Chapter 11
Personality and Cognitive Health in Aging

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11.1 Introduction

The world is getting older. Both the absolute number of older adults and the relative proportion of older adults in the population is increasing dramatically around the entire world (World Health Organization, 2015). Because of this, the age distribution across much of the world has shifted away from the classic 'population pyramid'—with a larger concentration of younger adults and a diminishing population of older adults—to a 'population rectangle' reflecting an increasingly growing segment of the population aged 65 and older. With this aging society comes growing concerns about the effects of senescence on cognitive and brain health. Indeed, adults in midlife, as young as their 40's, hold serious concerns about cognitive functioning, and many hold quite pessimistic views about maintaining brain health into old age (e.g., Vaportzis & Gow, 2018). Although one of the primary health concerns of older adults' centers on the development of Alzheimer's disease (AD) and related dementias, even in the absence of any neurodegenerative diseases, many aspects of cognitive functioning show normative changes in healthy adult development.

The normative senescence process brings about diffuse changes in many dimensions of brain and cognitive functioning in healthy aging. One of the most robust findings in the cognitive aging literature is the demonstration of negative age-related trajectories for cognitive abilities, including episodic memory (Park et al., 1996), working memory (Bopp & Verhaeghen, 2005), processing speed (Eckert, 2011; Salthouse, 1996; Salthouse & Madden, 2013), reasoning (Schaie, 1996), and

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executive control (Braver & West, 2008). Indeed, a general picture of normal cognitive aging is marked by decline in this constellation of highly-interrelated cognitive abilities, often termed "mental mechanics" or "fluid" cognitive abilities, those that require the ability to maintain and quickly transform information and effectively control attention (Deary, Penke, & Johnson, 2010). At the same time, not all cognitive functions change the same with advancing age. In other domains, a maintenance of functioning or even improvement, is observed in so-called "crystallized" intelligence, including world knowledge and verbal semantic memory (Salthouse & Ferrer-Caja, 2003). With advancing age, literate adults show preserved long-term memory for verbal information, including scoring upwards of 1 standard deviation above their younger counterparts in vocabulary assessments (Verhaeghen, 2003), as well as showing evidence for preserved semantic priming, reflecting efficient retrieval of lexical information in aging (Payne, Gao, Noh, Anderson, & Stine-Morrow, 2012; Federmeier, Van Petten, Schwartz, & Kutas, 2003; Lien et al., 2006). AU3 This divergent set of developmental trajectories, in which fluid abilities show negative age-related trajectories while crystallized abilities are maintained or grow, is one of the most well-replicated patterns of developmental change, observed both cross-sectionally and longitudinally (e.g., Salthouse, 2019).

Within these average developmental trajectories of change, there exist large individual differences in trajectories of cognitive change such that some individuals are able to maintain high levels of cognitive functioning until late in life while others show accelerated and abnormal rates of decline (Hertzog, Kramer, Wilson, & Lindenberger, 2008; Salthouse, 1996, 2019; Salthouse & Ferrer-Caja, 2003; Salthouse & Madden, 2013). Moreover, there exists substantial inter-individual variability in risk for the development of *non-normative* trajectories of cognitive aging, a term we will use throughout to broadly refer to both the development of probable dementia or clinically-relevant cognitive impairment. For instance, a growing literature shows that individuals vary considerably in the degree to which accumulating AD neuropathology manifests itself in terms of functional impairment in cognitive performance. This has led researchers to the argue that some individuals have greater neural or cognitive "reserve" capacity than others (for reviews see e.g., Manly, Touradji, Tang, & Stern, 2003; Stern, 2012; Stine-Morrow, Parisi, Morrow, & Park, 2008). Indeed, a substantial focus of the cognitive aging literature has been to identify the risk and protective factors that may be responsible for this considerable heterogeneity in trajectories of cognitive function in aging, with the goal of harnessing this information to create interventions to promote cognitive and brain health (see Hertzog et al., 2008; Smith, 2016). What are these pathways for cognitive enrichment in the face of normative decline? Several factors such as cardiovascular health, diet, fitness, social engagement, literacy ability, educational attainment, adult occupational complexity, and lifestyle have all appeared as important protective factors underlying maintenance of cognitive function and increased reserve capacity in older adulthood (Smith, 2016).

