GRIT AND COGNITIVE FUNCTIONING IN HEALTHY AGING AND MILD COGNITIVE IMPAIRMENT

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ABSTRACT

Objective: Grit is a noncognitive trait related to perseverance and consistent pursuit of long-term goals. Research on grit and aging provides evidence that grit increases with age and may be protective of cognitive and everyday functioning. However, no studies to date have examined relations between concurrently measured grit, cognitive abilities, and everyday functioning. This study tested two hypotheses: 1) that grit would predict cognitive performance and that this relation would be moderated by clinical diagnosis of cognitive status (i.e., healthy vs. mild cognitive impairment; MCI), and 2) that grit would predict everyday functioning and that this effect would be mediated by compensatory strategy use.

Methods: Sixty-one older adults were recruited from the Penn Memory Center's National Alzheimer's Coordinating Center (NACC) cohort, including forty healthy controls with normal cognition and twenty-one individuals with mild cognitive impairment (MCI). Participants completed tests of verbal episodic memory, executive functioning, grit, compensatory strategy use, and everyday functioning.

Results: Grit was not associated with cognitive functioning in either domain. Instead, memory performance was predicted only by clinical status (healthy vs. MCI), and executive functioning was predicted by clinical status, depressive symptoms, and years of education. Grit was negatively associated with everyday functional difficulties; however, there was no indirect effect of compensatory strategy use. Additionally, grit was moderately correlated with depression symptoms ($r = -0.41$).

Conclusions: Grit is predictive of preserved everyday functioning, but not cognitive functioning, in a sample of healthy older adults and individuals with MCI. Mechanisms explaining the role of grit on everyday function remain elusive, though secondary analyses support that grit also influences affective well-being and may have a weaker role in the context of cognitive impairment.

Keywords: grit, aging, memory, executive functioning, everyday functioning, mild cognitive impairment

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CHAPTER 1

INTRODUCTION

Grit, or "perseverance and passion for long-term goals," is a personality trait that has been identified as a powerful predictor of achievement across a variety of contexts, including educational attainment and occupational success (Duckworth, Peterson, Matthews, & Kelly, 2007, p. 1087). Duckworth and colleagues have described grit as the dogged pursuit of long-term goals that requires persistence of effort and interest over time, in spite of setbacks and failure. Grit is thought to account for variability in achievement not explained by innate qualities, such as intelligence and raw talent (Duckworth et al., 2007). For example, grit may explain why some gifted children go on to excel later in life, while other equally, if not more, gifted children fail to achieve at the same level. Grit is typically measured using one of two self-report questionnaires: the 12-item Grit Scale (Grit-O, Duckworth et al., 2007) or the 8-item Short Grit Scale (Grit-S, Duckworth & Quinn, 2009), which were designed to capture attitudes and behaviors associated with success and achievement across a variety of domains.

Associations between grit and achievement have been demonstrated in numerous contexts. Cross-sectional research has established positive correlations between grit, undergraduate GPA and lifetime educational attainment, in addition to a negative association between grit and number of lifetime career changes (Duckworth et al., 2007). Prospective longitudinal studies show that grit predicts retention of new West Point cadets better than a composite measure that accounts for SAT score, high school class rank, leadership potential, and physical aptitude (Duckworth et al., 2007). Grit has also been found to predict superior performance in the final competition of the National

Spelling Bee, as well as graduation from the Chicago Public School system, even after controlling for scores on standardized achievement tests (Duckworth et al., 2007; Duckworth & Quinn, 2009). Additionally, grit is predictive of marital stability, job retention, and engagement in a consistent exercise regimen (Duckworth et al., 2007; Reed, Pritschet, & Cutton, 2013). Importantly, grit not only predicts success in these contexts, but it predicts success to a greater degree than IQ, standardized achievement tests (e.g., SAT scores), and other relevant traits (e.g., physical fitness, conscientiousness). Though originally conceived as a relatively stable trait, recent research on grit-building behavioral interventions demonstrates that grit is malleable and can be cultivated in children and young adults, with positive downstream effects on effort and cognitive performance (Eskreis-Winkler, 2015).

Although most of the empirical literature on grit has shown predictive power for positive outcomes, recent experimental research has shown that high levels of grit may not always be advantageous. A study by Lucas and colleagues examined how grit influenced performance on laboratory tasks that allowed for manipulation of success and difficulty (Lucas, Gratch, Cheng, & Marsella, 2015). In a sample of healthy young adults, they found that grit was associated with costly perseverance, or the tendency to persist at a difficult or impossible task (e.g., unsolvable anagrams) even when persistence is detrimental to overall performance. Specifically, individuals high in grit were less likely to skip a difficult or impossible item on a timed test, more likely to increase effort when failing, and less likely to quit when failing, even when persistence came with a risk for monetary loss. This work offers a novel perspective on the potential drawbacks of grit, namely that individuals with high levels of grit may not know when to quit or disengage from a blocked goal.

Just as grit helps us understand individual differences in levels of achievement and success among young adults, it may also shed light on why some older adults age more successfully than others. Aging is a rich context for the study of grit, as it presents new developmental challenges and limitations that threaten independence and quality of life among even the highest of achievers. The ability to adapt to age-related losses, such as physical disability and cognitive decline, may represent a previously unexplored facet of grit that is specific to older adults. The extant literature on grit in aging provides evidence that grit increases with age and may be protective of functioning. Cross-sectional research has shown that, after controlling for education, grit increases monotonically with age; however, the relation between aging and grit has been examined in a limited sample of older adults, classified broadly by age as either 55-64 or 65 and older, and no information was provided on the maximum age within the 65 and older group, or the size, mean levels of education, or ratio of men to women within each group (Duckworth et al., 2007). Additionally, adults aged 65 and older showed the highest variability in grit scores, indicating a high degree of heterogeneity of self-reported grit in this age group (Duckworth et al., 2007). Duckworth and colleagues propose that grit may increase across the lifespan because perseverance and consistency become more important tools for success as we age and are reinforced by positive outcomes, though they also acknowledge that the linear association between grit and age demonstrated in cross-sectional research may be due to cohort effects (2007; Twenge, Zhang, & Im, 2004). Longitudinal research on a related construct, tenacious goal pursuit, has shown age-related reductions in tenacity, suggesting variability in the longitudinal trajectory of motivational personality traits in aging (Martinent et al., 2017). Less is known about factors that mediate the relationship between grit and age, and potential harmful effects, such as costly perseverance.

