Cleverness, contentiousness, creativity and curiosity. A meta-analytic investigation of predictors of academic performance

Alexander David Nettelbeck Monteath

This thesis is submitted in partial fulfilment of the Honours degree of Bachelor of Psychological Science (Honours)

School of Psychology

University of Adelaide

2019

Word Count: 9090

Table of Contents

LIST OF FIGURES IV

LIST OF TABLES... V

ABSTRACT.. VI

DECLARATION VII

ACKNOWLEDGEMENTS VIII

CHAPTER 1 INTRODUCTION 1

1.1 Overview of Academic Performance 1

1.2 Academic Performance and Intelligence 2

1.3 Academic Performance and Personality 3

1.4 The Role of Conscientiousness 4

1.5 The Role of Openness to Experience 5

1.6 Investment Theory 5

1.7 Need for Cognition 8

1.8 Context for the Present Study 10

CHAPTER 2 METHODS 13

2.1 Literature Search ……………………...13

2.2 Study Eligibility 13

2.3 Assessment of Measures ………………..16

2.4 Data Extraction ……………….. 17

2.5 Quality Assessment …………………..18

2.6 Meta-analytic Correlations………………...18

2.7 Moderation Analyses ………………...19

2.8 Corrections of von Stumm et al. (2011)………..20

2.9 Structural Equation Modelling ………………...20

CHAPTER 3 RESULTS 24

3.1 Study Characteristics 24
3.2 Meta-analyses 25
3.3 Comparison of NFC and TIE 28
3.4 Moderation Analyses....29
3.5 Re-examining TIE and Academic Performance....29
3.6 Structural Equation Modelling (TIE) 30
3.7 Structural Equation Modelling (NFC).... 32

CHAPTER 4 DISCUSSION 35

4.1 Key Findings.... 35
4.2 Strengths and Limitations 38
4.3 Directions for Future Research 42
4.4 Conclusion 43

REFERENCES.... 45

APPENDICES 49

Appendix A: List of References Included in Meta-analysis....49
Appendix B: Study Demographics and Correlations.... 54
Appendix C: Forest Plots for Meta-analytic Correlations.... 63

List of Figures

Chapter 2: Methods

Figure 1: Study screening procedure

Chapter 3: Results

Figure *2*: ‘Model 0’, and ‘model 4’, from von Stumm et al. (2011)

Figure 3: SEM models reproduced from von Stumm et al. (2011)

Figure 4: Corrected SEM models reproduced from von Stumm et al. (2011)

Figure 5: ‘Model 0’, fitted from meta-analytic coefficients derived from the present study (a) and from previous meta-analyses (b)

Figure 6: ‘Model 4’, fitted from meta-analytic coefficients derived from the present study (a) and from previous meta-analyses (b)

List of Tables

Chapter 2: Methods

Table 1: Meta-analytic coefficients borrowed from previous studies

Chapter 3: Results

Table 2: Pairs of Variables Correlated and Samples Size of Included Studies (present study)

Table 3: Pairs of Variables Correlated and Samples Size of Included Studies (von Stumm et al., 2011)

Table 4: Meta-analytic correlation of intervariable relationships

Table 5: Meta-analytic correlations for TIE and NFC

Abstract:

Intelligence and conscientiousness have long been recognised as key predictors of academic performance, but only account for about half of the variance in academic performance (von Stumm et al., 2011). Another factor that has shown promise as a potential predictor of academic performance is intellectual curiosity: the desire to acquire new knowledge (Berlyne, 1954). However, this relationship has arguably not been well established. One measure of intellectual curiosity that remains relatively unexplored is Need for Cognition (NFC), which measures the desire to engage in effortful cognitive activity (Cacioppo & Petty, 1982). NFC has been measured together with academic performance with varied findings. The present meta-analysis explores relationships between NFC, academic performance and other predictors of academic performance: namely, intelligence, conscientiousness, and openness to experience. A correlation matrix is derived from 63 studies measuring NFC and one or more of the relevant predictor variables. Structural equation modelling has explored the magnitude and significance of associations between the variables of interest. While moderately correlated with academic performance, NFC is not a significant predictor. This finding suggests that intellectual curiosity may not be such a significant predictor of academic performance as previous research has suggested.

Declaration

This thesis contains no material which has been accepted for the award of any other degree of diploma in any University, and, to the best of my knowledge, this thesis contains no material previously published except where due reference is made. I give permission for the digital version of this thesis to be made available on the web, via the University of Adelaide's digital thesis repository, the Library Search and through web search engines, unless permission has been granted by the School to restrict access for a period of time.

21st September 2019

Acknowledgement

I would like to acknowledge the support of my supervisors, Dr Matthew Dry, and Professor Nicholas Burns. This project would not have been possible without your guidance, and for that I cannot thank you enough. You have both helped me to learn so much throughout this project and our regular discussions have also made the process very enjoyable. I would also like to thank Maureen Bell. Your exceptional advice on database searching was crucial to forming the backbone of this project. Finally, I would like to thank Dr Chris Powell. Your previous research and valuable suggestions in the early stages of this project were the source of direction and inspiration for this thesis.

Chapter 1

Introduction

1.1 Overview of Academic Performance

Academic performance is a core determinant of career paths and other important life outcomes. In today's job market, there is an emphasis on educational qualifications, so careers are arguably less predetermined by social class or parental occupation, and more by demonstrated ability. The most significant, repeatedly demonstrated predictors of academic performance are Intelligence and Conscientiousness. That is to say, students who are high in cognitive ability and who are well organised tend to perform better academically than others. There is some evidence to show that "investment traits" (see below) are also core determinants of academic performance. Cattell (1943) provided a detailed theoretical account of how cultural constructs, particularly education, can influence the "investment" of fluid capacities in crystallised abilities and, following this lead, Ackerman (1996) has developed an investment theory that includes aspects of personality investment traits like intellectual curiosity, as well as personal interests and specific knowledge. A detailed account of these ideas has been provided by Powell (2017). Nonetheless, the promising contributions of Ackerman and colleagues notwithstanding, a substantial amount of variance in academic performance beyond that linked to intelligence, personality and possible investment traits remains to be explained.

Tests of academic performance are designed to measure individual differences in learning and educational outcomes. However, academic performance is also considered a proxy for cognitive ability. This introduction will outline the background and context to the most established predictors of academic performance and discuss existing research on Need for Cognition (NFC), which this thesis investigates as a predictor of academic performance, but where the relationship to academic performance is less established.

1.2 Academic Performance and Intelligence

Intelligence tests have been designed to measure innate cognitive ability. It is important to distinguish what is meant here by intelligence. Intelligence refers to a broad construct, which is by no means well defined. General intelligence (g) refers to a factor of intelligence which can be extracted from a battery of ability tests. General intelligence is the strongest predictor of academic performance with reported correlations as high as r = .81 (Deary et al., 2007) but has typically accounted for about 25% of variance in academic performance (Neisser et al., 1996). Such a strong association between intelligence tests and academic performance indicates a significant conceptual overlap between intelligence tests and tests of academic performance (Cattell, 1987). This is not surprising, given that the earliest intelligence tests were designed to identify children who were struggling with school curriculum. Intelligence tests continue to be validated by educational performance as a measure of ability (Neisser et al. 1996). If they failed to demonstrate association with academic performance, they would not be regarded as meaningful measures of intellectual ability.

1.3 Academic Performance and Personality

Intelligence is one primary predictor of academic performance, but research has shown that personality traits also account for substantial variance in academic performance (Poropat, 2009), perhaps explaining as much as four times more variance in university exam scores than intelligence (Chamorro-Premuzic & Furnham, 2003). However, this outcome is due in part to the effect of range restriction of intelligence in university samples, because such samples are already selected on the basis of intellectual ability. This increases the variability and importance of non-cognitive factors.

There are some key differences and similarities between constructs of intelligence and personality. Both refer to cognitive and behavioural differences which can be quantified through psychometric instruments (von Stumm & Ackerman, 2013). Both are also genetically influenced to different degrees. Both show relative stability over time and are thought to produce stable patterns of behaviour across lifespan. However, intelligence tests require test takers to perform at their maximal cognitive capacity, whereas personality measures have been designed to capture general tendencies regarding feelings and behaviours. There are no correct responses for personality measures, as there are for intelligence tests. Personality measures are also bidirectional, representing a spectrum between poles on two extremes, whereas intelligence test items are unidirectional by design.

The five-factor model of personality is used to describe the most important domains of personality: Openness to Experience, Conscientiousness, Agreeableness, Extraversion, and Neuroticism. Several meta-analyses have reviewed the variables of the five-factor model as predictors of academic performance. These have shown conscientiousness to be a significant predictor, and openness to be a more modest predictor (Poropat, 2009). Research on these two personality traits are discussed below as relevant to this study.

1.4 The Role of Conscientiousness

Unlike intelligence, Conscientiousness was not initially considered as a predictor of academic performance, but an association is now well established (Poporat, 2009). Conscientiousness describes an individual’s tendency towards self-awareness and a stronger work drive. It is made up of six facets: Competence, Order, Dutifulness, Achievement Striving, Self-discipline, and Deliberation (Costa & McCrae, 1992). These facets reflect individual differences in effort, responsibility and persistence, all of which have been associated with academic performance (von Stumm et al. 2011). Poropat (2009) reported a small-to-moderate correlation between Conscientiousness and academic performance (r = .20). Conscientiousness has also been shown to correlate with job performance across a range of occupations (von Stumm et al. 2011).

Although Conscientiousness has been found to be a predictor of academic performance, its predictive strength is diminished at the tertiary level due to range restriction in tertiary samples (Poropat, 2009). Conscientiousness has also been demonstrated to be largely independent of intelligence (Willis & Boron, 2008). Meta-analyses have found very low and even negative correlations between conscientiousness and intelligence (Poropat, 2009). A plausible explanation for a negative correlation is that individuals may develop high levels of conscientiousness to compensate for lower intelligence, and in contrast, intelligent people might excel more easily in academia, and thus can potentially afford to be less dutiful and organised (Chamorro-Premuzic & Furnham, 2005).

1.5 The Role of Openness to Experience

Openness to Experience is made up of six facets: Fantasy, Aesthetic Sensitivity, Attentiveness to Inner Feelings, Actions, Ideas, and Values (Costa & McCrae, 1992). Poropat (2009) found a moderate correlation between Openness and academic performance (r = .36). Openness to Experience and academic performance are conceptually related because both involve problem solving, decision making, learning and developing creative ideas. Poropat (2009) also found Openness to be correlated with intelligence, but more so with fluid intelligence (Gf) than crystallised intelligence (Gc). Correlations between Openness to Experience, intelligence, and academic performance are strongly influenced by the facet of Openness to Experience known as ‘Openness to Ideas’ (Costa & McCrae, 1992). Von Stumm et al., (2011) suggested that Openness to Ideas might be a stronger predictor of academic performance than Openness to Experience.

1.6 Investment Theory

Academic performance has also been theorised to be influenced by investment traits. The investment theory of intelligence proposes that differences in cognitive ability and the tendency to apply and invest in cognitive ability lead to individual differences in knowledge acquisition (Cattell, 1943; Cattell, 1963). Investment traits therefore determine how individuals invest in cognitive resources, as well as their tendency to pursue and enjoy cognitively challenging material (Ackerman & Heggestad, 1997).

There are numerous investment traits that measure a desire to pursue cognitively effortful tasks, including Need for Cognition, Typical Intellectual Engagement, Epistemic Curiosity, and Openness to Ideas. These investment traits reflect a tendency for likely accomplishment, whereas cognitive ability is ordinarily measured as maximum performance (Fiske & Butler, 1963; Klehe & Anderson 2007). However, investment traits such as Need for Cognition, Typical Intellectual Engagement, Epistemic Curiosity, and Openness to Ideas share many aspects and are highly correlated as a result (Powell, 2017). There is some debate about how the specific underpinnings of investment traits should be best described because scales lack discriminant validity (Mussel, 2010). Von Stumm et al. (2011) suggested that investment traits appear to measure the same trait dimension, and therefore might be used interchangeably.

As an early theorist of investment traits, Cattell (1943) concluded that “intelligence is of two kinds” (p. 178): fluid and crystallised. Fluid intelligence (Gf) has a genetic component and includes logical thinking, recognising and analysing patterns, and solving novel problems. Crystallised intelligence (Gc) is the product of cultural and educational experience, represented by general knowledge, vocabulary, and numerical and verbal reasoning skills. Cattell (1943) proposed that over time, Gf is invested into Gc, which then leads to individual differences in intellectual ability. In other words, expertise and knowledge arise from the continual investment of one’s fluid intelligence. This investment is thought to contribute to individual differences in cognitive ability and the acquisition of knowledge over the lifespan (von Stumm & Ackerman, 2013). Longitudinal research has confirmed that Gc is relatively stable across the adult lifespan, whereas Gf declines with age (von Stumm & Ackerman, 2013).

More recently, Ackerman (1996) extended Cattell's theory of adult intelligence, developing the theory of PPIK (process, personality, interests and knowledge). While maintaining that Gf is invested in Gc, the PPIK theory also incorporates interest and personality variables into this process (Ackerman, 1996). The PPIK framework emphasises that personality and investment traits influence the transition from the learning process to knowledge (von Stumm & Ackerman, 2013).

Von Stumm et al., (2011) emphasised the integrated role between investment traits and cognitive ability as "the hungry mind", which they claimed is the third pillar of academic performance, alongside intelligence and conscientiousness. The current evidence base of investment traits as predictors of academic performance is inconsistent, with conclusions varying, depending on the predictor measures included, but von Stumm et al. (2011) presented results that suggested that investment in terms of intellectual curiosity predicted academic performance to the same degree as Conscientiousness.

Even more assertively, Hayes (1962) claimed that all variation in intelligence results from investment traits, or the drive to engage in learning opportunities. He believed that differences in intellectual ability are the same as differences in acquired ability, rejecting a factor of general intelligence. While this is an extreme position, it is certainly plausible that investment traits play a role in the development of intellectual ability.

It is also plausible that higher intelligence enables someone to pursue learning experiences, meaning that cognitive ability can play a role in the development of investment traits (von Stumm & Ackerman, 2013). Under this assumption, association between investment traits and adult intelligence might be explained entirely by general intelligence (Gow et al. 2005).

In other words, it seems possible that intelligence and investment traits are developed interactively and might mutually influence one another. Higher levels of knowledge might facilitate more learning engagement because more knowledge engenders hunger for even more knowledge to fill informational gaps (von Stumm & Ackerman, 2013).

Different access to the amount and quality of opportunity to learn means that children have different capacity to invest in this way (Nisbett et al. 2012). Children who are offered a range of engagement opportunities tend to develop intellectually and they also develop an appetite to learn more (Barron et al. 2009). Such children are likely to establish a capacity for exploration and curiosity. In turn, this continues to benefit their cognitive development.

1.7 Need for Cognition

Need for Cognition (NFC) is characterised as reflecting cognitive motivation rather than cognitive ability (Cacioppo et al., 1996). However, it makes sense that it would be related to cognitive ability to some extent. A previous meta-analysis by Richardson et al. (2012), which investigated 50 distinct correlates of GPA, found NFC to be the third-highest non-cognitive predictor of GPA, besides procrastination and Conscientiousness.

NFC was first conceptualised by Cohen et al. (1955), who defined it as “a need to structure relevant situations in meaningful, integrated ways” (p. 291). Cacioppo & Petty (1982) then redefined it as “the tendency to engage in and enjoy effortful cognitive activity”. Cacioppo & Petty (1982) shifted the definition away from a behaviour motivated by ‘needs’ and ‘drives’ toward an individual’s desire or inclination for higher level cognition. Cacioppo & Petty developed the first published measure with the Need for Cognition Scale (NCS), which contained 34 self-report items. The authors later developed a shortened version of 18 items (Cacioppo et al., 1984). Studies with both adolescent and adult samples have supported the validity of both versions of the NCS (Cacioppo et al., 1996). Both versions have also been translated into various languages (Bless et al., 1994).

