Extraversion and Intelligence: A Meta-Analytic Investigation

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Extraversion and Intelligence:
A Meta-Analytic Investigation

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SUMMARY

Aspects of the Ackerman and Heggestad (1997) meta-analysis were updated to address the complex, contradictory findings on the extraversion-intelligence relation. Although the estimated effect sizes remained slightly positive, there was a universal decease in the magnitude of the effect across ability-personality pairs in comparison to Ackerman and Heggestad's meta-analytic results. Social closeness and social potency evidenced a different pattern of ability associations supporting the validity of measuring these two aspects of extraversion separately. Correlations computed between the extraversion-intelligence correlation and the date of publication of the study were generally negative supporting a decrease in the extraversion-intelligence relationship over time. Results also revealed differences between the measures used to assess the relationship.

CHAPTER 1

INTRODUCTION

For over half a century, differential psychologists have investigated how individual differences in personality, or non-ability characteristics, relate to individual differences in intelligence, or cognitive abilities (Zeidner & Matthews, 2000). Although differential psychologists typically have remained confined within the boundaries of their "principalities" (Cronbach, 1957, p. 671) by studying either personality or intelligence (Zeidner & Matthews, 2000), the distinction between person characteristics is artificial (Snow, 1995). The distinction is a fiction created by psychologists to aid in research. More recently, researchers have begun to bridge the gap between personality and intelligence and to incorporate person characteristics into integrated theoretical models (e.g., Saklofske & Zeidner, 1995). Although there has been a relatively substantial accumulation of studies investigating the relationship between individual differences in extraversion[1] and intelligence compared with other personality traits and intelligence (Ackerman & Heggestad, 1997), there have been relatively few reviews of the empirical evidence on the topic (e.g., Eysenck, 1994; Zeidner, 1995; Zeidner & Matthews, 2000). This paper reviews the association between extraversion and intelligence and examines meta-analytically the research evidence on the relationship.

According to Zeidner (1995), "A review of literature bearing on the relationship between extraversion and intelligence yields rather inconsistent results" (p. 309), and more recently, Roberts (2002) wrote, "that the link between extraversion level and ability/intelligence test score is likely to be fragile and inconsistent at best" (p. 517).

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[1]Unless otherwise stated, the term extraversion will be used to denote the personality characteristic. Other terms (e.g., extrovert, social introversion) will be used to designate a specific direction or a specific aspect of extraversion.

Zeidner and Matthews (2000) have conjectured that the measures used to assess extraversion and intelligence may moderate the relationship. The first objective of the current study is to summarize meta-analytically the extraversion-intelligence relationship in an effort to address the inconsistent empirical findings.

A meta-analysis conducted by Ackerman and Heggestad (1997) found generally positive relationships with extraversion across ten intelligence traits. That is, individuals who are more intelligent are also more likely to be more outgoing and energetic than individuals who are less intelligent. Several studies (Ackerman, 2000; Ackerman, Bowen, Beier, & Kanfer, 2001; Ackerman & Rolfhus, 1999; Furnham, Forde, & Cotter, 1998; Roberts, 2002; Rolfhus & Ackerman, 1999) since the meta-analysis suggest the opposite trend – a negative relationship between extraversion and intelligence. The pattern of results suggests a change in the relationship between extraversion and intelligence. The veracity of this observed change in the extraversion-intelligence relationship remains an empirical question, and appears to involve consideration of a number of factors, including the ways in which both extraversion and intelligence are defined, as well as the methods and validity of measures used to assess each construct. The second objective of the present study is to examine the relationship between extraversion and intelligence over time.

I begin by providing a brief review of the literature with respect to how the extraversion construct has been conceptualized and studied in relation to intelligence. I organize this review into four overlapping periods. The first time period reviews early scientific work on the extraversion construct starting in the 1920s and moves through Guilford and Guilford's (1934, 1936, 1939a, 1939b) factor-analytic studies analyzing the

multidimensional nature of extraversion and related measures developed into the 1950s (Guilford & Zimmerman, 1956). The second time period opens with Eysenck's (1967) arousal theory of extraversion, and delineates the extraversion-intelligence relation in the context of a biological approach to the study of personality. The third phase of theory and research, covering the period from 1980 to the early 1990s, includes studies critically examining Eysenck's (1967) arousal theory and his conceptions of extraversion. The fourth, contemporary, period of research begins with the Ackerman and Heggestad (1997) meta-analysis and moves to the present, building largely on programmatic research by Ackerman and his colleagues investigating, more generally, personality-intelligence relationships. In each section, I review and highlight key empirical findings. In the final two sections, I review three mechanisms that may account for a correlation between two psychological traits and introduce the hypotheses that will guide the meta-analytic examination of the extraversion-intelligence evidence.

CHAPTER 2

LITERATURE REVEIW

Early Scientific Work on Extraversion and Intelligence

With few exceptions, early studies examined the relationship between extraversion and intelligence without a driving theory or a hypothesis about the anticipated relationship, and neglected to substantively interpret the results. Although studies examined the relationship between extraversion and intelligence, the impetus for these studies was often on the connection between extraversion and other variables such as academic achievement (e.g., Finch & Nemzek, 1932; Gilliland & Voas, 1930; Hendrickson & Huskey, 1932; Stanger, 1933), superstition (e.g., Powers, 1931), or the vocational selection of teachers (e.g., Pechstein, 1928). Other authors sought to further examine the extraversion construct by developing new measures of extraversion (e.g., Hoitsma, 1925), or considered the relationships among a variety of person characteristics and extraversion (e.g., Hanna, 1932; Oliver, 1930; Stanger, 1932). Two exceptions include a study by South (1927) on the performance of committee members and a study by McGeoch and Whitely (1933) on extraversion, learning, and memory.

South (1927) found that extraverts were quicker and more accurate than introverts on a task where a committee must come to a consensus in selecting photographs of facial expressions that portrayed certain specified emotions. Conversely, introverts outperformed extroverts on an abstract multiple choice task in which each committee member worked independently. South suggested that extraverts favor concrete and personal problems, and introverts favor abstract and impersonal problems. McGeoch and Whitely (1933) found that extraversion was unrelated to intelligence (measured by the

Army Alpha), but that submissiveness and introversion (measured by the Allport Ascendance-Submission Test and the Conklin Scale of Introvert-Extrovert Interest Differences, respectively) showed small negative correlations across six tests of learning and memory (e.g., nonsense syllables recall). In other words, higher levels of extraversion were related with a higher degree of performance on learning and memory tests, but not highly associated with intelligence. The relationship was not generalized. Another extraversion scale, the Neyman-Kohlstedt Introvert-Extrovert Test, correlated in the opposite direction with some of the learning and memory tests.

Early empirical findings with respect to the extraversion-intelligence relationship were inconsistent. Several researchers found nonsignificant relationships (e.g., Finch & Nemzek, 1932; Gilliland & Voas, 1930; Guthrie, 1927; Hanna, 1932; Hoitsma, 1925; McGeoch & Whitely, 1933; Powers, 1931), and others a slight superiority in introverts (e.g., Guilford, 1934; Hendrickson & Huskey, 1932; Oliver, 1930; Pechstein, 1928; Stanger, 1932, 1933); correlation coefficients never exceeded a 0.2 magnitude. Guilford (1934) suggested that the inconsistent findings were due to the use of different measures of the construct and the assessment of different samples.

Studies examining the extraversion-intelligence relationship often included more than one measure of extraversion. Correlations among the measures of extraversion were low for two measures of the same construct (e.g., Gilliland, 1934; McGeoch & Whitely, 1933; Stanger, 1932). For example, Gilliland (1934) found that the correlation among four measures of extraversion (the Colgate Mental Hygiene Inventory C2, the Bernreuter Personality Inventory, the Marston Personality Rating Scale, and the Northwestern University Introversion-Extroversion Test) ranged from -.09 to .47. He proposed four

possibilities for the low correlations: (1) the measures were not reliable (split-half reliability coefficients ranged from 0.62 to 0.84), (2) the authors of the measures defined extraversion differently, (3) different definitions of extraversion led to different test items, and/or (4) the test items were scored differently. Thus, Gilliand (1934), in addition to Guilford (1934), suggested that the mixed empirical findings with respect to the correlation between extraversion and intelligence might be due to the use of the different measures of extraversion.

Systematic work on the extraversion construct began with a program of research conducted by Guilford and Guilford (1934, 1936, 1939a, 1939b) using factor analysis. Guilford and Braly (1930) hypothesized a "thinking introversion" factor. Guilford and Guilford (1939a) said, "[thinking introversion] would have at one extreme the individuals who habitually stop to think and like thought activity, and at the other extreme individuals who habitually act more promptly and who find thinking less to their linking" (p. 21). Throughout the program of research, Guilford and Guilford sought to accurately measure the multidimensional nature of extraversion and to create items underling a thinking introversion factor. Guilford and Guilford (1939a) noted substantial intercorrelation among Habitual Thinking of a Meditative Sort (i.e., thinking introversion), Social Introversion, and Depression and suggested that these three factors represented the three basic dimensions of extraversion.

Consistent with Guilford and Guilford's work, Evans and McConnell (1941) developed a 151-item, self-report measure of extroversion (Minnesota T-S-E Inventory) that included three scales: Thinking, Social, and Emotional. Investigation of the relationships between the Minnesota T-S-E Inventory scales and the Miller Analogies

Test among two samples of students revealed small, yet positive correlations (r = .15 and r = .26) with the Thinking Introversion scale. A subsequent study by Chalmers (1948) with a sample of 65 teachers revealed similar results. Higher scores on the Minnesota T-S-E Inventory indicated higher levels of extraversion in contrast to Evans and McConnell's study. In the Chalmers study, the Thinking Introversion scale correlated -.36 with the Otis Self-Administering Test of Mental Ability. Thus, early research based on the theory and work of Guilford and his colleagues led to an empirical connection between extraversion and intelligence.

Guilford and Zimmerman (1956) reanalyzed data collected by Lovell (1945) to support the existence of the 13 factors measured by the Guilford-Martin personality inventories (An Inventory of Factors GAMIN [General Activity, Ascendance, Masculinity, Inferiority Feelings, and Nervousness], An Inventory of Factors STDCR [Social Introversion-Extroversion, Thinking Introversion-Extroversion, Depression, Cycloid Disposition, and Rhathymia], and The Personnel Inventory [Objectivity, Agreeableness, and Cooperativeness]) in a single study. Guilford and Zimmerman rationally combined items into homogeneous groups, and verified the thirteen factors originally hypothesized. The thinking introversion factor was reinterpreted in the Guilford-Zimmerman Temperament Survey (GZTS) as "*Reflectiveness* [italics in original]: Given to meditative and reflective thinking; dreamer; philosophically inclined; has curiosity about and questioning attitude toward behavior of self and others" (Guilford and Zimmerman, 1956, p. 24). The GZTS includes 10 scales; 30 items measure each scale. Five primary factors combine to form two related secondary factors related to extraversion (Morris, 1979). Reflectiveness and Rhathymia (carefreeness) form the

secondary factor labeled introversion-extraversion (see Table 1 for a description of the primary traits). Ascendance (social boldness), General Activity (energetic), and Sociability (outgoingness) form the secondary factor labeled social activity.

Early empirical findings on the relationship between extraversion and intelligence were inconsistent and appear to have differed by measure used to assess extraversion. Although a couple of researchers provided several suggestions as to how the measures of extraversion differed (Gilliland, 1934; Guilford, 1934), very little evidence was collected in support of any of these suggestions. The program of study developed by Guilford and his colleagues more accurately and reliably measured the extraversion construct. They defined extraversion as a multidimensional construct, with a thinking introversion factor (relabeled Reflectiveness) that was found to correlate with intelligence. The work by Guilford and his colleagues provided the first systematic program of research leading to the development of a conceptual and reliable empirical link between extraversion and intelligence.

