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Investment and Intellect: A Review and Meta-Analysis

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Cognitive or intellectual investment theories propose that the development of intelligence is partially influenced by personality traits, in particular by so-called investment traits that determine when, where, and how people invest their time and effort in their intellect. This investment, in turn, is thought to contribute to individual differences in cognitive growth and the accumulation of knowledge across the life span. We reviewed the psychological literature and identified 34 trait constructs and corresponding scales that refer to intellectual investment. The dispositional constructs were further classified into 8 related trait categories that span the construct space of intellectual investment. Subsequently, we sought to estimate the association between the identified investment traits and indicators of adult intellect, including measures of crystallized intelligence, academic performance (e.g., grade point average), college entry tests, and acquired knowledge. A meta-analysis of 112 studies with 236 coefficients and an overall sample of 60,097 participants indicated that investment traits were mostly positively associated with adult intellect markers. Meta-analytic coefficients ranged considerably, from 0 to .58, with an average estimate of .30. We concluded that investment traits are overall positively related to adult intellect; the strength of investment–intellect associations differs across trait scales and markers of intellect; and investment traits have a diverse, multifaceted nature. The meta-analysis also identified areas of inquiry that are currently lacking in empirical research. Limitations, implications, and future directions are discussed.

Keywords: intellect, intelligence, investment, personality, cognitive development

The primary question this article addresses is the extent to which personality traits, and specifically so-called intellectual investment traits, are associated with intelligence in adulthood. The article is organized in four sections. In the first section, we describe the investment theory as a framework for understanding intelligence–personality associations. In the second section, we review existing investment trait constructs and scales from the psychological literature. In the third section, we use a meta-analysis procedure to estimate the associations between investment traits and markers of adult intelligence. In the fourth and final section, we summarize major conclusions and limitations of the current research, and we offer suggestions for future investigations.

Theoretical Framework

Intelligence–Personality Associations

Intelligence and personality traits have several characteristics in common. For example, they both refer to cognitive, affective, and behavioral differences that are quantifiable through standardized psychometric instruments (e.g., Funder, 2001); both are genetically influenced, albeit to different degrees (e.g., Plomin, DeFries, McClearn, & McGuffin, 2008); both show relative temporal stability and are thought to manifest as stable patterns of behavior across the life span (e.g., Caspi, 2000; Deary, Whalley, Lemmon, Crawford, & Starr, 2000); and finally, both are associated with individual differences in a wide range of outcomes, including educational and occupational performance, health, and longevity (e.g., Calvin, Batty, & Deary, 2011; Judge, Higgins, Thoresen, & Barrick, 1999; Poropat, 2009).

Notwithstanding these similarities, intelligence and personality constructs also differ—notably in their assessment. Intelligence tests are designed to assess maximal performance, or what a person can do, whereas personality measures capture general tendencies of behavior, or what a person typically does (Cronbach, 1949; Fiske & Butler, 1963; Wallace, 1966). In line with this disparity, psychometric assessment tools for intelligence and personality differ in their design, administration, and test completion instructions: For intelligence tests, examinees are instructed to do their best, but personality measures ask for candid, truthful responses (Zeidner & Matthews, 2000). That is, they have no "correct" answers, but individuals are to respond as they typically act or feel. Furthermore, intelligence is unidirectional and ranges from "little of" to "much of"; by contrast, most personality traits are thought to be bidirectional, with opposing poles of extreme dispositions (Zeidner & Matthews, 2000). Also, intelligence and personality measures are traditionally validated with different sets of criteria, even though both constructs are associated with most outcome variables, such as health, longevity, and occupational and academic attainment (Judge et al., 1999; Roberts, Kuncel, Shiner,

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Caspi, & Goldberg, 2007; von Stumm, Hell, & Chamorro-Premuzic, 2011; Weiss, Gale, Batty, & Deary, 2009). Nonetheless, personality measures are often employed to predict clinical, interpersonal, and intrapersonal outcomes, whereas intelligence tests are typically used to forecast achievement outcomes, such as academic and occupational performance (but see Wechsler, 1958, for an alternative approach). Finally, it has been suggested that the distinction between intelligence and personality is not merely historical convention or a methodological matter but reflects different kinds of evolutionary selection pressures that have shaped both character dimensions (Penke, Denissen, & Miller, 2007).

This (admittedly nonexhaustive) list of similarities and differences between intelligence and personality has led researchers to adopt one of three theoretical perspectives on intelligence–personality associations (von Stumm, Chamorro-Premuzic, & Ackerman, 2011). The first approach assumes conceptual and empirical independence of both constructs and, hence, recommends studying intelligence and personality with distinctive methods, in separate contexts, and following different research agendas. The second perspective suggests that personality traits influence performance on intelligence tests, emphasizing an association at the measurement level (e.g., a perfectionist's trade-off between accuracy and speed; Slade, Newton, Butler, & Murphy, 1991). Finally, the third perspective postulates a relationship at the conceptual level. Here, personality traits are thought to guide how, when, and where individuals apply and invest their intelligence, thereby shaping their cognitive development across the life span. It is this third approach that informs the theoretical rationale of the current study.