Important in this discussion then is understanding the mechanisms that can promote such healthy and engaging lifestyles in old age. Given that personality plays a role in lifestyle behaviors, discussions regarding the potential that personality traits

and dispositional characteristics may play in shaping trajectories of cognitive aging are growing. Recently, Hill and Payne (2017) outlined the need for researchers to more thoughtfully consider the role of personality, attitudes, beliefs, and other dispositional characteristics in research on cognitive aging and dementia prevention. Hill and Payne (2017) conceptualized of personality as a (1) *predictor* of concurrent cognitive ability in older adulthood, cognitive decline, and risk for cognitive impairment in aging, (2) as a *precursor* to cognitive health risks in aging, and (3) as a *promoter* of (cognitive) intervention responsiveness and adherence. We aim to expand upon this outline, providing further justification and evidence highlighting the 'three P's' underlying the relationships between personality and cognitive aging.

~~11.1.1~~ *Personality as a Predictor of Cognitive Health in Aging*

~~11.1.1.1~~ Personality-Cognitive Ability Correlations

A growing research base has now established consistent relationships between personality traits and individual differences in concurrent cognitive functioning and subsequent cognitive change in aging (Sutin et al., 2019). Some of the first studies examining concurrent personality-cognition relationships focused on relationships between personality and gross-scale measures of aptitude and fluid intelligence in young adults (Ackerman & Heggestad, 1997; Lorge, 1940). Much of this early work was motivated by the desire to show that dimensions of personality assessments were not completely reducible to measures of intellectual ability or cognitive function, but rather that measures of personality, cognitive functioning, and intellectual interests formed partially overlapping 'trait complexes' (Ackerman & Heggestad, 1997). In Lorge's (1940) first review, median effect sizes between measures of intellectual functioning and personality traits were r = .04, with effects ranging from +.079 to −.049 across assessments. Similarly, in a meta-analysis of over 100 studies and 2000 correlations in non-clinical samples, Ackerman and Heggestad (1997) found small (effects rarely exceeded r =. 20) but statistically significant correlations between ability and personality for about half of the relationships they examined. Despite the modest effect sizes, two clear trends emerged. First, there were consistent negative associations between traits associated with neuroticism and intellectual ability. Second, positive relationships were more consistently observed for openness and intellectual engagement, particularly for abilities loading on crystallized intelligence and knowledge. Following these initial meta-analyses, more systematic examinations of personality and cognition relationships have been explored.

Schaie, Willis, and Caskie (2004) provided one of the first systematic examinations of concurrent and longitudinal relationships between cognition and personality in older adults, in a cohort of over 2000 adults from the Seattle Longitudinal Study. Measures of reasoning, spatial cognition, psychomotor speed, numeracy, verbal ability, and memory were examined as a function of individual differences in a wide range of personality traits, including Big Five traits as well as a broader

13-dimensional factor model derived from the Test of Behavioral Rigidity, including traits such as *honesty, interest in science,* and *conservativism.* Similar to Ackerman and Heggestad's meta-analysis, results showed small-to-modest relationship between personality and cognitive function, with the exception of openness, which showed larger effect sizes (r = .3–.4 range) with measures of fluid and crystallized ability. Similarly, Soubelet and Salthouse (2011) found consistent relationships between openness and measures of reasoning and verbal episodic memory in a large sample of over 2000 adults ranging in age between 18–96 years old. Interestingly, they found that personality-cognition relationships were largely similar across age-range, with similar effect sizes in younger, middle-aged, and older adults. Moreover, higher neuroticism emerged as a ~~smaller~~ but reliable negative predictor of cognitive functioning. Perhaps unsurprisingly then, given the shared relationships between trait openness and intellect, higher endorsement of openness to experiences is associated with better cognitive performance across the lifespan. Although findings with conscientiousness have been less consistent than those of openness and neuroticism, findings do suggest that higher conscientiousness is weakly associated with better cognitive functioning.

Part of this inconsistency in the literature may be due in part to differences in the factors leading to relationships between cognitive functioning and trait conscientiousness. For example, some evidence suggests that conscientiousness is positively related to cognitive abilities because it influences health behaviors, which, in turn, are protective against age–related declines in brain and cognitive functioning (e.g., Sutin et al., 2011, 2019). On the other hand, conscientiousness has been negatively linked to cognitive functions, potentially because individuals with lower cognitive abilities may become more hardworking and organized over time in order to compensate for their lower functionality (Chamorro-Premuzic, Furnham, & Moutafi, 2004; Moutafi, Furnham, & Crump, 2003; Moutafi, Furnham, & Paltiel, 2004; Rammstedt, Danner, & Martin, 2016; c.f. Murray, Johnson, McGue, & Iacono, 2014).