Cacioppo & Petty (1982) proposed that NFC develops as the individual matures but is still a relatively stable trait over time. However, it is possible that NFC can be developed over time like other personality traits (Woo et al., 2014). There is some evidence from Padgett et al. (2010) who showed that NFC increased in students who had meaningful discussions with diverse peers and interactions outside of an educational setting. This suggests that NFC might be increased in a stimulating intellectual environment.

Individuals high in NFC are thought to naturally seek, acquire and reflect on information from their environment (Cacioppo & Petty, 1982). On the other hand, individuals low in NFC lack a tendency to engage in and enjoy effortful cognitive activity, and generally prefer to rely on simpler cues in social comparison processes (Cacioppo & Petty, 1982). People high in NFC also report more thought and reflection on varied issues and are prone to more rational arguments (Furnham & Throne, 2013). Grass et al. (2017) demonstrated that NFC is significantly correlated with study satisfaction.

There is a large conceptual overlap between NFC and other investment traits such as Typical Intellectual Engagement (TIE) (Mussel, 2010). Both TIE and NFC are concerned with intellectual behaviours, but both emphasize interest and engagement rather than cognitive capacity. Woo et al. (2007) found a high correlation between NFC and TIE ($r = .78$, $p < .001$).

High association between NFC and TIE is not surprising given their similar definitions, as well as some overlap in scale items.

TIE is defined as "an individual's aversion or attraction to tasks that are intellectually taxing" (Ackerman et al., 1995, p.276). It was originally developed to address a disproportionate focus on maximum intellectual performance within the intelligence literature, despite average performance being of practical relevance (Goff & Ackerman, 1992). Individuals do not always perform to the best of their cognitive ability, because the conditions for best possible performance are rarely always present (Woo et al., 2014). In contrast to best performance, TIE is concerned with how individuals perform on average. More specifically, it has been developed in relation to the tertiary level of education where the predictive validity of intelligence is diminished (Goff & Ackerman, 1992).

TIE has been demonstrated to predict variance in academic performance beyond that explained by intelligence and Conscientiousness (von Stumm et al., 2011). On the other hand, several studies (Powell & Nettelbeck, 2014; Powell, 2017) have questioned the conclusion of von Stumm et al. (2011). NFC is related to academic performance, because academic performance typically requires effortful thought. Students high in NFC utilise deeper learning strategies, which often leads to better acquisition of knowledge and subsequently stronger academic performance.

1.8 Context for the Present Study

It is established that the relationship between predictors of academic performance vary at different levels of education. Jacobs et al. (2002) reported that intrinsic motivation decreases over the school years. This might suggest that fostering intellectual curiosity in early academic development could be important for sustaining learning motivation (Luong et al. 2016). Predictors of academic performance have been reported to be valid across all levels of education (von Stumm et al. 2011). However, association between intelligence and Conscientiousness tends to be lower at the tertiary level of education due to range restrictions, because university entrants are already selected on the basis of intelligence. Scores on Conscientiousness are also likely to be higher in the university population. Despite these variations, intelligence as maximum cognitive performance has been demonstrated to be the most relevant predictor of academic success (Ackerman & Heggestad, 1997).

However, the amount of typically invested cognitive effort, which is described by investment traits, has not been explored to the same degree (von Stumm et al., 2011). No substantial meta-analyses have explored the relationship of NFC and academic performance. Individual investment traits have tended to be studied by separate groups of researchers, often without much notice taken between these groups.

This study aims to address a research gap in the role of Need for Cognition (NFC) as a predictor of academic performance and its relationship to other predictors of academic performance. In the present study, a meta-analytic correlation matrix is generated in order to fit meta-analytic coefficients to a series of path models. Correlation coefficients derived from the present meta-analysis were also compared to coefficients derived from previous meta-analyses. The study aims to assess the degree to which academic performance can be explained by ability and non-ability factors. In doing so, it seeks to determine whether intellectual curiosity is a meaningful third pillar of academic performance, as claimed by von Stumm et al. (2011).

The key research questions driving this study are:

1. How strong is the relationship between Need for Cognition and academic performance?
2. Does level of education (primary, secondary, tertiary) moderate the relationship between Need for Cognition and academic performance?

Chapter 2

Methods

2.1 Literature Search

Literature searches were conducted for six electronic databases: Pubmed, Embase, Scopus, PsychINFO, ERIC and Sociological Abstracts. Rather than creating a comprehensive list of search terms to cover all the variables of interest, the database searches included all results for Need for Cognition. This meant that there was no risk of excluding potentially relevant studies. Database searches were conducted to search for 'Need for Cognition' within titles, abstracts, and keywords, according to the syntax of the various electronic databases. The aim of these searches was to retrieve articles which included Need for Cognition and measures of any of the other variables of interest; intelligence, academic performance, Conscientiousness and Openness to Experience.

2.2 Study Eligibility

In order to be considered eligible for inclusion in the present study, articles were required to meet each of the following criteria:

1. Studies must utilise any version of the Need for Cognition Scale (NCS) (Cacioppo & Petty, 1982).
2. Studies must report original data.

3. Studies must report zero-order correlations between NFC, and any of the other variables of interest. Correlations must be convertible to Pearson's r (e.g. means, standard deviations).
4. The studies needed to be published prior to May of 2019 when database searches were conducted, and after the NCS was originally published (Cacioppo & Petty, 1982).
5. Studies must report sufficient information regarding method and results, including sample size.
6. Studies must additionally utilise at least one other relevant measure of Conscientiousness, Openness to Experience, intelligence and academic performance.
7. Measures of conscientiousness and openness must be measured within the five-factor model.
8. Measures of academic performance and intelligence must be representative of these respective constructs. In cases where the suitability of measures is unclear, this will be resolved by discussion with a panel of experts.
9. Studies not written in English must use the Roman alphabet so they may be translated.

The processing of screening articles is shown Figure 1. The initial searches yielded a total of 2,950 results. After removing duplicates within Endnote, 1,472 studies were retained. Studies were then screened for potential eligibility by reading the abstracts, and irrelevant studies were removed. Full texts were retrieved and examined against the eligibility criteria for 352 potentially relevant studies. Sixty-three were deemed to have appropriate methods and measures for the purposes of the present study, and thus correlations, sample size, and other demographic variables were recorded from each study. Each study was checked for independence of sample. One study was removed due to an overlapping sample with another included study. Von Stumm authored two original articles (von Stumm, 2012) and (von Stumm, 2013) using the same sample of 200 British adults. The first published article (von Stumm, 2012) was retained. For a full list for the included articles with references, see appendix A.

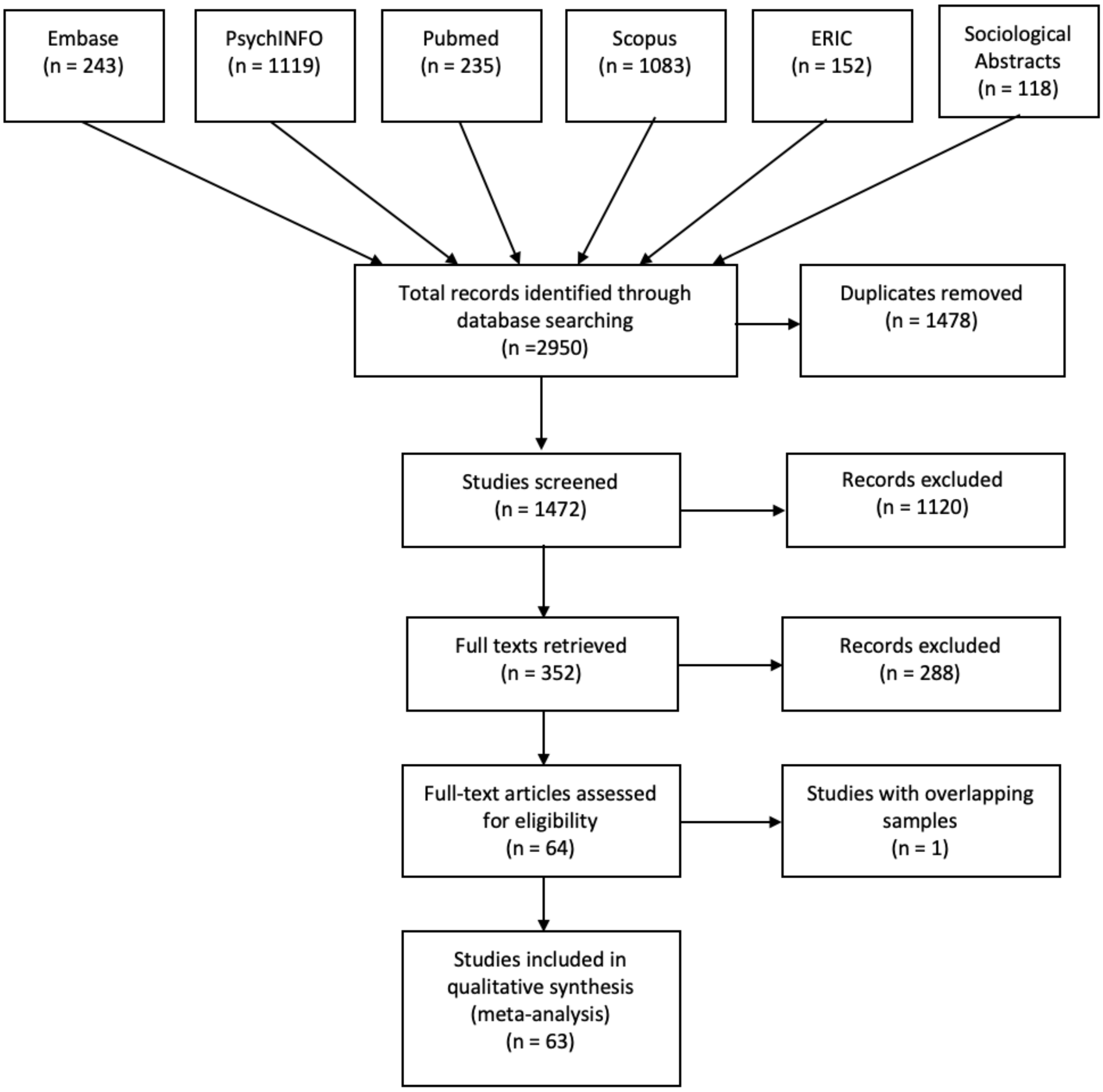


Figure 1: Study screening procedure

2.3 Assessment of Measures

Studies were included on the condition that measures employed within the studies were relevant to the variables of interest. For measures of Need for Cognition, studies either used a version of the original test from Cacioppo & Petty (1982) or a validated shortened version of the original test. All measures of Openness and Conscientiousness included in the present study were measured in accordance with the Five Factor Model. There is a high degree of similarity between different measures of the Five Factor model, such as the NEO Personality Inventory, the Big Five Inventory and the International Personality Item Pool (Costa & McCrae, 1987). These measures all consist of similar statements which subjects respond to on a 5-point Likert scale, responses ranging from strongly agree to strongly disagree, and they can be assumed to measure the same constructs. There are also verified short-form versions of these scales with fewer included items. These shortened scales have been tested against the full-form scales to which they are adapted to ensure internal consistency.

There are a range of tests claiming to measure intelligence and aspects of intelligence, which creates a challenge when making decisions for inclusion and exclusion of intelligence measures. Qualified staff from the school of Psychology at Adelaide University were consulted to determine whether measures were suitably representative of intelligence. Measures of intelligence were chosen to be broadly representative of general ability. Among studies at a university level, many reported Scholastic Aptitude Test (SAT) and American College Testing (ACT) scores. Although designed to assess what students have learned in high school, measures of adult intellect college entry tests have been shown to correlate highly with general intelligence (Mussel, 2010). Both were deemed suitable measures of intelligence rather than simply measures of academic performance, since they do not assess actual performance in an academic context, but rather the potential for academic performance across broad subject areas. Within the present study, measures of academic performance were required to reflect actual performance on academic assessment, such as GPA or course grade. For a full list of measures used in the included studies as well as sample sizes and demographic information, see Appendix B.

2.4 Data Extraction

The following information was extracted for those studies included: correlation values, measures, sample size, and sample demographic (i.e., mean age, gender, level of education). Level of education was categorised as either primary, secondary, tertiary, or as adult for samples that used a more general adult population (for example data collected in workplace or military environments).

Where studies reported correlations for multiple samples from different level of education categories, these samples were treated as separate studies. Where multiple measures were used for the same construct, correlations were recorded separately and then aggregated into one study for the purposes of statistical analysis. The same approach was taken for studies that reported correlations with NFC and multiple measures of intelligence, but not generalised intelligence. Taube (1997), MucCutcheon et al., (2003), von Stumm (2013), Chiesi et al., (2018), and Tirre (2018) each reported multiple measures of intelligence such as fluid intelligence and crystallised intelligence, or scores on the Scholastic Aptitude Test (SAT) and American College Testing (ACT), rather than any single measures of general intelligence. Heijne-Penninga et al., (2010) included correlations involving academic performance, measured by scores on an open-book test as well as scores on a closed-book test. All of these studies were divided into separate rows and correlations from different measures were then aggregated into single values so that meta-analytic correlations could be derived. The aggregation procedure was performed with the ‘MAc’ package in ‘R’ (Del Re & Hoyt, 2010). The ‘agg’ function aggregates within-study effect sizes, taking into account correlations among the within-study outcome measures. The functions of this package implement recommendations for aggregating dependent correlations from Hunter and Schmidt (2004).

2.5 Quality Assessment

While the methods of each study were not thoroughly scrutinised for methodological problems, each study was assessed for basic quality. No studies were excluded on the basis of methodological problems. Studies were not required to report statistically significant results and thus intercorrelations were included regardless of statistical significance. While it is important to assess the risk of bias among studies included in a meta-analysis, it was deemed unnecessary for the purposes of this thesis because all published studies on NFC were retrieved. Although tests of publication bias and other biases were not performed in the present study, funnel plots for each meta-correlation were produced and in no case did these reveal a clear indication of publication bias. While acknowledging that this is a subjective interpretation, this might suggest that adjusting for publication bias would not likely have altered the outcomes significantly.

2.6 Meta-analytic Correlations

The ‘meta’ package (Schwarzer, 2019), was used to calculate random effect estimates for correlations between each variable. As well as calculating random effects, the ‘meta’ package produces forest plots to display the results of the meta-analysis. Forest plots for correlations between all variables can be found in Appendix C. A random effects model was used, because it was assumed that the true effects would vary between the studies. Studies used a range of different but related measures to assess samples of different age ranges and level of education, so it is reasonable to assume that the included studies represent a random sample of the relevant distributions of effects. It follows that the combined effects of these studies are a reasonable estimate of the mean effects of the distributions between the relevant variables.

Interpretations of correlations followed guidelines by Cohen (1988), with values .1, .3, and .5 representing small, medium, and large relationships respectively. Three statistics were used to assess heterogeneity between each variable. Summary statistics reported by 'R' included Q values, T^2 values and I^2 values. Heterogeneity among variables intercorrelations was mainly assessed by I^2 values, which represent the ratio of true heterogeneity to total observed variation (Borenstein et al., 2009). However, it is important to acknowledge that I^2 is not a measure of absolute variance, and thus meaningful comparisons between correlations could not be made based on I^2 values due to variance of observed effects among correlations.