A Biologically-Based Conceptualization of Extraversion – The Eysenck Years

Based on Guilford and Guilford's (1934, 1936, 1939a, 1939b) work and the Guilford-Martin personality inventories discussed above (Guilford & Zimmerman, 1956; Martin, 1945), Eysenck (1956) developed the Maudsley Personality Inventory (MPI), which included an extraversion and a neuroticism scale. He did not include a thinking introversion factor in the measurement of extraversion. Instead, he considered extraversion to be primarily Rhathymia followed by General Activity and Ascendance. Designed in 1962, the MPI was the first personality measure developed by Eysenck to include an extraversion scale (Eysenck & Eysenck, 1975). The next instantiation of the

Eysenck notion of personality, named the Eysenck Personality Inventory (EPI), included the addition of several psychometrically desirable properties in accordance with Eysenck's conception of personality. The extraversion and neuroticism scales were independent of each other, and independent of intelligence test scores (Eysenck, 1970, 1971). Eysenck (1994) argued that extraversion was related to certain test-taking behaviors (e.g., planful strategy), and cautioned against blind empirical attempts to correlate extraversion and intelligence.

Although the scales discussed above are largely derived from factor analytic procedures and Eysenck (1956) initially used a correlational approach to study personality, he later developed a biological explanation for personality (Eysenck, 1967). Based on this biological approach to the study of extraversion, many predictions were made about how individuals with varying levels of extraversion would perform on different tasks of ability. Before considering an example, however, I will briefly review Eysenck's (1967) biological conceptualization of extraversion and its connection with the Yerkes-Dodson law.

Eysenck (1967) proposed the arousal theory to explain individual differences in personality that at the time included two factors – extraversion and neuroticism (for a review of neuroticism, see Eysenck, 1967). Specifically, he suggested that differential thresholds in the ascending reticular activating system (ARAS) account for the expression of extraversion. The ARAS regulates cortical arousal by sending and receiving impulses to and from the cortex forming a loop known as the cortico-reticular loop. That is:

Neural messages ("sensations") going along the classical ascending afferent

> pathways relay to the particular projection areas involved in the cortex; they also send collaterals into the reticular formation, which in turn sends "arousal" messages to the cortex to keep it in a state of functional tonus. Depending on the nature of the information transmitted, the cortex in turn instructs the reticular formation to continue sending "arousal" messages or else to switch to "inhibition." This loop then is concerned with information processing, with cortical arousal and inhibition, and in its application to personality differences with introversion and extraversion. (Eysenck, 1967, p. 231)

Lower levels of extraversion are associated with higher levels of activity (arousal) in the cortico-reticular loop. In other words, lower levels of extraversion are associated with higher levels of arousal in general and in response to specific stimuli.

Support for Eysenck's (1967) arousal theory has been established by several studies investigating group differences in electroencephalograph (EEG) readings (Gale, Coles, & Blaydon, 1969; Savage, 1964). Savage (1964) hypothesized that if higher levels of extraversion are associated with higher cortical inhibition as hypothesized by Eysenck (1955, 1967) than extraverts would have a significantly higher alpha rhythm amplitude than introverts. He found that individuals who scored high on the MPI measure of extraversion showed significantly higher alpha amplitude EEG scores than introverts. Research by Gale, Coles, & Blaydon (1969) similarly found differential EEG scores for introverts and extraverts, with extraverts showing EEG scores consistent with a greater level of cortical inhibition dynamism in accordance with the arousal theory.

Eysenck's (1967) arousal theory offers a physiological basis for the Yerkes-Dodson law, which provides a function to assess the relationship among arousal,

extraversion, and performance on cognitive ability tests. The Yerkes-Dodson law suggests that performance on a task increases as drive increases to an optimum level, and beyond the peak or optimum level performance decreases as drive increases (Broadhurst, 1957; Hebb, 1955). In addition, the peak level of performance is associated with the difficulty of the task such that easier tasks are associated with a higher level of arousal to attain peak performance than difficult tasks. It is generally described as an inverse U-relationship between arousal and performance. When applied to individual differences in extraversion, the Yerkes-Dodson law suggests that because the extravert is less highly aroused in general and by specific stimuli, an arousing task would move the extravert closer to the peak of the inverted-U toward optimum performance (Eysenck, 1967). In contrast, introverts would move past the peak and down the right side of the inverted-U function becoming over aroused with a drop in performance.

Several studies have provided support for the connection between the Yerkes-Dodson law and individual differences in extraversion (Corcoran, 1965; Revelle, Amaral, & Turriff, 1976). Corcoran (1965), for example, assessed individual differences in extraversion using the Heron scale of introversion-extraversion (Heron, 1956), and manipulated arousal levels (sleep deprivation and incentive conditions) among 48 participants before they completed a five-choice serial-reaction task. Based on the results, Corcoran suggested that introverts performed better on what was considered a low arousal task (five-choice serial-reaction), that extraverts were more adversely affected by the de-arousing condition, and that extraverts benefited more from the arousing manipulations than introverts.

Revelle, Amaral and Turriff (1976) provided further support for the connection

between Eysenck's (1967) arousal-extraversion association and the Yerkes-Dodson arousal-performance function. In the study, 101 undergraduate students completed three equivalent versions of a verbal ability test in three conditions over three consecutive nights: an untimed test condition, a timed plus placebo condition, and a timed plus caffeine condition. Participants completed the EPI while waiting for the placebo "to take effect." The results indicated that introverts performed best on the verbal test in the untimed condition, followed by the timed, placebo condition, and finally the timed, caffeine condition. Although extraverts performed similarly in the untimed and timed plus placebo condition, their performance improved above the introverts in the timed plus caffeine condition.

Eysenck (1994) suggested, "simple attempts to correlate any old IQ test that comes to hand with any old personality test that happens to be available, or any diagnostic psychiatric groups that happen to be around, are doomed to failure, and are a waste of time and energy" (p. 25), for extraversion is meaningfully related to certain behaviors (e.g., planful strategy) on cognitive ability tests. Test-taking behaviors are related to performance on tests based on the characteristics of the test (e.g., length, speededness). Thus, Eysenck suggested that it is necessary to build studies around established theories based on performance data.

Eysenck's (1967) arousal theory provides an established theory. For instance, the arousal theory suggests that introverts are more highly aroused than extraverts, and furthermore, would show greater vigilance and less inhibition in extended performance situations (Eysenck, 1967; Eysenck & Eysenck, 1985). The greater excitation of introverts leads to a greater control over risk taking to prevent over-stimulation; in other

words, introverts perform tasks at a slower rate to increase accuracy. On the other hand, the lower arousal level of extraverts leads to a faster work pace and a greater number of errors on cognitive ability tests. Howard and McKillen (1990) found evidence in support of the hypothesis that extraverts sacrifice accuracy for speed on cognitive ability tests and introverts sacrifice speed for accuracy. Their results suggested that by adopting a more planful strategy introverts responded more accurately and were able to outperform extraverts on the Perceptual Maze Test.

Eysenck (1994) advised that past theory and research should be reviewed while planning a study on the relationship between extraversion and intelligence. Based on a review of the literature, he developed a biological approach to the study of personality, which provides a theoretical connection between extraversion and arousal, a physiological basis for the Yerkes-Dodson law, and a connection between extraversion and performance on cognitive ability tests based on the conditions of the test (Eysenck, 1967). Although all three hypothetical connections have not been tested within a single study, empirical evidence has been provided for each of these aspects of the arousal theory. Studies have demonstrated the relationship between extraversion and arousal (e.g., Gale, Coles, & Blaydon, 1969; Savage, 1964), between the arousal theory and the Yerkes-Dodson law (e.g., Corcoran, 1965; Revelle, Amaral and Turriff, 1976), and between extraversion and performance on cognitive ability tests (e.g., Howard & McKillen, 1990).

Expanding Eysenck's Conception of Extraversion and Intelligence

Eysenck's (1967) biological conceptualization of personality increased interest in delineating what aspects of cognitive ability tests would be related to extraversion.

Although researchers of the third time period initially tested Eysenck's arousal theory in consideration of the extraversion-intelligence relationship, they found it inadequate to explain their research findings. In this section, I review two programs of research: Robinson's program of research, and Matthews and his colleagues' program of research.

Robinson (1982a, 1982b, 1983, 1985, 1986, 1989) adopted a neurophysiological methodology to examine extraversion and Wechsler Adult Intelligence Scale (WAIS) scores in light of electroencephalograph (EEG) characteristics based on Eysenck's (1967) arousal theory. Initially, Robinson (1985, 1986) proposed that extraverts display superiority on the verbal subtests and introverts on the performance subtests of the WAIS. To account for the inconsistent findings (Rawlings & Carnie, 1989; Rawlings & Skok, 1993; Saklofske & Kostura, 1990), Robinson (1989) later proposed that ambiverts (intermediate level of extraversion), due to their optimum level of arousal, performed better on the WAIS than either extraverts or introverts. Matthews and his colleagues (Matthews, 1985, 1987, 1989; Matthews, Davies, & Holley, 1990; Matthews, Davies, & Lees, 1990; Matthews, Jones, & Chamberlain, 1989) found little support for the connection between arousal, extraversion, and performance on cognitive ability tests as described by Eysenck (1967) or the Yerkes-Dodson law, and suggested that the association between extraversion and ability is complex, involving many interactions.

Robinson (1982a, 1982b) demonstrated that EEG activity mediated by the diffuse thalamocortical system (DTS) systematically related to individual differences in extraversion and intelligence. Robinson suggested that only the DTS has the capability to generate widespread yet discriminating cortical activation (arousal) in contrast to the highly localized ARAS proposed by Eysenck (1967). In later studies, Robinson (1985,

1986, 1989) examined EGG evoked potential parameters to investigate the connection between extraversion and WAIS scores based on Eysenck's arousal theory. Robinson (1985, 1986) found that extraverts and introverts had significantly different profiles on the WAIS subtests, but full scale scores were similar. Extraverts were defined as participants scoring 1 SD above the mean, and introverts as 1 SD below the mean. Weights for 11 extraverts and nine introverts were computed by calculating the percent deviation of the groups' mean subtest score from the mean score on all of the subtests (Robinson, 1985). The absolute differences between the weights for the extraverts and introverts ranged from 4.15 to 29.57. Introverts outperformed extraverts on all of the verbal subtests except for Arithmetic, and extraverts outperformed introverts on the performance subtests except for Picture Completion. Robinson (1985) suggested that introverts have an advantage on any task where ability is related to sensory associative learning (e.g., paired associates), for according to Robinson, ". . . [the] thalamocortical activity of introverts favors the development of greater lateral connectivity" (p. 204). In other words, introverts have a greater number of associations than extraverts for any one stimulus. As a result, introverts should be able to access any one stimulus more quickly than extraverts. All the verbal subtests, except Arithmetic, involve recalling information to answer a query from the test administrator. On the other hand, the greater resting arousal level of introverts causes stronger inhibition in the brain-stem systems, which impairs the introvert's ability to acquire automatic motor (manipulative) processes. As the performance subtests, except for Picture Completion, involve covert cognitive manipulation more so than the verbal subtests, extraverts should have an advantage over introverts.

Rawlings and Carnie (1989) offered an alternative explanation for Robinson's (1985, 1986) findings based on the distinction between timed and untimed subtests of the WAIS. All the verbal subtests are untimed except Arithmetic, and all the performance subtests are timed. Based on Eysenck's (1967) hypothesis of a speed-accuracy preference difference between extraverts and introverts, Rawlings and Carnie (1989) suggested that Robinson's (1985, 1986) results may be better explained by a time-pressure variable. Parallel versions of the Information, Picture Arrangement, Arithmetic, and Digit Span subtests from the WAIS—R (revised) were created to administer a timed and untimed version of each test. Rawlings and Carnie found a two-way interaction between (1) extraversion and condition (time versus untimed), $F(2, 37) = 5.85$, $p = .006$, and (2) extraversion and subtest, $F(6, 37) = 3.64$, $p = .002$. Extraverts performed slightly better on all the subtests in the timed condition and on the Information subtest. Introverts performed slightly better in the untimed condition and on the Digit Span and Arithmetic subtests. Only the means of the Digit Span subtest were in the direction predicted by Robinson's hypothesis.