Successful aging is a multi-dimensional construct that generally refers to physical and psychological well-being among the elderly (Depp & Jeste, 2006). Despite a wealth of inter-disciplinary literature on successful aging, only two studies have explored the association between grit and successful aging. A study of Korean older adults found that grit was more strongly associated with successful aging than physical functioning, suggesting that grittier older adults may continue to age successfully despite reduced physical functioning due to disease or disability (Kim & Lee, 2015). A second study from our lab (Rhodes & Giovannetti, 2017) similarly showed strong relations between grit and multiple components of successful aging, including better physical functioning, emotional well-being, social functioning, energy, and overall health. Our study also found that grit moderated the association between cognitive decline and everyday functioning, such that among older adults who reported cognitive decline, those with higher grit scores experienced fewer role limitations compared to those with lower grit scores. This suggests that high levels of grit may be protective of everyday functioning and promote active adaptation to the developmental challenges of aging.

Additional evidence for the role of grit in successful aging comes from research using neuropsychological tests to measure cognitive functioning. Preserved cognitive functioning among the elderly is an important component of successful aging that promotes independence and quality of life (Jeste, Depp, & Vahia, 2010). Recent findings from our lab show that grit in adolescence is implicated in episodic memory performance, a domain of cognition that is especially sensitive to aging. When measured in adolescence, grit predicts better performance on tests of episodic memory in late-life, even after statistically controlling for the effect of IQ (Rhodes et al., 2016). Specifically, grit predicted delayed recall of a word list to a greater extent than did IQ, whereas grit and IQ were equally predictive of immediate recall. These findings are unique, in that the existing literature on children, adolescents, and young adults has found grit to be independent of or negatively associated with performance on standardized measures of cognitive functioning (e.g., IQ), indicating that the relative contribution of grit on cognitive performance may vary across the lifespan (Duckworth & Quinn, 2009; Duckworth et al., 2007; Eskreis-Winkler, Shulman, Beal, & Duckworth, 2014). While less is known about the association between concurrently measured grit and cognitive functioning in older adults, these findings suggest that grit measured early in life promotes preserved late-life cognitive functioning and raise the question of precisely how grit measured across the lifespan influences cognition.

A potential mechanism that may explain the link between concurrent grit and memory performance in older adults is the use of compensatory strategies aimed at mitigating the effects of cognitive decline on everyday functioning. Compensation is an active attempt to mitigate losses in cognitive functioning and requires the same effortful persistence in the face of failure that is described in the grit literature. Common compensatory strategies include the use of external aids (e.g., shopping lists, smartphone alerts, day planners); internal aids (e.g., mnemonics devices, mental imagery); recruitment of assistance from others; and allocation of more time and effort to complete tasks (Dixon, 2007). Compensatory strategy use is reported by healthy older adults and is associated with better outcomes in response to the challenges of normal aging (Dixon & de Frias, 2007; Farias et al., 2018; Lang, Rieckmann, & Baltes, 2002).

Investigations of self-reported compensatory strategy use show that compensation increases across the lifespan until age 70, at which point it drops precipitously (Rothermund & Brandstädter, 2003). This reduction is thought to be due to a decline in available resources that promote active compensation. Cognitive resources are particularly important in supporting the successful use of compensatory strategies, especially metacognitive and executive processes such as error monitoring, problem solving, and initiation (Bäckman & Dixon, 1992; Prigatano, 1999). Thus, compensation is likely to decrease when cognitive resources are reduced, either by normal aging or neurodegenerative processes such as Alzheimer's disease. While grit may promote better memory performance in some older adults via compensation, age-associated cognitive disorders may represent a context in which grit can be maladaptive. If cognitive decline reaches a certain threshold such that metacognitive and executive abilities are sufficiently impaired, grit may fail to promote effective compensation and may instead result in the use of unsuccessful strategies or costly perseverance. High levels of grit may also reduce the likelihood of help-seeking behaviors that may provide external support for everyday functioning.

Study Aims and Hypotheses

The overarching aim of this study is to investigate the link between grit, cognitive performance, and everyday functioning in older adults with varying levels of cognitive abilities, with a focus on the role of compensatory strategy use. To our knowledge, this will be the first study to examine grit in relation to concurrent cognitive and everyday functioning in older adults. We recruited a sample of healthy older participants as well as individuals with mild cognitive impairment (MCI) to examine the role of grit in normal and pathological aging, which is an important gap in the existing literature. This study also will add to the literature by investigating compensatory behaviors as a potential mechanism for the role of grit in cognitive and everyday functioning. Finally, we will expand on the budding evidence for possible drawbacks of high grit.

This study has two specific aims. The first is to examine the relations between concurrently measured grit and cognitive functioning in a sample of healthy older adults and individuals with MCI. Specifically, this study assesses the association between grit and performance on tests of episodic memory and executive functioning. These cognitive domains were selected for their sensitivity to cognitive aging and neurodegenerative disease as well as their potential for enhancement with the use of compensatory strategies. Additionally, episodic memory and executive functioning are widely studied in healthy and pathological aging and commonly used to define clinical syndromes, including subtypes of MCI. It is hypothesized that grit will be positively associated with performance on tests of episodic memory and executive functioning. It is further hypothesized that diagnosis pertaining to clinical status (i.e., healthy vs. MCI) will moderate the relationship between grit and cognitive functioning, such that cognitive performance will be most strongly associated with grit among individuals with intact cognitive resources.

The second aim is to investigate compensation as a mechanism by which grit influences everyday function. Specifically, relations among grit, everyday functioning, and compensatory strategy use were evaluated. It is hypothesized that grit will be negatively associated with informant-report of everyday dysfunction and that this relation will be mediated by the use of compensatory strategies. Thus, individuals with higher levels of grit will exhibit greater compensatory strategy use, which will in turn enhance everyday functioning. It is further hypothesized that the indirect effect of compensatory strategy use will be moderated by cognitive functioning, such that the effect of compensatory strategy use will be stronger for older adults with preserved cognitive resources. Separate analyses considered measures of different types of cognitive resources (executive function, episodic memory, etc.) to explore whether specific cognitive resources have stronger or weaker moderation effects.

