
A.Atru.	-0.08	0.04	-0.15	**-0.47**	**-0.35**	**0.19**	**0.23**	1														
A.Compli.	0.05	0.02	-0.1	**-0.49**	**-0.4**	0.12	**0.23**	**0.6**	1													
O.Aesth	-0.07	**0.25**	-0.06	-0.07	-0.04	-0.06	0.01	**0.21**	**0.21**	1												
O.Ideas	-0.15	**0.23**	**-0.25**	**-0.34**	**-0.42**	**0.16**	**0.3**	**0.21**	0.1	**0.36**	1											
E.Assert	-0.07	0.06	-0.11	**-0.24**	**-0.23**	0.13	**0.23**	**0.29**	0.05	0.08	**0.35**	1										
E.Active	**-0.24**	0.06	**-0.51**	**-0.47**	**-0.43**	**0.29**	**0.55**	**0.37**	**0.17**	0.15	**0.5**	**0.4**	1									
RMC1	**0.25**	-0.02	**0.26**	**0.26**	**0.29**	**-0.32**	**-0.44**	**-0.28**	-0.16	-0.12	**-0.27**	**-0.28**	**-0.45**	1								
RMC2	0.12	0.09	**0.22**	**0.34**	**0.26**	**-0.31**	**-0.41**	**-0.17**	**-0.17**	-0.09	**-0.2**	**-0.25**	**-0.3**	**0.53**	1							
RMC3	**0.31**	-0.12	**0.23**	0.08	0.04	**-0.16**	**-0.18**	-0.13	0.07	**-0.2**	-0.12	-0.11	**-0.25**	**0.52**	**0.49**	1						
RMC4	**0.16**	-0.01	**0.25**	**0.4**	**0.35**	**-0.34**	**-0.44**	**-0.29**	-0.15	-0.03	**-0.2**	**-0.29**	**-0.35**	**0.57**	**0.67**	**0.54**	1					
RMC5	0.15	0.04	0.16	**0.31**	**0.22**	**-0.28**	**-0.32**	-0.09	-0.15	0.1	-0.1	0.02	**-0.23**	**0.37**	**0.48**	**0.33**	**0.43**	1				
PMC1	0.08	0.04	**0.24**	**0.17**	**0.22**	**-0.32**	**-0.33**	-0.07	-0.01	-0.02	-0.15	**-0.18**	**-0.28**	**0.44**	**0.46**	**0.33**	**0.46**	**0.25**	1			
PMC2	0.07	0.04	0.16	**0.19**	0.16	**-0.23**	**-0.22**	**-0.19**	-0.16	0.01	-0.12	-0.14	**-0.21**	**0.49**	**0.45**	**0.44**	**0.34**	**0.32**	**0.6**	1		
PMC3	0.15	0.02	**0.21**	**0.2**	**0.29**	**-0.32**	**-0.39**	-0.04	-0.09	-0.04	-0.15	-0.14	**-0.32**	**0.36**	**0.48**	**0.34**	**0.33**	**0.44**	**0.58**	**0.54**	1	
DEXtotal	**0.23**	-0.02	**0.38**	**0.62**	**0.54**	**-0.46**	**-0.63**	**-0.45**	**-0.47**	-0.14	**-0.32**	**-0.28**	**-0.5**	**0.51**	**0.61**	**0.37**	**0.62**	**0.46**	**0.34**	**0.36**	**0.36**	1