In another attempt to replicate Robinson's (1985, 1986) studies, this time with children, Saklofske and Kostura (1990) did not find a significant difference among introverts, extraverts, or ambiverts as measured by the Junior Eysenck Personality Questionnaire on the verbal, performance, or full scale of the Wechsler Intelligence Scale for Children – Revised (WISC-R). The results also failed to support Rawlings and Carnie's (1989) alternate time-pressure explanation. Also in contrast to Robinson's and Rawlings and Carnie's findings, Rawlings and Skok (1993) found that differences between extraverts and introverts were in the opposite direction as predicted by either

view on the majority of WISC-R subtests administered.

To account for the contradictory findings, Robinson (1989) suggested that a curvilinear relationship as described by the Yerkes-Dodson law between EEG characteristics and WAIS scores may better explain the data. In a similar design as the previous studies (Robinson, 1985, 1986), Robinson found that the highest WAIS scores were associated with an intermediate level of overall arousability. The results suggested that ambiverts performed better on the WAIS than either extraverts or introverts. Stough et al. (1996) replicated Robinson's findings.

Matthews and his colleagues (Matthews, 1985, 1987, 1989; Matthews, Davies, & Holley, 1990; Matthews, Davies, & Lees, 1990; Matthews et al., 1989) have conducted several studies assessing extraversion (usually with the 16 Personality Factor Questionnaire), self-reported arousal, and performance on a variety of tasks in an effort to investigate Eysenck's (1967) arousal theory. Performance was assessed using tests of intelligence (e.g., AH5 Group Test of High-Grade Intelligence, AH6 Group Test of High-Level Intelligence), creativity (e.g., Originality and Word Fluency from the Comprehensive Ability Battery), lower level cognitive abilities (e.g., digit span), attention tasks (e.g., sustained attention, visual/memory search), and reaction time tasks (e.g., serial reaction). Manipulations included: time of day, complex noise, and task characteristics. Matthews and his colleagues measured arousal by questionnaire, which was validated with physiological measures such as skin conductance and heart rate (Matthews, 1987). In general, they found little support for a curvilinear relationship between the different arousal levels of extraverts and task performance as suggested by the Yerkes-Dodson law. Matthews and his colleagues suggested that interactions of

variables predict task performance. Single variables such as extraversion were rarely related significantly to performance. Finally, they criticized earlier research for attempting to manipulate arousal without measuring it, and found the validity of direct measures of arousal such as EEG readings to be contentious.

More specifically, Matthews and his colleagues did not replicate the negative correlation of extraversion with arousal as proposed by Eysenck (1967), and the results were more complex than Eysenck's arousal theory allows. Interaction effects involving extraversion and arousal were not dependent on a significant relationship between the two variables. The association between extraversion and performance was not mediated by the relationship between extraversion and arousal. Matthews and his colleagues suggested that extraversion may not be related to performance through arousal level. In addition, the speed-accuracy trade-off preference difference hypothesized by Eysenck was not replicated.

Robinson (1982a, 1982b) suggested that the DTS, as opposed to the ARAS as described by Eysenck, mediates cortical activity and relates meaningfully to extraversion and intelligence. Also, in contrast to Eysenck's emphasis on extraversion relating to specific behaviors on tests of cognitive ability, Robinson (1989) demonstrated that ambiverts who are at an intermediate level of arousal outperform extraverts and introverts on intelligence tests. Matthews and his colleagues (Matthews, 1985, 1987, 1989; Matthews, Davies, & Holley, 1990; Matthews, Davies, & Lees, 1990; Matthews, Jones, & Chamberlain, 1989), on the other hand, found little support for the connection between extraversion and intelligence as described by Eysenck or the Yerkes-Dodson law. Moreover, they suggested that the extraversion-intelligence relationship may not be

mediated by arousal level, and that interaction effects involving extraversion, intelligence, and additional variables may better explain their results. Findings from both programs of research, Robinson's and Matthews and his colleagues, suggested that the extraversion-intelligence relationship is more complicated than the arousal theory predicts.

Contemporary Research: The Dynamics of Extraversion-Intelligence Research

A review of the extraversion–intelligence relation suggests that the findings are inconsistent with respect to the nature of the relationship (Saklofske & Zeidner, 1995). Zeidner (1995), for example, reviewed personality trait correlates including extraversion and intelligence and suggested that, in general, this body of research is contradictory and complex often involving interaction effects. He cited several studies that found negligible, nonsignificant relationships (e.g., Eysenck, 1971; Robinson, 1985; Saklofske & Kostura, 1990), and a couple that found modest positive correlations (e.g., Crookes, Pearson, Francis, & Carter, 1981; Lynn, Hampson, & Magee, 1983).

Results from a meta-analysis between personality and intelligence conducted by Ackerman and Heggestad (1997), however, found relatively consistent modest positive relations between extraversion and intelligence. In the Ackerman and Heggestad meta-analysis, extraversion was operationalized as the dimension of personality associated with the extraversion factor in the five factor model (e.g., John & Srivastava, 1999), Eysenck's extraversion factor (Eysenck & Eysenck, 1975), and Cattell's (1966) exvia factor. Their findings, shown in Table 2, indicate a positive relationship of the estimated effect sizes for extraversion across the ability categories ranging from 0.05 to 0.14 (Ackerman & Heggestad, 1997). In addition, half of the Q statistics were significant

suggesting that a moderator variable may underlie the distribution of observed correlations. Also in Table 2, they included two traits related to extraversion – social potency (i.e., the preference for dominance in social situations) and social closeness (i.e., the desire to be in the company of others; Tellegen, 1982). In general, the results for social potency and social closeness are similar to those found for extraversion.

Several subsequent studies by Ackerman and his colleagues (Ackerman, 2000; Ackerman et al., 2001; Ackerman & Rolfhus, 1999; Rolfhus & Ackerman, 1999), Furnham et al. (1998), and Roberts (2002) found significant negative relationships between extraversion and intelligence. Rolfhus and Ackerman (1999) investigated the relationship between extraversion (assessed by the NEO-FFI) and different scales designed to assess domain knowledge, a construct posited to resemble crystallized intelligence. In contrast to the positive extraversion-knowledge/achievement relationship in the Ackerman and Heggestad (1997) meta-analysis, Rolfhus and Ackerman found that extraversion was significantly negatively correlated with all but one of twenty domain knowledge scales (see Table 3). Similar findings were obtained in a second study involving 135 middle-aged adults (Ackerman & Rolfhus, 1999). Again, Ackerman and Rolfhus found a significant negative association between extraversion (assessed by the NEO-FFI) and scores on nine of the twenty domain knowledge scales (see Table 3).

Ackerman (2000) addressed the contradictory nature of these findings by suggesting that broad measures of extraversion, such as those derived from the five factor model, may confound social closeness and social potency (also see Tellegen, 1982). During the development of the Multidimensional Personality Questionnaire (MPQ), social potency was designed to capture "broad interpersonal effectiveness and a desire to

make an impact on others" (Tellegen & Waller, in press, p. 21). On the other hand, social closeness was characterized by warmth and a need for intimacy. The distinction between social potency and social closeness is not captured by the five factor approach (e.g., the NEO measures; Tellegen and Waller, in press). Although the most salient MPQ correlate of extraversion is social closeness, as a higher order dimension of personality, extraversion is better represented by the MPQ's Communal Positive Emotionality (Church, 1994; Tellegen and Waller, in press). Communal Positive Emotionality includes three MPQ scales: social closeness, social potency, and well-being (i.e., the tendency to experience positive emotions). Extraversion includes six facets. The warmth and gregariousness facets are similar to the MPQ social closeness scale and the positive emotions facet is similar to the MPQ well-being scale. In addition, NEO extraversion also includes activity and excitement seeking facets. The sixth facet, Assertiveness (i.e., social potency) is not captured well by the NEO extraversion dimension, for "submissive-versus-dominant" is a weak marker of extraversion (Tellegen and Waller, in press). Other personality measures in addition to the MPQ divide the measurement of extraversion into two separate scales (e.g., 16PF, California Psychological Inventory, Hogan Personality Inventory; see Table 4 through Table 6).

Ackerman (2000) assessed the utility of using the more narrow scales designed to independently evaluate individual differences in social closeness and social potency from the MPQ. As seen in Table 3, results from a sample of 228 students demonstrated that social closeness was significantly negatively correlated with four knowledge composites (Business/law, Civics, Humanities, and Science) and with crystallized intelligence. Social potency was significantly negatively correlated with one of the four knowledge

scales (Humanities) and with crystallized intelligence. Social closeness had a greater negative association with domain knowledge than social potency, which supports separating these two aspects of extraversion.

Ackerman et al. (2001) replicated the findings from these earlier studies (Ackerman, 2000; Ackerman & Rolfhus, 1999; Rolfhus & Ackerman, 1999). A sample of 320 university freshmen completed the NEO-FFI scale of extraversion and the MPQ scales of social closeness and social potency, composites of crystallized and fluid intelligence, and domain knowledge scales. As seen in Table 7, extraversion was significantly negatively related with all of the ability/knowledge domain traits, social closeness was significantly negatively related to all of the ability/knowledge domain traits except for fluid intelligence, and social potency was significantly negatively related with two knowledge domains (Biology/Psychology and Physical Science), general knowledge, and fluid intelligence. The different pattern of correlations between social potency and social closeness, again, supports measuring these two aspects of extraversion separately.

Recent studies by other researchers have shown similar patterns of negative relationships between extraversion and intelligence. Furnham et al. (1998) examined the relationship between extraversion (assessed using the Eysenck Personality Profiler) and performance on two speeded measures of general intelligence, the Baddeley Reasoning Test (Baddeley, 1968) and the Wonderlic Personnel Test (Wonderlic, 1992) with 233 middle-management applicants. Results indicated that both the extraversion "superfactor" and the seven primary factors of extraversion (e.g., inferiority, unhappy) were significantly negatively related with the Wonderlic and six of the seven primary

factors were significantly negatively related with the Baddeley. Roberts (2002) examined the relationship between extraversion (assessed by the Eysenck Personality Questionnaire Short Scale) and cognitive ability (assessed with the Saville and Holdsworth Ltd. Advanced Test Battery Spatial Reasoning and Verbal Concepts tests) with 214 first-year university students. He found a significant linear trend in which introverts outscored extraverts on the verbal test, $F(1, 206) = 7.42$, $p < .01$, and a similar nonsignificant trend on the spatial test, $F(1, 206) = 1.93$.

A review of the relationship between extraversion and intelligence described empirical findings as inconsistent citing studies that found either a nonsignificant or modest positive relationship (Zeidner, 1995). The Ackerman and Heggestad (1997) meta-analysis found a general positive pattern of correlations between extraversion and ten ability traits. Studies published after the meta-analysis demonstrated a negative relationship with extraversion and a variety of ability traits (Ackerman, 2000; Ackerman et al., 2001; Ackerman & Rolfhus, 1999; Furnham et al., 1998; Roberts, 2002; Rolfhus & Ackerman, 1999). This pattern of results suggests that the relationship between extraversion has changed from a positive relationship to a negative relationship. In addition, two studies demonstrated the validity of separating extraversion into social closeness and social potency (Ackerman, 2000; Ackerman et al., 2001).

Determinants of the Correlation between Extraversion and Intelligence

An observed change in the relationship between extraversion and intelligence suggests two possibilities: (1) a change in the measures used to assess at least one of the constructs or (2) a change in the samples used to assess the constructs. Three mechanisms may underlie the development of an association between personality and

intelligence traits such as the extraversion-intelligence relation: an overlap in psychological components, external environmental fields, and hereditary determinants (Anastasi, 1970, 1983; Tyron, 1935). A change in the measures or constructs would represent a change in the overlap of the psychological components. A change in the samples would represent a change in either the external environmental fields or the hereditary determinants. The present study only investigates a change in the overlap of the psychological components and is not diagnostic of changes to environmental fields or hereditary determinants. Therefore, only a change to the psychological components will be discussed in further detail, for a review of the other two mechanisms see Anastasi (1970, 1983) or Tyron (1935).