CHAPTER 2

METHOD

Participants

Participants were recruited from the Penn Memory Center (PMC), the clinical core of the University of Pennsylvania's Alzheimer's Disease Center (ADC). All participants were enrolled in the National Alzheimer's Coordinating Center (NACC) research study, a longitudinal investigation of over 450 adults over the age of 55, including individuals with normal cognition, MCI, and Alzheimer's disease or related dementia. The NACC cohort includes both clinical and community-dwelling participants and informants. Sixty-one participants who completed new or follow-up NACC visits were enrolled in the present study. The sample was 60.7% female, with a mean age of 73.97-years-old (SD = 7.27) and 16.43 years of education (SD = 2.68). Twenty-one participants (34.4%) met criteria for MCI, while 40 participants (65.6%) were classified as healthy controls. For MCI participants, the average age of initial diagnosis was 69.35 years. Study procedures were completed in accordance with the ethical standards of the University of Pennsylvania Institutional Review Board, which approved the study, and with the Helsinki Declaration of 1975, as revised in 2000.

All clinical patients who were enrolled as participants underwent an extensive evaluation by a neurologist, geriatric psychiatrist or gerontologist, including physical and neurologic exam; history from both the participant and an informant; and completion of a uniform assessment battery designed to characterize clinical and cognitive functioning (Weintraub et al., 2018). Normal controls were evaluated by consensus of the research team and completed the uniform assessment battery. Clinical diagnosis was determined at a consensus conference attended by neurologists, neuropsychologists, geriatricians, psychiatrists, and social workers. Diagnosis of MCI was made according to the Petersen criteria, which require the presence of 1) change in cognition recognized by the affected individual or informant, 2) objective impairment in one or more cognitive domains, 3) independence in functional activities, and 4) absence of dementia (Albert, et al., 2011). Inclusion criteria for all participants included age between 55 and 95, >7 years education, and English speaking at an early age. Participants were excluded if they had a diagnosis of dementia (determined by consensus conference), history of clinical stroke, traumatic brain injury, alcohol or drug abuse/dependence, prior electroconvulsive therapy, or any significant disease or medical/psychiatric condition (other than MCI) that was felt to impact neuropsychological test performance. Healthy control participants who served as clinical informants for MCI participants were also excluded to insure independence of observations.

Procedures

Each NACC visit included a comprehensive clinical assessment in which demographic, neurologic, psychiatric, and other medical variables are obtained from self- and informant-report. Informants were required for all NACC clinical and control participants and had to be a single individual who was considered the best source of information available on the participant. Informants provided subjective observations regarding participants' cognitive function, behavior, and level of functional ability in activities of daily living, providing evidence for decline in these areas. All participants in the present study completed the NACC Uniform Data Set 3 (UDS3) Neuropsychological Battery, which consists of standardized measures of attention, processing speed, executive function, episodic memory, and language (for more detail, see Weintraub et al., 2018). UDS3 assessments are independent of measures that are used in clinical diagnosis of study participants. A subset of UDS3 measures was used to address the aims of this study, which are described in more detail in the following section.

Measures

Dementia Severity Rating Scale (DSRS)

The DSRS is a 12-item informant report questionnaire designed to measure everyday functional difficulties in neurodegenerative disease, including (a) cognitive difficulties, (b) orientation to time and place, (c) social and community activity, (d) home activities and responsibilities, (e) personal care/cleanliness, (f) eating, (g) control of urination and bowels, and (h) transportation (Clark & Ewbank, 1996). The DSRS includes a broad range of scores, which permits the detection of subtle difficulties in everyday function over time (Xie et al., 2009). It has been shown to reliably measure everyday dysfunction throughout all stages of neurodegenerative disease, including MCI. The DSRS demonstrated high concurrent validity with established measures of functional ability, including the Clinical Dementia Rating Scale (CDR) and Mini Mental State Examination (MMSE; Clark & Ewbank, 1996; Folstein, Folstein, & Folstein, 2010). The total score was derived from the sum of scores in 12 functional areas, and ranges from zero (no impairment) to 54 (severe impairment).

Montreal Cognitive Assessment (MoCA)

The MoCA is a global cognitive screening test designed to assist health professionals in the detection of MCI and dementia (Nasreddine et al., 2005). It evaluates short term memory (immediate and five-minute delayed recall of a word list), visuospatial abilities (figure copy and clock drawing), executive functioning (dual sequencing, phonemic fluency, verbal abstraction), language (confrontation naming and sentence repetition), as well as attention, concentration, and working memory (target detection, digits forward and backward, serial subtraction). The MoCA was scored on a scale from 0-30, with lower scores indicative of poorer performance and greater cognitive impairment.

Craft Story

The Craft Story test is a standardized assessment of narrative episodic memory consisting of immediate and delayed recall trials (Craft et al., 1996). The Craft Story was added to the UDS v3.0 in March 2015 as a non-proprietary alternative to the Logical Memory subtest of the Wechsler Memory Scale - Fourth Edition (Wechsler, 2009). A study of new UDS3 measures demonstrated good concurrent validity with Logical Memory (Monsell et al., 2016). A short story is presented orally and the examinee is asked to recall the story. The examinee is then asked to recall as many details as possible about the story following a 20-minute distraction-filled delay. Participants received separate scores for the total amount of information recalled verbatim and accurate paraphrases. To control for the effects of learning ability, delayed recall of verbatim story information was subtracted from immediate recall to produce a memory score, with lower scores reflecting better retention of information over time.

Trail Making Test

The Trail Making Test is a measure of processing speed and executive functioning that consists of two subtests. Trail Making Test A (TMT A) involves the speeded visuomotor sequencing of numbers. Trail Making Test B (TMT B) involves alternating speeded visuomotor sequencing of numbers and letters. The Trail Making Test is scored as the number of seconds required to complete the task, with higher scores indicating greater impairment. To control for the effects of attention, information processing speed, and basic visuomotor abilities, TMT A was subtracted from TMT B to produce an executive score (Mez et al., 2013). Lower scores are indicative of better performance (i.e., less difficulty performing the executive component of the task).