Bold correlations, $p < 0.05$

Table 4. Model fit and test of invariance summary for gender

Model	χ^2	*df*	RMSEA 90% CI	CFI	TLI	BIC	AIC
Measurement (Parcels)	291.49	167	0.08 [0.06-0.09]	0.91	0.88	-2095.70	-2338.12
Measurement (Single Indicator)	205.56	131	0.07 [0.05 0.08]	0.93	0.91	-1677.19	-1899.64
Mult. Regression	230.86	182	0.05 [0.03-0.06]	0.95	0.93	-171.22	-433.51
Mult. Regression Trimmed	241.45	192	0.05 [0.03-0.06]	0.95	0.94	-208.28	-442.36
Single Criterion EF	234.86	182	0.05 [0.03-0.07]	0.94	0.93	-167.05	-429.33
Single Criterion EF Trimmed	244.83	196	0.05 [0.02-0.06]	0.95	0.94	-223.16	-445.96
Model	χ^2	*df*	RMSEA	CFI	TLI	BIC	AIC
Configural	367.15	256	0.08 [0.06-0.10]	0.90	0.87	-1401.80	-1863.83
Weak	387.56	268	0.08 [0.06-0.10]	0.90	0.87	-1436.14	-1863.95
Strong	395.54	279	0.08 [0.06-0.10]	0.90	0.88	-1484.20	-1880.64
Strong + Means	398.87	287	0.08 [0.06-0.10]	0.90	0.89	-1517.27	-1890.89
Test	$\Delta\chi^2$	Δ*df*	ΔRMSEA	ΔCFI	*p-value*		
Weak vs. Configural	19.81	12	0	0	0.23		
Strong vs. Weak	5.27	11	0	0	0.92		
Strong vs. Strong + Means	6.12	8	0	0	0.63		

Table 5. Standardized measurement model factor loadings and covariances.

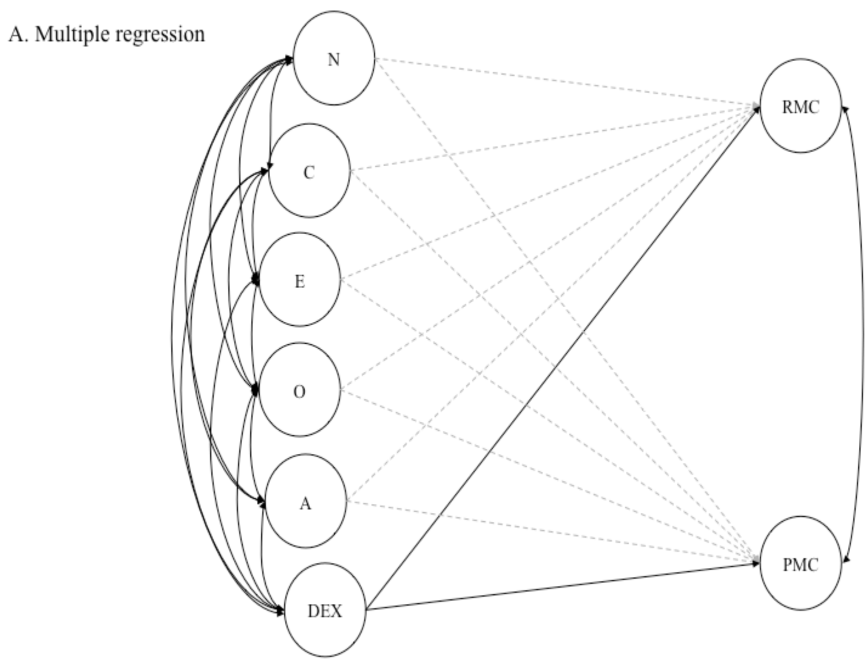
Parameter					
Factor		Indicator	λ	*SE*	*p-value*
Neuroticism	on	Depression	0.79	0.02	0.00
Neuroticism	on	Anxiety	0.77	0.02	0.00
Conscientiousness	on	Self-Disc.	0.98	0.01	0.00
Conscientiousness	on	Order	0.69	0.01	0.00
Agreeableness	on	Altruism	0.77	0.01	0.00
Agreeableness	on	Compliance	0.75	0.01	0.00
Openness	on	Aesthetics	0.54	0.02	0.00