A change in the constructs suggests that the definition of one or both of the constructs changed leading to a change in the items used to assess the construct. For example, the popularity of the five-factor approach has led to the use of NEO-based measures, when in the past psychologists may have used one of the Eysenck extraversion scales that are based on a biological approach to the study of personality. Alternatively, the conceptualizations may have remained the same, but the measures may have changed such as the revision from the EPI to the EPQ or from the NEO-PI to the NEO-PI-R. As suggested by the two examples above, the change may have occurred at the measure level, one measure replacing another, or at the item level, a revision of the items of an existing measure.

Tyron (1935) ascribed the majority of associations between different psychological measures to an overlap in psychological components. For example, ability tests tend to correlate because each test with a varying degree of generality or specificity

samples from psychologically similar areas. Theoretical and empirical connections between extraversion and intelligence have been reviewed in the preceding sections. The present study will examine the psychological components of the extraversion-intelligence relationship.

Hypotheses

Gilliland (1934) and Guilford (1934) suggested that the extraversion-intelligence relationship may differ based on different measures of extraversion. Evans and McConnell (1941) found a significant positive correlation between the Thinking Introversion scale and the Miller Analogies Test. Neither the Social nor the Emotional scales were significantly related to intelligence. Although Guilford, his colleagues, Evans, and McConnel found the Thinking Introversion scale useful in the measurement of extraversion, others did not include such a scale as seen in Table 4. For example, the extraversion factor in the Eysenck measures combines sociability and impulsivity (Guilford, 1975). Thus, it is less clear how the extraversion-intelligence relationship should vary based on measures of extraversion.

On the other hand, Eysenck (1967) posited several connections between extraversion and performance on different tests of cognitive ability based on the arousal theory. Eysenck (1971, 1994) argued that intelligence was not meaningfully related to extraversion. Instead, he maintained that certain test-taking behaviors are associated with extraversion. More recent research suggests that the relationship between extraversion and intelligence is inconsistent and performance on cognitive ability tasks may be associated with interactive effects of extraversion, arousal, and other moderators (e.g., time of day); such that, the relationship is more complex than Eysenck's arousal theory

predicts (Matthews & Dorn, 1995).

Several associations between extraversion and aspects of performance with varying levels of reliability have been replicated (Eysenck & Eysenck, 1985; Matthews, 1992; Matthews & Deary, 1998; Matthews & Dorn, 1995; Zeidner & Matthews, 2000). Extraverts have demonstrated superiority in divided attention, resistance to distraction, retrieval from memory, and short-term memory tasks, and inferiority in vigilance, reflective problem solving, and long-term memory tasks. Results have been inconsistent with respect to attentional selectivity tasks, reaction-time tasks, and general intelligence tests (Zeidner & Matthews, 2000). For a more comprehensive review of performance correlates of extraversion see Eysenck & Eysenck (1985) or Matthews (1992). Although connections between extraversion and specific cognitive patterns have been demonstrated in the literature, intelligence tests (e.g., WAIS) usually employ several of the cognitive correlates listed above. The relationship between extraversion and intelligence based on human performance data is not clear unless a test includes items solely from one of those cognitive correlates. Ackerman and Heggestad (1997) provided an empirical summary suggesting a positive relationship. Although more recent studies suggest a change in the relationship, it is unclear how these more recent studies will impact the findings of the current meta-analysis. The first hypothesis predicts a positive pattern of correlations between extraversion and intelligence consistent with Ackerman and Heggestad's findings.

Several studies have demonstrated a different pattern of effects between social potency and social closeness related to cognitive abilities (Ackerman, 2000; Ackerman et al., 2001). The present study will also examine the validity of separating social potency

and social closeness. It is expected that the pattern of correlations of social potency and social closeness will be different. In general, social closeness was related to intelligence traits to a greater extent than social potency.

Thus, the relationship between extraversion and intelligence may be importantly moderated by the measures used to assess each construct (Roberts, 2002; Zeidner & Matthews, 2000). As such, the first objective of the present study is to investigate the potential moderating influence of the type of measures used to assess the extraversion-intelligence relationship.

H_1: The extraversion-intelligence relationship will differ by different measures used to assess the two person characteristics. Specifically,

1a. Measures of extraversion and measures of intelligence are expected to demonstrate a positive relationship.

1b. Measures of social closeness are expected to show a different pattern of results than measures of social potency, such that the effect size for social closeness will be greater in magnitude, in general, across intelligence traits than social potency.

Reviews of the literature suggested that the relationship between extraversion and intelligence was either not significantly different from zero or slightly positive (Zeidner & Matthews, 2000; Zeidner, 1995). Ackerman and Heggestad's (1997) empirical summary of the extraversion-intelligence relation suggest a general positive association. A number of more recent studies have demonstrated a negative association between extraversion and a variety of ability traits (Ackerman, 2000; Ackerman et al., 2001; Ackerman & Rolfhus, 1999; Furnham et al., 1998; Roberts, 2002; Rolfhus & Ackerman, 1999). This pattern of results suggests that the extraversion-intelligence relationship may

have been moderated by time. It was proposed that the psychological components of the extraversion measures, intelligence tests, or both are responsible for the change. The second objective of the study is to investigate the change in the extraversion-intelligence relationship over time. The year of publication associated with the study will be used as the time moderator variable. Although year of publication associated with the results of a study is an imperfect measure of time, it provides an objective variable. Specifically:

H_2: After updating the literature search from the Ackerman and Heggestad (1997) meta-analysis to the present, there will be an observed change in the relationship between extraversion and intelligence such that the relationship has changed from positive to negative as a function of the date of publication.

CHAPTER 3

METHODOLOGY

Data Collection

Empirical data for use in the meta-analysis were obtained using multiple methods. First, as a starting point for data collection, all references from the Ackerman and Heggestad (1997) meta-analysis were examined. Next, to identify studies that have been conducted or published since 1992, electronic database searches were performed with the American Psychological Association's on-line PsycINFO. The search terms related to ability and extraversion used to conduct the Ackerman and Heggestad (1997) meta-analysis were used plus five search terms related to social closeness. The search terms were added because social closeness was used as a personality category in the Ackerman and Heggested meta-analysis (1997), but was not represented by any search terms. None of the five additional search terms revealed a study conducted before 1992 that reported a useful correlation. As shown in Table 8, personality and ability search terms included trait constructs (e.g., extroversion and spatial), measures and abbreviations of measures (e.g., Eysenck Personality Questionnaire and DPQ [differential personality questionnaire]), related organizations (e.g., ETS), and alternate spellings of the aforementioned search terms (e.g., Meyers-Briggs). Each of the 42 personality search terms were crossed with each of the 18 ability search terms. This led to a total of 9,761 hits on PsycINFO. In addition, the following were searched: personality and ability battery manuals, articles from Phillip L. Ackerman's files (1,500+ items), articles referenced by articles obtained in the search, books, and book chapters.

To be included in the meta-analysis, the study had to report a zero-order

correlation between at least one measure of extraversion or related trait and one measure of cognitive ability. Exclusion criteria were designed to retain studies useful in the present meta-analysis and consistent with the studies used in the Ackerman and Heggestad (1997) meta-analysis to avoid a selection confound. Studies were excluded if participants were not human, younger than 10 years old[2], from a clinical or highly restricted population, the study was a non-correlational or extreme groups design, or written in a language other than English. When available, each study's abstract was examined for inclusion in the meta-analysis as an initial screening process. The entire study was examined if an abstract was not available. A total of 234 studies were obtained, including 50 studies used by Ackerman and Heggestad (1997). All 234 studies were reviewed in entirety for inclusion in the meta-analysis. A total of 100 studies reported a useful correlation and were included. These studies included 166 independent samples, 1,018 correlations, and 56,016 participants. Studies that contributed a correlation to the meta-analysis are designated by an asterisk in the Reference section.

Data Coding

For each study the following information was coded: year of publication, zero-order correlation, sample size, mean age of sample, measures used to assess the constructs, the estimated reliability of the measures, and the source of the reliability estimate. Ability and personality correlations were grouped into the same categories used by Ackerman and Heggestad (1997); general intelligence, crystallized intelligence, ideational fluency, knowledge and achievement, learning and memory, speed, visual perception, closure, fluid intelligence, and math-numerical were used for ability and

[2]The standardization data for the Junior Eysenck Personality Questionnaire suggested that the measurement of extraversion is unreliable for younger children (Eysenck & Eysenck, 1975). The six month test-retest reliability

social potency, social closeness, and extraversion for personality. In the case of introversion and submissiveness, the opposite magnitude of the correlation was used to obtain agreement with the other correlations.

Classifications for measures used in the Ackerman and Heggestad (1997) meta-analysis were retained. All new measures were coded independently by two raters, a faculty member and a graduate student. An additional category was used to code measures for exclusion. Disagreements were discussed and consensually coded. Interrater agreement was 81 percent ($\kappa = .78$) for the ability tests and 69 percent ($\kappa = .59$) for the personality measures. The interrater agreement for the personality measures was within the range of agreement reported by Ackerman and Heggestad (from 61%, $\kappa = .57$ to 79%, $\kappa = .77$; 1997). Interrater agreement was considered generally acceptable, in part, because more common ability and personality measures had most likely been coded by Ackerman and Heggestad (1997). Thus, the remaining measures were potentially less established and more difficult to independently code.

Procedure

Overview. The meta-analysis was conducted with procedures described by Hedges and Olkin (1985). After accounting for missing data, correlations were corrected for attenuation due to unreliability of the measures. Next, sample-size weighted mean correlations were computed using corrected and uncorrected correlations. Mean sample-weighted correlations were used to compute 95% confidence intervals. Assessment of heterogeneity was evaluated by computing a Q-statistic for each mean sample-weighted corrected correlation. Correlations were used to assess the change in the extraversion-intelligence relationship over time.

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estimates dropped below .6 for children nine years old and younger.

Missing Data. An estimate was used for studies that reported only significant correlations. When the correlation was reported as nonsignificant and the sign of the correlation was unknown, zero was used as the expected value (Bushman & Wang, 1995).

Aggregation of Within-Sample Effect Sizes. Several studies reported multiple correlations between ability and personality that were classified into a single ability-personality category (e.g., Carson, Stalikas, & Bizot, 1997). Studies with correlations falling into one ability-personality category were aggregated to create an independent set of effect sizes (Lipsey and Wilson, 2001). Selecting one correlation at random was not used to avoid discarding data. Correlations were aggregated using Fisher's r-to-z transformation. Fisher's z-transformed correlations were used for aggregation to eliminate bias that systematically underestimates effect sizes. Reliability estimates used to correct for attenuation due to the unreliability of the measures were similarly aggregated.

Correction for Attenuation due to Unreliability of the Measures. The standard correction for attenuation due to unreliability of measures was used:

$$r_i^* = \frac{r_{xy}}{\sqrt{r_{xx} r_{yy}}}, \tag{1}$$

where r_i^* is the corrected correlation between personality variable x and ability variable y for study i, r_{xx} and r_{yy} are the estimated reliabilities of personality variable x and ability variable y, respectively, and r_{xy} is the observed personality-ability correlation. Test-retest reliability estimates were considered most desirable and used whenever possible. If not available, tests of internal consistency from the same source were used. If no reliability estimate was reported, an attempt was made to locate reliability estimates reported in

similar research studies that used the same measures. If no reliability estimate could be located than a mean substitution was conducted within the ability or personality category (Roth, 1994).