Grit Scale

Grit was measured using the self-report version of the 8-item Short Grit Scale (Grit-S; Duckworth & Quinn, 2009). The Grit-S uses a 1 (*Not like me at all*) to 5 (*Very much like me*) Likert scale to capture attitudes and behaviors associated with the capacity for sustained effort in the face of adversity (e.g., “I have overcome setbacks to conquer an important challenge”) and the consistency of interests over time (e.g., “I have been obsessed with a certain idea or project for a short time but later lost interest”). The Grit-S has been shown to have satisfactory psychometric properties, including internal reliability, test-retest reliability, and convergent and discriminant validity, in a large sample (N = 1,554) that included healthy older adults age 65 and over (n = 65; Duckworth & Quinn, 2009).

Everyday Compensation Questionnaire (EComp)

The EComp consists of 38 items designed to measure the use of compensatory strategies in six general areas of everyday living: seven items relate to managing appointments, six items relate to shopping, seven items relate to cooking, seven items relate to managing finances, six items relate to transportation, and five items relate to managing medications. A self-report version of the EComp was completed by the study participant. Participants rated the frequency with which the participant utilized each compensation strategy on a five-point scale: 0 = *never*, 1 = *rarely*, 2 = *sometimes*, 3 = *frequently*, 4 = *always*. A response choice indicating that the rater "could not say/not applicable" was also included (Farias et al., 2018). The EComp score was calculated by computing the mean of all valid items, excluding any items marked as "could not say/not applicable," with higher scores indicating greater everyday compensatory strategy use.

Geriatric Depression Scale (GDS) – Short Form

The GDS is a 15-item self-report questionnaire designed to measure symptoms of clinical depression among the elderly. The GDS differs from other self-report measures of depressive symptomatology by excluding somatic complaints, which are more likely to be endorsed by older adults even in the absence of a mood disorder (Sheikh & Yesavage, 1986; Yesavage et al., 1982). Each item is answered using "Yes/No" format to facilitate use among individuals with cognitive impairment. Total scores range from 0-15, with higher scores reflecting greater depression. The GDS is widely-used and well-validated in inpatient, outpatient, primary care, nursing home, and community-dwelling populations (Wancata, Alexandrowicz, Marquart, Weiss, & Friedrich, 2006).

Marlowe-Crowne Social Desirability Scale (MC-SDS) – Short Form

The MC-SDS is a 33-item questionnaire that uses true/false response format to measure socially desirable responding (Crowne & Marlowe, 1960). A short form developed by Strahan and Gerbasi (Form X3; 1972) using confirmatory factor analysis consists of 13 items and has high internal consistency and high concurrent validity with the original 33-item SDS (Fischer & Fick, 1993). A high score reflects a tendency to respond in a way to avoid the disapproval of others and conform to social conventions.

Statistical Analysis

Prior to analysis, data were screened for missingness, outliers, and normality. In most analyses missing data were managed using full information maximum likelihood estimation (FIML), which allows parameters to be estimated for all participants, including those with missing data. All dependent variables were assessed for skewness, kurtosis, and normality using Shapiro-Wilk and Kolmogrov-Smirnov tests. Boxplots and Q-Q plots were used to identify outliers. Analyses of variance or chi-squared tests were used to detect group differences in demographic and clinical variables. All analyses were conducted in Mplus 8.0 (Muthén & Muthén, 2017).

Aim 1

Multiple linear regression analyses were used to test the hypothesis that grit is positively associated with episodic memory and executive functioning. The interaction between grit and clinical status (healthy or MCI) was also included in the regression to evaluate the hypothesis that clinical status will moderate the relation between grit and cognitive functioning, such that cognitive performance would be most strongly associated with grit among individuals with intact cognitive resources. Grit, clinical status (healthy or MCI), and the interaction between grit and clinical status were entered as predictors into separate multiple linear regressions with memory and executive scores as outcome variables. If significant, differences in the strength of the main effect of grit on the two cognitive domains would be assessed by comparing standardized beta coefficients to determine whether grit has a greater influence on one domain. If the interaction effect is significant, it would be investigated according to procedures described by Holmbeck

(2002) for post-hoc probing a two-way interaction between a dichotomous categorical variable and a continuous variable.

Aim 2

SEM path analysis was used to test a mediation hypothesis in which compensatory strategy use mediates the relation between grit and everyday dysfunction. This analytic approach included three component models composed of independent (X), dependent (Y), and mediator (M) variables (see Figure 1). First, we examined an unelaborated model consisting of the direct relation between grit (X) and everyday dysfunction (Y). Second, we examined an elaborated model including compensation as a mediator (M). The final index of mediation was the change in variance accounted for by the inclusion of the mediator in the model. This was determined by a significance test of the change in the square of the multiple correlation coefficient (R^2 change)

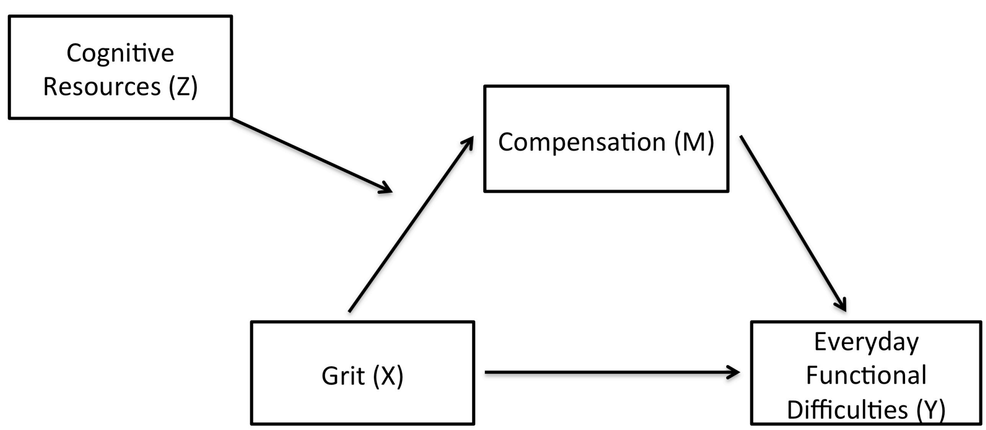

Figure 1. Proposed Model of Moderated Mediation (Aim 2)

with the mediator included in the model. Nonparametric bootstrapping using 1,000 iterations was employed to estimate SEs in the direct and indirect effects for significance testing.