Investment Theory

On the basis of his extensive review of the "general muddle" (p. 161) that characterized—and continues to characterize—definitions of intelligence, and on the observation of age-related performance changes in specific cognitive ability tests (e.g., Jones & Conrad, 1933; see also Salthouse, 1991), Cattell (1943) concluded that "adult mental capacity is of two kinds" (p. 178): Fluid intelligence, or the general ability to discriminate, comprehend, and reason, increases until adolescence and declines thereafter, whereas crystallized intelligence "consists of discriminatory habits long established in a particular field, originally through the operation of fluid ability, but no longer requiring insightful perception for their successful operation" (Cattell, 1943, p. 178). Accordingly, Cattell proposed that fluid intelligence transforms into crystallized intelligence over time. In a more explicit vein, Hayes (1962) suggested that intelligence equaled the totality of knowledge that was accumulated through the application of experience-producing drives: "Manifest intelligence is nothing more than an accumulation of learned facts and skills; and . . . innate intellectual potential consists of tendencies to engage in activities conducive to learning, rather than inherited intellectual capacities, as such" (p. 337). In Hayes's perspective, individual differences in intelligence resulted from genetic variations in the drive to learn, which in turn led to differential experiences. Building on Cattell's and Hayes's ideas, Ackerman (1996) introduced the model of intelligence-as-process, personality, interests, and intelligence-as-knowledge (PPIK), suggesting a causal linkage from intelligence-as-process to intelligence-as-knowledge. Intelligence-as-knowledge is thought to form the core of adult intellect and comprises the "dark matter" of adult intelligence (Ackerman, 2000). The PPIK framework emphasizes that the transition from process to knowledge is influenced by personality traits and interests (Ackerman, 1996), in particular by so-called intellectual investment traits (Ackerman & Heggestad, 1997; Ackerman & Rolfhus, 1999; Goff & Ackerman, 1992; for interest associations, see Ackerman, 1996). Intellectual investment traits are defined as "stable individual differences in the tendency to seek out, engage in, enjoy, and continuously pursue opportunities for effortful cognitive activity" (von Stumm, Chamorro-Premuzic, & Ackerman, 2011, p. 225). Accordingly, investment traits are likely to explain interindividual differences in the pursuit of learning opportunities, such as visiting museums and galleries, solving riddles and puzzles, and reading newspapers (cf. von Stumm, 2012). Alternatively, investment traits may help people to construct experiences—exotic or mundane—in a cognitively stimulating manner prompting mental development and growth (Kashdan, Rose, & Fincham, 2004; Stine-Morrow, 2007). Thus, whereas investment traits are recognized to refer to relatively stable individual differences in the propensity to seize learning opportunities, directly observable investment behaviors (e.g., going to the theatre) are not clearly defined.[1]

Hayes's experience-producing drives and Ackerman's investment traits evidently refer to the same thing: a general learning orientation, or, more colloquially, the hunger for knowledge. However, Hayes viewed learning orientation as the only source of individual differences in intelligence, whereas Ackerman's theory has room for reciprocal effects of intelligence-as-process, investment traits, and interests to explain differences in intelligence-as-knowledge. Notwithstanding these theories, the causal order of variables might be reversed in two ways. In the first way, it is plausible that higher levels of intelligence enable people to pursue learning experiences, and thus, level of ability precedes the development of investment traits (see, e.g., Holland, 1959, regarding the interactive developments of personality, interests, and intellectual competence). Here an association between investment traits and adulthood intelligence may be fully explained by general intelligence (e.g., Gow, Whiteman, Pattie, & Deary, 2005). In the second way, greater knowledge may prompt learning engagement because it produces hunger for even more knowledge to fill information gaps or reduce uncertainty (e.g., Kang et al., 2009). It seems most plausible to us that intelligence and investment traits develop interactively and share reciprocal influences that ultimately affect adult intellectual development. Although investment theories unanimously advocate that intelligence or "the capacity for knowledge" is an ongoing process that transforms into adult intellect or "knowledge possessed" (Henmon, 1921, p. 195), the underlying mechanisms of this transformation are unknown. Most longitudinal studies on the development of adult intelligence—such as Bayley's (1928, as cited in Eichorn, 1973) Berkeley Growth Study, Schaie's (2005) Seattle Longitudinal Study, and Terman's (1921, as cited in Terman & Oden, 1959) study of gifted children—focused on age-related changes in cognitive ability. For example, data from the Seattle Longitudinal Study confirmed the relative stability of crystallized intelligence across the adult life span, whereas the fluid-type abilities declined noticeably with increasing

[1] We thank an anonymous reviewer for highlighting this point.

age in adults (Schaie, 2005). However, the Seattle Longitudinal Study did not assess investment traits, even though some personality traits were measured (Schaie, 2005; Schaie & Parham, 1976). To date, many research efforts have gone into evaluating cognitive development or decline in adulthood, but no longitudinal study has tested how investment traits affect the development and nature of intellect in a sample representative of the general adult population (von Stumm, Chamorro-Premuzic, & Ackerman, 2011).