In contrast, effects of extraversion and agreeableness have been less consistently found to relate to cognitive abilities (Curtis, Windsor, & Soubelet, 2015). Although these effect sizes tend to be modest across studies, an excellent meta-analysis by Luchetti, Terracciano, Stephan, and Sutin (2016) showed that these associations were generally larger than that of many risk factors currently well-understood to impact cognitive health in aging– including hypertension, diabetes, obesity, smoking, and physical inactivity. These findings suggest that there are reliable relationships between personality and cognitive health and aging.

~~11.1.1.2~~ Personality and Cognitive Impairment in Aging

A companion literature has begun exploring the role that personality plays in non-normative cognitive aging, including in dementia and mild cognitive impairment. The term dementia describes a cluster of symptoms associated with cognitive deficits that are severe enough to impact everyday activities of daily living. Alzheimer's dementia, the most commonly diagnosed dementia, is a progressive

neurodegenerative disease comprising of severe deficits in multiple cognitive domains, including memory, reasoning, language processing and production, and executive functioning, in addition to emotional and behavioral symptoms. Mild cognitive impairment (MCI) is a transient pre-demented state that occurs between normal and pathological cognitive aging, marked by a concern regarding a change in cognition, an impairment in one or more cognitive domains, but a relative preservation of independence of functional abilities.

A meta-analysis by Terracciano et al. (2014) found evidence for consistent relationships between Neuroticism, Conscientiousness, and risk for Alzheimer's dementia. Individuals in the top quartile of Neuroticism or the lowest quartile of Conscientiousness had a 3-fold increased risk of incident AD. Conscientiousness may hold particular importance for predicting patterns of cognitive aging, because conscientious individuals may engage in more memory recall and long-term planning, to maintain their dispositionally organized and self-controlled manner. There were also weaker but significant effects for openness and agreeableness. This literature suggests that personality may have unique predictive capacity for clinically significant cognitive impairment over and above cross-sectional associations with cognitive performance. As such, recent work has begun to focus on relationships between personality and risk factors associated with dementia and MCI development in aging (for a review see Segerstrom, 2018 and Terracciano & Sutin, 2019).

In previous work, Payne and Stine-Morrow (2018) have also applied a novel psychometric approach to determining risk for amnestic and non-amnestic variants of mild cognitive impairment (MCI) in a large community-based sample, based on performance across a wide battery of neuropsychological tests (N = 461). In this study, based on performance across a large sample of neuropsychological tasks (see Payne & Stine-Morrow, 2014 for more information), participants were classified for increased risk for amnestic (memory-specific) or (single- or multi-domain) non-amnestic MCI. Adults displaying significant impairment (at least 1 SD below average) in at least one non-memorial cognitive domain (such as reasoning, or visuospatial ability) were classified as at increased risk for non-amnestic MCI, while participants who showed impairment only in tasks assessing episodic memory (<1 SD below average) were classified as at increased risk for amnestic MCI. Such psychometric classification schemes have shown to be predict longitudinal conversion to AD (Cook et al., 2013), and show high overlap with clinical consensus (Clark et al., 2013).

In this study, Payne and Stine-Morrow observed an interesting dissociation between personality traits and risk for amnestic and non-amnestic variants of MCI. Those at higher risk for non-amnestic MCI displayed lower trait openness and also higher agreeableness. However, those with a memory-specific impairment had reliably lower conscientiousness. Interestingly, this was also one of the few studies to implicate trait agreeableness as a risk factor for pathological cognitive aging (see also Terracciano et al., 2014), and suggest that such multivariate assessments of cognitive impairment may have unique predictive capacity compared to typical correlational approaches to assess personality and specific cognitive domains. Overall,

these findings suggest that personality traits may be useful indicators for different clinically-relevant risk factors of cognitive impairment in aging.