If the mediation were significant, then a directional chi-squared difference test would be conducted to examine cognitive functioning as a moderator of the proposed mediation relation (i.e., moderated mediation, see Figure 1). We would compare the fit of a model where paths from grit to compensatory strategy use to everyday dysfunction are constrained to equality between individuals with intact and impaired cognition to the fit of an unconstrained model where all paths are estimated freely for all participants. Separate models would be used to independently assess three different types of cognitive resources as potential moderators of the mediation relation: 1) executive functioning, 2) episodic memory, and 3) global cognitive functioning. For this moderation analysis, neuropsychological test scores were dichotomized by median split to reflect high versus low cognitive resources.

Sample Size and Power Analysis

Little research has evaluated the effect of grit on cognitive performance, but existing literature suggests that effect sizes may be moderate (Rhodes et al., 2016). To detect a main effect of grit (Aim 1) of moderate effect sizes with Power = .80 and $\alpha = .05$, a sample size of 68 is required. A larger sample will be required to detect interaction effects. Given the recent rise in the use of mediational analyses in the social sciences, traditional methods of power analyses (e.g., G*Power) are not readily available. The following power analysis is based on work by Fritz and Mackinnon (2007), which provides a guide for the necessary sample size using the most common mediation methods. To detect moderate effect sizes with Power = .80 for the α and β paths using a percentile bootstrap method in the proposed mediation model (Aim 2), a sample size of 78 is required; similarly, if utilizing the Baron and Kenny mediation model method (1986), a sample size of 75 is required, not including covariates.

CHAPTER 3

RESULTS

Missingness and Distributions

Data were collected for 61 participants. Grit scale total score was available for 60 participants. Informant-reported DSRS was available for 59 participants. SDS data were available for 56 participants. With regard to neuropsychological test variables, one participant was unable to complete the TMT B. All other study data were available for the full sample.

Normally distributed variables included EComp and Grit-S. Non-normally distributed variables included GDS, MoCA, DSRS, memory score, executive functioning score, and SDS. GDS scores were positively skewed, showed multiple outliers, and failed Kolmogrov-Smirnov and Shapiro-Wilk tests of normality. MoCA scores were negatively skewed. DSRS scores were positively skewed, with over 45% of scores equal to 0, and contained two outliers. Memory score Kolmogrov-Smirnov test data indicated non-normality, though no outliers were present and skewness and kurtosis values were acceptable. Executive functioning scores showed significant kurtosis, multiple outliers, and abnormal Q-Q plots, in addition to non-normality indicated by Kolmogrov-Smirnov and Shapiro-Wilk test data. SDS Kolmogrov-Smirnov test data indicated non-normality, no outliers were present and skewness and kurtosis values were acceptable. Outcome variables demonstrating non-normality (memory score, executive functioning score) were transformed into standardized *z*-scores. Outliers remained present in the executive functioning score following *z*-score transformation. This was corrected by replacing two extreme raw values with the next largest value prior to z-transformation, which resulted in a normal distribution.

Characteristics of the Sample and Bivariate Relations of the Study Variables

Table 1 displays the means, standard deviations, and Pearson correlations for all study variables. On average, participants in the sample were 74-years-old and completed 16 years of education. Overall level of cognitive impairment was mild (MoCA), and on average participants endorsed only 1-2 symptoms of depression (GDS).

Education, GDS (depression symptoms), DSRS (informant-rated functional difficulties), EComp (self-reported compensatory strategy use), and measures of cognitive functioning were significantly correlated. Values for the variance inflation factor fell between 1.02 and 1.17, well within acceptable limits, indicating that multicollinearity was not a concern for the regression analyses. Of note, there was no significant relation between grit (Grit-S) and social desirability (MC-SDS), suggesting that participants' self-report of grit likely was not biased by their interest in being viewed favorably by others. Also, the episodic memory and executive function scores were not significantly correlated, suggesting that these variables likely reflect distinct cognitive constructs. Grit was not significantly correlated with measures of cognitive ability, but there was a significant correlation between grit and depression symptoms (GDS), such that people who were lower in grit demonstrated more depression symptoms. The use of compensatory strategies, as measured by the EComp, was significantly associated with lower overall cognitive function (MoCA), and everyday function (DSRS), but stronger executive function abilities (EF score).

Table 1

Correlation matrix with all study variables for the whole sample

Stubhead	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Age	-									
2. Education	0.14	-								
3. MoCA	-0.17	0.20	-							
4. GDS	-0.23	-0.11	-0.25	-						
5. MC-SDS	-0.25	0.07	-0.01	0.17	-					
6. DSRS	0.16	-0.07	-0.65***	0.29*	-0.05	-				
7. EComp	0.03	0.15	-0.27*	0.24	-0.09	0.30*	-			
8. Grit Score	-0.25	-0.09	0.18	-0.41**	0.01	-0.39**	-0.15	-		
9. EF Score	-0.06	0.31**	0.47***	-0.37**	-0.03	-0.36**	0.27*	0.15	-	
10. Memory Score	-0.15	-0.25*	0.23	-0.03	-0.23	-0.31*	0.10	0.21	0.07	-
M	73.97	16.43	24.82	1.15	21.28	3.28	2.27	3.65	-53.48	1.43
SD	7.27	2.68	3.23	1.77	1.62	4.80	0.54	0.61	34.34	1.61
n	61	61	61	61	56	59	61	60	60	61

Note. MoCA= Montreal Cognitive Assessment; GDS = Geriatric Depression Scale; MC-SDS = Marlowe-Crowne Social Desirability Scale; EComp = Everyday Compensation Scale; EF = Executive Functioning.
$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

Characteristics of the Healthy and MCI groups

Table 2 displays demographic and primary study variable differences by clinical status (healthy control vs. MCI). Groups did not differ on age, distribution of racial identity, or years of education; however, the healthy control (HC) group contained a smaller proportion of women compared to the MCI group (χ^2 (1, N = 61) = 4.25, p = .04, Φ = 0.26). Self-reported depressive symptoms were higher in the MCI group compared to the HC group (GDS; $F(1, 59) = 4.06$, p = .04, d = 0.49), though both groups reported few depression symptoms and fell well below the cut-off for clinical depression. The MCI group performed worse on a measure of global cognitive functioning (MoCA; $F(1, 59) = 16.35$, p <.001, d = 1.26) and verbal episodic memory (memory score; $F(1, 59) = 15.22$, p <.001, d = 0.97) and had greater informant-reported everyday dysfunction (DSRS; $F(1, 57) = 67.06$, p <.001, d = 1.96) compared to the HC group. Groups did not differ on self-reported grit (Grit-S), compensatory strategy use (EComp), social desirability (MC-SDS), or executive functioning score (all F-values < 3.7, p-values > 0.05, d = 0.46, 0.41, 0.32, and 0.50, respectively).