Preliminary evidence for investment theories comes from previous meta-analyses (Ackerman & Heggestad, 1997; von Stumm, Hell, & Chamorro-Premuzic, 2011) and numerous empirical studies (e.g., Ackerman, Kanfer, & Goff, 1995; Cacioppo, Petty, & Morris, 1983; Furnham, Swami, Arteche, & Chamorro-Premuzic, 2008; Goff & Ackerman, 1992; von Stumm & Deary, 2012). However, most of these studies focused on one particular investment trait scale (e.g., Typical Intellectual Engagement) and its association with one particular indicator of adult intellect (e.g., crystallized intelligence). Here we review investment trait constructs in the psychological literature, and test the strength and direction of their relationship with several markers of adult intellect.

Review of Investment Trait Scales and Constructs

Investment Trait Search

An abundance of measures exist that capture individual differences in the desire to comprehend and engage in intellectual problems, such as Intellectual Efficiency (Gough, 1953), Need for Cognition (Cacioppo & Petty, 1982), and Typical Intellectual Engagement (Goff & Ackerman, 1992), to name a few. It has been claimed that many of these scales comprise "isolated personality measures . . . with no linkage to any personality theory" (Ackerman & Heggestad, 1997, p. 222). It is our aim here to undertake a unifying research endeavor to identify, aggregate, and analyze investment traits that have occurred throughout the psychological literature. To this end, we consulted publications dating from 1900 to 2011 for traits that referred to "the tendency to seek out, engage in, enjoy, and continuously pursue opportunities for effortful cognitive activity" (von Stumm, Chamorro-Premuzic, & Ackerman, 2011, p. 225). To identify relevant trait scales and constructs, we traced the development of early theories in intelligence and personality research. Specifically, our search was not guided by Boolean special terms (i.e., no adequate search terms were known) but by broadly surveying the history of individual-differences literature. Cross-referencing ensured that no relevant scales were overlooked. To allow for the broadest possible search and review, we included constructs that only partially addressed "cognitive activity" but perhaps described more accurately seeking opportunities to engage in "novel activity," such as Cloninger's (1994) Novelty Seeking Scale. Furthermore, we included constructs that were originally conceived to assess the lower end or opposite of an investment trait dimension, such as Intolerance for Ambiguity (e.g., Frenkel-Brunswik, 1949) and Need for Closure (Kruglanski, 1989; Kruglanski, Webster, & Klem, 1993), both of which focus on the tendency to avoid ambiguous or uncertain emotional and cognitive situations. However, this review excluded trait constructs and scales that exclusively referred to motivation, ambition, self-discipline, or entity theories of self (e.g., Duckworth & Seligman, 2005; Dweck & Leggett, 1988). That is, care was taken not to include traits that predominantly assess goal striving in achievement contexts rather than the tendency to pursue learning opportunities.

Identified Investment Traits

Table 1 shows the complete list of the 34 identified trait constructs, respective authors, and personality taxonomies where applicable; construct description; and corresponding example items. Considering their communal definition, it is perhaps not surprising that the recognized trait scales have by and large similar conceptual roots and even share semantic resemblances (Mussel, 2010; von Stumm, Hell, & Chamorro-Premuzic, 2011; Woo, Harms, & Kuncel, 2007). The vast number of identified trait scales highlights the long-standing research interest in and, hence, the importance of mapping the investment personality space. Furthermore, the multitude of identified investment traits exemplifies the difficulty of, and necessity for, a comprehensive review of this research area.

The earliest identified scale dates back to 1938 (Murray's Information Need; Murray, 1938),[2] and the most recent scale development was published in 2006 (Social Curiosity; Renner, 2006). All identified psychometric scales relied on a self-report measurement design, spanning Likert-type, ipsative, and dichotomous response formats. More than half the investment traits have been developed independently of a personality taxonomy and use a single assessment scale, such as Intellectence (Welsh, 1975), Need for Cognition (Cacioppo & Petty, 1982), and Typical Intellectual Engagement (Goff & Ackerman, 1992). Exceptions were, for example, Absorption, which is most frequently associated with Tellegen's (1982) Multidimensional Personality Inventory but also with works by Elliot and Harackiewicz (1996) and Schaufeli, Martínez, Marques Pinto, Salanova, and Bakker (2002); and Intolerance for Ambiguity, which was originally conceived by Frenkel-Brunswik (1949) and later further developed, including novel assessment scales and alternative definitions of the construct space (Brengelmann & Brengelmann, 1960; Budner, 1962).

With regard to the Five Factor Approach to personality, Openness to Experience (Costa & McCrae, 1992) and Intellect (Goldberg, 1982), which are thought to cover the same personality space (Saucier, 1992), have been most frequently studied as proxies for investment traits (Ackerman, 1996; Ackerman & Heggestad, 1997; Bates & Shieles, 2003; Beier, Campbell, & Crook, 2010; Chamorro-Premuzic & Furnham, 2006). Openness to Experience spans six facets, including Fantasy (vivid imagination), Aesthetics (appreciation for art), Feelings (perceptive to emotions), Actions (novelty seeking), Ideas (intellectual curiosity), and Values (readiness to challenge preconceived notions; Costa & McCrae, 1992). Recent brain imagining and behavior genetic research have suggested that Openness to Experience entails at least two distinct

[2] We thank an anonymous reviewer for pointing out that even earlier Terman (1921, as cited in Terman & Oden, 1959) included an assessment of "intellectual traits" in his longitudinal study of gifted children. The assessment comprised four items (i.e., desire to know, general intelligence, originality, and common sense), on which parents and teachers rated the gifted children. Even prior to Terman, personality traits were known to affect intellectual development (e.g., Webb, 1915). However, none of these earlier studies assessed a trait construct that was specific to the investment personality space.