~~11.1.1.3~~ Memory Self-Efficacy in Aging

Although most of the existing work on personality-cognition relationships has focused on the Big Five personality traits, likely given their broad application across samples (John, Naumann, & Soto, 2008), there are a number of other important dispositional traits to consider in differential studies of cognitive aging. For instance, individuals vary considerably in their beliefs and self-appraisals of their own cognitive capabilities. In older adulthood, context-independent self-appraisals of one's own memory status are a stable trait-like dimension (Bandura, 1989; Berry & West, 1993). Importantly, while memory beliefs correlate with memory performance, they are not solely reflective of accurate meta-cognitive appraisals of ones' own memory status. A meta-analysis of over 100 studies by Beaudoin and Desrichard (2011) estimated a reliable but quite modest relationship between subjective memory beliefs and objective memory performance (r = .15) with substantial heterogeneity in effect sizes across studies, which shows the relevance of self-concepts in understanding cognitive functioning.

A major topic in the literature on cognitive self-efficacy beliefs revolves around the domain generality of such 'trait' or 'global' measures (see e.g., Hertzog and Pearman, 2013; Hertzog McGuire, Horhota, & Jopp, 2010). Although memory self-efficacy beliefs appear to be relatively stable longitudinally, some studies have shown that global measures of memory beliefs are associated with depression and the endorsement of negative personality traits (e.g., neuroticism). This has led some to argue that global memory belief measures show relationships with observed cognitive performance in part due to developmental changes in emotional and personality characteristics over the lifespan (Hertzog and Pearman, 2013; Pearman & Storandt, 2004).

Building on this literature, some studies (Amariglio, Townsend, Grodstein, Sperling, & Rentz, 2011; Haslam et al., 2012; Jopp & Hertzog, 2007; Payne et al., 2017) have begun exploring broader relationships between memory beliefs and cognitive performance, outside of the narrow scope of memory performance alone. For example, Payne et al. (2017) used bi-factor structural equation models to parse the shared and independent variance among cognitive factors representing episodic memory, psychomotor speed, executive reasoning, and general fluid cognition (g) and further, to explore the relationship between these cognitive factors and concurrent memory self-efficacy beliefs in two large cohort studies of older adults (Senior Odyssey, Stine-Morrow et al., 2014, N = 462; ACTIVE, Ball et al., 2002, N = 2802). First, they examined the simultaneous prediction of memory beliefs from psychomotor speed, reasoning, and memory to test whether memory self-efficacy beliefs were specific to objective memory performance. They found modest relationships between memory beliefs and episodic memory status in both samples. However, accounting for general fluid cognition in the model substantially attenuated the

domain-specific relationships between memory beliefs and memory function. In fact, general fluid cognition was the strongest predictor of memory beliefs in both samples. Such findings suggest that negative self-referent beliefs about memory are not necessarily reflective of specific age-related declines in memory per se. Instead, dispositional memory beliefs appear to reflect individual differences in cognitive status more generally, suggesting that self-reports of memory status have broader predictive validity than was previously believed. Indeed, this interpretation is consistent with research showing that memory beliefs are predictive of adherence and responsiveness in cognitive interventions among older adults that do not explicitly target memory performance (e.g., Payne et al., 2012).

11.1.1.4 Summary

The findings presented in the sections above highlight that personality and dispositional traits have a reliable relationship with cognitive aging. Not only do individual differences in personality predict concurrent cognitive functioning and longitudinal change in cognitive functioning in older adulthood, but certain personality traits may hold additional predictive validity in separating expected cognitive change in aging from non-normative trajectories of change as observed in MCI and AD. Finally, we argue that we need to move beyond the Big Five personality traits often studied in younger adulthood, and to consider personality constructs that are more relevant to later adulthood, including memory self-efficacy. In the next section, we discuss how personality can serve as a precursor of both risk and protective factors in cognitive health over the lifespan.

~~11.1.2~~ *Personality as a Precursor to Risk/Protective Factors in Cognitive Aging*

In a review, Smith (2016) highlighted important candidate factors for offsetting cognitive decline in aging, including physical fitness, positive health behaviors (e.g., smoking cessation), intellectual engagement, diet, and social engagement. These important health behaviors serve as protective factors for maintaining cognitive health in older adulthood. Importantly, research on personality and health behaviors has consistently established personality traits that are predictive of these important behavioral factors (see Hill & Allemand, this edition; Mroczek & Weston, this edition). In short, personality is likely to play a critical role as a precursor of engagement across many of these domains (Hill & Payne, 2017). For example, higher conscientiousness predicts positive health behaviors, such as lower rates of drinking, smoking, and obesity. It may not be surprising then that conscientiousness has emerged as an all-cause predictor of mortality (Turiano, Chapman, Gruenewald, & Mroczek, 2015). Related to this, age-of-onset of several critical diseases can be

predicted by individual differences in trait Conscientiousness, Neuroticism, and Openness (Weston, Hill, & Jackson, 2015).