Openness	on	Ideas	0.83	0.02	0.00
Extraversion	on	Assertiveness	0.62	0.02	0.00
Extraversion	on	Active	0.73	0.02	0.00
DEX	on	DEXtotal	1.00	0.01	0.00
RMC	on	RMC1	0.74	0.02	0.00
RMC	on	RMC2	0.84	0.01	0.00
RMC	on	RMC3	0.64	0.02	0.00
RMC	on	RMC4	0.84	0.01	0.00
RMC	on	RMC5	0.56	0.02	0.00
PMC	on	PMC1	0.80	0.01	0.00
PMC	on	PMC2	0.78	0.02	0.00
PMC	on	PMC3	0.73	0.02	0.00
Parameter			*r*	SE	*p*-value
Agreeableness	with	Extraversion	0.45	0.13	0.00
Agreeableness	with	Openness	0.37	0.15	0.01
Agreeableness	with	PMC	-0.19	0.13	0.15
Agreeableness	with	RMC	-0.27	0.10	0.01
Agreeableness	with	DEX	-0.60	0.08	0.00
Conscientiousness	with	Agreeableness	0.35	0.11	0.00
Conscientiousness	with	DEX	-0.66	0.06	0.00
Conscientiousness	with	Extraversion	0.67	0.09	0.00
Conscientiousness	with	Openness	0.32	0.12	0.01
Conscientiousness	with	PMC	-0.41	0.09	0.00
Conscientiousness	with	RMC	-0.52	0.07	0.00
DEX	with	PMC	0.48	0.09	0.00
DEX	with	RMC	0.72	0.05	0.00
Extraversion	with	DEX	-0.68	0.10	0.00
Extraversion	with	PMC	-0.49	0.11	0.00
Extraversion	with	RMC	-0.59	0.08	0.00
Neuroticism	with	Agreeableness	-0.76	0.11	0.00
Neuroticism	with	Conscientiousness	-0.62	0.09	0.00
Neuroticism	with	DEX	0.74	0.06	0.00
Neuroticism	with	Extraversion	-0.76	0.10	0.00
Neuroticism	with	Openness	-0.59	0.13	0.00
Neuroticism	with	PMC	0.35	0.12	0.00
Neuroticism	with	RMC	0.48	0.08	0.00
Openness	with	DEX	-0.40	0.12	0.00
Openness	with	Extraversion	0.82	0.10	0.00
Openness	with	PMC	-0.23	0.11	0.04
Openness	with	RMC	-0.35	0.09	0.00
RMC	with	PMC	0.72	0.07	0.00