2.7 Moderation Analyses

The R package, 'meta' was used to conduct moderation analyses between each variable pairing. Moderation analyses were conducted to determine whether level of education moderated relationships between the chosen variables. Samples were coded as belonging to either primary school, high school, tertiary, or other adult categories. Moderation analyses then tested the interactions between each possible combination of variables with level of education as a moderator. Estimates of moderation effect for each level of education were used to indicate direction and strength of moderation and *p*-values were calculated to determine the level of significance. It should be noted that there was a wide range in the number of studies that reported correlations for variable relationships, and thus some relationships were more likely than others to demonstrate statistical significance.

2.8 Corrections of von Stumm et al. (2011)

A significant aspect of the meta-analysis by von Stumm et al., (2011) was calculating the relationship between TIE and academic performance. Using a random effects model, the authors generated an estimate of r_s = .33 between TIE and academic performance, with a confidence interval of .17 to .49, which is no doubt due to the small number of studies (k=4, N=608). However, the authors included two correlations from the same study which were treated as separate rather than aggregated into a single coefficient. Authors included correlations from Wilhelm, Shulze, Schmiedek, and Süß, (2003) twice, including correlations between TIE and Humanities GPA, as well as correlation between TIE and Science GPA, with r-values of .26 and .37 respectively. Correcting for this error, the true size of their combined sample is 3 studies (N=425) rather than 4 studies (N=608) for TIE and academic performance. In the present study, a correction is made to the original data presented in von Stumm et al., (2011) in order to re-examine their original findings.

2.9 Structural Equation Modelling

The ‘lavaan’ package in ‘R’ was used to fit structural equation models (SEM) to the data, with the ‘sem’ function. The SEM models were based on direct predictor models produced by von Stumm et al., (2011). In order to ensure the method of the present study is compatible with the method of von Stumm et al., (2011), their original results are replicated by fitting their reported meta-analytic coefficients to their direct predictor models. Additionally, these models are replicated with the same data after aggregating the correlations they reported twice and reducing the number of studies to 3 and the number of observations to 425 for the relationship between TIE and academic performance. Based on the same direct predictor models, models which replaced TIE with NFC were then produced using correlations derived from the present study. Since the overall sample size was relatively low for some relationships in the present study, meta-analytic coefficients between academic performance, intelligence, Openness and Conscientiousness were substituted with the same meta-analytic coefficients used in von Stumm et al. (2011). The previous meta-analyses from which these coefficients are derived can be seen in Table 1. The first model fitted in von Stumm et al., (2011), labelled ‘model 0’, was a full intercorrelation model where all predictor variables could correlate freely and directly affect academic performance. Since this model revealed a negative association between Openness and academic performance, von Stumm et al., (2011) excluded Openness from the subsequent mediation models and final predictor model (‘model 4’). For ease of comparison, models in the present study are also referred to as model 0 or model 4, as they have been labelled in von Stumm et al., (2011) (see Figure 2).

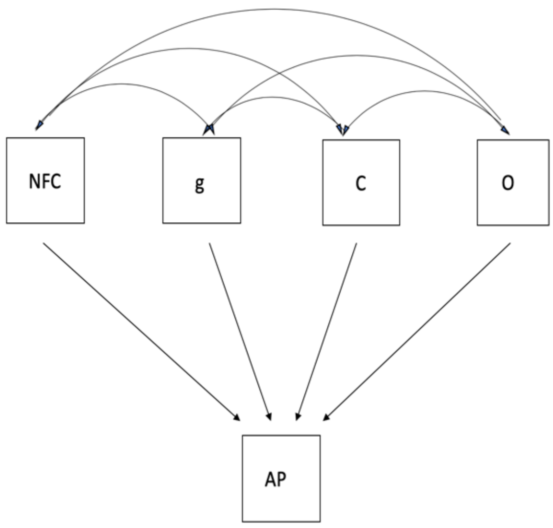
Table 1.

Meta-analytic coefficients derived from previous studies

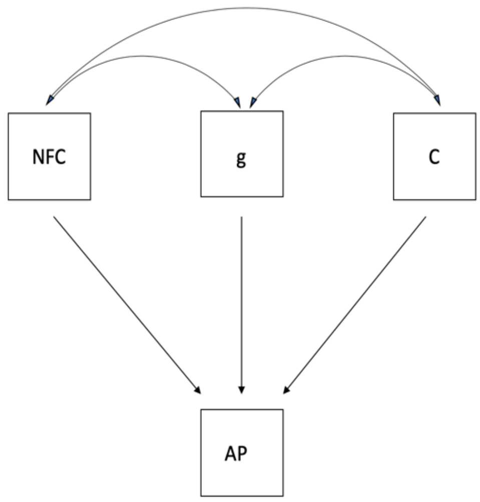
Correlation	Source	N	k	r_s
C-AP	Poropat, 2009	32,887	92	.23
O-AP	Poropat, 2009	28,471	77	.07
O-C	Mount, Barrick, Scullen, and Rounds, 2005	4,000	4	.09
g-AP	Kuncel, Hezlett, and Ones, 2004	11,368	70	.39
g-C	Judge, Jackson, Shaw, Scott, and Rich, 2007	15,429	56	-.04
g-O	Judge et al., 2007	13,182	46	.22

Note: C = Conscientiousness; AP = Academic Performance; O = Openness to Experience; g = general intelligence; TIE = Typical Intellectual Engagement; N = total samples size; k = number of studies; r_s = Spearman's rho.

Model 0



Model 4



Note: C = Conscientiousness; AP= Academic Performance; O = Openness to Experience; g = general intelligence; NFC = Need for Cognition

Figure 2: ‘Model 0’, and ‘Model 4’, from von Stumm et al. (2011)

Chapter 3

Results

3.1 Study Characteristics

Sixty-three independent studies were included in the present meta-analysis, comprising a total sample size of 43,899. The average age of participants was 27 years old. The average percentage of female participants within the included studies was 59%. While age and gender were generally well reported, very few studies reported separate correlations for different age groups and for different gender among participants. For these reasons it was not possible to perform meaningful moderation analyses on the basis of gender or age. Most studies originated from North America (32), followed by Europe (21), followed by Asia (5). All included samples could be classed by categories of ‘level of education’, which were either primary, secondary, tertiary, or adult samples. Most of the included studies measured university samples (k=45, N=23,550), followed by general adult samples (k=12, N=13,724), followed by secondary school samples (k=10, N=3,267), followed by primary school samples (k=4, N=3358). The reason that the total number of independent samples is 71 rather than 63 is because several studies reported correlations for separate samples. Luong et al. (2016) reported correlations for two samples of primary school students, and one sample of secondary students. Ghorbani et al., (2005) included separate samples for secondary school students and for teachers. Because systems of schooling vary around the world, level of education was categorised in accordance with the Australian standard, where primary school year levels range from 0 to 7, and secondary school levels from 8 to 12. Although university samples tended to be around the same age group (mean age = 22.7), age ranges were not restricted in the same way as primary and secondary school samples. There were a wide range of ages represented in the 'adult category', with the mean age of included adult samples ranging from 20 to 57 years old, with a mean age of 40 years old. Most studies met the minimum sample size requirements to produce statistically significant effects. However, statistical significance was not an inclusion requirement. All studies reported correlation coefficients as Pearson's r, so conversion of effect sizes was not necessary. Meta-analytically derived correlations and overall sample sizes included in the present study and in von Stumm et al., (2011) are displayed in Table 1 and Table 2 respectively.

Table 2.

Pairs of Variables Correlated and Samples Size of Included Studies (present study)

relationship	NFC-AP	NFC-g	NFC-O	NFC-C	AP -g	AP -C	AP-O	g-O	g-C	O-C
Number of studies (k)	24	32	32	18	2	3	2	7	5	13
N (total)	8,490	28,421	21,958	14,540	488	931	659	1,824	1,381	8,398

Table 3.

Pairs of Variables Correlated and Samples Size of Included Studies (von Stumm et al., 2011)

relationship	TIE-AP	TIE-g	TIE-O	TIE-C	AP-g	AP-C	AP-O	g-O	g-C	O-C
Number of studies (k)	4	5	11	9	70	92	77	46	56	4
N (total)	608	1,230	1,998	1,662	11,368	32,887	28,471	13,182	15,429	4,000

3.2 Meta-analyses

Data were pooled from 63 independent studies reporting correlations between Need for Cognition, academic performance, intelligence, Openness and Conscientiousness. Meta-analytic coefficients were produced for each relationship between variables. Coefficients of relationships between variables were mostly statistically significant, with the exceptions of academic performance and openness to experience (r_s= .08, *p*=.47), and openness and conscientiousness (r_s= .28, *p*=.06). This may be due in part to generally lower sample sizes for most correlations which did not include NFC. Meta-analytic coefficients for NFC and other variables were all in the small-medium range (r_s= .21 to .44) and were all statistically significant (p <.0001). The largest correlation between the study variables was NFC and O (r_s = .44, *p* <.0001). This might indicate moderate conceptual overlap between these variables. Table 4 displays relevant statistics for tests of meta-analytic correlation as well as levels of heterogeneity for each intervariable relationship. There was a high level of inconsistency across effect estimates, as indicated by moderate to large I^2 values, with the exception of the relationship between g and C (I^2 = 42.1%). This may be due in part to the broad demographic characteristics within the included studies, such as a range of age groups, ‘level of education’ and other uncontrolled variables. Fairly wide confidence intervals for many of the intervariable relationships not including NFC suggests some imprecision in the meta-analytic correlations of these relationships. Lower overall sample size for relationships between academic performance and intelligence, academic performance and Openness, academic performance and Conscientiousness, intelligence and Openness, and Conscientiousness and intelligence (all based on samples of 1,381 participants or fewer) contributed to a low level of precision.

Table 4.

Meta-analytic correlation of intervariable relationships

Meta-analytic correlation						Heterogeneity			
Correlates	k	N	r_s	*p*	CI	T^2	I^2	Q	*p*
NFC-AP	24	8,490	.21	<.0001	0.14; 0.26	.0194	86.4%	169.62	<.0001
NFC-g	32	28,421	.26	<.0001	0.21; 0.29	.0099	88.9%	280.20	<.0001
NFC-O	32	21,958	.44	<.0001	0.37; 0.50	.0486	96.8%	969.81	<.0001
NFC-C	18	14,540	.27	<.0001	0.20; 0.33	.0185	92.5%	228.15	<.0001
AP-g	2	488	.36	<.0001	0.21; 0.48	.0081	65.3%	2.89	0.0894
AP-O	2	659	.08	.47	-0.14; 0.29	.0216	87.4%	7.95	0.0048
AP-C	3	931	.28	.0053	[0.08; 0.45	.0283	89.6%	19.22	<.0001
g-O	7	1,824	.25	<.0001	0.14; 0.36	.0207	83.6%	36.68	<.0001
g-C	5	1,381	-.12	.001	-0.19; -0.05	.0029	42.1%	6.91	0.1407
O-C	13	8,398	.10	.06	-0.01; 0.21	.0353	94.7%	226.22	<.0001

Note: NFC = Need for Cognition; AP = academic performance; g = general intelligence; O = Openness to Experience; C = Conscientiousness; k = number of studies; N = total sample size; r_s = Spearman' rho; *p* = probability value; CI = 95% confidence interval; T^2 = tau-squared; I^2 = degree of heterogeneity; Q = Cochran's Q

3.3 Comparison of NFC and TIE

Most of the meta-analytic coefficients produced in the present study were similar in strength to those presented by von Stumm et al., (2011). See Table 5 for a comparison of meta-analytic correlations with academic performance, intelligence, Openness, and Conscientiousness for both NFC and TIE. Meta-analytic correlation revealed that NFC was more weakly correlated with academic performance and Openness than TIE was correlated with these variables. However, there was a higher correlation between NFC and intelligence, than was found for TIE and intelligence in von Stumm et al., (2011). Generally similar correlations between NFC and TIE suggest a moderate conceptual similarity between NFC and TIE variables. This is to be expected as both are measures of intellectual curiosity. Relationships between NFC and other variables were derived from a larger number of studies and subsequently larger total samples than were relationships with TIE. However, correlations between the remaining variables were based on larger samples in von Stumm et al., (2011) than in the present study, with the exception of the relationship between Openness to Experience and Conscientiousness. However, meta-analytic coefficients from each study appear generally similar with some minor variation.

Table 5.

Meta-analytic correlations for TIE and NFC

	TIE			NFC		
	r_s	k	N	r_s	k	N
AP	.33	4	608	.21	24	8,490
g	.22	5	1,230	.26	32	28,421
O	.64	11	1,998	.44	32	21,958
C	.28	9	1,662	.27	18	14,540

Note: TIE = Typical Intellectual Engagement; NFC = Need for Cognition; AP = academic performance; g = general intelligence; O = Openness to Experience; C = Conscientiousness; r_s = Spearman's rho; k = number of studies; N = total sample size

3.4 Moderation Analyses

Moderation analyses were conducted for interactions between each variable pairing with level of education as a moderating variable. Interaction between NFC and g was moderated by level of education as was interaction between NFC and C. Moderation analysis indicated that level of education is a significant moderating variable in the relationship between NFC and g for university samples ($b = -0.12$, $p < .01$). Moderation analysis also indicated that level of education is a significant moderator in the relationship between NFC and C for high school samples ($b = .37$, $p < .001$).

3.5 Re-examining TIE and academic performance

As previously mentioned, there was an error in the calculation of the TIE-academic performance relationship in von Stumm et al., (2011). The authors included two correlations between TIE and GPA (Humanities and Science) reported by Wilhelm, Shulze, Schmiedek, and Süß, (2003), treating them as separate samples within their analysis when these correlations were in fact derived from the same sample. Since von Stumm et al., (2011) only included four studies, twice including Wilhelm, Shulze, Schmiedek, and Süß, (2003), this error influenced their results substantially. This particular correlation was corrected for, using the same procedure of aggregation performed in the present study. The correlations between TIE and academic performance reported in Wilhelm, Shulze, Schmiedek, and Süß, (2003) were aggregated, returning an aggregated correlation of .36. Using the same procedure as the present study, a corrected meta-analytic coefficient for TIE and academic performance was produced using the aggregated correlation and correlations from the other two studies. The number of studies was revised to three and the total number of observations was set at 425. The resulting meta-analytic coefficient was 0.26 (p=.02), which was lower than the originally reported coefficient of .33.

3.6 Structural Equation Modelling (TIE)

Von Stumm et al. (2011) identified 'model 4' as the best fit for the data they generated. This determination was arrived at after testing 'model 0', and a series of meditation models. Since 'model 0' indicated a negative association between academic performance and Openness, the authors excluded Openness from the subsequent models. In the original 'model 4', von Stumm et al., (2011) also omitted the relationship between intelligence and conscientiousness due to an insignificant relationship. This relation was included in the corrected version of the original model. The relationship between intelligence and conscientiousness was maintained, because the association was found to be statistically significant in the present study (r_s = .12, p = .001). A series of structural equation models were produced using meta-analytic correlations obtained from the present study and also using correlations used in von Stumm et al., (2011). To demonstrate consistency of the method present study with the method of von

Stumm et al., (2011), the original direct predictor models presented by von Stumm et al., (2011) were successfully replicated with some minor variation (see Figure 3). The same models were then replicated with the meta-analytic coefficient between TIE set as $r_s = .26$, reduced from $r_s = .33$ (See Figure 4).