Pearson correlations among study variables differed between groups. Table 3 shows bivariate correlations within the HC group. Among healthy participants, grit (Grit-S) was negatively associated with age, depression (GDS), and everyday dysfunction (DSRS). Everyday dysfunction (DSRS) was also negatively correlated with executive functioning (EF score) and positively correlated with age and depression (GDS). Additionally, global cognitive functioning (MoCA) was positively associated with executive functioning (EF score). Table 4 shows bivariate correlations within the MCI group, where grit (Grit-S) showed no significant association with any other study variable. Among MCI participants, educational attainment was positively correlated with executive functioning (EF score) and social desirability (MC-SDS).

Table 2

Descriptive Statistics and Differences in Study Variables

Stubhead	HC M/n (SD/%)	MCI M/n (SD/%)	*p*-value
N = 61	40 (65.6%)	21 (34.4%)	-
Age	74.60 (7.22)	72.76 (7.38)	0.35
Race (White)	28 (70.0%)	19 (90.4%)	0.07
Sex (Female)*	12 (30.0%)	12 (57.1%)	0.04
Education (Years)	16.33 (2.73)	16.61 (2.61)	0.68
Geriatric Depression Scale (GDS)*	0.83 (1.27)	1.76 (2.36)	0.04
Montreal Cognitive Assessment (MoCA)**	25.9 (2.61)	22.76 (3.33)	0.00
Dementia Severity Rating Scale (DSRS)**	0.87 (2.06)	8.37 (4.99)	0.00
Everyday Compensation Scale (EComp)	2.18 (0.55)	2.44 (0.46)	0.10
Short Grit Scale	3.74 (0.64)	3.47 (0.53)	0.10
Marlowe Crowne Social Desirability Scale (MC-SDS)	21.10 (1.61)	21.63 (1.64)	0.25
Executive Functioning Z-Score	0.17 (0.98)	-0.33 (0.98)	0.06
Memory Z-Score**	0.25 (0.95)	-0.48 (0.93)	0.00

Note. HC = Healthy control; MCI = Mild cognitive impairment; M = Mean; SD = Standard deviation
**p*<.05, ***p*<.001.

Table 3

Correlation matrix with all study variables for the HC group

Stubhead	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Age	-								
2. Education	0.23	-							
3. MoCA	-0.22	0.19	-						
4. GDS	0.12	-0.16	-0.10	-					
5. MC-SDS	-0.26	-0.15	0.05	0.05	-				
6. DSRS	0.52**	-0.07	-0.50	0.47**	-0.24	-			
7. EComp	0.13	0.23	-0.18	-0.06	-0.31	0.16	-		
8. Grit Z-Score	-0.37*	0.01	0.18	-0.62***	0.04	-0.56***	-0.04	-	
9. EF Z-Score	-0.23	0.27	0.40**	-0.17	0.12	-0.48**	-0.19	0.25	-
10. Memory Z-Score	-0.13	-0.29	0.19	-0.05	-0.19	-0.17	-0.06	0.15	0.06

Note. HC = Healthy control; MoCA= Montreal Cognitive Assessment; GDS = Geriatric Depression Scale; MC-SDS = Marlowe-Crowne Social Desirability Scale; EComp = Everyday Compensation Scale; EF = Executive Functioning
**p*<.05, ***p*<.01, ****p*<.001

Table 4

Correlation matrix with all study variables for the MCI group

Stubhead	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Age	-								
2. Education	-0.03	-							
3. MoCA	-0.32	0.34	-						
4. GDS	-0.57**	-0.09	-0.10	-					
5. MC-SDS	-0.16	0.48*	0.09	0.25	-				
6. DSRS	0.39	-0.20	-0.53*	-0.04	-0.13	-			
7. EComp	-0.12	-0.06	-0.20	0.53*	0.27	0.26	-		
8. Grit Z-Score	-0.07	-0.33	-0.07	-0.13	0.07	-0.22	-0.27	-	
9. EF Z-Score	0.18	0.48*	0.45*	-0.53	-0.21	-0.08	-0.29	-0.24	-
10. Memory Z-Score	0.07	-0.28	-0.08	0.18	-0.18	-0.01	0.10	0.13	-0.18

Note. MCI – Mild cognitive impairment; MoCA= Montreal Cognitive Assessment; GDS = Geriatric Depression Scale; MC-SDS = Marlowe-Crowne Social Desirability Scale; EComp = Everyday Compensation Scale; EF = Executive Functioning
*p<.05, **p<.01, ***p<.001

Global cognitive functioning (MoCA) was negatively correlated with everyday dysfunction (DSRS) and positively correlated with executive functioning (EF score). Finally, depression (GDS) was positively associated with compensatory strategy use (EComp).

Aim 1. Grit and Cognitive Functioning

Multiple linear regression analyses were performed using grit, clinical status (HC vs. MCI), and the interaction between grit and clinical status as independent variables, with age, education, and depressive symptoms as covariates. Two aspects of cognitive functioning served as outcome variables in separate analyses: memory and executive functioning scores. With regard to memory functioning (see Table 5), the model accounted for 19.5% of the variance (p = .02), with only clinical status as a significant predictor (β = -0.32, p = .008).

Table 5

Summary of Regression Analysis for Variables Predicting Episodic Memory (Aim 1)

Stubhead	*B*	*SE B*	β	*p*
Age	0.007	0.018	0.048	0.714
Education	-0.082	0.044	-0.220	0.060
GDS	0.061	0.079	0.108	0.436
Grit	0.196	0.164	0.195	0.228
Clinical Status	-0.691	0.256	-0.331	0.005
Grit × Clinical Status	-0.107	0.278	-0.055	0.699

Note. GDS = Geriatric Depression Scale; clinical status was coded as 0 = HC and 1 = MCI.