Correlational Analysis. The procedure described by Hedges and Olkin (1985) was used to compute the estimated effect size:

$$\overline{Z} = \frac{\sum_{i=1}^{k}(n_i - 3)z_{r_i}}{\sum_{i=1}^{k}(n_i - 3)}, \tag{2}$$

where z_{r_i} is the Fisher's z-transformed correlation between personality variable x and ability variable y for study i after the correction for attenuation due to unreliability of measures, n_i is the sample size for that correlation, and k is the number of aggregated correlations in the cell. The estimated population correlation ($\hat{\rho}$) was obtained through a z-to-r transformation of $\overline{Z}$.

Confidence Intervals. Confidence intervals (CI's) for $\hat{\rho}$ were calculated using formulas described by Hedges and Olkin (1985, p. 227):

$$Z_L = \overline{Z} - (1.96/\sqrt{N - 3k}) \tag{3}$$

$$Z_U = \overline{Z} + (1.96/\sqrt{N - 3k}), \tag{4}$$

where 1.96 is the two-tailed critical z value for a 95% CI, N is the total sample size, and k is the number of studies. The lower and upper bounds of the estimated population correlation are obtained through a z-to-r transformation of $z_{L(ower)}$ to $\hat{\rho}_{L(ower)}$ and $z_{U(pper)}$ to $\hat{\rho}_{U(pper)}$.

Test for Heterogeneity. Assessment of heterogeneity of correlation coefficients

was made within each personality-ability pair, following the procedure of Hedges and Olkin (1985, p. 234-235):

$$Q = \sum_{i=1}^{k}(n_i - 3)(z_{r_i} - \bar{z})^2, \quad (5)$$

where n_i is the sample size from study i, z_{r_i} is the Fisher's z-transformed aggregated correlation from study i, and $\bar{z}$ is the weighted average correlation within the ability-personality cell. The Q statistic is distributed as χ^2 with k – 1 degrees of freedom (where k represents the number of z_{ri}^*). A significant Q statistic suggests that more than one distribution may underlie the sample of correlations (i.e., heterogeneity) and that the investigator may not want to pool the data into a single estimate. Because of its relation to the χ^2 distribution, the Q statistic is sensitive to sample size. Thus, with large enough samples, even small variations among the sample correlations may lead to significant heterogeneity statistics. If samples are large, Hedges and Olkin suggested that it may be acceptable to examine the pooled estimate, even if the Q statistic is significant.

Moderator Analyses. Two moderators were selected a priori for further investigation: date of publication and differences between measures. To assess the change in the relationship between intelligence and extraversion over time a correlation was computed between year of publication of the study and the reported extraversion-intelligence correlation. The year the study was conducted was used for unpublished studies. To assess differences among either personality or ability measures additional ability-personality cells were calculated by measure (i.e., the name of the measure). An additional cell was computed if a single measure was used to compute an ability-personality correlation in at least four independent studies. To obtain at least four studies

for one ability or personality measure, the correlate person variable (i.e., ability or personality) was summed across categories. For example, all observed ability correlations (e.g., SAT [general intelligence], Wechsler Adult Intelligence Scale-Revised Verbal [crystallized intelligence]) involving the NEO-PI were used to compute its meta-analytic cell by measure. Computing the additional ability-personality cells by measure also enabled additional correlational analyses of change over time for those cells.

CHAPTER IV

RESULTS

Meta-analytic results with the measures corrected for attenuation due to unreliability are shown in Table 9 and uncorrected results in Table 10. The tables also include the correlational analysis of the change in the ability-personality correlations over time. Consistent with past research (Ackerman and Heggestad, 1997; Zeidner and Matthews, 2000; Zeidner, 1995), all of the estimated effect sizes were close to zero. Correcting for attenuation due to unreliability of the measures only slightly increased the magnitude of the estimated effect sizes. The table (i.e., Table 9) with the corrected correlations will be referred to throughout the remainder of the paper to allow for a comparison with the Ackerman and Heggestad (1997) meta-analytic results, which were also corrected for attenuation due to unreliability of the measures.

The first hypothesis examined the pattern of estimated ability-personality effect sizes. Based on the results of the Ackerman and Heggestad (1997) meta-analysis, the first part of this hypothesis predicted that the estimated effect sizes for extraversion and intelligence would be positive. In support of the first hypothesis, there was a general slight positive relationship of extraversion across ability categories including extraversion and all ability ($\hat{\rho}_{all\ ability,\ extraversion} = .06$). Eighty-two percent (9 out of the 11) of the estimated effect sizes were positive; 64 percent (7 of the 11) were significantly greater than zero. Similar to the Ackerman and Heggestad (1997) results, there was a general positive relationship across ability-extraversion pairs.

The second aspect of the first hypothesis predicted that social potency and social closeness, as different aspects of extraversion, would demonstrate different patterns of

associations across ability categories. Ackerman and his colleagues (2000; Ackerman et al., 2001) suggested that extraversion may confound the effects of social potency and social closeness. Specifically, it was predicted that social closeness would have a greater association across intelligence categories than social potency. This aspect of the hypothesis was not supported. Social closeness and social potency had an equal number of significant meta-analytic cells. Thirty-six percent (4 of 11) of the ability-personality cells for both social closeness and social potency were significantly different from zero. Although these two aspects of extraversion had an equal number of significant cells, the pattern of associations with ability was different.

Consistent with past research, the estimated effect sizes for social closeness were smaller than the estimated effect sizes for social potency (Ackerman, 2000; Ackerman et al., 2001). Three of the individual ability categories were significantly different between social closeness and social potency (knowledge/achievement, visual perception, and math-numerical; see Table 9). In addition, the estimated effect sizes between social closeness-all ability and social potency-all ability were significantly different ($\hat{\rho}_{all\ ability,\ social\ closeness} = -.01$, $\hat{\rho}_{all\ ability,\ social\ potency} = .04$). When significantly different, the estimated effect sizes for social closeness were smaller than the estimated effect sizes for social potency. Moreover, in just over half of the personality-ability cells, social closeness had a smaller estimated effect size than social potency. Although the second part of the first hypothesis was not fully supported, the validity of measuring these two aspects of extraversion separately was maintained (Ackerman, 2000; Ackerman et al., 2001).

Comparison with Ackerman and Heggestad (1997) Results

Ackerman and Heggestad (1997) observed that extraversion was a popular ability correlate compared to other personality characteristics. In support of this observation, extraversion was a more popular ability correlate than social potency or social closeness. Studies reported a correlation between extraversion and ability about three times more frequently than a correlation between either social potency or social closeness and ability. Furthermore, the number of studies reporting an ability-personality correlation with a higher representation in the 1997 meta-analysis increased more so than less represented pairs in the current study. For example, about 27 additional studies (an average increase of 60%) were located beyond those located in the Ackerman and Heggestad (1997) meta-analysis for the three most studied ability-personality combinations (extraversion crossed with crystallized intelligence, general intelligence, and fluid intelligence). And in the six most under-studied cells, no new studies were located (social potency and social closeness crossed with closure, ideational fluency, and learning and memory).

As stated above, most of the estimated effects sizes were slightly positive similar to the Ackerman and Heggestad (1997) results. A closer comparison with the Ackerman and Heggestad (1997) results reveals that most of the estimated effect sizes from the current study are slightly smaller (compare Table 2 and Table 9). If only the cells with new data are considered, than all but one of the 24 ability-personality cells have slightly decreased. The greatest change from the 1997 meta-analysis was in the knowledge/achievement category across all three personality categories (from $\hat{\rho}_{extraversion} = .05$, $\hat{\rho}_{social\ potency} = .12$, $\hat{\rho}_{social\ closeness} = .02$ to $\hat{\rho}_{extraversion} = -.06$, $\hat{\rho}_{social\ potency} = .03$, $\hat{\rho}_{social\ closeness} = -.10$). The knowledge/achievement-extraversion and

crystallized intelligence-social closeness (from $\hat{\rho} = .06$ to $\hat{\rho} = .00$) cells were significantly different. This lends initial support to the second hypothesis that the relationship between extraversion and intelligence has changed negatively over time.

Change Over Time

A significant Q statistic suggests that the distribution of the sample of correlations may be heterogeneous (Hedges and Olkin, 1985). An examination of the Q statistics indicated that the investigation of moderator variables was warranted. Seventy-five percent (33 out of 44) of the ability-personality cells included a significant Q statistic including all of the extraversion cells. The Q statistic is not informative with respect to what variable may underlie an addition distribution of observed correlations. Two moderator variables were selected a priori for further investigation. (1) Correlational analyses by the year of publication were conducted to evaluate change over time. (2) Additional meta-analytic results were computed to investigate differences between specific measures of ability and personality.

Several studies (Ackerman, 2000; Ackerman & Rolfhus, 1999; Furnham, Forde, & Cotter, 1998; Roberts, 2002; Rolfhus & Ackerman, 1999) since the Ackerman and Heggestad (1997) meta-analysis provided the impetus for the second hypothesis that the relationship between extraversion and intelligence has changed from positive to negative. The pervasive decrease in the estimated effect sizes in the current study compared to the Ackerman and Heggestad (1997) results provides initial support for this hypothesis. In addition, the estimated effect size from more recent studies was significantly negative. If the estimated effect size between extraversion and all ability is computed for studies in the year 2000 and later than the estimated effect size is $\hat{\rho} = -.04$ ($p < .05$).

To more precisely examine the validity of this decreasing trend, correlations were computed between the ability-personality correlations and the year the study was published. The correlational analyses also supported the validity of this decreasing trend. Ninety-three percent (37 of the 40) of the ability-personality cells demonstrated a negative correlation; 43 percent (17 of the 40) were significant. The only three positive correlation coefficients were close to zero ($r_{\text{extraversion, visual perception}} = .05$, $r_{\text{all personality, learning and memory}} = 05$, $r_{\text{social potency, math/numerical}} = .04$). The correlation over time for extraversion-all ability was significantly negative, $r(164) = -.36$, $p < .05$. In addition, the correlations over time for social potency-all ability and social closeness-all ability were also significantly negative, $r(47) = -.31$, $p < .05$, $r(46) = -.34$, $p < .05$, respectively. Thus, the correlational analyses provide general support across ability-personality categories for the decrease in magnitude of the extraversion-intelligence relationship as well as the social closeness-intelligence and social potency-intelligence relationships.

Meta-Analytic Results by Measure

Meta-analytic results computed by specific ability and personality measures corrected for attenuation due to unreliability in the measures and uncorrected results are reported in Table 11 through Table 16. The personality measures are summed across all of the ability measures and the ability measures are summed across both all of the personality measures and all of the extraversion measures. The results of the ability measures summed across all of personality are very similar to the ability measures summed across all the extraversion measures. The similarity reflects the greater representation of extraversion in the all personality cells than social closeness or social potency. The tables with correlations corrected for attenuation due to unreliability of the

measures (i.e., Table 11, Table 12, and Table 13) and the ability measures summed across all of extraversion will be referred to throughout the remainder of the paper.

The ability-extraversion meta-analytic results computed by extraversion measure yielded less heterogeneous samples of correlations than partitioning by ability measure. Thirty-six percent (4 of 11) of the extraversion measures summed across all of ability had significant Q statistics, and 26 percent (5 of 19) of all personality measures summed across all of ability had significant Q statistics. On the other hand, 86 percent (7 of 8) of the ability tests summed across extraversion had significant Q statistics. In other words, these results suggest that differences between extraversion measures, which the ability tests are summed across, are greater than the differences between ability tests.

The pattern of estimated effect sizes is interpretable within the second hypothesis. That is, it was predicted that measures used in the past would evidence a positive relation and more recently used measures would evidence a negative relation. All of the ability tests had slightly positive effect sizes except for the more recently used Wonderlic Personnel Test ($\hat{\rho} = -.05$, 1998 to 2001). The extraversion measures, on the other hand, demonstrated a greater variety of effect sizes with just under half as slightly positive (5 out of 11). Similar to the ability measures, this pattern of estimated effect sizes was interpretable within the second hypothesis. Extraversion measures used in the past tended to evidence positive relations (e.g., 16PF Surgency, $\hat{\rho} = .05$, 1966 to 1998; Junior Eysenck Personality Questionnaire, $\hat{\rho} = .11$, 1968 to 1983), and measures used more recently tended to evidence negative relations (e.g., NEO-FFI, $\hat{\rho} = -.10$, 1997 to 2002). This pattern of estimated effect sizes, however, was not entirely consistent (e.g., Eysenck Personality Inventory, $\hat{\rho} = -.05$, 1979 to 2000). This trend generalized to the social

closeness and social potency measures (see Table 12).