Table 1
Investment Traits Identified From the Psychological Literature

Trait	Author/taxonomy	No. items per scale	Description	Example item
Absorption	Tellegen (1982), MPQ; Tellegen & Atkinson (1974)	34	Tendency to be emotionally responsive to engaging sights and sounds; readily captured by entrancing stimuli and images; absorbed in vivid and compelling recollections and imaginings; synaesthetic and other cross-modal experiences with episodes of expanded (extrasensory, mystical) awareness and other altered states.	My thoughts often don't occur as words but as visual images.
	Elliot & Harackiewicz (1996)	6	Measure of task involvement, encompassing absorption in the activity and lack of distraction from the task.	While solving . . . puzzles, I lost track of time.
	Schaufeli et al. (2002)	6	Part of the Utrecht Work Engagement Scale, assessing engagement in work and study tasks with three subscales: vigor, dedication, and absorption.	When I am studying, I forget everything else around me.
Analytical cluster	Jackson (1976), JPI	60	Cluster of complexity (abstract over pragmatic problems), innovation (creative, progressive), breadth of interest, and tolerance (nonprejudiced openness).	I prefer complex to simple problems.
Curiosity	Diverse	n/a	Emergence predates psychology; traditionally a philosophical concept; understood as driving force of development and growth, educational attainment, and science (see Loewenstein, 1994). The "innate love of learning and of knowledge . . . without the lure of any profit" (Cicero, 1914, p. 48).	n/a
Academic	Vidler & Rawan (1974)	80	Enjoyment of education and training; pleasure in learning and knowledge acquisition; curiosity in educational settings.	n/a
Epistemic	Litman & Spielberger (2003)	10	The "drive to know" (Berlyne, 1954, p. 187), aroused by conceptual puzzles and gaps in knowledge.	I am interested in discovering how things work.
Perceptual	Collins et al. (2004)	10	"The curiosity which leads to increased perception of stimuli" (Berlyne, 1954, p. 180), evoked in animals and humans by visual, auditory, or tactile stimulation.	When I see a new fabric, I like to touch and feel it.
Social	Renner (2006)	10	Interest in how other people behave, think, and feel.	When I meet a new person, I am interested in learning more about him or her.
California Critical Thinking Inventory	Facione & Facione (1992)	75	Tendency to consistently and willingly incorporate critical thinking skills into life situations; need to know; accepting divergent view points and multiple possibilities.	Considering all alternatives is a luxury I can't afford. (R)
Complexity	F. Barron (1953)[a]	n/a	(Aesthetic) preference for perceiving and dealing with complexity to a preference for perceiving and dealing with simplicity, when both alternatives are phenomenally present.	The unfinished and the imperfect often have greater appeal for me than the completed and the polished.
Information needs	Murray (1938)	n/a	Differentiates cognizance, referring to seeking knowledge and asking questions, from exposition, referring to the tendency to educate others.	n/a
Inquiring Intellect	Fiske (1949)	30	Factors of broad interests, independent mindedness, and imagination; intellectual curiosity; active, exploring mind; the Inquiring Intellect of the true scientist.	Examines every question persistently and individualistically.

Table 1 (*continued*)