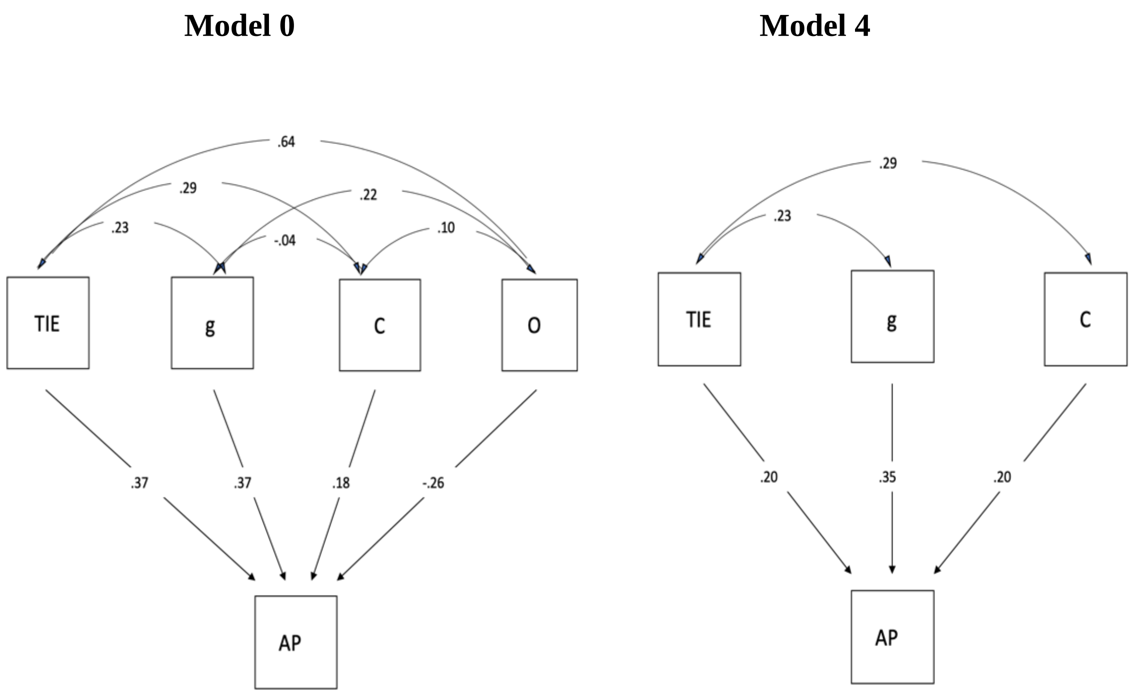


Figure 3: SEM models reproduced from von Stumm et al. (2011)

Model 0 **Model 4**

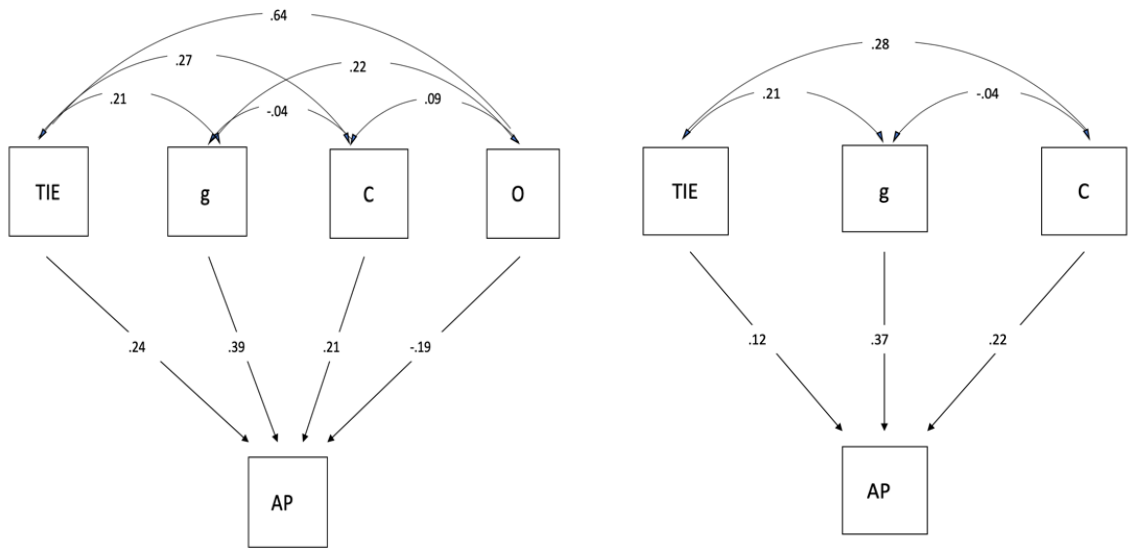


Figure 4: Corrected SEM models reproduced from von Stumm et al., (2011)

Correcting for the error in von Stumm et al. (2011) reduced the path weight between TIE and academic performance from .37 to .24 in ‘Model 0’, and .20 to .12 in ‘Model 4’. This correction also led to a decreased path weight between O and academic performance, from -.26 to -.19 in ‘Model 0’, while other path weights were relatively unaffected in both models.

3.7 Structural Equation Modelling (NFC)

Meta-analytic coefficients derived from the present study were fitted to the same direct predictor models fitted by von Stumm et al. (2011). Meta-analytic correlations between NFC and other variables were fitted to both models, using the remaining meta-analytic correlations from the present study and additionally using the meta-analytic correlations used in von Stumm et a., (2011), which were borrowed from previous meta-analyses. ‘Model 0 (a)’ uses meta-analytic correlations all derived from the present study and ‘Model 0 (b)’ uses meta-analytic correlations involving NFC from the present study, substituting the remaining coefficients from previous meta-analyses (See Figure 5). The same comparison is made for 'Model 4' (See Figure 6). In Figure 5, path weights are generally similar between models, although 'Model 0 (a)' (current study) indicates a stronger prediction of Conscientiousness towards academic performance, and weaker association between intelligence and Conscientiousness than 'Model 0 (b)' (previous analyses). Marginal differences between other variable relationships are indicative of robust samples contained in the present study. Similarly, in Figure 6, the path weights of intelligence and Conscientiousness towards academic performance are stronger in 'Model 0 (a)' than in 'Model 0 (b)', and the relationship between intelligence and Conscientiousness is weaker in 'Model 0 (a)'. In model 4, NFC was more highly correlated with intelligence in 'Model 4 (a)' than in 'Model 4 (b)'. Across all models, relationships between NFC and academic performance were weak and were not statistically significant.

Model 0 (a) **Model 0 (b)**

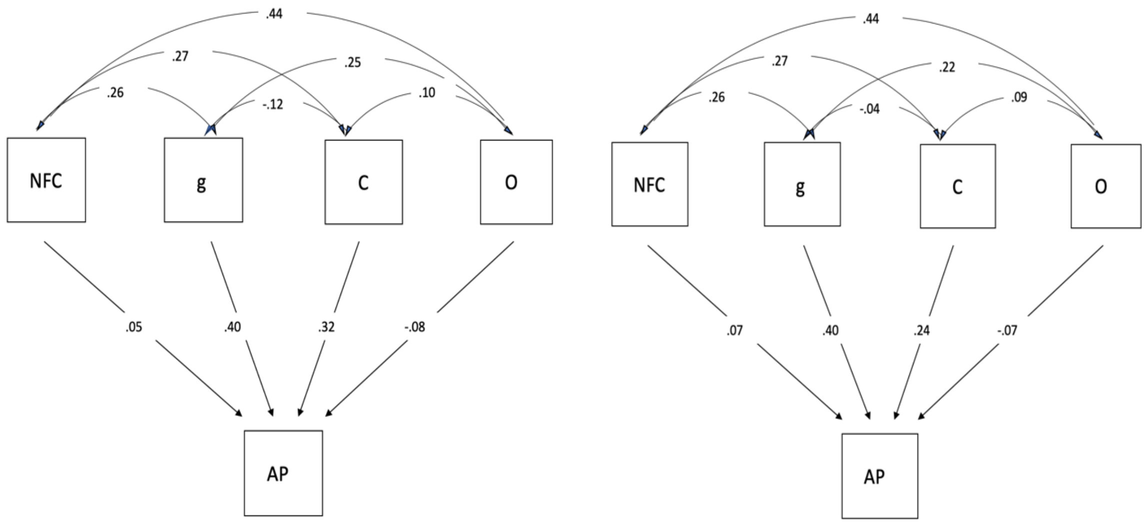


Figure 5: 'Model 0', fitted from meta-analytic coefficients derived from the present study (a) and from previous meta-analyses (b)

Model 4 (a) **Model 4 (b)**

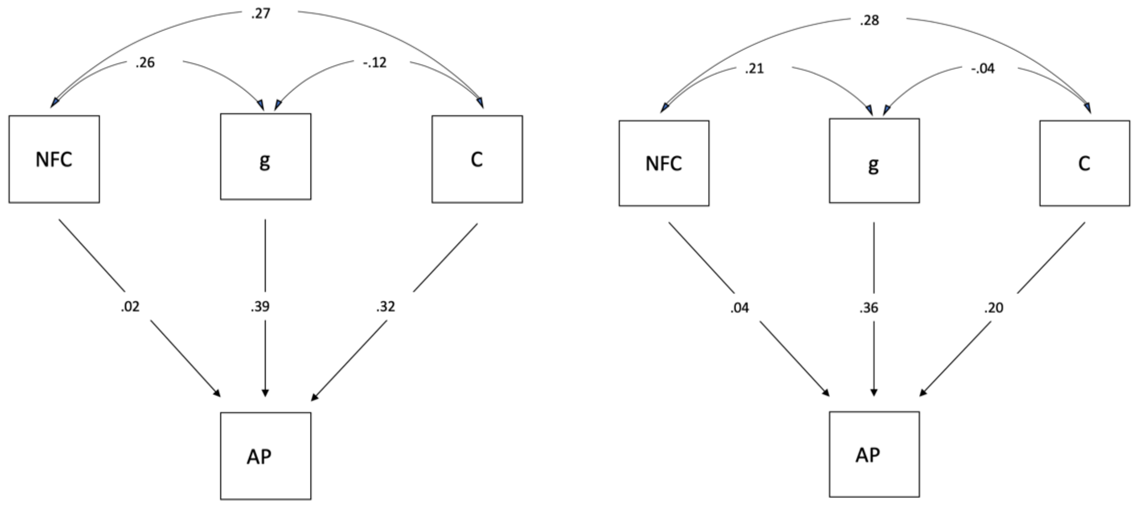


Figure 6: ‘Model 4’, fitted from meta-analytic coefficients derived from the present study (a) and from previous meta-analyses (b)

Chapter 4

Discussion

4.1 Key Findings

The present meta-analysis synthesises 29 years of research on Need for Cognition (NFC) and other predictors of academic performance. It identifies 63 suitable studies which reported original correlations between NFC and academic performance or predictors of academic performance.

Path analysis of the relationships between NFC and academic performance revealed that the distinct contribution of NFC to the model was marginal. Therefore, NFC was not a significant predictor of academic performance under either of the direct predictor models borrowed from von Stumm et al. (2011). However, this meta-analysis confirms previous findings which suggest that intelligence and Conscientiousness are key predictors of academic performance (eg., von Stumm et al. 2011). Across all direct predictor models, intelligence was the strongest predictor of academic performance, and Conscientiousness was a consistently strong predictor. Openness to Experience was demonstrated to be a weakly negative predictor, and so it was justifiably omitted from the final predictor model.

Consistent with previous research, the present study found a moderating effect of the level of education. Moderation analyses indicated that the interaction between NFC and intelligence was negatively moderated by level of education in university samples. This supports previous findings of an effect of range restriction on intelligence in university samples. An explanation for this is that university samples are already selected on the basis of intelligence, and thus the variability and importance of intelligence as a predictor is reduced whereas the importance of non-cognitive factors is increased. Level of education was also a significant moderator between NFC and Conscientiousness for high school samples. This suggests that the relationship between NFC and Conscientiousness is particularly strong at the high school level where learning habits are in formation.

The present meta-analysis also highlighted a methodological problem in the study by von Stumm et al. (2011), which has been an influential study in the field of intelligence and personality research. The original study found that TIE was a strong predictor of academic performance, and thus concluded that intellectual curiosity is ‘the third pillar of academic performance’ (von Stumm et al. 2011). This was a key finding of their study and would have significant implications for research on academic performance if it could be replicated. However, an error of calculation in their meta-analytic correlation between TIE and academic performance led them to suggest the existence of a stronger relationship than would have otherwise been found. After correcting for an error in the method of von Stumm et al. (2011), this meta-analysis has demonstrated that TIE was not a key predictor of academic performance, according to the model which they originally identified as best fitting the data. This exercise demonstrates that minor changes in these structural path models can amount to finding considerable differences in the path weights between variables. This in turn reveals that intellectual curiosity may not be a key predictor of academic performance as von Stumm et al. (2011) have proposed. While TIE maintained a strong level of prediction in a direct predictor model which also included Openness, intelligence, and Conscientiousness as predictors, this is insufficient evidence on which to draw a conclusion that TIE is a reliable predictor of academic performance.

Strong correlation between NFC and TIE have previously been demonstrated (r = .78) (Woo et al. 2007). This is not surprising, given that both TIE and NFC are concerned with intellectual behaviours and both emphasize interest and engagement rather than cognitive capacity. Furthermore, NFC and TIE are similar in definition, both reflecting an intrinsic motivation to think rather than the ability to think. The motivational component of NFC is concerned with enjoyment and a tendency to seek out situations involving thought. Additionally, there is a degree of overlap in scale items. Given the near equivalence of NFC and TIE, the conclusions of von Stumm et al. (2011) are called into question. This is not to argue that substituting values of TIE with NFC would be sufficient grounds to reject the original conclusions of von Stumm et al. (2011). However, given the strong correlations between TIE and NFC, and the limited research correlating TIE with academic performance, it is difficult to determine the true relationship between TIE and academic performance. The present meta-analysis has indicated that TIE was more strongly associated with academic performance than was NFC. However, after correcting for a methodological error by von Stumm et al. (2011), the predictive strength of TIE was greatly reduced and their original conclusion that intellectual curiosity is the ‘third pillar of academic performance’ becomes untenable.

These authors’ choice of TIE as a measure of intellectual curiosity is also questionable. Their justification for selecting TIE as a measure of intellectual curiosity was that it has been more frequently employed in research on intelligence, personality and academic performance compared to other investment trait scales. However, this seems not to be the case: the present study identified 23 more studies that reported correlations between NFC and intelligence, 21 more studies for both NFC and academic performance and NFC and Openness, and nine more studies for NFC and Conscientiousness than von Stumm et al. (2011) identified between TIE and the same variables. Even considering the difference of 8 years between von Stumm et al. (2011) and the present meta-analysis, it seems that there is a more substantive base of intelligence, personality and academic performance research employing NFC as a measure of intellectual curiosity. As a result of the small number of studies examined in von Stumm et al. (2011) (k=3, N=425), these results are questionable, and in any case might not have been built on a sufficient evidence base to support their conclusion. Moreover, the correlations between TIE and academic performance in the three studies which von Stumm et al. (2011) used to calculate a meta-analytic correlation varied considerably from one study to another.

4.2 Strengths and Limitations

Like all meta-analyses, deriving meta-analytic coefficients from a large number of studies is both a strength and a weakness of the present study. The meta-analytic approach allows for a more robust estimate of the relationships between variables, where those relationships can be affected by the context in which they are measured. However, meta-analysis is not intended to explain variation between the integrated studies. Although the inclusion of a large number of studies provides a greater overall sample size, the samples measured for each relationship are only as reliable as the studies they are generated from. Tests for publication bias were not performed in the present study. It is possible that containing the scope to published studies exclusively might have inflated the effect size estimates. However, funnel plots which were generated for each variable relationship indicated that publication bias was not a significant problem for these data.