Small but consistent effects of conscientiousness, openness, extraversion and neuroticism and physical exercise have been established (Wilson & Dishman, 2015). Such a relationship is critical for understanding cognitive and brain health given the strong associations between cardiovascular health, exercise, and neurological integrity in aging (Kramer and Hillman, 2006). Additionally, health literacy and medical adherence are in-and-of themselves complex cognitive behaviors that are both predicted by changes in cognitive functioning and predict sustained cognitive health throughout adulthood (Chin et al., 2015). Previous work (Hill & Roberts, 2011) has shown that higher levels of conscientiousness in older adulthood are associated with better medication adherence, again suggesting that personality traits may be important precursors to health behaviors to maintain effective cognitive functioning throughout adulthood.

Building on Hill and Payne (2017), we propose a conceptual model in which health-relevant personality traits reflect stable dispositional factors that contribute to the propensity to engage in positive health behaviors on a daily basis and maintain such behaviors over time in the face of daily stressors and life events. These positive health and lifestyle factors are likely to accumulate over decades, yielding a net preventive effect on cognitive decline across a range of domains. Although such a model has not been thoroughly empirically tested, there are findings from some domains, notably in intellectual activity engagement, that are consistent with this model (e.g., Jopp and Hertzog, 2007, Soubelet & Salthouse, 2011; Jackson et al., in review).

Findings from the Women's Health and Aging study (Carlson et al., 2012) suggested one such potential pathway between activity engagement and cognitive health. In this study, they showed that individuals who self-reported a greater *variety* of activities, rather than the frequency of engagement in specific intellectually stimulating or cognitively demanding activities, showed improved cognition. A greater variety of participation in activities, regardless of cognitive challenge, was associated with an 8–11% reduction in the risk of impairment in verbal memory and global cognitive outcomes. Furthermore, participation in a variety of lifestyle activities was more predictive than frequency or level of cognitive challenge for significant reductions in risk of incident impairment on measures sensitive to cognitive aging and risk for dementia.

Recently, Jackson and colleagues (under review) revisited the question of whether activity diversity is related to cognitive health outcomes in older adulthood and further examined whether increased activity diversity may be one putative mechanism underlying the relationship between trait openness and cognitive functioning in older adulthood. First, they replicated the finding from Carlson and colleagues showing that the total number of different activities one participates in is more strongly related to a number of cognitive outcomes compared to just the frequency of time spent in any set of activities. This even held true when examining a subset of activities that were judged as most cognitively engaging. Activity diversity reliably predicted composite measures of inductive reasoning, divergent thinking

(i.e., ideational fluency), psychomotor speed, verbal ability, and episodic memory, with effect sizes ranging from .23 to .27. Importantly, they also found that trait openness was positively related to reported activity diversity, but not with the total number of hours spent in all activities or in cognitively demanding activities alone. Putting this altogether, they used bootstrapped mediation tests to examine whether activity diversity mediated the relationship between openness and each cognitive composite. They found evidence that activity diversity partially mediated the relationship between openness and three cognitive composites—inductive reasoning, processing speed, and episodic memory. These findings are valuable as first steps in establishing data consistent with the conceptual model discussed above and provide evidence in support of the idea that personality traits may serve as precursors to positive lifestyle factors that promote cognitive health in older adulthood. At the same time, considerable work remains to further examine such health-behavior and lifestyle mediational pathways between personality and cognition, and examine such relationships longitudinally to attempt to address causal mechanisms.

11.1.2.1 Summary

It is crucial for researchers to more thoughtfully consider the role of personality in future research on cognitive aging, not simply because certain personality traits are correlates of cognitive functioning in older adulthood but because personality may serve as an important and potentially actionable precursor to many health-related behaviors and cognitive health risks in adulthood. In the above section, we highlighted a theoretical model whereby certain personality traits may impact daily life behaviors that have net positive or negative effects on cognitive functioning in adulthood. Although only a small number of studies have empirically tested this model, we view it as a fruitful way forward to understanding the multiple pathways that link personality constructs to patterns of cognitive decline in aging, which will eventually help us to understand how we may personally individualize interventions to promote cognitive health in adulthood. This is the topic of our final section, below.