The pervasive negative association between ability-personality correlation and date of publication is less consistent at the measure level. Sixty-three percent (5 of 8) of the ability tests had a negative correlation with date of publication, and 74 percent (14 of 19) of the personality measures had a negative association. Two findings support the inference that the change in the extraversion-intelligence relationship over time is related to between-measure differences rather than within-measure differences. The directions of the estimated effect sizes computed by measure are interpretable within the second hypothesis representing a between-measure difference. The correlational analyses of change over time by measure failed to support change over time within measure.

CHAPTER V

DISCUSSION

The results provide support for both of the study's hypotheses. Similar to the Ackerman and Heggestad (1997) meta-analysis, the extraversion-intelligence relationship was slightly positive, and different patterns of relationships were found for social closeness and social potency. The results also support the validity of the observation that the extraversion-intelligence relationship has changed over time from positive to negative. The first hypothesis was employed to guide aspects of the meta-analysis. For, it was demonstrated that if the extraversion-intelligence relationship is computed with studies conducted in 2000 or later than the estimated effect size is significantly negative. A more updated consideration of the extraversion-intelligence relationship would conclude that the association is slightly negative.

The results demonstrated a different pattern of relationships between social potency and social closeness consistent with past research (Ackerman, 2000; Ackerman et al., 2001). This finding provides additional support for the utility of measuring these two aspects of extraversion separately. Further research will be needed to fully explicate the differences. The results only examined the relationship between these two aspects of extraversion and abilities, and are not informative of how the measures differ or the meaningfulness of the differences. A more effective strategy may be to examine related and unrelated personality correlates and meaningful life outcomes in a multitrait multimethod matrix (Campbell & Fiske, 1959).

The results supported the existence of two moderators of the extraversion-intelligence relationship: date of publication and differences among measures. Two

pieces of evidence support the effect of date of publication on the extraversion-intelligence relationship, which was generalized to the social closeness-intelligence and social potency-intelligence relationships. Almost universally, the estimated effects sizes in the current study were less than the estimated effect sizes in the Ackerman and Heggestad (1997) meta-analysis, and almost universally, the correlations of the extraversion-intelligence association and date of publication for the ability-personality categories were negative. Although, many of the estimated effect sizes computed by measure were not negative, many of these results are interpretable within the second hypothesis based on the range of years. This moderator (i.e., specific ability and personality measure) appears to be related to the trend that the extraversion-intelligence relationship has decreased.

Three mechanisms were discussed as determinants of a correlation between two person characteristics: an overlap in psychological components, environmental fields, and gene blocks. The results of the current study were limited to inferences as to whether the psychological components of the measures have changed, and are not diagnostic of the other two mechanisms. As stated above, the meta-analytic results support changes in the psychological components (i.e., changes in the measures used to assess the extraversion-intelligence relationship). The results suggest focusing on further examining the differences between measures, especially differences between measures of extraversion.

Past research has demonstrated the complicated nature of the relationship between different measures of extraversion and different measures of intelligence (Roberts, 2002; Zeidner & Matthews, 2000; Zeidner, 1995). The findings from the present paper help to clarify the complicated relationship by identifying two moderators: year of publication

and differences between the measures used to assess extraversion and intelligence.

APPENDIX A: TABLES

Table 1

Description of Selected Traits from the Guilford-Zimmerman Temperament Survey

Personality trait	Description
Introversion-Extroversion	
Reflectiveness	"Thoughtfulness or reflectiveness vs. unreflectiveness" (Guilford, 1975, p.806)
Rhathymia	"Restraint and seriousness vs. rhathymia and impulsiveness" (Guilford, 1975, p.806)
Social Activity	
Ascendance	"Ascendance and social boldness vs. submissiveness and timidity" (Guilford, 1975, p.806)
General Activity	"General activity vs. slowness and lacking in energy" (Guilford, 1975, p.806)
Sociability	"Sociability and social interest vs. seclusiveness and shyness" (Guilford, 1975, p.806)

Table 2

Correlations between Personality and Ability

	General Intelligence (G)	Crystallized Intelligence (Gc)	Ideational Fluency	Knowledge/ Achievement	Learning/ Memory	Speed	Visual Perception	Closure	Fluid Intelligence (Gf)	Math-Numerical
Extroversion										
$\hat{\rho}^a$	.08*	.11*	.14*	.05	.05	.06*	.06*	.05	.06*	.09*
No. of r's (N)[b]	35 (15,931)	63 (24,280)	4 (1,707)	7 (1,530)	7 (1,577)	12 (2,713)	16 (4,831)	5 (1,899)	40 (11,395)	27 (13,379)
CI[c]	.06 to .09	.10 to .12	.10 to .19	.00 to .10	.00 to .10	.02 to .10	.03 to .09	.00 to .09	.05 to .08	.07 to .11
Q[d]	115.81†	216.71†	4.95	6.51	14.32	25.06†	22.53	7.73	81.33†	84.55†
Social Potency										
$\hat{\rho}$	.09*	.07*	.04	.12*	.00	-.06	.13*	.07	.02	.08*
No. of r's	16 (1,718)	19 (4,085)	3 (571)	2 (665)	2 (201)	4 (884)	8 (1,240)	2 (201)	13 (2,229)	6 (1,084)
CI	.04 to .13	.04 to .10	-.05 to .12	.04 to .19	-.14 to .14	-.13 to .00	.07 to .18	-.07 to .21	-.02 to .07	.02 to .14
Q	17.37	52.24†	3.01	0.71	0.14	4.75	22.05†	0.00	23.37	13.45
Social Closeness										
$\hat{\rho}$	.04*	.06*	.09*	.02	.08	.05	-.07*	.07*	.04	-.02
No. of r's	18 (2,253)	20 (5,084)	2 (938)	2 (665)	2 (201)	4 (884)	8 (1,240)	4 (1,197)	12 (2,596)	6 (1,084)
CI	.00 to .08	.03 to .08	.03 to .15	-.06 to .09	-.06 to .22	-.01 to .12	-.12 to -.01	.01 to .12	.00 to .07	-.08 to .04
Q	65.90†	99.19†	9.10†	0.14	0.18	6.74	31.57†	4.34	15.78	8.76

Note. r and Q were only tested with $p < .05$ and .01, respectively. From "Intelligence, Personality, and Interests: Evidence for Overlapping Traits," P. L. Ackerman and E. D. Heggestad, 1997, *Psychological Bulletin, 121,* p. 230, 231. Copyright 1997 by the American Psychological Association. Adapted with permission from the author.
[a]Estimated population correlation (*$p < .05$). [b]Number of correlations (N = total aggregate sample size). [c]95% CI of estimated population correlation. [d]Heterogeneity statistic (†$p<.01$).

Table 3

Correlations between Personality and Ability/Domain Knowledge

Knowledge	Extraversion	Extroversion	Social Closeness	Social Potency
Humanities			-.156*	-.134*
American Literature	-.271**	-.186*		
Art	-.079	-.196		
Geography	-.180*	-.234*		
Music	-.210*	-.208*		
World Literature	-.191*	-.213*		
Sciences			-.201**	-.106
Biology	-.325**	-.162		
Business/Management	-.280**	-.041		
Chemistry	-.283**	-.266**		
Economics	-.276**	-.207*		
Physics	-.283**	-.166		
Psychology	-.256**	-.082		
Statistics	-.196*	-.083		
Technology	-.178*	-.249*		
Civics			-.285**	-.026
American Government	-.336**	-.225*		
American History	-.275**	-.178		
Law	-.265**	-.138	-.164*[a]	-.067[a]
Western Civilization	-.218*	-.148		
Mechanical				
Astronomy	-.282**	-.250*		
Electronics	-.170*	-.068		
Tools/Shop	-.167*	-.165		
General Knowledge			-.266**	-.110
gf			-.075	-.106
gc			-.188**	-.138*
Age			-.127	-.071
Education			.009	.094

Note: The data in column 2 are from "Assessing Individual Differences in Knowledge: Knowledge, Intelligence, and Related Traits," by E. L. Rolfhus and P. L. Ackerman, 1999, *Journal of Educational Psychology*, 91, p. 521. Copyright 1999 by the American Psychological Association. Adapted with permission of the author. The data in column 3 are from "The Locus of Adult Intelligence: Knowledge, Abilities, and Nonability Traits," by P. L. Ackerman and E. L. Rolfhus, 1999, *Psychology and Aging*, 14, p. 327. Copyright 1999 by the American Psychological Association. Adapted with permission of the author. The data in columns 3 and 4 are from "Domain-Specific Knowledge as the 'Dark Matter' of Adult Intelligence: Gf/Gc, Personality and Interest Correlates," by P. L. Ackerman, 2000, *Journal of Gerontology, 55B,* p. 80. Copyright by The Gerontological Society of America. Adapted with permission of the author.

[a]Business/Law

*$p < .05$. **$p < .01$.

Table 4

Description of Extraversion Scales and Lower Order Factors

Personality scales	Description
16PF Questionnaire	
Extraversion[a]	Is social, outgoing, and unreserved; good at making and maintaining relationships (IPAT Staff, 1986).
Factor F (Surgency)	Is cheerful, positive, open, energetic, gregarious, easy going, and expressive (IPAT Staff, 1986).
CPI[b]	
Social Presence	Is self-confident and composed; spontaneous; good conversationalist (Gough, 1987).
EPI, EPQ, JEPI, JEPQ, MPI, PEN[c]	
Extraversion	Is social; enjoys parties and needs to talk to others; avoids solitary tasks with little stimulation; acts impulsively and spontaneously; generally cheerful, carefree, and positive; may behave aggressively with a quick temper, not always reliable (Eysenck & Eysenck, 1975).
HPI[d]	
Sociable	". . . measures the degree to which a person seems to need and/or enjoy interacting with others" (Hogan & Hogan, 1992, p. 12).
MBTI[e]	
Introversion/ extraversion	The extrovert is characterized as having an outward orientation, with thoughts, feelings, and behavior largely determined by and consistent with objective conditions" (Girelli and Stake, 1993, p. 290).
NEO-FFI, NEO-PI, NEO-PI-R[f]	
Extraversion	Is sociable, gregarious, and assertive; enjoys the company of others; likes excitement and activity; generally warm, happy, and optimistic (Costa Jr. & MaCrae, 1992).
E1: Warmth[g]	"Warm people are affectionate and friendly. They genuinely like people and easily form close attachments to others" (Costa Jr. & MaCrae, 1992, p. 17).
E2: Gregariousness[g]	Prefers to be in the company of others (Costa Jr. & MaCrae, 1992).
E3: Assertiveness[g]	Is dominant, forceful, and often takes leadership roles in groups (Costa Jr. & MaCrae, 1992).
E4: Activity[g]	Keeps a busy schedule with a fast-paced life (Costa Jr. & MaCrae, 1992).
E5: Excitement-seeking[g]	Crave excitement, stimulation, and noisy environments (Costa Jr. & MaCrae, 1992).
E6: Positive Emotions[g]	Often experiences joy, happiness, love, and excitement; frequently laughs; often is cheerful and optimistic (Costa Jr. & MaCrae, 1992).