A strength of this meta-analysis is that variable relationships were all obtained from the same set of included studies. However, many of the included studies only reported correlations for NFC and one other variable. Only one study (Strobel et al. 2019) reported correlations between each of the variables included in this meta-analysis. Having a substantial amount of missing data from correlation matrices can lead to bias, especially under a random effects model, where variability in effect sizes is expected. A strength of the present study is that it has included all of the literature on NFC. Rather than using specific search terms for the variables of interest, the present study aimed to explore the entire body of research on NFC to date, to ensure nothing of relevance was excluded.

Meta-analytic correlations obtained from four of the variable relationships were based on five or fewer independent correlations, so may not be as generalisable as other variable relationships, which were based on a larger number of correlations. In saying this, correlations between Conscientiousness, Openness, intelligence, and academic performance were for the most part consistent with those reported in von Stumm et al. (2011). Von Stumm et al. (2011) borrowed meta-correlation coefficients from various other meta-analyses. These meta-analyses are likely to be reliable estimates of the relationships between these variables because they have been based on large samples. However, using meta-analytic correlation coefficients from different sets of studies could cause problems of inconsistency among these coefficients, and therefore studies which employ meta-analytic correlations from multiple meta-analyses, including von Stumm's et al. (2011) study and the present study, should be interpreted cautiously.

It is likely that complex relationships exist between intelligence, personality, and other predictors of academic performance. The interaction between intelligence and personality needs to be studied with a wide range of other variables in order to explain the mechanisms of cognitive development. It seems likely that intelligence is influenced by factors such as investment traits, and that it becomes relatively stable once adulthood is reached. However, this study did not consider all these variables. Determinants of academic performance such as sex, performance self-efficacy, test anxiety, fluid and crystallised intelligence were not included here because there is an insufficient number of studies that have included all of these effects.

NFC was consistently measured with different versions of the NCS. Measures of Openness and Conscientiousness were measured consistently with different tests of the five-factor model. However, the measures of intelligence included in the present study varied considerably. Measures of Conscientiousness and Openness were selected partly because they are widely studied and therefore a large number of studies could be identified using these measures. There could possibly be a more suitable measure of effort than Conscientiousness, which might prove a better predictor of academic performance. The same is true for the personality factor Openness to Experience, and Goldberg's (1990) 'Intellect' might have been a more suitable choice of predictor. The most common measures included as being measures of intelligence were SAT and ACT scores. College entry tests resemble maximum performance measures, and therefore could be viewed as being explained by general intelligence. However, a range of measures were included for the purpose of measuring intelligence, and an assumption which this study relies on is that the sum of these measures constitutes a representative measure of general intelligence. A range of academic performance measures were included in the present study. Some studies reported grades from tests, some from coursework, some from overall course grades. While these are all representative of academic performance, there may be some variation within these measures.

For example, test anxiety would likely be a significant determinant of scores on tests, especially for major exams, but not for coursework assessment. Tests are usually conducted under timed constraints. Although timed tests are in part a maximal performance setting, they reflect typical performance in the students' preparation.

The present study has also relied on self-report measures, which can only capture aspects of the personality that are introspective (James, 1998). Self-report measures also assume truthful responses, which may not be always be the case. Objectivity is an advantage of measures that are not self-reported, such as tests of intelligence and academic performance. However, it should be noted that several studies included here utilised self-reported measures of grades or college entrance scores, and such reports might not reflect true scores.

A further limitation of this study is the high level of heterogeneity between studies. The inclusion of a wide range of measures from a range of different samples would have likely contributed to this heterogeneity. However, given that the equivalence of specific measures is not well-established, it is arguably more beneficial to include a larger number of samples rather than to omit studies based on their chosen measures. Heterogeneity could also have resulted from systematic differences between studies. For example, potentially moderating variables such as age, sex, and country of origin may have influenced the effect sizes reported. Age was largely controlled for within moderation analysis of level of education, because primary, secondary and university samples tend to be in roughly the same age range. However, university students do not necessarily fall into a particular age group, and the mean age of university samples did vary somewhat between the included samples.

Most of the samples included in the study (k=45, N=23,550) were university samples. Within those university samples, many of the participants were psychology undergraduates. The overall associations between variables might not be representative either of university student samples or of the more general population. While the overall sample has included samples across a range of demographics, the distribution of effects is likely to be more constrained than in a community-wide sample. For this reason, the results of the present meta-analysis should be interpreted cautiously.

4.3 Direction for Future Research

Individual investment traits have tended to be studied by separate groups of researchers, often without much notice taken between these groups, even though evidence suggests that measures of investment lack discriminant validity and may be measuring the same construct (Mussel, 2010). Conducting multiple studies with seemingly different constructs might be inhibiting to research in intelligence, academic performance and personality. There is a clear need to integrate the research of investment traits and possibly develop a single measure of investment. Development of a standardised and reliable measure of investment would allow for more cohesive and accurate research of investment and academic performance. This may indicate fewer predictors of academic performance which are demonstrably distinct from one another. Much of the research in this field has been cross-sectional, which does not provide insight into the process of investment, which is theorised to occur over time (Cattell, 1943). Therefore, longitudinal research that looks at a range of variables and observes outcomes of academic performance across the lifespan would fill a crucial gap in this field.

Further research that includes a wider range of determinants for academic outcomes is crucial to better determine the role of intellectual curiosity in academic performance, and better identify which other factors are predictive of academic outcomes. Further research might investigate the role of other investment traits such as Openness to Ideas. Future research on personality and investment might also employ tests that rely less on self-report bias, such as observer-rated tests. The present study makes a contribution to a greater body of research on cognitive and non-cognitive abilities and their relation to academic outcomes.

The key research questions driving this study were:

1. How strong is the relationship between Need for Cognition and academic performance?
2. Does level of education (primary, secondary, tertiary) moderate the relationship between Need for Cognition and academic performance?

This study suggests that NFC is not a significant predictor of academic performance. It also suggests that level of education does not moderate the relationship between NFC and academic performance. However, although this study has found intellectual curiosity to be a non-significant predictor of academic performance, it is not a definitive study on the matter.

4.4 Conclusion

The findings of this study support findings of previous studies that both intelligence and Conscientiousness are key predictors of academic performance, intelligence being the strongest predictor. However, the findings of this study contradict previous studies such as von Stumm et al. (2011) and challenge the conclusion that intellectual curiosity might be ‘the third pillar of academic performance'. Based on the findings of the current study, the role of intellectual curiosity in academic outcomes does not seem to be significant. While moderately correlated with academic performance, both NFC and TIE uniquely account for a small amount of variance in academic outcomes. It is clear that academic performance is influenced by a range of factors. Therefore, the association between academic performance and investment may only be small due to a number of alternative factors which influence academic outcomes. Intellectual curiosity may contribute to a wider framework of variables which determine academic outcomes. However, the conclusion made by von Stumm et al. (2011) that intellectual curiosity is the 'third predictor of academic performance' seems to have been premature. This research provides valuable evidence for the role, or lack thereof, of Need for Cognition in academic outcomes, which has remained relatively unexplored until now. This study challenges the idea that intellectual curiosity is a key determinant of academic outcomes and adds to the broader understanding of why some perform better than others academically.

References

Ackerman, P.L. (1996). A theory of adult intellectual development: Process, personality, interests, and knowledge. *Intelligence,* 22, 227–257

Ackerman, P. L., Kanfer, R., & Goff, M. (1995). Cognitive and noncognitive determinants and consequences of complex skill acquisition. *Journal of Experimental Psychology: Applied*, 270–304.

Ackerman, P. L., & Heggestad, E. D. (1997). Intelligence, personality, and interests: Evidence for overlapping traits. *Psychological Bulletin, 121*, 219–245.

Barron, B., Martin, C. K., Takeuchi, L., & Fithian, R. (2009). Parents as learning partners in the development of technological fluency. *International Journal of Learning and Media, 1,* 55–77

Berlyne, D. E. (1954). A theory of human curiosity. *British Journal of Psychology, 45*, 180-191.

Bless, H., Wänke, M., Bohner, G., Fellhauer, R. F., & Schwarz, N. (1994). Need for cognition -A scale measuring engagement and happiness in cognitive tasks. *Zeitschrift für Sozialpsychologie, 25*, 147–154.

Borenstein, M. (2009). Introduction to meta-analysis. Chichester, West Sussex, U.K.; Hoboken: John Wiley & Sons

Cacioppo, J. T., and Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology.* 42, 116–131

Cacioppo, J. T., Petty, R. E., & Kao, C. E. (1984). The efficient assessment of need for cognition. *Journal of Personality Assessment, 48*, 306–307.

Cacioppo, J. T., Petty, R. E., Feinstein, J. A., & Jarvis, W. B. (1996). Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. *Psychological Bulletin, 119*, 197-253.

Cacioppo, J. T., Petty, R. E., Feinstein, J. A., & Jarvis, W. G. (1996). Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. *Psychological Bulletin, 119*(2), 197–253.

Cattell, R. B. (1943). The description of personality: basic traits resolved into clusters. *The Journal of Abnormal and Social Psychology, 38*(4), 476-506

Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology*, *54*, 1-22

Chamorro-Premuzic, T., & Furnham, A. (2003). Personality predicts academic performance: Evidence from two longitudinal university samples. *Journal of Research in Personality*, *37*(4), 319-338.

Cohen, A. R., Stotland, E., & Wolfe, D. M. (1955). An experimental investigation of need for cognition. *The Journal of Abnormal and Social Psychology*, *51*(2), 291-294

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). New York: Lawrence Erlbaum Associates, Publishers.

Costa, P. T., & McCrae, R. R. (1992). Four ways five factors are basic. *Personality and Individual Differences*, 13, 653–665.

Costa, P.T., Jr., & McCrae, R.R. (1992). Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEOFFI): Professional manual. Odessa, FL: Psychological Assessment Resources.

Del Re, A. C & Hoyt, W.T. (2010). Meta-Analysis with Correlations. http://rwiki.sciviews.org/doku.php?id=packages:cran:ma_meta-analysis

Furnham, A., & Thorne, J. (2013). Need for Cognition. *Journal of Individual Differences*, *34*(4), 230-240.

Grass, J., Strobel, A., & Strobel, A. (2017). Cognitive investments in academic success: The role of need for cognition at university. *Frontiers in Psychology*, *8*.

Goff, M., & Ackerman, P. L. (1992). Personality-intelligence relations: Assessing typical intellectual engagement. *Journal of Educational Psychology*, *84*, 537–552.

Goldberg, L.R. (1990). An alternative Description of personality: The Big-Five factor structure. *Journal of Personality and Social Psychology*, *59*, 1216–1229.

Gow, A. J., Whiteman, M. C., Pattie, A., & Deary, I. J. (2005). The personality–intelligence interface: Insights from an ageing cohort. *Personality and Individual Differences*, *39*, 751–761

Hayes, K.J. (1962). Genes, drives, and intellect. *Psychological Reports*, 10, 299–342.

Jacobs, J. E., Lanza, S., Osgood, D. W., Eccles, J. S., & Wigfield, A. (2002). Changes in children's self-competence and values: Gender and domain differences across grades one through twelve. *Child Development,* 73, 509–527.

James, L.R. (1998). Measurement of personality via conditional reasoning. *Organizational Research Methods, 1*, 131–163.

Klehe, U., & Anderson, N. (2007). Working hard and working smart: Motivation and ability during typical and maximum performance. *Journal of Applied Psychology,* 92, 978–992.

Luong, Strobel, Wollschläger, Greiff, Vainikainen, & Preckel. (2017). Need for cognition in children and adolescents: Behavioral correlates and relations to academic achievement and potential. *Learning and Individual Differences, 53*, 103-113.

McCrae, R. R., & Costa, P. T. (1987). Validation of the five-factor model of personality across instruments and observers. *Journal of Personality and Social Psychology,* 52(1), 81-90

Mussel, P. (2010). Epistemic curiosity and related constructs: Lacking evidence of discriminant validity. *Personality and Individual Differences, 49,* 506–510.

Neisser, U. J., Boodoo, G. W., Bouchard Jr., T. F., Boykin, A. C., Brody, N., Ceci, S., &. Urbina, S. (1996). Intelligence: Knowns and Unknowns. *American Psychologist, 51*(2), 77-101

Nisbett, R. E., Aronson, J., Blair, C., Dickens, W., Flynn, J., Halpern, D. F., & Turkheimer, E. (2012). Intelligence. New findings and theoretical developments. *American Psychologist, 67,* 130 –159

Padgett, R. D., Goodman, K. M., Johnson, M. P., Saichaie, K., Umbach, P. D., & Pascarella, E. T. (2010). The impact of college student socialization, social class, and race on need for cognition. *New Directions For Institutional Research, 145*, 99–111.

Poropat, A. (2009). A meta-analysis of the five-factor model of personality and academic performance. *Psychological Bulletin,* 135, 322–338

Powell, C. (2017). Do Investment Traits Intellectual Curiosity and Confidence Predict Academic Performance? *University of Adelaide*

Powell, C., & Nettelbeck, T. (2014). May intellectual curiosity prevail. *Personality and Individual Differences, 70, 254-256.*

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological Correlates of University Students' Academic Performance: A Systematic Review and Meta-Analysis. *Psychological Bulletin, 138*(2), 353-387.

Schwarzer, G. (2019). General Package for Meta-Analysis. https://github.com/guido-s/meta http://meta-analysis-with-r.org

von Stumm, S., & Ackerman, P. L. (2013). Investment and intellect: a review and meta-analysis. *Psychol. Bull.* 139, 841–869

von Stumm, S., Hell, B., & Chamorro-Premuzic, T. (2011). The Hungry Mind: Intellectual Curiosity Is the Third Pillar of Academic Performance. *Perspectives on Psychological Science, 6*(6), 574-588

von Stumm, S. (2018). Better Open Than Intellectual: The Benefits of Investment Personality Traits for Learning. *Personality and Social Psychology Bulletin, 44*(4), 562-573.

Woo, S. E., Chernyshenko, O., Longley, A., Zhang, Z., Chiu, C., & Stark, S. (2014). Openness to experience: Its lower level structure, measurement, and cross-cultural equivalence. *Journal of Personality Assessment, 96,* 29–45.

Woo, S. E., Harms, P. D., & Kuncel, N. R. (2007). Integrating personality and intelligence: Typical intellectual engagement and need for cognition. *Personality and Individual Differences, 43*, 1635–1639.

Appendix A:

List of References Included in Meta-analysis

Akpur, U. (2017). The Predictive Degree of University Students' Levels of Metacognition and Need for Cognition on Their Academic Achievement. *European Journal of Foreign Language Teaching, 2*(2), 52-63.

Basta, J. C. (1998). Exploring the relationships among mathematics disposition, need for cognition, and mathematics achievement in middle school students. *Dissertation Abstracts International Section A: Humanities and Social Sciences, 59*(5-A), 1497.

Bertrams, A., & Dickhäuser, O. (2009). High-school students' need for cognition, self-control capacity, and school achievement: Testing a mediation hypothesis. *Learning and Individual Differences, 19*(1), 135-138.

Berzonsky, M. D., & Sullivan, C. (1992). *Social-Cognitive Aspects of Identity Style: Need for Cognition, Experiential Openness, and Introspection*. Retrieved from

Birney, D. P., Beckmann, J. F., Beckmann, N., Double, K. S., & Whittingham, K. (2018). Moderators of learning and performance trajectories in microworld simulations: Too soon to give up on intellect!? *Intelligence, 68*, 128-140.

Bodner, T. E. (2001). On the assessment of individual differences in mindful information processing. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 61*(9-B), 5051.

Bridier, N. L. (2017). Defining intellectual curiosity in higher education. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 77*(9-B(E)), No-Specified.