Trait	Author/taxonomy	No. items per scale	Description	Example item
Intellect	Goldberg (1982), IPIP	10/50	Refers to intellectual curiosity and quick thinking (Goldberg, 1982).	I have a rich vocabulary.
Intellectance	Hogan & Hogan (1992), HPI	25	Interest in science, curiosity about the world, enjoying intellectual games, creativity and imagination, intolerance to boredom, quick-witted.	I have taken things apart just to see how they work.
Intellectence	Welsh (1975)	n/a	Inclination for analytic, cognitive approaches to symbolic and abstract complexes.	n/a
Intellectual Disposition	Heist & Yonge (1968), OPI	191	Thinking introversion (adapted from C. Evans & McConnell, 1941), theoretical orientation, aestheticism, and complexity; interests in ideas and reflective thought; use of abstractions and problem solving; aesthetic appreciation and open creative approach to phenomena.	You enjoy thinking through complicated problems.
Intellectual Efficiency	Gough (1953), CPI	52	"Subtle" measure of intelligence; ease and efficiency with which an individual is able to apply one's intellectual resources.	I must admit I have no great desire to learn new things.
Intolerance for Ambiguity[b]	Walk (1950)[c]	8	Coined by Frenkel-Brunswik (1949, p. 113) as "one of the basic variables in both the emotional and the cognitive orientation of a person toward life"; accordingly, Walk (1950) designed the so-called A Scale.	There is more than one right way to do anything.
	Budner (1962)	16	Tendency to perceive ambiguous situations as desirable; items tap indicators of perceived threat, that is, phenomenological submission or denial, and operative submission or denial; three types of ambiguous situations: novelty, complexity, and insolubility. See also MacDonald (1970), whose Tolerance for Ambiguity constitutes a reversed match to Budner's (1962) scale.	I am unsettled because everything is uncertain in modern times. You never know what to expect. (R)
	Brengelmann & Brengelmann (1960)	10	Tendency for prejudiced, closed-minded attitudes that define one's values as rigid black-and-white perceptions of the world.	Es beunruhigt mich, daß heutzutage alles so unsicher und wechselhaft ist. Man weiß nie, was man zu erwarten hat.[d]
Liking for Thinking	Guilford et al. (1956/1993)	30	Enjoyment of cognitive activity.	I enjoy thinking out complicated problems.
Love of truth	Scheffer (1991)	n/a	Philosophical concept referring to the hunger and passion for scientific enquiry and explanatory answers.	n/a[e]
Mindfulness	Langer (1989)	21	Novelty seeking (perceiving opportunities to learn), engagement (heightened awareness of environment), novelty producing (generating new information to learn more about current situation), and flexibility (welcoming changes rather than resisting them).	I seek out new things to experience.
Need for Closure	Kruglanski (1989); Kruglanski et al. (1993)	42	Need for (or to avoid) cognitive closure; preference for closure/openness of situations, conditions, and theories.	I enjoy the uncertainty of going into a new situation without knowing what might happen. (R)
Need for Cognition	Cohen et al. (1955)[f]	n/k	Need to understand and make reasonable the experiential world; need to structure relevant situations in meaningful, integrated ways.	n/a

(*table continues*)

Table 1 (*continued*)

Trait	Author/taxonomy	No. items per scale	Description	Example item
	Cacioppo & Petty (1982)	34[g]	Tendency to seek out, to engage in, and to enjoy cognitively effortful activity; preference for cognitively demanding tasks; pleasure in thinking; cognitive effort for the purpose of cognitive effort.	The idea of relying on thought to make my way to the top appeals to me.
Novelty Experiencing	Pearson (1970)	80	External Sensation: Active, physical participation in "thrilling" activities. Internal Sensation: Unusual dreams, fantasy, or feelings that are internally generated. External Cognitive: Seeking out facts, how things work, and learning how to do new things. Internal Cognitive: Cognitive processes focused on explanatory principles and cognitive schemes.	External Sensation: Exploring the ruins of an old city in Mexico. Internal Sensation: Letting myself go in fantasy before I go to sleep.
Novelty Seeking	Cloninger (1994), TCI; Cloninger et al. (1991)	33	Temperament and Character Inventory including novelty seeking with four subcomponents of exploratory excitability, impulsiveness, extravagance, and disorderliness.	It is difficult for me to keep the same interests for a long time because my attention often shifts to something else.
Openness to Experience	Costa & McCrae (1992), NEO	12/60	Six facets: Fantasy (vivid imagination), Aesthetic Sensitivity, Attentiveness to Inner Feelings, Actions (engagement in unfamiliar and novel activities), Ideas (intellectual curiosity), and Values (readiness to reexamine traditional social, religious, and political concepts).	I am intrigued by the patterns I find in art and nature.
School Success	Hogan & Hogan (1992), HPI	14	Enjoyment in academic activities; tendency to attribute high value to educational achievement.	I have a large vocabulary.
Sensation Seeking	Zuckerman et al. (1964)	40	Seeking varied, novel, complex and intense sensations and experiences; willingness to take physical, social, legal and financial risks for the sake of such experiences.	I like "wild" uninhibited parties. (versus) I prefer quiet parties with good conversation.
Sentience	Jackson (1989), PRF		Emphasis on smells, sounds, sights, tastes, and touch; sensitive to many forms of experience; hedonistic and aesthetic view of life.	One of my favorite pastimes is sitting before a crackling fire.
Stimulus Variation Seeking Scale	Penney & Reinehr (1966)	58	Exteroceptive stimulus variation seeking, underlies exploration, alternation, curiosity, and play; actively approaching novel stimuli and situations	An element of risk adds to my enjoyment of an activity or event.
Thinking dispositions	Stanovich & West (1997)	n/a	Malleable cognitive styles with nine scales: flexible thinking, openness–ideas, openness–values, absolutism, dogmatism, categorical thinking, superstitious thinking, counterfactual thinking, and outcome bias.	A person should always consider new possibilities.
Thinking Introversion–Extraversion	C. Evans & McConnell (1941)	151	Based on Guilford and Guilford's (1936) Introversion/Extraversion dimension; thinking introversion refers to preference for reflective, abstract thinking without external domination; thinking extraversion refers to preference for ideas of overt action, dominated by objective conditions and generally accepted ideas.	I enjoy thinking through complicated problems.
Thoughtfulness	Guilford & Zimmerman (1949), GZTS	30	Based on Thinking Introversion (see C. Evans & McConnell, 1941), referring to reflectiveness, meditativeness, observing others, preference for thinking over overt activity, and philosophical inclination.	I enjoy thinking through complicated problems.