[a]Extraversion is a second order factor made up of a linear combination of Factor A, Factor F, Factor H, and Factor Q_2.
[b]CPI = California Personality Inventory.
[c]EPI = Eysenck Personality Inventory, EPQ = Eysenck Personality Questionnaire, JEPI = Junior Eysenck Personality Inventory, JEPQ = Junior Eysenck Personality Questionnaire, MPI = Maudsley Personality Inventory, PEN = Psychoticism-Extraversion-Neuroticism.
[d]HPI = Hogan Personality Inventory.
[e]MBTI = Myers-Briggs Type Indicator.
[f]NEO-FFI = NEO Five Factor Inventory, NEO-PI = NEO Personality Inventory, NEO-PI-R = NEO Personality Inventory Revised.
[g]Facet scales of the NEO-PI-R.

Table 5

Description of Social Potency Scales and Lower Order Factors

Personality scales	Description
16PF Questionnaire	
Factor E (Dominance)	Is forceful, forward, obstinate, competitive, and domineering (IPAT Staff, 1986).
Factor Q_2 (Self-sufficiency)	Is independent, prefers to use own resources, and avoids asking others for help (IPAT Staff, 1986).
CPI	
Dominance	Is self-assured, aggressive, forward, and task-oriented (Gough, 1987).
HPI	
Ambition	". . . measures the degree to which a person seems socially self-confident, leader like, competitive, and energetic" (Hogan & Hogan, 1992, p. 12).
MPQ[a]	
Social Potency	"Is forceful and decisive; is persuasive and likes to influence others; enjoys or would enjoy leadership roles; enjoys being noticed, being the center of attention" (Tellegen and Waller, in press, p. 59).
Personality Research Form	
Dominance	"Attempts to control his environment, and to influence or direct other people; expresses opinions forcefully, enjoys the role of leader and may assume it spontaneously" (Jackson, 1974, p. 6).

[a]MPQ = Multidimensional Personality Inventory.

Table 6

Description of Social Closeness Scales and Lower Order Factors

Personality scales	Description
16PF Questionnaire	
Factor A (Warmth)	Is good natured, carefree, affectionate, sensitive to others, and tender (IPAT Staff, 1986).
CPI	
Sociability	Is social and cordial; enjoys the company of others (Gough, 1987).
MPQ	
Social Closeness	"Is sociable, likes to be with people; takes pleasure in and values close interpersonal ties; is warm and affectionate; turns to others for comfort and help" (Tellegen and Waller, in press, p. 59).
Personality Research Form	
Affiliation	"Enjoys being with friends and people in general; accepts people readily; makes efforts to win friendships and maintain associations with people" (Jackson, 1974, p. 6).

Table 7

Correlations between Personality and Ability/Domain Knowledge

Knowledge	Extroversion	Social Closeness	Social Potency
Humanities	-.168**	-.192**	-.086
Physical Sciences	-.259**	-.256**	-.182**
Civics	-.157**	-.214**	-.019
Biology/Psychology	-.199**	-.113*	-.209**
General Knowledge	-.237**	-.250**	-.120
Gf	-.127*	-.088	-.118*
Gc	-.162**	-.181**	-.061
g	-.163**	-.152**	-.101

Note: "Determinants of Individual Differences and Gender Differences in Knowledge," by P. L. Ackerman, K. R. Bowen, M. E. Beier, and R. Kanfer, 2001, *Journal of Educational Psychology*, 93, p. 809. Copyright 2001 by the American Psychological Association. Adapted with permission of the author.

*$p < .05$. **$p < .01$.

Table 8

Ability and Personality Search Terms

Ability	Personality	
Abilities	16PF	Meyers-Briggs
ACT	Affiliative	Minnesota Multiphasic Personality Inventory
American College Test	California Psychological Inventory	MMPI
DAT	Constructive Thinking Inventory	MPQ[a]
ETS	CPI	Multidimensional Personality Questionnaire[a]
Intelligence	CTI	Myers-Briggs
IQ	Differential Personality Questionnaire[a]	NEO
Math	Dominance[b]	NEO-FFI
Numerical	DPQ[a]	NEO-PI
OTIS	EPQ	NEO-PI(R)
Performance	Extraversion	Personality Research Form
Raven	Extroversion	Potency
SAT	Eysenck Personality Questionnaire	PRF
Spatial	High School Personality Questionnaire	Self-Sufficiency
Stanford-Binet	Hogan Personality Inventory	Sixteen Personality Factor Questionnaire
Verbal	Hogan	Sociability
WAIS	Hogen	Social Closeness[a]
Wechsler	HPI	Submissiveness
	HSPQ	Surgency
	Introversion	
	Junior Eysenck	
	Maudsley	
	MBTI	

[a]New search terms.

[b]To eliminate publications irrelevant to the present meta-analysis the following terms "not brain" and "not hemisphere" were included with the dominance search term.

Table 9

Correlations between Extraversion and Ability: Corrected for Attenuation

	General Intelligence (G)	Crystallized Intelligence (Gc)	Ideational Fluency	Knowledge/ Achievement	Learning/ Memory	Speed	Visual Perception	Closure	Fluid Intelligence (Gf)	Math-Numerical	All Ability
Extraversion											
$\hat{\rho}$[a]	.05*	.08*	.10*	-.06*	.04	.05*	.00	.02	.05*	.07*	.06*
No. of r's	63	94	8	20	15	23	26	10	63	44	149
(N)[b]	(23,053)	(31,153)	(2,358)	(4,400)	(2,815)	(3,930)	(4,277)	(2,753)	(15,465)	(16,066)	(51,582)
CI[c]	.04 to .06	.07 to .10	.06 to .14	-.09 to -.03	.00 to .08	.02 to .08	-.03 to .03	-.02 to .05	.04 to .07	.05 to .08	.05 to.07
Q[d]	245.26†	358.74†	25.73†	73.31†	42.30†	42.31†	64.62†	21.27†	163.59†	189.04†	495.73†
r[e]	-.21	-.27*	-.43	-.60*	-.19	-.37	.05	-.59	-.16	-.15	-.32*
Social Potency											
$\hat{\rho}$	.05*	.01	.04	.03	.00	-.04	.12*	.07	-.02	.09*	.04*
No. of r's	26	31	3	6	2	7	10	2	18	11	49
(N)	(4,773)	(6,707)	(571)	(1,725)	(201)	(1,353)	(1,660)	(201)	(3,226)	(1,807)	(10,157)
CI	.03 to .08	-.01 to .04	-.04 to .12	-.02 to .07	-.14 to .14	-.09 to .02	.07 to .17	-.07 to .21	-.05 to .02	.05 to .14	.02 to .06
Q	35.56	75.61†	3.25	21.32†	0.16	8.84	23.09†	0.00	34.59†	19.59†	92.39†
r	-.16	-.49*	-.95	-.84*	--	-.41	-.09	--	-.55*	.04	-.31*
Social Closeness											
$\hat{\rho}$	.00	.00	.09*	-.10*	.08	.02	-.09*	.07*	.00	-.03	-.01
No. of r's	27	30	2	5	2	6	10	4	17	9	48
(N)	(4,271)	(7,321)	(938)	(1,366)	(201)	(1,304)	(1,660)	(1,197)	(3,593)	(1,603)	(9,930)
CI	-.03 to .03	-.03 to .02	.03 to .15	-.15 to -.05	-.06 to .22	-.04 to .07	-.14 to -.04	.01 to .12	-.04 to .03	-.08 to .02	-.03 to .01
Q	95.30†	145.11†	9.10†	19.52†	0.16	10.73	34.79†	4.34	34.66†	16.25†	126.76†
r	-.26	-.58*	--	-.86	--	-.91*	-.63	-.66	-.64*	-.21	-.34*
All Extraversion											
$\hat{\rho}$	.05*	.08*	.09*	-.06*	.04	.04*	.00	.02	.05*	.07*	.06*
No. of r's	70	103	10	21	16	27	28	11	70	49	166
(N)	(24,688)	(33,844)	(2,791)	(4,628)	(2,878)	(4,422)	(4,597)	(2,816)	(16,617)	(16,880)	(56,016)
CI	.04 to .06	.07 to .09	.05 to .12	-.08 to -.03	.00 to .08	.01 to .07	-.03 to .03	-.02 to .05	.03 to .06	.05 to .08	.05 to .07
Q	259.22†	414.03†	23.58†	76.68†	41.10†	41.25†	66.67†	16.92	176.81†	194.53†	532.14†
r	-.32*	-.32*	-.33	-.65*	.05	-.51*	-.02	-.74*	-.18	-.10	-.36*

Note. r and Q were only tested with $p < .05$.
[a]Estimated population correlation (*$p < .05$). [b]Number of correlations (N = total aggregate sample size). [c]95% CI of estimated population correlation. [d]Heterogeneity statistic (†$p < .05$). [e]Correlation between ability-personality correlation corrected for unreliability and date of publication (*$p < .05$).

Table 10

Correlations between Extraversion and Ability: Uncorrected

	General Intelligence (G)	Crystallized Intelligence (Gc)	Ideational Fluency	Knowledge/ Achievement	Learning/ Memory	Speed	Visual Perception	Closure	Fluid Intelligence (Gf)	Math-Numerical	All Ability
Extraversion											
$\hat{\rho}$ [a]	.04*	.07*	.08*	-.05*	.03	.04*	.00	.01	.04*	.06*	.05*
No. of r's	63	94	8	20	15	23	26	10	63	44	149
(N)[b]	(23,053)	(31,153)	(2,358)	(4,400)	(2,815)	(3,930)	(4,277)	(2,753)	(15,465)	(16,066)	(51,582)
CI[c]	.03 to .06	.06 to .08	.04 to .12	-.08 to -.02	-.01 to .07	.01 to .07	-.03 to .03	-.03 to .05	.03 to .06	.04 to .08	.04 to.06
r[d]	-.21	-.26*	-.43	-.61*	-.22	-.37	.06	-.59	-.17	-.14	-.32*
Social Potency											
$\hat{\rho}$	.05*	.01	.02	.02	.00	-.03	.11*	.06	-.02	.08*	.03*
No. of r's	26	31	3	6	2	7	10	2	18	11	49
(N)	(4,773)	(6,707)	(571)	(1,725)	(201)	(1,353)	(1,660)	(201)	(3,226)	(1,807)	(10,157)
CI	.02 to .08	-.01 to .03	-.06 to .10	-.03 to .07	-.14 to .14	-.08 to .02	.06 to .15	-.08 to .19	-.05 to .02	.03 to .12	.01 to .05
r	-.16	-.49*	-.95	-.84*	--	-.40	-.08	--	-.55*	.04	-.30*
Social Closeness											
$\hat{\rho}$	.00	-.01	.07*	-.09*	.07	.01	-.08*	.05	.00	-.03	-.01
No. of r's	27	30	2	5	2	6	10	4	17	9	48
(N)	(4,271)	(7,321)	(938)	(1,366)	(201)	(1,304)	(1,660)	(1,197)	(3,593)	(1,603)	(9,930)
CI	-.03 to .03	-.03 to .02	.01 to .13	-.14 to -.03	-.07 to .20	-.04 to .07	-.13 to -.03	.00 to .11	-.04 to .03	-.08 to .02	-.03 to .01
r	-.27	-.59*	--	-.87	--	-.91*	-.62	-.66	-.65*	-.21	-.36*
All Extraversion											
$\hat{\rho}$	.04*	.07*	.06*	-.05*	.03	.03	.00	.01	.04*	.06*	.05*
No. of r's	70	103	10	21	16	27	28	11	70	49	166
(N)	(24,688)	(33,844)	(2,791)	(4,628)	(2,878)	(4,422)	(4,597)	(2,816)	(16,617)	(16,880)	(56,016)
CI	.03 to .06	.05 to .08	.03 to .10	-.08 to -.02	-.01 to .06	.00 to .06	-.03 to .03	-.03 to .05	.03 to .06	.04 to .07	.04 to .06
r	-.31*	-.32*	-.29	-.65*	.00	-.50*	-.02	-.72*	-.19	-.09	-.35*

Note. r and Q were only tested with $p < .05$.
[a]Estimated population correlation (*$p < .05$). [b]Number of correlations (N = total aggregate sample size). [c]95% CI of estimated population correlation. [d]Correlation between ability-personality correlation and date of publication (*$p < .05$).