Bruggen, E., & Dholakia, U. M. (2010). Determinants of participation and response effort in web panel surveys. *Journal of Interactive Marketing, 24*(3), 239-250

Castle, T. D., Jr. (2015). The impact of cooperative learning on the development of need for cognition among first-year college students. *Dissertation Abstracts International Section A: Humanities and Social Sciences, 76*(6)

Chang, C.-K., & McDaniel, E. D. (1995). Information search strategies in loosely structured settings. *Journal of Educational Computing Research, 12*(1), 95-107.

Chiesi, F., Morsanyi, K., Donati, M. A., & Primi, C. (2018). Applying item response theory to develop a shortened version of the need for cognition scale. *Advances in Cognitive Psychology, 14*(3), 75-86.

Connors, S. (1999). Effects of the interaction between verbal intelligence and life experiences on individual coping styles. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 59*(7-B), 3685.

Coutinho, S. A. (2006). The Relationship between the Need for Cognition, Metacognition, and Intellectual Task Performance. *Educational Research and Reviews, 1*(5), 162-164.

Egan, R. G. (2015). Reconceptualizing metacomprehension calibration accuracy. *Dissertation Abstracts International Section A: Humanities and Social Sciences, 75*(7-A(E)), No-Specified.

Festini, S. B., Hertzog, C., McDonough, I. M., & Park, D. C. (2019). What makes us busy? Predictors of perceived busyness across the adult lifespan. *J Gen Psychol, 146*(2), 111-133.

Fleischhauer, M., Enge, S., Brocke, B., Ullrich, J., Strobel, A., & Strobel, A. (2010). Same or different? Clarifying the relationship of need for cognition to personality and intelligence. *Pers Soc Psychol Bull, 36*(1), 82-96.

Fleischhauer, M., Miller, R., Wekenborg, M. K., Penz, M., Kirschbaum, C., & Enge, S. (2019). Thinking Against Burnout? An Individual's Tendency to Engage in and Enjoy Thinking as a Potential Resilience Factor of Burnout Symptoms and Burnout-Related Impairment in Executive Functioning. *Front Psychol, 10*, 420.

Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives, 19*(4), 25-42.

Furnham, A., & Thorne, J. D. (2013). Need for cognition: Its dimensionality and personality and intelligence correlates. *Journal of Individual Differences, 34*(4), 230-240.

Ghorbani, N., Framarz, A. G., & Watson, P. J. (2005). Philosophy, self-knowledge, and personality in iranian teachers and students of philosophy. *Journal of Psychology: Interdisciplinary and Applied, 139*(1), 81-95.

Ghorbani, N., Watson, P. J., Chen, Z., & Dover, H. (2013). Varieties of openness in Tehran and Qom: Psychological and religious parallels of faith and intellect-oriented Islamic religious reflection. *Mental Health, Religion & Culture, 16*(2), 123-137.

Ghorbani, N., Watson, P. J., & Mirhasani, V. S. (2007). Religious commitment in Iran: Correlates and factors of quest and extrinsic religious orientations. *Archiv fur Religionspsychologie / Archive for the Psychology of Religion, 29*, 245-257

Gottfried, A. E., Nylund-Gibson, K., Gottfried, A. W., Morovati, D., & Gonzalez, A. M. (2017). Trajectories from academic intrinsic motivation to need for cognition and educational attainment. *The Journal of Educational Research, 110*(6), 642-652.

Graham, E. K. (2011). Personality and cognition: Characteristics that drive the cognition/personality link across the adult lifespan. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 71*(10-B), 6473.

Grass, J., Strobel, A., & Strobel, A. (2017). Cognitive investments in academic success: The role of need for cognition at university. *Frontiers in Psychology, 8*.

Heijne-Penninga, M., Kuks, J. B. M., Hofman, W. H. A., & Cohen-Schotanus, J. (2010). Influences of deep learning, need for cognition and preparation time on open- and closed-book test performance. *Med Educ, 44*(9), 884-891.

Kamble, S. V., Watson, P. J., Marigoudar, S., & Chen, Z. (2014). Varieties of openness and religious commitment in India: Relationships of attitudes toward Hinduism, Hindu religious reflection, and religious schema. *Archiv fur Religionspsychologie / Archive for the Psychology of Religion, 36*(2), 172-198.

Karakelle, S. (2012). Interrelations between metacognitive awareness, perceived problem solving, intelligence and need for cognition. *Egitim ve Bilim, 37*(164), 237-250.

Kudrick, T. R. (1999). Personality and the subjective experience of mental effort. (subjective workload assessment technique, task load index). *Dissertation Abstracts International: Section B: The Sciences and Engineering, 60*(5-B), 2401.

Kuijpers, M., Douglas, S., & Kuiken, D. (2019). Personality traits and reading habits that predict absorbed narrative fiction reading. *Psychology of Aesthetics, Creativity, and the Arts, 13*(1), 74-88.

Lag, T., Bauger, L., Lindberg, M., & Friborg, O. (2014). The role of numeracy and intelligence in health-risk estimation and medical data interpretation. *Journal of Behavioral Decision Making, 27*(2), 95-108.

Lin, Y., Durbin, J. M., & Rancer, A. S. (2016). Math Anxiety, Need for Cognition, and Learning Strategies in Quantitative Communication Research Methods Courses. *Communication Quarterly, 64*(4), 390-409.

Luong, C., Strobel, A., Wollschläger, R., Greiff, S., Vainikainen, M. P., & Preckel, F. (2017). Need for cognition in children and adolescents: Behavioral correlates and relations to academic achievement and potential. *Learning and Individual Differences, 53*, 103-113.

Martin, G. L., & Seifert, T. A. (2011). The Relationship between Students' Interactions with Student Affairs Professionals and Cognitive Outcomes in the First Year of College. *Journal of Student Affairs Research and Practice, 48*(4), 389-410.

Martin, N., Hughes, J., & Fugelsang, J. (2017). The Roles of Experience, Gender, and Individual Differences in Statistical Reasoning. *Statistics Education Research Journal, 16*(2), 454-475.

Maurer, M. M., & Simonson, M. R. (1993). The reduction of computer anxiety: Its relation to relaxation training, previous computer coursework, achievement, and need for cognition. *Journal of Research on Computing in Education, 26*(2), 205-219.

McCutcheon, L. E., Ashe, D. D., Houran, J., & Maltby, J. (2003). A cognitive profile of individuals who tend to worship celebrities. *J Psychol, 137*(4), 309-322.

Nicoli, G. T. (2012). The impact of co-curricular involvement on college students' need for cognition. *Dissertation Abstracts International Section A: Humanities and Social Sciences, 73*(5-A), 1688.

Parry, R., & Stuart-Hamilton, I. (2010). Animism begins at forty: Evidence that animism and other naïve beliefs are established before the onset of old age. *Educational Gerontology, 36*(10), 1043-1050.

Preckel, F., Lipnevich, A. A., Boehme, K., Brandner, L., Georgi, K., Konen, T., . . . Roberts, R. D. (2013). Morningness-eveningness and educational outcomes: the lark has an advantage over the owl at high school. *Br J Educ Psychol, 83*(Pt 1), 114-134.

Reed, A. (2011). Critical reflection among marriage and family therapy students: An examination of cognitive complexity and content. *Dissertation Abstracts International Section A: Humanities and Social Sciences, 71*(9-A), 3143.

Sadowski, C. J., & Gülgös, S. (1996). Elaborative processing mediates the relationship between need for cognition and academic performance. *Journal of Psychology: Interdisciplinary and Applied, 130*(3), 303-307.

Schiefer, J., Golle, J., Tibus, M., Trautwein, U., & Oschatz, K. (2017). Elementary school children's understanding of science: The implementation of an extracurricular science intervention. *Contemporary Educational Psychology, 51*, 447-463.

Seifert, T. A., Gillig, B., Hanson, J. M., Pascarella, E. T., & Blaich, C. F. (2014). The Conditional Nature of High Impact/Good Practices on Student Learning Outcomes. *Journal of Higher Education, 85*(4), 531-564.

Sevincer, A. T., Mehl, P. J., & Oettingen, G. (2017). Well self-regulated people use mental contrasting. *Social Psychology, 48*(6), 348-364.

Sherrod, N. B. (2003). A few good men ii: Distinguishing between men with high and low endorsement of rape-supportive attitudes. *Dissertation Abstracts International Section A: Humanities and Social Sciences, 63*(12-A), 4235.

Soubelet, A., & Salthouse, T. A. (2010). The role of activity engagement in the relations between Openness/Intellect and cognition. *Personality and Individual Differences, 49*(8), 896-901.

Soubelet, A., & Salthouse, T. A. (2017). Does Need for Cognition Have the Same Meaning at Different Ages? *Assessment, 24*(8), 987-998.

Strobel, A., Behnke, A., Gärtner, A., & Strobel, A. (2019). The interplay of intelligence and need for cognition in predicting school grades: A retrospective study. *Personality and Individual Differences, 144*, 147-152.

Taasoobshirazi, G., Heddy, B., Bailey, M. L., & Farley, J. (2016). A multivariate model of conceptual change. *Instructional Science, 44*(2), 125-145.

Taube, K. T. (1997). Critical Thinking Ability and Disposition as Factors of Performance on a Written Critical Thinking Test. *Journal of General Education, 46*(2), 129-164.

Teovanovic, P., Knezevic, G., & Stankov, L. (2015). Individual differences in cognitive biases: Evidence against one-factor theory of rationality. *Intelligence, 50*, 75-86

Tirre, W. C. (2018). Dimensionality and determinants of self-reported cognitive failures. *International Journal of Psychological Research, 11*(1), 9-18.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2014). Rational thinking and cognitive sophistication: development, cognitive abilities, and thinking dispositions. *Dev Psychol, 50*(4), 1037-1048.

Treger, S. (2018). Who is playing that wonderful music? Exploring predictors of playing a musical instrument. *Psychology of Music*.

Tuten, T. L. (2001). Understanding differences in web usage: The role of need for cognition and the five factor model of personality. *Social Behavior and Personality, 29*(4), 391-398.

van Seggelen-Damen, I. C. M. (2013). Reflective Personality: Identifying Cognitive Style and Cognitive Complexity. *Current Psychology, 32*(1), 82-99.

Von Stumm, S. (2013). Investment traits and intelligence in adulthood. *Journal of Individual Differences, 34*(2), 82-89.

Waters, L. K., & Zakrajsek, T. D. (1990). Correlates of Need for Cognition total and subscale scores. *Educational and Psychological Measurement, 50*(1), 213-217.

Watson, P. J., Ghorbani, N., Vartanian, M., & Chen, Z. (2015). Religious openness hypothesis: II. Religious reflection and orientations, mystical experience, and psychological openness of Christians in Iran. *Journal of Psychology and Christianity, 34*(2), 114-124.

Weissgerber, S. C., Reinhard, M. A., & Schindler, S. (2018). Learning the hard way: Need for Cognition influences attitudes toward and self-reported use of desirable difficulties. *Educational Psychology, 38*(2), 176-202.

Wolfe, R. N., & Grosch, J. W. (1992). *Negative Relationship between Achievement in High School and Self-Concept in College*.

Zhou, M. (2009). Operationalizing and tracing goal orientation and learning strategy. *Dissertation Abstracts International Section A: Humanities and Social Sciences, 70*(3-A), 800.

Appendix B:

Study Demographics and Correlations

Author/year	demographic	construct	measure	N	r
Strobel et al., 2019	university students	AP	GPA	290	0.31
		g	IST-2000 R	290	0.08
		O	NEO-FFI	290	0.45
Frederick, 2005	university students	G	Wonderlic Personal Test	276	0.19
			SAT	64	0.3
			ACT	190	0.3
Kuijpers, 2018	university students	O	BFI	264	0.19
Birneya, 2018	adults	O	IPIP	142	0.3
		C	IPIP	142	0.13
		g	Abstract Reasoning	142	0.3
Soubelet and Salthouse, 2017	adults	O	IPIP	5004	0.13
		C	IPIP	5004	0.6

		g	Raven's Progressive Matrices	5004	0.36
Gottfried, 2017	secondary students	g	Wechsler Intelligence Scale for Children-Revised	107	0.23
Schiefer et al., 2017	primary students	g	BEFKI-short	117	0.25
Fleischhauer, 2019	adults	O	BFI-10	4134	0.23
		C	BFI-10	4134	0.16
Festini, 2019	adults	O	NEO-PI-R	463	0.37
		C	NEO-PI-R	463	0.25
Weissgerber, 2018	secondary students	AP	graduation grade	91	0.23
	secondary students	AP	graduation grade	93	0.14
Treger, 2018	adults	O	TIPI	369	0.63
Sevincer et al., 2017	university students	O	NEO-FFI	201	0.4
		C	NEO-FFI	201	0.26
Martin et al., 2017	university students	g	Wonderlic Personal Test	199	0.27

Luong et al., 2016	primary students	AP	school grades	1487	0.09
	primary students	AP	school grades	1550	0.27
	secondary students	AP	school grades	1242	0.31
Grass et al., 2017	university students	AP	GPA	369	0.19
		O	BFI	369	0.21
		C	BFI	369	0.27
Bridier, 2016	university students	O	BFI	822	0.54
		C	BFI	822	0.29
Akpur, 2017	university students	AP	GPA	253	0.61
Taasoobshirazi et ak., 2016	university students	AP	course grade	117	0.19
Lin et al., 2016	university students	AP	GPA	196	0.17
Watson et al., 2015	adults	O	IPIP	250	0.42
Teovanovic, 2015	university students	g	Raven's Progressive Matrices	243	0.19
		O	NEO-FFI	243	0.58

	university				
Egan, 2012	students	AP	GPA	116	0.22
Castle Jr., 2015	university students	AP	ACT	3066	0.3
Toplak, 2014	primary students	g	Wechsler Abbreviated Scales of Intelligence	204	0.18
Seifert et al., 2014	university students	AP	ACT	2063	0.1
Kamble et al., 2014	university students	O	IPIP	320	0.35
van Seggelen-Damen, 2013	university students	O	Openness to Experience - 12 items	178	0.43
Preckel et al., 2013	secondary students	AP	GPA	272	0.18
		C	Inventar Minimal Redundanter Skalen	272	0.72
Ghorbani et al., 2013	university students	O	Openness to Experience - 20 items	337	0.61
Furnham and Thorne, 2013	university students	O	NEO-FFI	197	0.46

		C	NEO-FFI	197	0.05
		g	Wonderlic Personal Test	197	0.42
Nicoli, 2011	university students	AP	ACT or SAT equivalent	4913	0.25
Karakelle, 2012	university students	g	Raven's Progressive Matrices	108	0.13
Reed, 2010	university students	O	BFI	33	0.13
Martin and Seifert, 2011	university students	AP	ACT or equivalent GPA	3999	0.12
Graham, 2010	adults	O	NEO-FFI	154	0.3
		C	NEO-FFI	154	0.25
Soubelet and Salthouse, 2010	adults	O	IPIP	2257	0.63
		g	Gf	2257	0.3
		g	Gc	2257	0.33
Parry and Stuart Hamilton, 2010	adults	g	Raven's Progressive Matrices	34	0.74
Fleischhauer et al., 2010	university students	C	NEO-PI-R	300	0.41
		O	NEO-PI-R	300	0.25

Bruggen and Dholakia, 2010	university students	C	BFI	751	0.33
		O	BFI	751	0.29
Zhou, 2009	university students	AP	Test Grade	103	0.32
Bertrams and Dickhauser, 2009	secondary students	AP	Self-reported grade	604	0.35
Ghorbani et al., 2009	university students	O	Openness to Experience - 10 items	251	0.51
Coutinho, 2006	university students	g	GRE general test	417	0.24
Ghorbani et al., 2005	secondary students	O	IPIP	397	0.22
Ghorbani et al., 2005	adults	O	IPIP	165	0.22
Sherrod, 2002	university students	C	NEO-PI-R	116	0.41
		O	NEO-PI-R	116	0.21
Tuten, 2001	university students	O	BFI-30	400	0.37
		C	BFI-30	400	0.23
Bodner, 2000	university students	O	NEO-FFI	200	0.41