11.2 Personality and Intervention Promotion

In the prior section, we considered the degree to which personality may shape patterns of positive health behaviors and activities over the lifespan in such a way to promote cognitive health. Another important consideration through which personality may relate to cognitive health is through promoting engagement in targeted interventions designed to improve the cognitive functioning of older adults. In fact, there is a small but growing literature highlighting the seemingly powerful role that individual differences in personality traits play in cognitive interventions. Below, we review several recent and diverse examples that suggest individual differences in personality could moderate the efficacy of interventions designed to target cognitive

functioning in healthy adults of varying ages, as well as those that target cognitive symptomology in adults with dementia.

In the clinical literature, the influence of personality on activity participation among individuals with dementia has been consistently demonstrated (Kolanowski, Litaker, Buettner, Moeller, & Costa, 2011; Hill, Kolanowski, Fick, Chinchilli, & Jablonski, 2014). For example, Kolanowski et al. (2011) reported results from a randomized clinical trial in which 128 cognitively impaired nursing-home residents were randomly assigned to an individually-designed activity engagement intervention that was tailored to either their functional level, personality characteristics, or both personality and functional level together. Personality-based activities were defined based on self-reports of certain facets of extraversion (gregariousness, assertiveness, activity, excitement seeking) and openness (fantasy, aesthetics, feelings, ideas). For example, if a participant scored high on excitement seeking and gregariousness, they could be assigned to a novel tetherball game with other individuals. Patients randomly assigned to the personality-tailored activities reported greater engagement, alertness, and attention as well as reduced agitation and passivity compared to the other groups, suggesting that tailoring individualized activities based on personality may result in better adherence-related outcomes, which are critical for yielding long-term benefits.

Similar findings were reported by Hill et al. (2014) who examined the moderating effects of personality traits on cognitive function following an individualized activity engagement intervention among a sample of individuals with delirium superimposed on dementia. The activity engagement intervention was administered individually each day for 30 minutes for a maximum 30 days and entailed customized mentally challenging recreational activities that became incrementally difficult over the course of the intervention. They found that participants scoring high on agreeableness showed differentially improved delayed recall, and those with lower extraversion showed improved executive functioning following the intervention. Moreover, openness, agreeableness, and conscientiousness were associated with greater engagement in the activity intervention. Collectively, these findings suggest that personality traits are important to consider when selecting and tailoring cognitive interventions for older individuals with cognitive impairment.

In the literature on individualized cognitive training in healthy young and older adults, personality traits have been shown to be consistent predictors of individual differences in training adherence and the degree of improvement due to training. Double and Birney (2016) examined the influence of personality and self-referent beliefs on cognitive training adherence and performance outcomes in a large sample of 831 older Australians who self-selected into a commercial brain training program. They found that openness, need for cognition, and age predicted continuation in the computerized training program. Moreover, they observed that openness, implicit theories of intelligence, and age independently predicted task performance. These findings suggest that one pathway through which personality can impact improvements in performance is through predicting program adherence (see also Payne et al., 2012).

Studer-Luethi, Jaeggi, Buschkuehl, and Perrig (2012) examined individual differences in trait conscientiousness and neuroticism as moderators of an intensive working memory training intervention among 112 young adults (mean age = 19.5). Participants were randomly assigned to either a single or dual *n-back* working memory training task or to a no-contact control group. The n-back task is a continuous performance task in which participants are instructed to monitor a series of stimuli (e.g., letters or digits) and respond if the current stimulus is identical to the one presented *n* trials previously (e.g., two-trials previously). In the dual n-back variant, participants have to simultaneously monitor two stimulus streams (e.g., visually presented digits and aurally presented letters). Participants in the challenging dual n-back task who scored high in neuroticism showed lower overall gains in both near transfer tasks (e.g., n-back) and far transfer tasks (e.g., fluid intelligence), as well as reporting lower training enjoyment overall. However, in the single n-back group, participants high in neuroticism showed *better* performance in the simpler WM training intervention. These findings suggest that the high demand of the dual n-back training task led subjects with high levels of neuroticism to perform suboptimally, derailing potential transfer processes. A similar training x trait interaction was observed as a function of conscientiousness, where higher conscientiousness was associated with high immediate training improvement in the single n-back task, as well as greater improvement in near transfer measures, but at the same time, reduced far-transfer performance. The authors argued that these findings suggested that participants with high conscientiousness may have developed task-specific skills to perform as efficiently as possible, thus reducing any potential generalizing effects of the training. Thus, individual differences in personality had a substantial influence on the cognitive strategies adopted during training, leading to differential responsiveness to simple versus complex training paradigms.