Table 11

Correlations between Extraversion Measures and Ability: Corrected for Attenuation

	Extraversion					
	16PF Extraversion	16PF Surgency	EPI Extraversion	EPQ Extraversion	HSPQ Surgency	JEPI Extraversion
$\hat{\rho}$[a]	-.01	.05*	-.05	-.08	.02	.09*
No. of r's	10	14	11	6	5	20
(N)[b]	(1,357)	(2,348)	(2,019)	(486)	(1,033)	(8,191)
CI[c]	-.07 to .04	.01 to .10	-.09 to .00	-.17 to .01	-.04 to .08	.07 to .12
Q[d]	12.92	14.64	17.06	1.00	3.61	38.32†
r[e]	-.42	.38	-.10	.15	.45	-.14
Date Range	1966 to 2000	1966 to 1998	1979 to 2000	1985 to 2001	1963 to 1978	1968 to 1997
	JEPQ Extraversion	MBTI Extraversion	NEO-FFI Extraversion	NEO-PI Extraversion	NEO-PI-R Extraversion	
$\hat{\rho}$	.11*	.11*	-.10*	-.08*	.00	
No. of r's	5	29	8	9	10	
(N)	(1,992)	(19,874)	(1,654)	(2,122)	(2,498)	
CI	.07 to .15	.09 to .12	-.14 to -.05	-.12 to -.03	-.04 to .04	
Q	25.54†	86.76†	27.20†	1.89	8.27	
r	-.53	-.56*	.32	-.10	-.30	
Date Range	1968 to 1983	1978 to 2003	1997 to 2002	1992 to 2001	1995 to 2003	

Note. *r* and *Q* were only tested with $p < .05$.
[a]Estimated population correlation (*$p < .05$). [b]Number of correlations (N = total aggregate sample size). [c]95% CI of estimated population correlation. [d]Heterogeneity statistic (†$p < .05$). [e]Correlation between ability-personality correlation corrected for unreliability and date of publication (*$p < .05$).

Table 12

Correlations between Social Potency and Social Closeness Measures and Ability: Corrected for Attenuation

	Social Potency				
	16PF Dominance	16PF Self-Sufficiency	HSPQ Dominance	HSPQ Self-Sufficiency	MPQ Social Potency
$\hat{\rho}^a$	.10*	.08*	-.04	.14*	-.05
No. of r's	12	13	5	5	7
(N)[b]	(2,113)	(2,257)	(1,033)	(1,033)	(1,488)
CI[c]	.06 to .14	.04 to .12	-.10 to .02	.08 to .20	-.11 to .00
Q[d]	11.87	5.07	8.95	14.64†	11.07
r[e]	-.26	-.03	.61	-.82	-.64
Date Range	1969 to 1988	1966 to 1988	1963 to 1978	1963 to 1978	1995 to 2001

	Social Closeness		
	16PF Warmth	HSPQ Warmth	MPQ Social Closeness
$\hat{\rho}$	-.06*	.08*	-.14*
No. of r's	14	5	7
(N)	(2,757)	(1,033)	(1,488)
CI	-.10 to -.02	.02 to .14	-.19 to -.09
Q	20.88	7.43	6.25
r	-.04	-.31	-.52
Date Range	1966 to 1997	1963 to 1978	1995 to 2001

Note. r and Q were only tested with $p < .05$.
[a]Estimated population correlation (*$p < .05$). [b]Number of correlations (N = total aggregate sample size). [c]95% CI of estimated population correlation. [d]Heterogeneity statistic (†$p < .05$). [e]Correlation between ability-personality correlation corrected for unreliability and date of publication (*$p < .05$).

Table 13

Correlations between Ability Measures and Extraversion: Corrected for Attenuation

All Extraversion[a]

	16PF Intelligence	Mill Hill Vocabulary	Raven Progressive Matrices Test	Raven Standard Progressive Matrices
$\hat{\rho}$[b]	.06*	.05*	.09*	.09*
No. of r's	7	7	8	18
(N)[c]	(2,187)	(3,351)	(2,499)	(3,747)
CI[d]	.02 to .10	.01 to .08	.05 to .13	.05 to .12
Q[e]	7.49	18.79†	17.51†	30.60†
r[f]	-.49	-.04	.82*	-.20
Date Range	1966 to 1988	1961 to 2000	1961 to 2000	1968 to 2001

	SAT Math	SAT Verbal	WAIS[g]	Wonderlic Personnel Test
$\hat{\rho}$	.09*	.16*	.05	-.01
No. of r's	17	17	10	5
(N)	(10,440)	(10,440)	(1,340)	(1,446)
CI	.07 to .11	.14 to .18	.00 to .10	-.06 to .04
Q	42.29†	51.88†	7.47	24.11†
r	-.20	-.59*	-.10	.43
Date Range	1985 to 1988	1985 to 1988	1976 to 1987	1998 to 2001

Extraversion

	16PF Intelligence	Mill Hill Vocabulary	Raven Progressive Matrices Test	Raven Standard Progressive Matrices
$\hat{\rho}$	.05*	.05*	.09*	.09*
No. of r's	7	7	8	17
(N)	(2,187)	(3,351)	(2,499)	(3,647)
CI	.01 to .09	.01 to .08	.05 to .13	.05 to .12
Q	13.21†	18.75†	17.42†	33.66†
r	-.15	-.04	.86*	-.20
Date Range	1966 to 1988	1961 to 2000	1961 to 2000	1968 to 2001

	SAT Math	SAT Verbal	WAIS	Wonderlic Personnel Test
$\hat{\rho}$	.09*	.16*	.06	-.05
No. of r's	17	17	10	4
(N)	(10,440)	(10,440)	(1,340)	(1,144)
CI	.08 to .11	.14 to .18	.00 to .11	-.11 to .01
Q	42.23†	50.02†	10.97	15.01†
r	-.13	-.53*	.18	.40
Date Range	1985 to 1988	1985 to 1988	1976 to 1987	1998 to 2001

Note. r and Q were only tested with $p < .05$.

[a]Includes measures classified as extraversion, social potency, and social closeness. [b]Estimated population correlation (*$p < .05$). [c]Number of correlations (N = total aggregate sample size). [d]95% CI of estimated population correlation. [e]Heterogeneity statistic (†$p < .05$). [f]Correlation between ability-personality correlation corrected for unreliability and date of publication (*$p < .05$). [g]WAIS = Wechsler Adult Intelligence Scale.

Table 14

Correlations between Extraversion Measures and Ability: Uncorrected

	Extraversion					
	16PF Extraversion	16PF Surgency	EPI Extraversion	EPQ Extraversion	HSPQ Surgency	JEPI Extraversion
$\hat{\rho}$[a]	-.01	.04	-.04	-.07	.02	.08*
No. of r's	10	14	11	6	5	20
(N)[b]	(1,357)	(2,348)	(2,019)	(486)	(1,033)	(8,191)
CI[c]	-.07 to .04	.00 to .09	-.09 to .00	-.16 to .02	-.04 to .08	.06 to .10
r[d]	-.44	.38	-.10	.12	.45	-.15
Date Range	1966 to 2000	1966 to 1998	1979 to 2000	1985 to 2001	1963 to 1978	1968 to 1997
	JEPQ Extraversion	MBTI Extraversion	NEO-FFI Extraversion	NEO-PI Extraversion	NEO-PI-R Extraversion	
$\hat{\rho}$	.09*	.09*	-.08*	-.07*	.00	
No. of r's	5	29	8	9	10	
(N)	(1,992)	(19,874)	(1,654)	(2,122)	(2,498)	
CI	.05 to .14	.08 to .11	-.13 to -.03	-.11 to -.03	-.04 to .04	
r	-.52	-.58*	.31	-.11	-.30	
Date Range	1968 to 1983	1978 to 2003	1997 to 2002	1992 to 2001	1995 to 2003	

Note. r and Q were only tested with $p < .05$.

[a]Estimated population correlation (*$p < .05$). [b]Number of correlations (N = total aggregate sample size). [c]95% CI of estimated population correlation. [d]Correlation between ability-personality correlation and date of publication (*$p < .05$).

Table 15

Correlations between Social Potency and Social Closeness Measures and Ability: Uncorrected

	Social Potency				
	16PF Dominance	16PF Self-Sufficiency	HSPQ Dominance	HSPQ Self-Sufficiency	MPQ Social Potency
$\hat{\rho}^a$	.08*	.06*	-.04	.12*	-.05
No. of r's	12	13	5	5	7
(N)[b]	(2,113)	(2,257)	(1,033)	(1,033)	(1,488)
CI[c]	.04 to .12	.02 to .11	-.10 to .03	.06 to .18	-.10 to .00
r[d]	-.31	-.04	.63	-.82	-.64
Date Range	1969 to 1988	1966 to 1988	1963 to 1978	1963 to 1978	1995 to 2001

	Social Closeness		
	16PF Warmth	HSPQ Warmth	MPQ Social Closeness
$\hat{\rho}$	-.05*	.07*	-.13*
No. of r's	14	5	7
(N)	(2,757)	(1,033)	(1,488)
CI	-.09 to -.01	.01 to .13	-.18 to -.08
r	-.04	-.37	-.54
Date Range	1966 to 1997	1963 to 1978	1995 to 2001

Note. r and Q were only tested with $p < .05$.
[a]Estimated population correlation (*$p < .05$). [b]Number of correlations (N = total aggregate sample size). [c]95% CI of estimated population correlation. [d]Correlation between ability-personality correlation and date of publication (*$p < .05$).

Table 16

Correlations between Ability Measures and Extraversion: Uncorrected

All Extraversion[a]

	16PF Intelligence	Mill Hill Vocabulary	Raven Progressive Matrices Test	Raven Standard Progressive Matrices
$\hat{\rho}$[b]	.04	.04*	.08*	.07*
No. of r's	7	7	8	18
(N)[c]	(2,187)	(3,351)	(2,499)	(3,747)
CI[d]	.00 to .09	.01 to .07	.04 to .11	.04 to .10
r[e]	-.50	-.08	.83*	-.21
Date Range	1966 to 1988	1961 to 2000	1961 to 2000	1968 to 2001

	SAT Math	SAT Verbal	WAIS	Wonderlic Personnel Test
$\hat{\rho}$	.08*	.14*	.05	-.01
No. of r's	17	17	10	5
(N)	(10,440)	(10,440)	(1,340)	(1,446)
CI	.06 to .10	.12 to .16	-.01 to .10	-.06 to .04
r	-.18	-.58*	-.15	.41
Date Range	1985 to 1988	1985 to 1988	1976 to 1987	1998 to 2001

Extraversion

	16PF Intelligence	Mill Hill Vocabulary	Raven Progressive Matrices Test	Raven Standard Progressive Matrices
$\hat{\rho}$	.04	.04*	.07*	.07*
No. of r's	7	7	8	17
(N)	(2,187)	(3,351)	(2,499)	(3,647)
CI	.00 to .08	.01 to .07	.03 to .11	.04 to .10
r	-.14	-.08	.86*	-.21
Date Range	1966 to 1988	1961 to 2000	1961 to 2000	1968 to 2001

	SAT Math	SAT Verbal	WAIS	Wonderlic Personnel Test
$\hat{\rho}$	.08*	.14*	.05	-.05
No. of r's	17	17	10	4
(N)	(10,440)	(10,440)	(1,340)	(1,144)
CI	.06 to .10	.12 to .16	.00 to .11	-.10 to .01
r	-.14	-.53*	.12	.38
Date Range	1985 to 1988	1985 to 1988	1976 to 1987	1998 to 2001

Note. r and Q were only tested with $p < .05$.

[a]Includes measures classified as extraversion, social potency, and social closeness. [b]Estimated population correlation (*$p < .05$). [c]Number of correlations (N = total aggregate sample size). [d]95% CI of estimated population correlation. [e]Correlation between ability-personality correlation and date of publication (*p < .05).

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