		C	NEO-FFI	200	0.14
		g	Wonderlic Personal Test	200	0.37
Kudrick, 1999	univerity students	O	NEO-FFI	173	0.44
		C	NEO-FFI	173	0.17
Connors, 1998	univerity students	AP	Estimated GPA	132	-0.2
Basta, 1998	secondary students	AP	Mathematics grade	141	0.21
Basta, 1998	secondary students	AP	Mathematics grade	151	0.28
Sadowski and Gulgoz, 1996	university students	AP	sum of 3 course test grades	47	0.24
Maurer and Simonson, 1993	university students	AP	course grades	101	-0.09
Wolfe and Grosch, 1992	university students	AP	average high school grade	134	-0.04
		g	SAT	134	-0.08
Wolfe and Grosch, 1992	university students	AP	average high school grade	173	0.01
		g	SAT	173	0.1
Berzonsky and Sullivan, 1992	secondary students	O	NEO-FFI	169	0.37

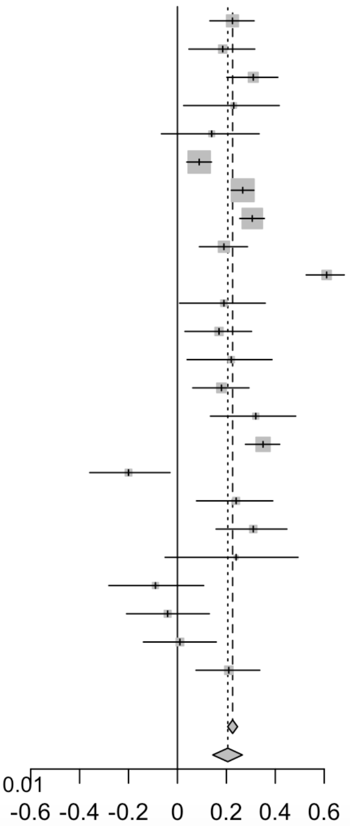
Waters and Zakrajsek, 1990	univerity students	AP	GPA	207	0.21
		g	ACT	207	0.18
Chang and McDaniel, 1995	univerity students	AP	SAT	32	0.31
Tirre, 2018	adults	g	SCAT	552	0.19
		g	Abstract Reasoning	552	0.18
		O	TSD inventory	552	0.61
		C	TSD inventory	552	0.34
Chiesi et al., 2018	university students	g	Racademic performanceM (with NFC-10)	274	0.2
	university students	g	Racademic performanceM (with NFC-18)	274	0.18
Lag et al., 2014	university students	g	WAIS-information subtests	202	0.24
	university students	g	WAIS-matrix subtetsts	202	0.23
von Stumm, 2013	adults	g	Gf	200	0.34
		g	Gc	200	0.35
		O	NEO-FFI	200	0.54

Heijne-Penninga et al., 2010	university students	AP	Open Book Test	423	0.19
		AP	Closed Book Test	423	0.2
McCutcheon, 2003	university students	g	Multidimensional Aptitude Battery-information subscale	102	0.28
		g	Multidimensional Aptitude Battery-arithmatic subscale	102	0.29
Taube, 1997	university students	AP	GPA	198	0.16
		g	SAT-verbal	198	0.26
		g	SAT-mathematics	198	0.22

Appendix C:

Forest Plots for Meta-analytic Correlations

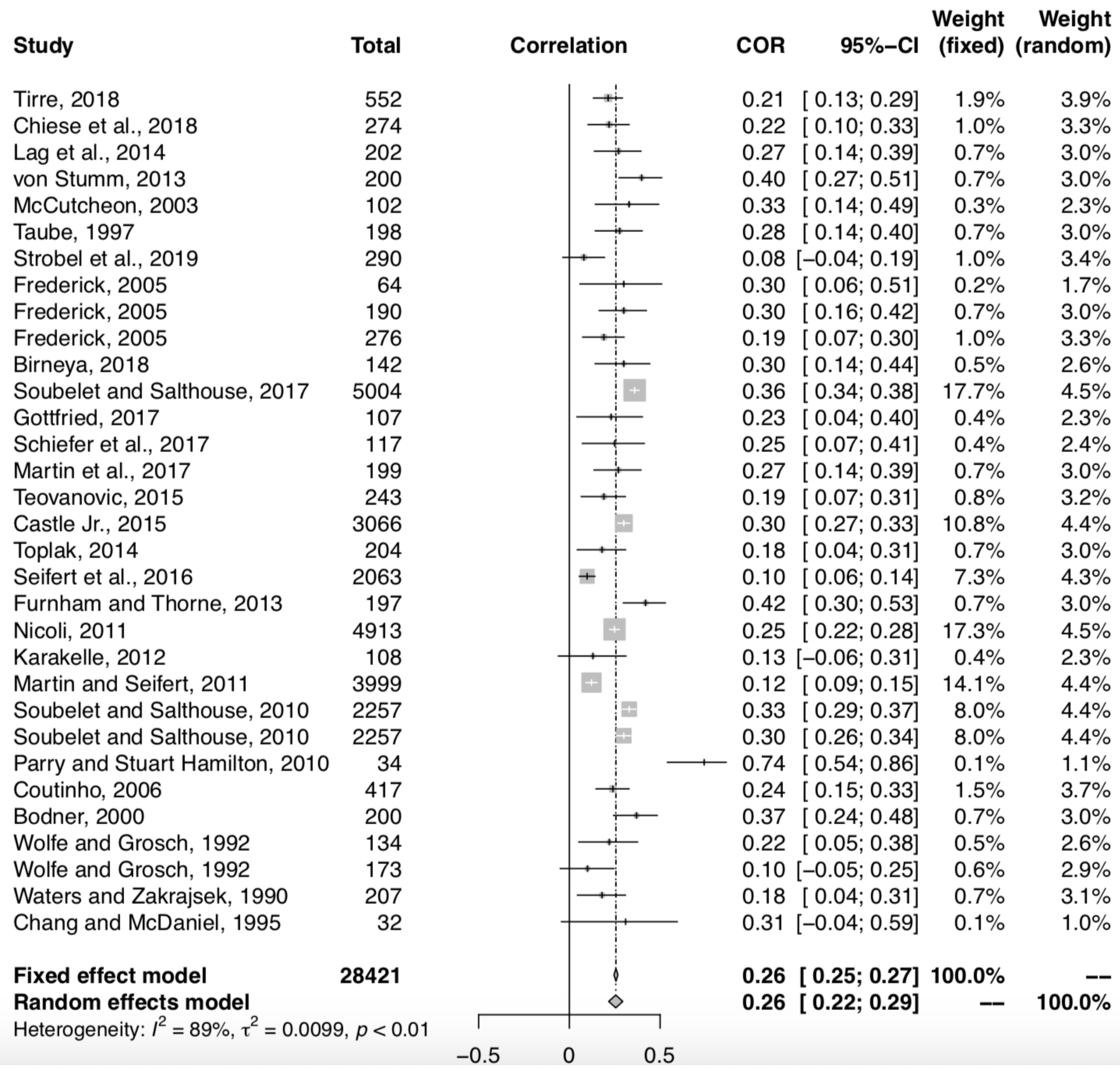
NFC and AP



Study	Total	COR	95%-CI	Weight (fixed)	Weight (random)
Heijne-Penninga et al., 2010	423	0.23	[0.13; 0.31]	5.0%	4.8%
Taube, 1997	198	0.19	[0.05; 0.32]	2.3%	4.3%
Strobel et al., 2019	290	0.31	[0.20; 0.41]	3.4%	4.6%
Weissgerber, 2017	91	0.23	[0.03; 0.42]	1.0%	3.4%
Weissgerber, 2017	93	0.14	[-0.07; 0.33]	1.1%	3.4%
Luong et al., 2016	1487	0.09	[0.04; 0.14]	17.6%	5.2%
Luong et al., 2016	1550	0.27	[0.22; 0.31]	18.4%	5.2%
Luong et al., 2016	1242	0.31	[0.25; 0.36]	14.7%	5.2%
Grass et al., 2017	369	0.19	[0.09; 0.29]	4.3%	4.7%
Akpur, 2017	253	0.61	[0.53; 0.68]	3.0%	4.5%
Taasoobshirazi, 2016	117	0.19	[0.01; 0.36]	1.4%	3.7%
Lin et al., 2016	196	0.17	[0.03; 0.30]	2.3%	4.3%
Egan, 2012	116	0.22	[0.04; 0.39]	1.3%	3.7%
Preckel et al., 2013	272	0.18	[0.06; 0.29]	3.2%	4.5%
Zhou, 2004	103	0.32	[0.13; 0.48]	1.2%	3.6%
Bertrams and Dickhauser, 2009	604	0.35	[0.28; 0.42]	7.1%	5.0%
Connors, 1998	132	-0.20	[-0.36; -0.03]	1.5%	3.8%
Basta, 1998	141	0.24	[0.08; 0.39]	1.6%	3.9%
Basta, 1998	151	0.31	[0.16; 0.45]	1.8%	4.0%
Sadowski and Gulgoz, 1996	47	0.24	[-0.05; 0.49]	0.5%	2.5%
Maurer and Simonson, 1993	101	-0.09	[-0.28; 0.11]	1.2%	3.5%
Wolfe and Grosch, 1992	134	-0.04	[-0.21; 0.13]	1.6%	3.9%
Wolfe and Grosch, 1992	173	0.01	[-0.14; 0.16]	2.0%	4.1%
Waters and Zakrajsek, 1990	207	0.21	[0.08; 0.34]	2.4%	4.3%
Fixed effect model	**8490**	**0.23**	**[0.21; 0.25]**	**100.0%**	**--**
Random effects model		**0.21**	**[0.14; 0.27]**	**--**	**100.0%**

Heterogeneity: $I^2 = 86\%$, $\tau^2 = 0.0194$, $p < 0.01$

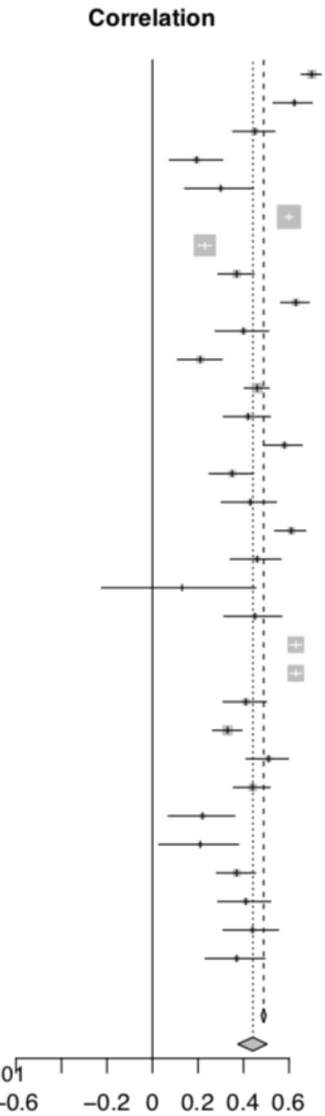
NFC and g


Study Total Correlation COR 95%–CI Weight (fixed) Weight (random)
Tirre, 2018 552 0.21 [0.13; 0.29] 1.9% 3.9%
Chiese et al., 2018 274 0.22 [0.10; 0.33] 1.0% 3.3%
Lag et al., 2014 202 0.27 [0.14; 0.39] 0.7% 3.0%
von Stumm, 2013 200 0.40 [0.27; 0.51] 0.7% 3.0%
McCutcheon, 2003 102 0.33 [0.14; 0.49] 0.3% 2.3%
Taube, 1997 198 0.28 [0.14; 0.40] 0.7% 3.0%
Strobel et al., 2019 290 0.08 [−0.04; 0.19] 1.0% 3.4%
Frederick, 2005 64 0.30 [0.06; 0.51] 0.2% 1.7%
Frederick, 2005 190 0.30 [0.16; 0.42] 0.7% 3.0%
Frederick, 2005 276 0.19 [0.07; 0.30] 1.0% 3.3%
Birneya, 2018 142 0.30 [0.14; 0.44] 0.5% 2.6%
Soubelet and Salthouse, 2017 5004 0.36 [0.34; 0.38] 17.7% 4.5%
Gottfried, 2017 107 0.23 [0.04; 0.40] 0.4% 2.3%
Schiefer et al., 2017 117 0.25 [0.07; 0.41] 0.4% 2.4%
Martin et al., 2017 199 0.27 [0.14; 0.39] 0.7% 3.0%
Teovanovic, 2015 243 0.19 [0.07; 0.31] 0.8% 3.2%
Castle Jr., 2015 3066 0.30 [0.27; 0.33] 10.8% 4.4%
Toplak, 2014 204 0.18 [0.04; 0.31] 0.7% 3.0%
Seifert et al., 2016 2063 0.10 [0.06; 0.14] 7.3% 4.3%
Furnham and Thorne, 2013 197 0.42 [0.30; 0.53] 0.7% 3.0%
Nicoli, 2011 4913 0.25 [0.22; 0.28] 17.3% 4.5%
Karakelle, 2012 108 0.13 [−0.06; 0.31] 0.4% 2.3%
Martin and Seifert, 2011 3999 0.12 [0.09; 0.15] 14.1% 4.4%
Soubelet and Salthouse, 2010 2257 0.33 [0.29; 0.37] 8.0% 4.4%
Soubelet and Salthouse, 2010 2257 0.30 [0.26; 0.34] 8.0% 4.4%
Parry and Stuart Hamilton, 2010 34 0.74 [0.54; 0.86] 0.1% 1.1%
Coutinho, 2006 417 0.24 [0.15; 0.33] 1.5% 3.7%
Bodner, 2000 200 0.37 [0.24; 0.48] 0.7% 3.0%
Wolfe and Grosch, 1992 134 0.22 [0.05; 0.38] 0.5% 2.6%
Wolfe and Grosch, 1992 173 0.10 [−0.05; 0.25] 0.6% 2.9%
Waters and Zakrajsek, 1990 207 0.18 [0.04; 0.31] 0.7% 3.1%
Chang and McDaniel, 1995 32 0.31 [−0.04; 0.59] 0.1% 1.0%
Fixed effect model 28421 0.26 [0.25; 0.27] 100.0% --
Random effects model 0.26 [0.22; 0.29] -- 100.0%
Heterogeneity: I^2 = 89%, τ^2 = 0.0099, $p < 0.01$
−0.5 0 0.5