With regard to executive functioning (see Table 6), the model accounted for 30.8% of the variance (*p* = .008), with three variables identified as significant predictors: depression (β = -0.37, p = .01), education (β = 0.29, *p* = .021), and clinical status (β = -0.23, *p* = .023). Better executive functioning was associated with fewer self-reported depression symptoms, higher levels of education, and HC status. Neither grit nor the interaction between grit and clinical status were significant predictors in either model (all *p*-values > .05). As a result, no post hoc probing was conducted. Bootstrapping estimation was employed using 1,000 samples but did not alter the outcome of the analyses.

Table 6

Summary of Regression Analysis for Variables Predicting Executive Function (Aim 1)

Stubhead	*B*	*SE B*	β	*p*
Age	-0.033	0.017	-0.237	0.057
Education	0.110	0.041	0.294	0.006
GDS	-0.202	0.073	-0.357	0.004
Grit	-0.011	0.152	-0.011	0.943
Clinical Status	-0.508	0.244	-0.242	0.034
Grit × Clinical Status	-0.250	0.258	-0.129	0.330

Note: GDS = Geriatric Depression Scale; clinical status was coded as 0 = control and 1 = MCI.

Aim 2. Grit, Everyday Dysfunction, and Compensatory Strategy Use

Regression analysis was used to investigate the hypothesis that compensatory strategy use mediates the effect of grit on everyday dysfunction. Results (see Figure 2) indicated that higher levels of grit were associated with lower levels of everyday dysfunction (DSRS; $\beta = -0.72$, $p < .001$). Grit was not a significant predictor of compensatory strategy use (EComp; $\beta = -0.15$, $p = .27$); thus, the mediation hypothesis was not supported. However, compensatory strategy use (EComp) emerged as a significant predictor of everyday dysfunction (DSRS; $\beta = 0.61$, $p = .001$), such that individuals who reported greater compensatory strategy use also reported greater functional impairment. The indirect effect was tested using a bootstrapping estimation approach using 1000 samples (Shrout & Bolger, 2002), but did not alter the outcome of the mediation analysis. No potential moderators were explored because of the lack of a mediation effect.

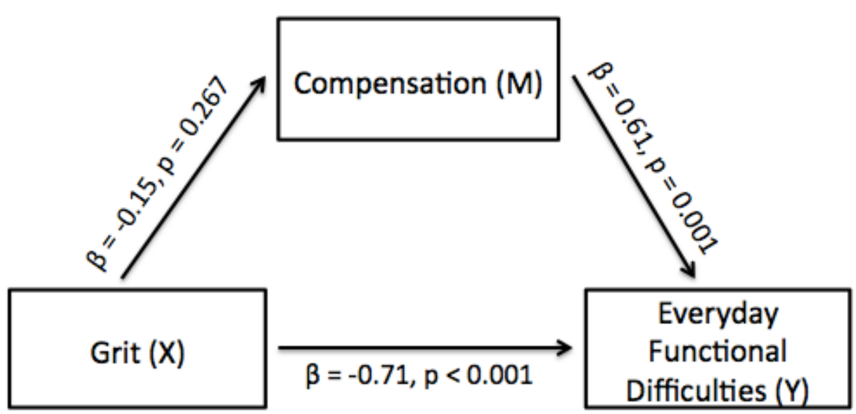

Figure 2. Mediation Results (Aim 2)

CHAPTER 4

DISCUSSION

The overarching goal of this study was to examine the relations among grit, cognitive performance, and everyday functioning in older adults with normal cognition and MCI. The first aim was to assess the association between grit and cognitive functioning, as measured by tests of verbal episodic memory and executive functioning. It was hypothesized that higher levels of grit would predict better cognitive performance in both domains and that this relation would be moderated by clinical status, such that grit would be more strongly associated with cognitive performance among individuals with normal cognition (i.e., healthy controls). This hypothesis was not supported by regression analyses, as there was no significant relation between grit and cognitive functioning in either domain. The second aim was to investigate the relations between grit, everyday functioning, and compensatory strategy use. It was hypothesized that grit would be negatively associated with everyday dysfunction and that this association would be mediated by compensatory strategy use. This hypothesis was partially supported, as higher levels of grit predicted less everyday dysfunction. However, there was no significant association between grit and compensatory strategy use; thus, there was no mediation effect. It was further hypothesized that cognitive functioning would moderate the indirect effect of compensation, but this hypothesis was not assessed because of the lack of significant mediation.

This is the first study to investigate the relations between concurrently measured grit and cognitive functioning in older adults. Previous research identified grit as a non-cognitive facet of cognitive reserve, showing that grit measured in adolescence predicted preserved late-life episodic memory performance (Rhodes et al., 2016). The first aim of this project was to extend these findings to determine if grit measured later in life continues to predict better performance in cognitive domains commonly affected by cognitive aging and neurodegenerative disease. The present study found that grit was not associated with performance on measures of verbal episodic memory or executive functioning. Instead, memory performance was predicted only by clinical status, and executive functioning was predicted by clinical status, depressive symptoms, and years of education. This suggests that while grit functions as a facet of cognitive reserve when measured earlier in life (i.e., adolescence), it may not continue to protect against cognitive decline later in the lifespan. Rather, the present data suggest an alternate mechanism whereby grit may promote reserve via facilitation of early academic success, which subsequently increases the likelihood of exposure to enriched developmental contexts that impart reserve.

Despite the lack of significant relations between grit and cognitive functioning, grit was significantly negatively associated with everyday dysfunction. The second aim of the present study was to assess the role of grit in everyday functioning and test the hypothesis that grit promotes active adaptation to age-related losses via the use of compensatory strategies. While the data did not support the hypothesized indirect effect of compensation, there was a negative effect of grit on functional difficulties in older adults, which is consistent with our previous findings (Rhodes & Giovannetti, 2017). The differential impact of grit on everyday functioning compared to cognitive functioning may be due to greater opportunity for grit to play a role in everyday actions, which allow for more chances to persist at a task or develop strategies or adaptations to facilitate task completion. In contrast, neuropsychological tests are designed to measure isolated cognitive processes and prevent a range of common compensatory strategies (e.g., note taking, slowing down, elaborative rehearsal, etc.).