Table 1 (*continued*)

Trait	Author/taxonomy	No. items per scale	Description	Example item
Typical Intellectual Engagement	Goff & Ackerman (1992)	59	Operationalizing intelligence as typical performance; desire to engage and understand one's world, interest in a wide variety of things; preference for complete understanding of complex topics and problems.	I prefer my life to be filled with puzzles I must solve.
Understanding	Jackson (1989), PRF	32	Exploring many areas of knowledge; synthesis of ideas, verifiable generalization and logical thought to satisfy intellectual curiosity.	I like magazines offering thoughtful discussions of politics and art.

Note. (R) refers to items that are reversed; n/a and n/k refer to cases in which example items for corresponding trait scales were unobtainable because scales are unpublished or copies of the original are no longer available. Traits are presented in alphabetical order. MPQ = Multidimensional Personality Questionnaire; JPI = Jackson Personality Inventory; IPIP = International Personality Item Pool; HPI = Hogan Personality Inventory; OPI = Omnibus Personality Inventory; CPI = California Personality Inventory; TCI = Temperament and Character Inventory; NEO = Neuroticism–Extraversion–Openness Personality Inventory; PRF = Personality Research Form; GZTS = Guilford–Zimmerman Temperament Survey.
[a] Complexity was first introduced by F. Barron (1953), referring to artistic preferences, but was later incorporated in several personality taxonomies to describe intellectual investment. [b] Only those scales of Intolerance for Ambiguity are described, which have been most frequently validated in previous research. Omitted instruments include, for example, Frenkel-Brunswik's (1949) scale, MacDonald's (1970) Tolerance for Ambiguity measure, and Rydell's (1966) tests. [c] P. O'Connor (1952) published Walk's (1950) A Scale for the Intolerance for Ambiguity scale in 1952 under Walk's supervision. [d] The English translation reads, "I am concerned that today everything is changing and inconsistent. You never know what to expect." [e] This concept has only been theoretically discussed but was never translated into a testing or research reality. [f] Cohen et al.'s (1955) original scale has been lost (see Cacioppo & Petty, 1982). [g] There are also 47- and 18-item versions of Cacioppo and Petty's (1982) Need for Cognition scale (Cacioppo, Petty, Feinstein, & Jarvis, 1996).

lower order trait dispositions, often referred to as Openness on the one hand and Intellect on the other (e.g., DeYoung, Quilty, & Peterson, 2007; DeYoung, Samosh, Green, Braver, & Gray, 2009; Wainwright, Wright, Luciano, Geffen, & Martin, 2008). Trait Intellect refers to a tendency for engaging in intellectually stimulating activities and is represented by the Ideas facet, whereas Openness is composed of artistic and contemplative qualities that are associated with the facets of Fantasy, Aesthetics, Feelings, and Actions. For example, DeYoung et al. (2009) showed that trait Intellect—but not Openness—was associated with brain activity in neural systems of working memory. They concluded that trait Intellect shares neuronal networks with intelligence, whereas Openness relies on brain circuits that are unrelated to cognitive ability. Similarly, trait Intellect has also been found to be influenced by the same genetic factors as intelligence and academic performance, which was not the case for Openness (Wainwright et al., 2008). It follows that trait Intellect and Openness must be carefully differentiated to avoid obscuring associations with other variables (Mussel, Winter, Gelléri, & Schuler, 2011; von Stumm, Hell, & Chamorro-Premuzic, 2011). However, most previous research has treated Openness to Experience as an undifferentiated higher order factor. It is therefore not surprising that Openness to Experience is inconsistently related to (fluid) intelligence (Ackerman & Goff, 1994; Ackerman & Heggestad, 1997; Noftle & Robins, 2007), and has meaningful relationships with some markers of adult intellect but not with others. For example, three recent meta-analyses estimated the relationship of Openness and academic performance between .06 and .13 (M. C. O'Connor & Paunonen, 2007; Poropat, 2009; Trapmann, Hell, Hirn, & Schuler, 2007), whereas Ackerman and Heggestad (1997) reported a meta-analytic correlation with crystallized intelligence of .30. Thus, associations of Openness to Experience with markers of adult intellect (or the lack thereof) do not invalidate the investment theory but encourage a more differentiated research approach to this Five Factor Approach trait dimension. In summary, then, a comparatively large number of investment trait constructs was identified from the psychological literature. These constructs and scales overlap substantially in their scope and psychometric design, but they also differ in their historical development and measurement emphasis.

Investment Trait Categories

To summarize the identified trait scales further, each of the authors—independently of one another—classified the identified investment trait scales into as many categories as they thought necessary. The classifications were based on the trait descriptions in Table 1, and proposed categories were subsequently compared. The initial interrater agreement for the proposed trait categories was relatively low, at 60%. However, developing fixed categories of the investment scales is not without problems, considering their substantial overlap in content and their discrepancy in scope (some are relatively broad traits, others are relatively narrow). Disagreements in trait classification were later discussed and consentaneously solved in all cases. Overall, eight trait categories emerged (see Figure 1 and Appendix A).