Table 6. Mediation parameter estimates and significance.

Factor	Path/effect	Bootstrap Estimate		95% CI		
		B	SE	CI Upper	CI Lower	p value
Neuroticism	c_{PMC}	0.57	0.13	0.87	0.34	0
	c_{RMC}	0.4	0.15	0.77	0.17	0
	a	1.04	31.32	1.65	0.7	0.98
	b_{PMC}	0.74	0.17	0.64	-0.02	0.06
	b_{RMC}	0.74	0.19	0.38	1.1	0.00
	c'_{PMC}	0.03	0.34	-0.38	0.61	0.93
	c'_{RMC}	-0.13	0.44	-0.6	0.34	0.34
	$a*b_{PMC}$	0.34	0.28	0.003	0.69	0.00
	$a*b_{RMC}$	0.77	0.44	0.42	1.32	0.08
Conscientiousness	c_{PMC}	-0.43	0.12	-0.37	-0.76	0.00
	c_{rMC}	-0.56	0.1	-0.21	-0.68	0.00
	a	-0.75	0.16	-0.46	-1.1	0.00
	b_{PMC}	0.3	0.12	0.54	0.05	0.01
	b_{RMC}	0.72	0.13	0.98	0.48	0.00
	c'_{PMC}	-0.2	0.15	0.08	-0.52	0.19
	c'_{RMC}	-0.1	0.13	0.16	-0.33	0.42
	$a*b_{PMC}$	-0.22	0.1	-0.04	-0.44	0.03
	$a*b_{RMC}$	-0.54	0.13	-0.32	-0.83	0.00
Extraversion	c_{PMC}	-0.51	0.16	-0.26	-0.9	0.00
	c_{RMC}	-0.61	0.35	-0.35	-1.01	0.08
	a	-0.76	37	-0.31	-1.84	0.98
	b_{PMC}	0.22	0.22	0.51	-0.1	0.86
	b_{RMC}	0.66	5.34	0.22	1.03	0.90
	c'_{PMC}	-0.34	21.38	-0.03	-0.9	0.99
	c'_{RMC}	-0.22	15.28	0.23	-0.66	0.99
	$a*b_{PMC}$	-0.17	4.56	0.07	-0.49	0.97
	$a*b_{RMC}$	-0.5	18.14	-0.24	-1.16	0.98
Agreeableness	c_{PMC}	-0.19	2.5	0.08	-0.52	0.94
	c_{RMC}	-0.32	0.67	-0.08	-0.6	0.63
	a	-0.75	0.5	-0.45	-1.28	0.13
	b_{PMC}	0.51	1.01	0.79	0.28	0.61
	b_{RMC}	0.97	5.9	0.14	0.69	0.87
	c'_{PMC}	0.22	3.64	0.64	-0.14	0.95
	c'_{RMC}	0.36	12.8	0.97	-0.01	0.98
	$a*b_{PMC}$	-0.39	3.83	-0.2	-0.8	0.92
	$a*b_{RMC}$	-0.73	15.35	-0.42	1.51	0.96
Opneness	c_{PMC}	-0.25	0.14	-0.01	-0.6	0.08
	c_{RMC}	-0.39	5.37	-0.15	-0.82	0.94
	a	-0.29	25.98	0.01	-0.71	0.99
	b_{PMC}	0.45	0.86	0.71	0.2	0.6
	b_{RMC}	0.89	2.63	1.21	0.6	0.74
	c'_{PMC}	-0.06	2.27	0.237	-0.35	0.98
	c'_{RMC}	-0.9	3.62	0.01	-0.64	0.98
	$a*b_{PMC}$	-0.13	2.42	-0.001	-0.413	0.96
	$a*b_{RMC}$	-0.26	4.23	0.01	-0.64	0.95

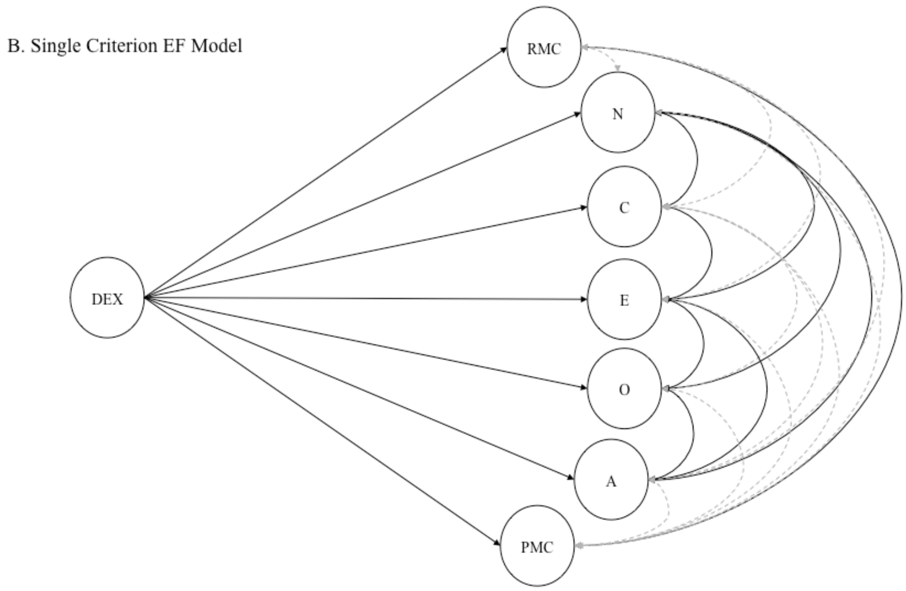
Figures

Figure 1.