Although affective well-being was not a primary outcome of the current study, bivariate correlations showed a negative association between grit and depressive symptoms. This is consistent with cross-sectional research showing that grit is inversely related to depression, both in younger and older adults, as well as directly associated with happiness and life satisfaction (Kern, Benson, Steinberg, & Steinberg, 2016; Rhodes & Giovannetti, 2017; Singh & Jha, 2008; Von Culin, Tsukayama, & Duckworth, 2014). Taken together, these findings contribute to a growing body of evidence suggesting that grit is protective of functional independence and affective well-being in older adults, though this may only be true for individuals with intact cognitive functioning (Rhodes & Giovannetti, 2017). When bivariate correlations were examined separately by group, the associations between grit, depression, and everyday functioning were not significant in the MCI group. This pattern of findings may indicate that grit becomes less useful or meaningful in the context of impaired cognition.

Several findings were noteworthy for their divergence from the extant literature. First, the direction of the relation between compensatory strategy use and everyday functioning suggests that greater compensation is associated with lower functional independence. This is inconsistent with prior research showing that use of compensatory strategies predicts higher levels of everyday functioning in a large sample comprised of healthy older adults as well as individuals with MCI and dementia, though moderators of this effect, including clinical status and cognitive functioning, were not examined (Farias et al., 2018). Therefore, the positive relation between compensation and everyday functioning reported by Farias and colleagues may have been driven by the lack of compensation and lower functional independence found in the dementia participants. In the absence of marked everyday dysfunction in the current sample, increased compensation appears to more generally reflect a decreased level of everyday functioning and global cognition, suggesting that the compensatory strategies surveyed by the EComp are used more frequently by people with functional difficulties but were not effective in ameliorating their relatively mild everyday dysfunction. Furthermore, this relation may be influenced by differences in informant- and self-report of everyday activities and functioning, given that everyday dysfunction was measured via informant-report, while compensation was measured via self-report. Thus, it is possible that participants overestimated compensatory strategy use or that informants over-reported everyday dysfunction. Future research should examine informant-reported use of compensation alongside standard informant-report measures of everyday functioning to clarify this effect.

A second unexpected finding was an inverse correlation between grit and age that trended towards significance and appeared to be driven by the HC group. The direction of this relation is noteworthy, as the existing cross-sectional literature on grit supports the notion that grit increases with age, while related longitudinally-studied concepts (e.g., tenacious goal pursuit) show age-related reductions that begin around age 70 (Bailly, Le Joulain, Herveánd, & Alaphilippe, 2012; Brandtstadter & Rothermund, 2002; Duckworth & Quinn, 2009; Duckworth et al., 2007; Frazier, Newman, & Jaccard, 2007; Henselmans et al., 2011; Martinent et al., 2017). Our findings do not rule out the possibility that a similar age-related reduction in grit may be observed among individuals after the eighth decade of life. Similarly, the lack of association between grit and compensation is inconsistent with research showing that tenacious goal pursuit predicts compensatory strategy use among the elderly (Bailly et al., 2012; Brandtstädter, 2006; Brandtstädter & Renner, 1990; Heyl, Wahl, & Mollenkop, 2007). Although previous work from our lab has shown significant overlap between tenacious goal pursuit and grit in a larger sample of community-dwelling older adults (Rhodes & Giovannetti, 2017), the present findings suggest questionable concurrent validity between the two measures in a smaller sample of older adults with varying levels of cognitive function. Future research is needed to determine the extent to which lack of relation between grit and compensation in this study was due to insufficient power to detect a significant effect or the inclusion of individuals with cognitive impairment.

Though this study offers useful information on the role of grit in cognitive and everyday functioning in older adults, it is limited by several methodological issues. First, recruitment of study participants failed to meet the proposed sample size, resulting in a reduced cohort for statistical analyses and inadequate statistical power to detect significant interaction effects. The MCI sample was smaller; thus, there was an imbalance in statistical power in the exploratory bivariate correlations and an overrepresentation of HC in the primary analyses. Another limitation is the use of cognitive outcome variables derived from single neuropsychological tests. Performance on a single measure may be less likely to accurately and reliably capture an individual's level of cognitive functioning in a particular domain compared to composite scores comprised of scores from multiple measures of the same cognitive domain, which is a plausible alternate approach to analysis of cognitive functioning using the NACC UDS data. Additionally, the nature of the NACC sample may have had an unanticipated impact on the findings. Specifically, given that all participants are recruited from a clinical center (PMC), healthy control participants may have heightened concerns or anxiety about cognitive decline and the development of a neurodegenerative condition. This has the potential to skew self-report measures of compensation, as these individuals may be more likely to engage in compensatory strategy use even in the absence of significant cognitive decline. Indeed, both groups reported the same amount of compensation behavior, despite significantly different levels of everyday dysfunction. Thus, the present study may benefit from the use of a true community sample of healthy older adults as a reference group. Finally, the results of the present analyses may be impacted by the use of self- versus informant-reported data on compensation, which may be less accurate and reliable in older adults with cognitive impairment.

These limitations notwithstanding, this study suggests that grit is predictive of everyday function but not cognitive functioning in a sample of healthy older and adults and individuals with MCI. These findings support the notion that grit promotes affective well-being and functional independence in older adults, though there is some evidence to suggest that grit may be less useful in the context of cognitive impairment. The impact of grit on everyday functioning could inform low-cost behavioral interventions designed to increase life satisfaction and functional independence in older adults, especially individuals with normal cognition. Future research should assess the efficacy of grit-building interventions with healthy older adults, as well as continue to investigate possible links between grit and aspects of cognitive functioning in the elderly using robust neuropsychological measures. Longitudinal research on grit should explore alternate mechanisms to explain the relation between grit and preserved everyday functioning and further assess the contribution of grit as a facet of cognitive reserve across the lifespan. The present study also highlights the importance of examining everyday functioning as an outcome variable in addition to cognitive functioning, as grit in older adults may be more relevant to the completion of complex everyday tasks.

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