Payne et al. (2012) examined the moderating effects of memory self-concept on cognitive training adherence and outcomes in a non-memorial domain, that of inductive reasoning. Although a number of researchers had previously examined memory training and self-efficacy beliefs (West, Bagwell, & Dark-Freudeman, 2008; McDougal, 2009), little work had previously examined the predictive utility of trait memory self-efficacy beliefs on interventions not explicitly targeting memory outcomes. In this study (Payne et al., 2012), 105 older-adult participants (mean age = 72.9) were randomly assigned to a no-contact control group or a home-based inductive reasoning intervention (Margrett & Willis, 2006), in which participants were trained in recognizing novel patterns and using these patterns to solve problems. Reasoning training materials were designed to increase in level of difficulty from week to week.

Overall, the training group showed substantial improvements in reasoning but no evidence for transfer to other cognitive domains, consistent with prior reasoning interventions (see e.g., Ball et al., 2002). Latent change score models were used to examine individual differences in latent reasoning change as a function of the intervention. Importantly, within the training group only, better memory self-belief was associated with improved reasoning outcomes, suggesting that self-referent memory beliefs are predictive of intervention responsiveness. Furthermore, those adults

with more positive beliefs were shown to allocate more time to the training materials over the course of the intervention, whereas adults with lower beliefs began allocating less time to the training over the course of the intervention. Such findings indicate that self-referential beliefs about cognitive potential may be an important factor contributing to intervention responsiveness in adulthood. Importantly, such findings may be more pronounced among interventions that require greater self-regulation and allocation of time and effort, as some more stereotyped lab-based training interventions (e.g., useful field of view training for processing speed) do not show such heterogeneity in training outcomes (Sharpe, Holup, Hansen, & Edwards, 2014).

~~*11.2.1 The Senior Odyssey Project*~~

Finally, we discuss findings from the Senior Odyssey Intervention (Stine-Morrow et al., 2008, 2014), a socially-enriched activity engagement intervention designed to improve cognitive health. This study serves as one of the largest and best tests of the role of personality characteristics as moderators of treatment effects. In the Senior Odyssey intervention, older adults are embedded in a cognitively and socially stimulating environment to promote activity engagement. Participants work in collaboration with the Odyssey of the Mind (OOTM) Program, which has been in existence since the late 1970's for university-level students. Participants compete in team-based collaborative and creative problem-solving activities over an entire 'season' of the OOTM program. An example of a long-term problem is, designing a play or designing structures out of balsa wood that can hold the most weight possible. Such problems require long-term planning, testing, and revision in a socially engaging environment to achieve desired solutions. Two phases of the study were conducted. In the first preliminary study (Stine-Morrow et al., 2008), 181 highly active adults were randomly assigned to the intervention or to a no-contact control group. This group showed broad improvement across a number of cognitive domains, but not substantial evidence of individual differences in training responsiveness.

In the second phase of the study (Stine-Morrow et al., 2014), over 400 'low activity' older adults were targeted (less than 10 hours of scheduled activities a week), as this training may be differentially beneficial for less engaged adults. Participants were randomly assigned to the OOTM program, or to either a waitlist control group or an active control group that completed home-based reasoning training (Willis et al., 2006; Payne et al., 2012). The lower-activity sample showed very different responsiveness to the training, showing effects that resembled specific training benefits in ideational fluency (a key component of the OOTM problems). However, participants also showed substantial individual differences in responsiveness to the intervention.

Moderators of individual differences in fluency change as a function of the intervention were examined. Here, effects of age and initial cognitive status predicted training improvement, but importantly, independent effects of trait openness and

social network size also moderated the magnitude of improvement in the intervention group, consistent with the idea that these features are critical to engage in this kind of broad and open-ended social problem-solving type activity. That is, in socially-mediated real-world activities, social and personality factors may play a larger role in engagement and adherence than in other types of more contrived or individualized interventions. Notably, the effect sizes for openness and social network size were the same magnitude as the moderating influence of baseline age and initial cognitive status, showing again the power of personality and dispositional individual differences characteristics in predicting cognitive intervention outcomes in aging.