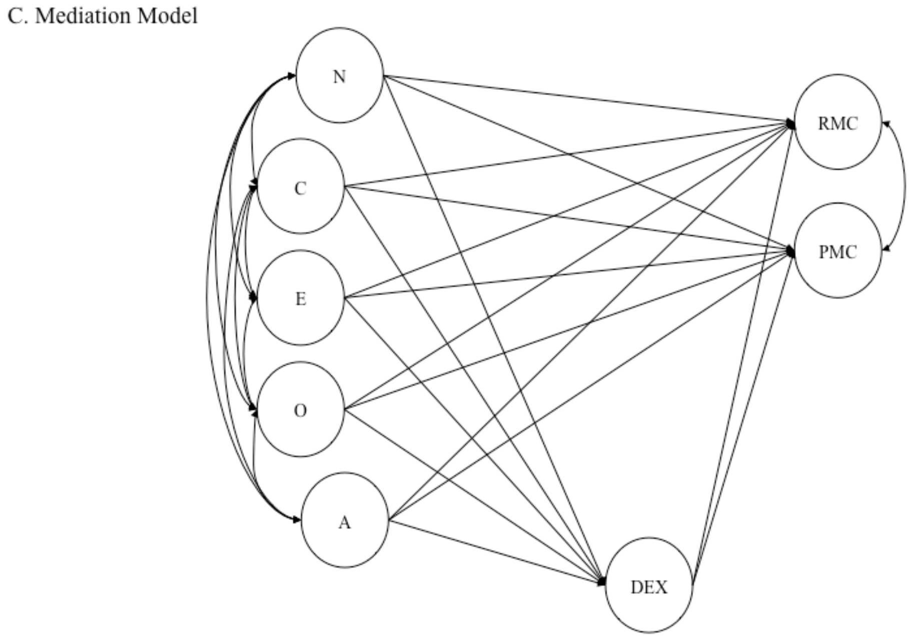
Note: Gray dashed lines indicate non-significant paths that were constrained to equal 0.

Figure 2.



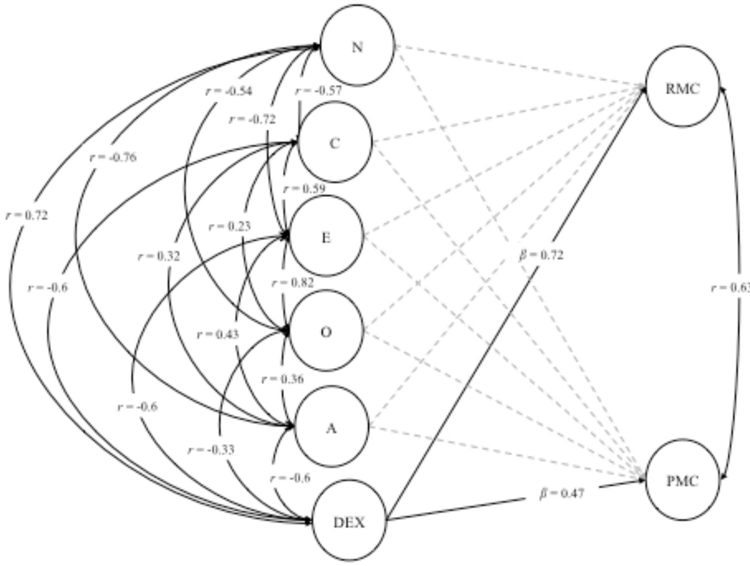
Note: Gray dashed lines indicate non-significant paths that were constrained to equal 0.

Figure 3.