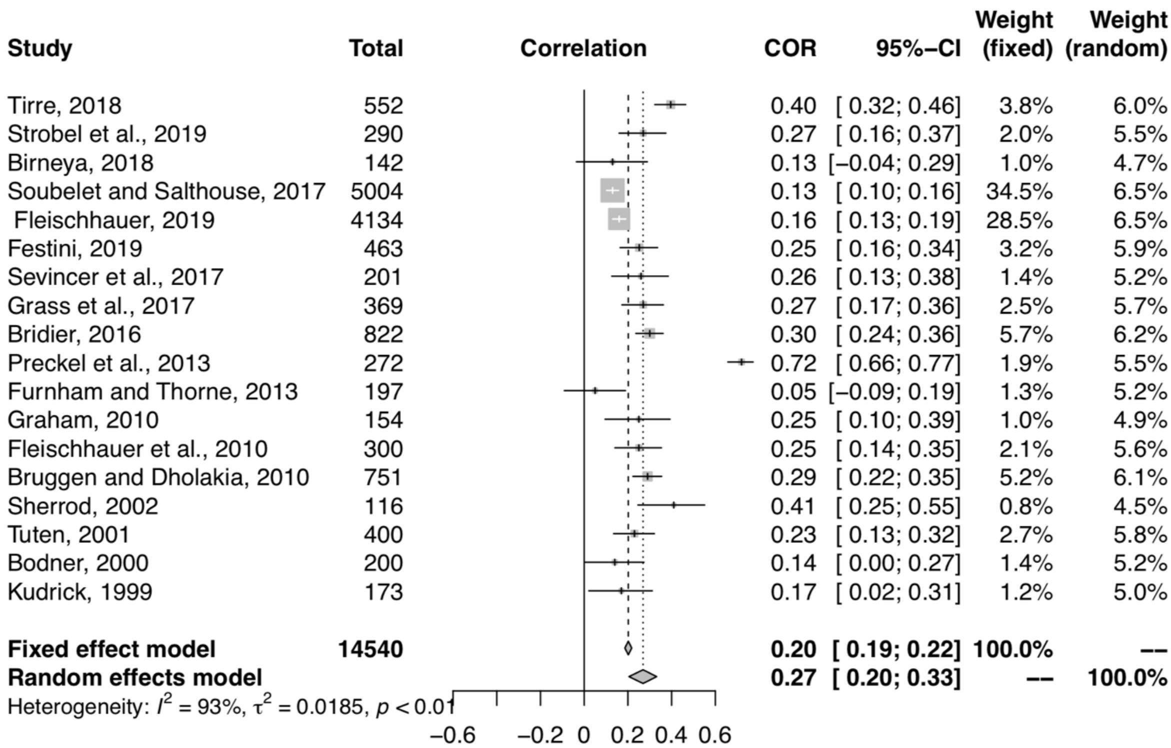
NFC and O

Study	Total	COR	95%−CI	Weight (fixed)	Weight (random)
Tirre, 2018	552	0.70	[0.65; 0.74]	2.5%	3.3%
von Stumm, 2013	200	0.62	[0.53; 0.70]	0.9%	3.1%
Strobel et al., 2019	290	0.45	[0.35; 0.54]	1.3%	3.2%
Kuijpers, 2018	264	0.19	[0.08; 0.31]	1.2%	3.1%
Birneya, 2018	142	0.30	[0.14; 0.44]	0.6%	3.0%
Soubelet and Salthouse, 2017	5004	0.60	[0.58; 0.62]	22.9%	3.4%
Fleischhauer, 2019	4134	0.23	[0.20; 0.26]	18.9%	3.4%
Festini, 2019	463	0.37	[0.29; 0.45]	2.1%	3.2%
Treger, 2018	369	0.63	[0.56; 0.69]	1.7%	3.2%
Sevincer et al., 2017	201	0.40	[0.28; 0.51]	0.9%	3.1%
Grass et al., 2017	369	0.21	[0.11; 0.31]	1.7%	3.2%
Bridier, 2016	822	0.46	[0.40; 0.51]	3.7%	3.3%
Watson et al., 2015	250	0.42	[0.31; 0.52]	1.1%	3.1%
Teovanovic, 2015	243	0.58	[0.49; 0.66]	1.1%	3.1%
Kamble et al., 2014	320	0.35	[0.25; 0.44]	1.5%	3.2%
van.Seggelen−Damen, 2013	178	0.43	[0.30; 0.54]	0.8%	3.0%
Ghorbania et al., 2013	337	0.61	[0.54; 0.67]	1.5%	3.2%
Furnham and Thorne, 2013	197	0.46	[0.34; 0.56]	0.9%	3.1%
Reed, 2010	33	0.13	[−0.22; 0.45]	0.1%	2.0%
Graham, 2010	154	0.45	[0.31; 0.57]	0.7%	3.0%
Soubelet and Salthouse, 2010	2257	0.63	[0.60; 0.65]	10.3%	3.4%
Soubelet and Salthouse, 2010	2257	0.63	[0.60; 0.65]	10.3%	3.4%
Fleischhauer et al., 2010	300	0.41	[0.31; 0.50]	1.4%	3.2%
Bruggen and Dholakia, 2010	751	0.33	[0.26; 0.39]	3.4%	3.3%
Ghorbani et al., 2009	251	0.51	[0.41; 0.60]	1.1%	3.1%
Ghorbani et al., 2005	397	0.44	[0.36; 0.52]	1.8%	3.2%
Ghorbani et al., 2005	165	0.22	[0.07; 0.36]	0.7%	3.0%
Sherrod, 2002	116	0.21	[0.03; 0.38]	0.5%	2.9%
Tuten, 2001	400	0.37	[0.28; 0.45]	1.8%	3.2%
Bodner, 2000	200	0.41	[0.29; 0.52]	0.9%	3.1%
Kudrick, 1999	173	0.44	[0.31; 0.55]	0.8%	3.0%
Berzonsky and Sullivan, 1992	169	0.37	[0.23; 0.49]	0.8%	3.0%
Fixed effect model	**21958**	**0.49**	**[0.48; 0.50]**	**100.0%**	**--**
Random effects model		**0.44**	**[0.38; 0.50]**	**--**	**100.0%**

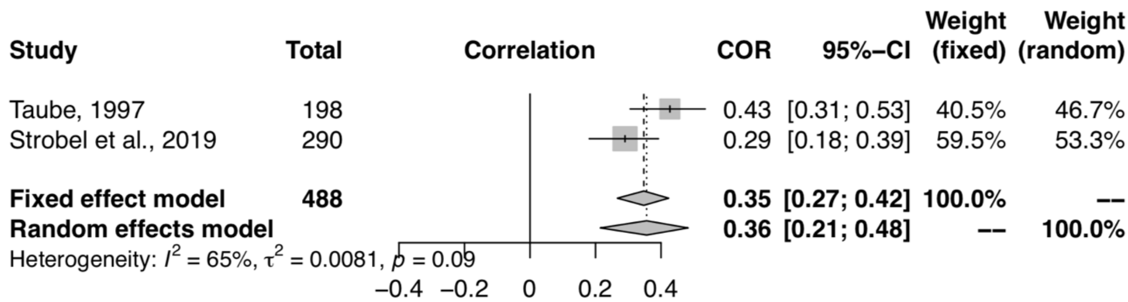
Heterogeneity: $I^2 = 97\%$, $\tau^2 = 0.0486$, $p < 0.01$



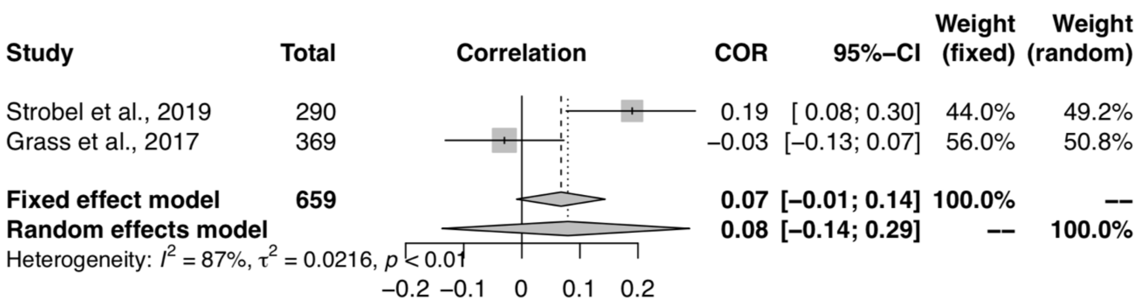
NFC and C



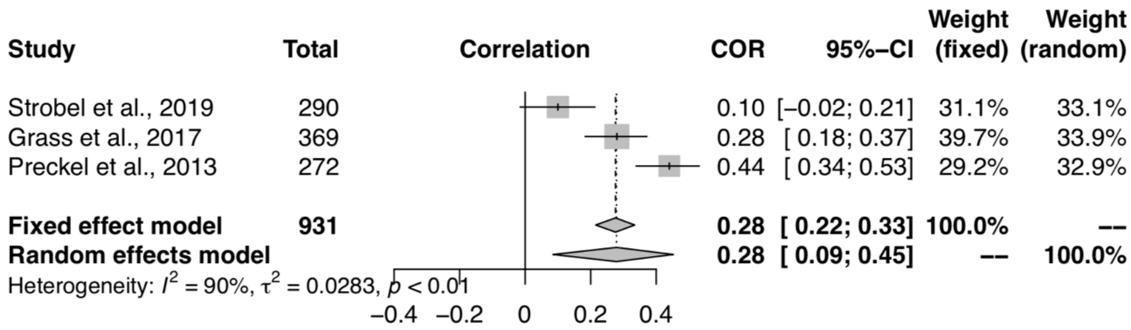
AP and g



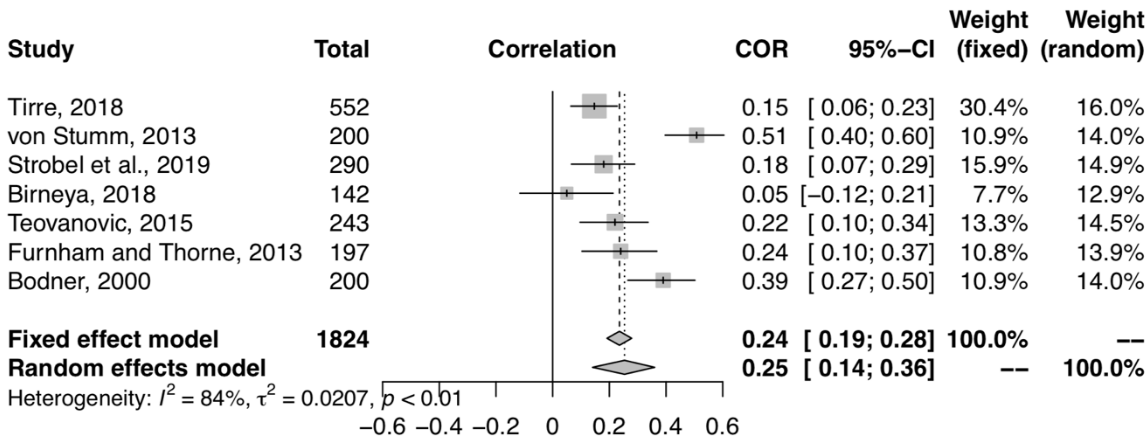
AP and O



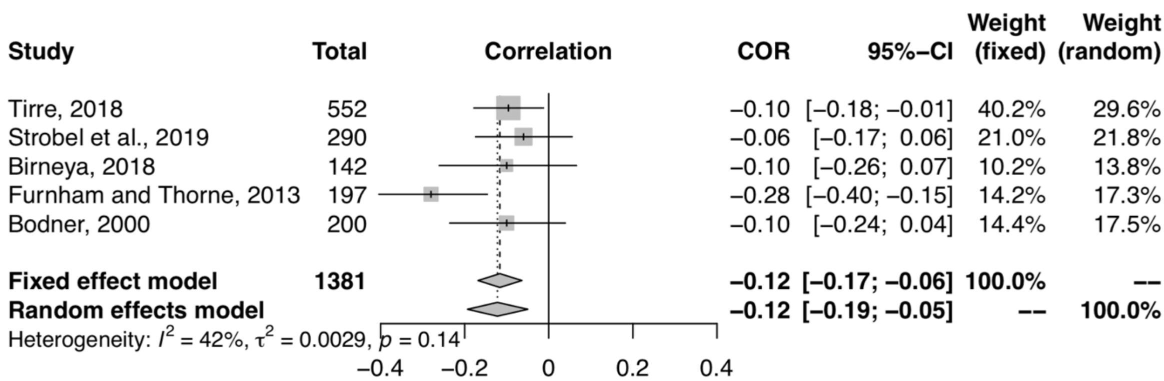
AP and C



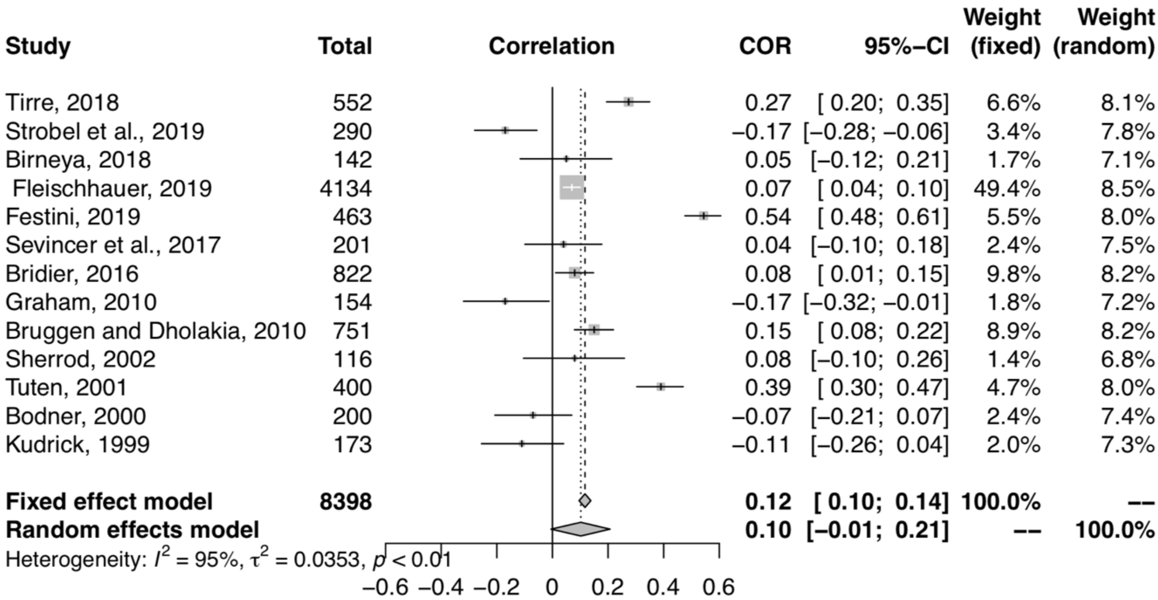
g and O



g and C



O and C


Study
Total
Correlation
COR
95%−CI
Weight (fixed)
Weight (random)
Tirre, 2018 552 0.27 [0.20; 0.35] 6.6% 8.1%
Strobel et al., 2019 290 −0.17 [−0.28; −0.06] 3.4% 7.8%
Birneya, 2018 142 0.05 [−0.12; 0.21] 1.7% 7.1%
Fleischhauer, 2019 4134 0.07 [0.04; 0.10] 49.4% 8.5%
Festini, 2019 463 0.54 [0.48; 0.61] 5.5% 8.0%
Sevincer et al., 2017 201 0.04 [−0.10; 0.18] 2.4% 7.5%
Bridier, 2016 822 0.08 [0.01; 0.15] 9.8% 8.2%
Graham, 2010 154 −0.17 [−0.32; −0.01] 1.8% 7.2%
Bruggen and Dholakia, 2010 751 0.15 [0.08; 0.22] 8.9% 8.2%
Sherrod, 2002 116 0.08 [−0.10; 0.26] 1.4% 6.8%
Tuten, 2001 400 0.39 [0.30; 0.47] 4.7% 8.0%
Bodner, 2000 200 −0.07 [−0.21; 0.07] 2.4% 7.4%
Kudrick, 1999 173 −0.11 [−0.26; 0.04] 2.0% 7.3%
Fixed effect model 8398 0.12 [0.10; 0.14] 100.0% --
Random effects model 0.10 [−0.01; 0.21] -- 100.0%
Heterogeneity: I^2 = 95%, τ^2 = 0.0353, p < 0.01
−0.6 −0.4 −0.2 0 0.2 0.4 0.6