~~11.2.2~~ *Summary*

The above findings strongly suggest that personality traits and dispositional beliefs in adulthood can have a substantial impact on responsiveness to cognitive training interventions. Individual differences in traits at the beginning of the interventions appear to influence a number of factors, including the strategies adopted to complete the tasks, belief and enjoyment in the intervention, and maintained adherence and engagement with the tasks, and degree of cognitive change as a result of the intervention. Some work suggests that individual differences may play a larger role in cases where the intervention is open-ended and self-guided, requiring more self-regulation, motivation, and social engagement. For example, in lab-based computerized cognitive training programs individual differences in personality traits may only moderately impact training outcomes, as factors like conscientiousness and cognitive self-efficacy may moderate how participants maintain adherence to the training. However, in less structured interventions, such as home-based or socially-interactive group-based interventions, such as Senior Odyssey (Stine-Morrow et al., 2008, 2014), which require additional self-motivation, planning, and engagement in open-ended problem solving, individual personality characteristics appear to play a larger role in determining training responsiveness.

~~11.3~~ Future Directions

The goal of this chapter was to systematically review the multiple pathways through which personality traits and cognitive functioning interact in aging and adult development. Importantly, the above review shows a small but rapidly growing literature highlighting the importance of personality traits in shaping trajectories of normal cognitive functioning and cognitive health maintenance in old age. As such, we argue that cognitive aging research should more seriously integrate personality science into basic research on cognitive change in normal and pathological aging as well as applied research on interventions to promote cognitive health in adulthood.

Below, we briefly outline several ways in which personality traits can be readily integrated into adult developmental research on cognitive and brain health.

Ongoing longitudinal studies of cognitive and brain health should integrate personality theory and assessment into their existing protocols. Aside from simply including a brief Big Five measure into existing measurement batteries, as is currently the convention, such studies should explore the predictive validity of including behavioral and observer-report assessments into existing and planned future studies, as well as examining facet-level differences, and more age-relevant traits, such as self-referent cognitive beliefs. Likewise, intervention and training studies should consider the measurement of personality not only at the onset of assessment (e.g., as a moderator of cognitive change, e.g., Payne et al., 2012), but also longitudinally, to examine whether and to what degree such interventions may change personality and associated behaviors (e.g., Jackson, Hill, Payne, Roberts, & Stine-Morrow, 2012). Such intervention-related personality change, if observed, may result in more long-term effectiveness than the direct cognitive benefits of the intervention. Indeed, the effects of short-term cognitive interventions typically do not persist far beyond the conclusion of the intervention (see Rebok et al., 2014). However, if certain cognitive interventions can lead to changes in factors like openness, and conscientiousness, this personality trait change may result in longer-term and stable changes to behaviors, such as seeking out novel and intellectually engaging experiences, which may lead to broader and more lasting change in cognition than the direct but more transient cognitive benefits.

Moreover, personality science can be more thoroughly integrated in person-centered approaches to promote cognitive resilience in aging. As reviewed above, some promising examples of personality-tailored interventions have been applied in clinical interventions for dementia. However, very little work has attempted to integrate personality and dispositional belief change directly into cognitive interventions. One exception to this comes from West et al. (2008), who have implemented memory training interventions that are supplemented with tasks to improve perceived memory self-efficacy. Not only can such multifaceted approaches to intervening along multiple fronts prove successful (e.g., see Aschwanden & Allemand's theoretical model in this edition), but future interventions should additionally consider individually adjusting interventions to individual belief and trait profiles. For example, given the work reviewed above, namely that older adults with low self-efficacy and high neuroticism do not respond as strongly to cognitive training interventions, it is worth considering how such baseline information could be used to supplement such interventions, for example by increasing task engagement or 'gamification' or providing longer training intervals. Given that a one-size-fits-all approach is likely ineffective for cognitive interventions, such future work should consider such personality-integrated individually-adaptive interventions.

With the considerable public discussion over the last several decades on the 'graying of America', the conversation has focused largely on tools needed to stave off cognitive decline and improve brain health. Importantly, this view of cognitive and brain health largely leaves behind attention to *the person*. Consideration of the substantial heterogeneity in personality, beliefs, and dispositions is critical for a

complete understanding of optimal adult life span development. We propose a shift in cognitive aging research, whereby we not only take into account normative and non-normative age-related changes (and variability in changes), in cognitive functioning and personality, but consider the dynamic interplay between these factors that have historically been examined in isolation. Such integration will prove valuable not only for forwarding basic research on personality and cognitive development, but will provide novel inroads for non-traditional approaches to improve cognitive health and maintain cognitive resilience over the adult lifespan.

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