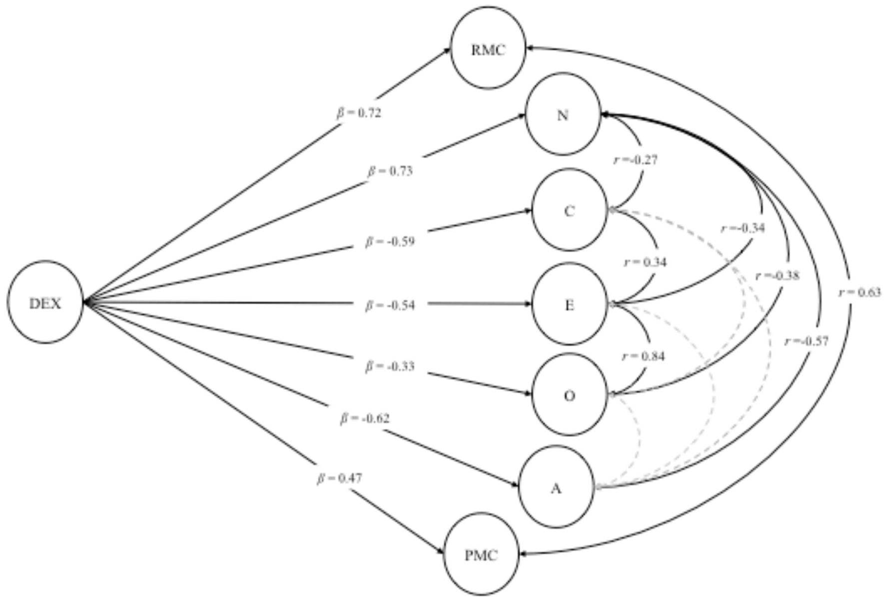
Note: This model resulted in inflated standard errors and confidence intervals indicating poor parameter estimability. Results from this model were not retained (see Results section).

Figure 4. Multiple regression SEM parameter estimates.



Note: Gray dashed lines indicate non-significant paths that were constrained to equal 0.

Figure 5. Single-criterion EF SEM parameter estimates



Note: Gray dashed lines indicate non-significant paths that were constrained to equal 0.

Figure 6. Mediation model: neuroticism.

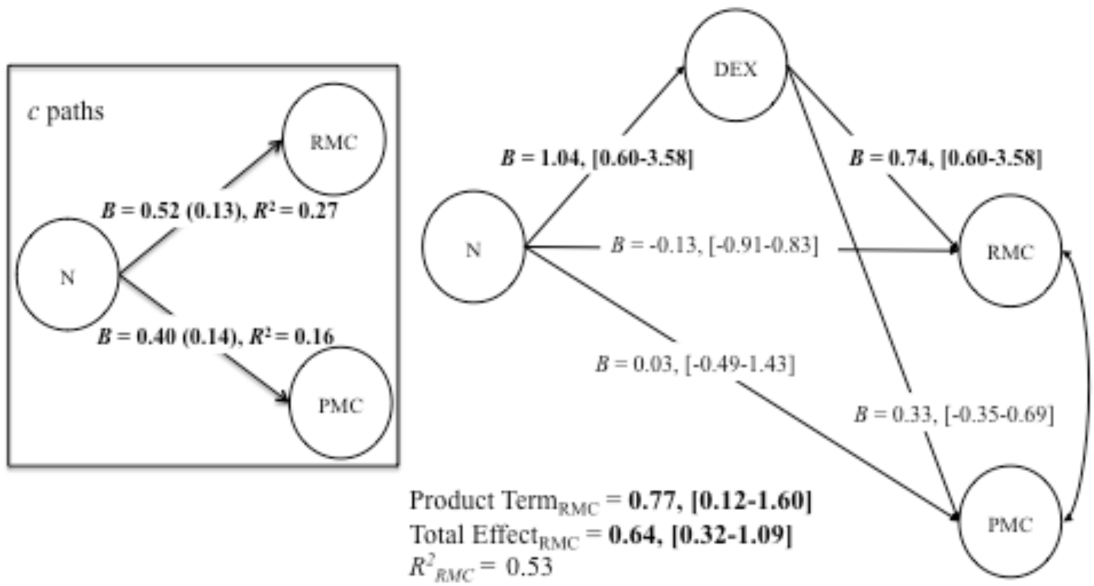


Figure 7. Mediation model: conscientiousness.