A first category included the core of investment—that is, "the tendency to seek out, engage in, enjoy, and continuously pursue opportunities for effortful cognitive activity" (von Stumm, Chamorro-Premuzic, & Ackerman, 2011, p. 225)—with two scales: Typical Intellectual Engagement and Need for Cognition. Both scales, which are highly intercorrelated and lack divergent validity (e.g., Woo et al., 2007), may be thought of as the higher order dimension of investment. Their scale content and items equally emphasize the assessment of individual differences in the need to engage (cognitively) with and understand the environment. The next, perhaps most closely related trait cluster was identified as Intellectual Curiosity, which included 13 trait constructs that

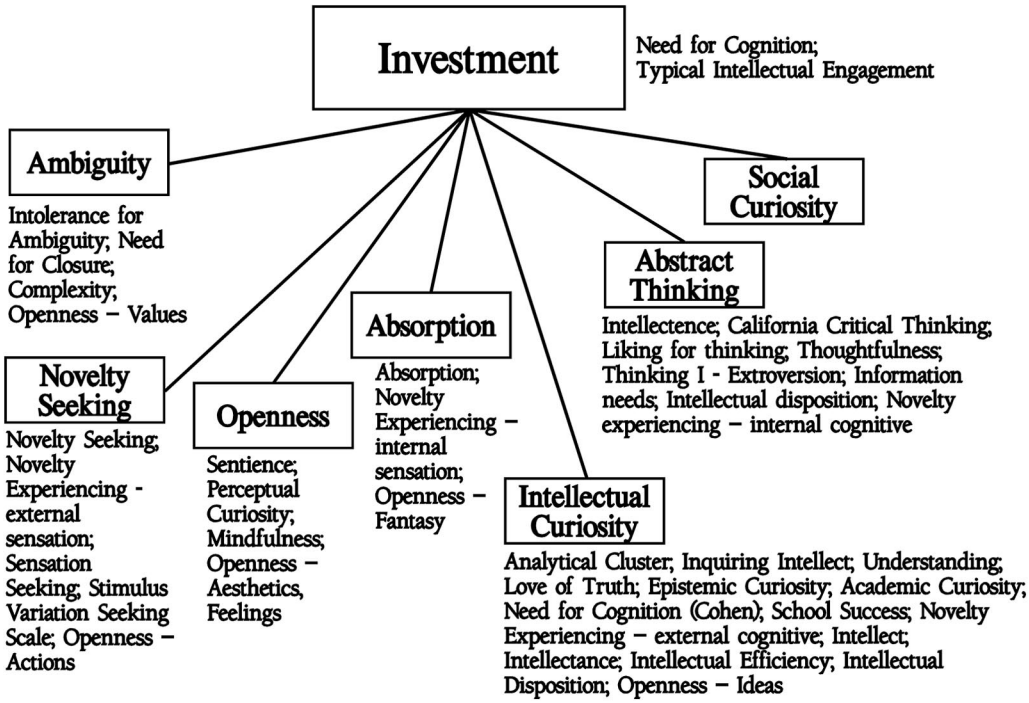

Figure 1. Investment trait categories and scales.

captured individual differences in the hunger for knowledge and engagement in cognitively stimulating activities. In contrast to the higher order investment trait category, the Intellectual Curiosity cluster strongly emphasized a preference for seeking out information or epistemic pursuits but referred to a lesser extent to a general desire to comprehend one's surroundings. A next category of Abstract Thinking included eight scales that described inclinations to engage in cognitive puzzles, problem solving, and theoretical contemplations. In comparison to the Intellectual Curiosity cluster, scales in this category appear to encompass an individual's engagement with precisely defined problems or riddles over intellectual exploration and free information seeking. The category Novelty Seeking included five measures that focused on a sense of adventure and individual differences in seeking stimulation or excitation, and the need for varied, novel, and complex sensations and experiences (e.g., see Zuckerman, 1979). This category is perhaps more closely associated with thrill-seeking, impulsive, and risk-taking behaviors than are other investment traits. The category also refers to exploration outside the cognitive-intellectual domain and, thus, may even be predictive of physically harmful experiences. The category Openness included four scales, all of which referred in part to aesthetic awareness and open imagination. It is distinct from Absorption, which was defined by three scales suggesting a tendency for immersion experiences, because Openness predominantly assesses sensitivity to and perception of one's surroundings rather than "being lost" in an experience (McCrae, 1994). Another category was Ambiguity, defined by three scales that emphasized individual differences in the tolerance for uncertainty and the enjoyment of vagueness and the unknown. A final scale or category was Social Curiosity (i.e., a tendency to seek people related information, perhaps even gossip), which did not fit within any of the other trait categories. The seven "lower order" clusters of Intellectual Curiosity, Abstract Thinking, Openness, Absorption, Ambiguity, Novelty Seeking. and Social Curiosity are likely to differ in how closely they are associated with the higher order dimension of investment. Similarly, they might be related to slightly different kinds of adult intelligence and knowledge. For example, novelty seeking is probably conducive to learning about adventure sports, whereas abstract thinking may lead to establishing a collection of philosophy books.