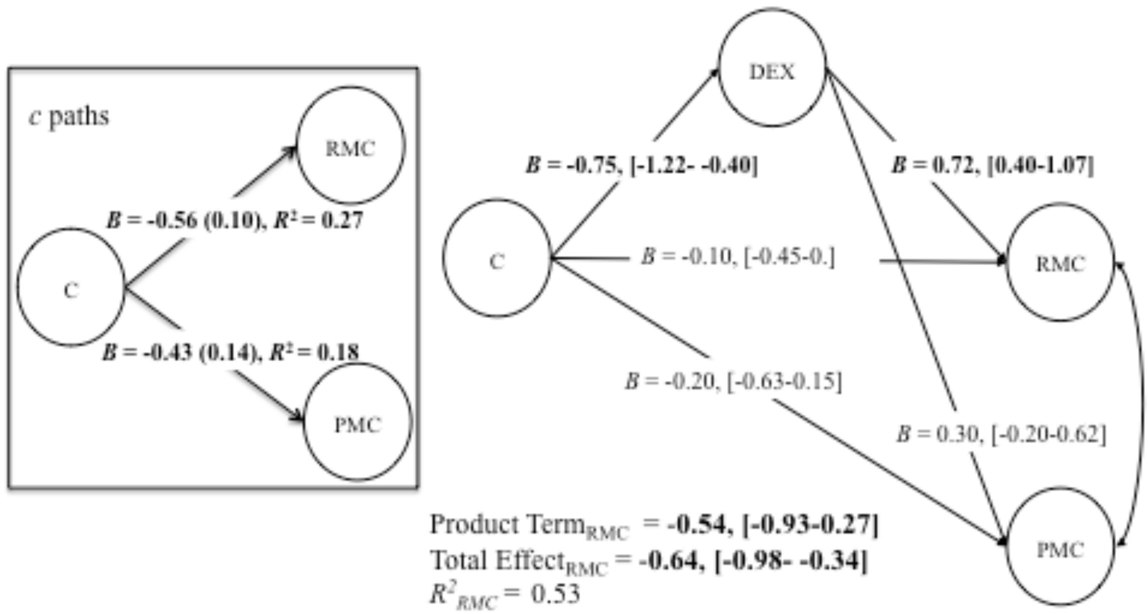
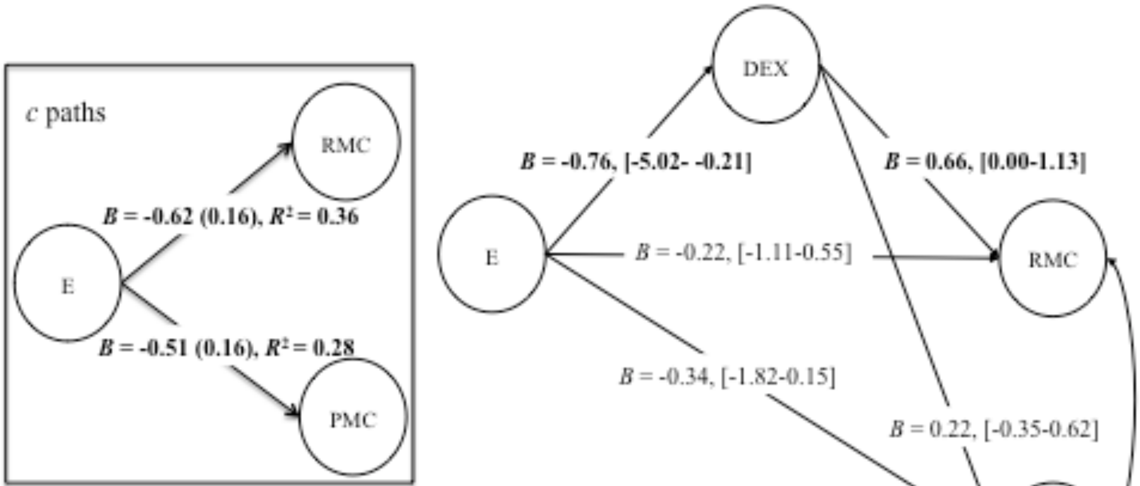


Figure 8. Mediation model: extraversion.



Product Term$_{RMC}$ = **-0.72, [-1.22- -0.30]**
Total Effect$_{RMC}$ = **-0.72,[-1.22- -0.30]**
R^2_{RMC} = 0.55

Figure 9. Mediation model: agreeableness.