Meta-Analysis

Psychological and Pedagogical Methods

For assessment of intelligence, Binet and Simon (1905/1961) differentiated the psychological method, which aims to make direct observations and measurements of the degree of intelligence, and the pedagogical method, which judges intelligence according to the sum of acquired knowledge (for a discussion, see Ackerman, 1996).[3] These two methods lend themselves to the assessment of fluid and crystallized intelligence, respectively. Psychological tests are designed to capture maximum performance, whereas pedagogical measures represent levels of typical performance. However, most tests assess a mixture of intelligence-as-process and intelligence-as-knowledge, and they tend to emphasize process

[3] Binet and Simon (1905/1961) also discussed the medical method that analyzes anatomical, physiological, and pathological signs of inferior intelligence, which they found to constitute an inadequate assessment method.

aspects regardless of the "two kinds of intelligence" (Ackerman, 1996, 2000; Carroll, 1993). The asymmetry in assessment results from two central premises of early intelligence research: Mental ability is innate and stable across the life span (e.g., Terman, 1916). Later empirical research demonstrated that both of these notions are questionable (Nisbett et al., 2012; for detailed discussions, see also Sternberg & Grigorenko, 2005; Nisbett, 2009). Focusing on the life-span stability of intelligence, longitudinal studies have shown that intelligence in childhood and adulthood is highly correlated (e.g., Deary et al., 2000; Larsen, Hartmann, & Nyborg, 2008). However, test scores show substantial intraindividual variance across time (e.g., Larsen et al., 2008; Ramsden et al., 2011), and so do developmental trajectories of cognitive ability (e.g., Bayley, 1955, 1968). Although the evidence for the life-span stability of pedagogical intelligence (i.e., knowledge) is comparatively sparse, it has been referred to as "the locus of the 'dark matter' of adult [intellect]" (Ackerman, 2000, p. 69). Thus, assessments of adult intellect should entail aspects of academic study, active engagement in society (e.g., government functioning), occupational knowledge (e.g., specific skills and technical understanding), and knowledge associated with avocational hobbies (e.g., literature or music; Ackerman, 2000). Adult intellect is a multidimensional construct that covers a wide range of information and expertise, and it varies greatly across individuals. The variability, specialist nature, and breadth of knowledge complicate a nomothetic research approach. Cattell (1987, p. 143) observed that

> in the twenty years following school, the judgmental skills one should properly be measuring as the expression of learning by fluid ability must become different for different people. If these are sufficiently varied and lack a common core, the very concept of general intelligence begins to disappear.

To ensure a comprehensive and reliable operationalization of intelligence-as-knowledge, we selected several markers of typical adult intellect for the current meta-analysis, including college entry tests, indicators of academic performance, measures of crystallized intelligence, and pedagogical (i.e., knowledge) assessments. As mentioned before, these markers, like any other measures of ability, typically capture both fluid and crystallized intelligence (Ackerman, 1996, 2000; Cattell, 1943); however, they are selected here because they are generally thought to be relatively more representative of crystallized than fluid aspects of intelligence.

Markers of Adult Intellect

College entry tests, such as the SAT (formerly Scholastic Aptitude Test) or the ACT (formerly American College Test), are typically completed at the end of high school and may represent the level of early adult intellect. Although they are designed to assess what a student has learned in high school (Lehman, 1999), college entry tests have been shown to correlate highly with general intelligence (Frey & Detterman, 2004; Koenig, Frey, & Detterman, 2008). Therefore, college entry tests may be more maximal than typical performance measures, capturing intelligence-as-process to a greater degree than intelligence-as-knowledge. Nonetheless, we included college entry tests in our current review, partly to avoid omitting a substantial body of research. In particular, we chose to include the verbal scales of college entry tests, where available, which comprise more pedagogical measures than mathematical SAT scores do (Koenig et al., 2008).

Intelligence tests—the psychological kind—were originally developed to predict individual differences in academic performance (Binet & Simon, 1905/1961), and account typically for about 40% of the variance in measures of academic success (e.g., Kuncel, Hezlett, & Ones, 2004; Poropat, 2009). Academic performance includes typical (e.g., exam preparation time) and maximal performance tasks (e.g., exam completion) and, hence, represents both intellectual potential and accomplishment. In line with this, scholastic achievement is known to depend on a number of additional factors, such as motivation, zeal and effort, self-perceived ability, parental aspirations, and peer support (see Richardson, Abraham, & Bond, 2012). In addition, investment traits have been shown to play an important role in academic performance (von Stumm, Hell, & Chamorro-Premuzic, 2011), which in turn has long-term effects on educational attainment and life-span development (Kern & Friedman, 2009). Notwithstanding, academic performance data are typically collected in comparatively young adulthood, and thus, they may not be an ideal marker of adult intellect.

By definition, crystallized intelligence tests are designed to assess individual differences in knowledge acquired through education and experience, recommending them as adequate proxies of adult intellect (Carroll, 1993; Johnson & Bouchard, 2005). Corresponding tests typically measure verbal ability, such as vocabulary, synonym understanding, verbal comprehension, and spelling ability (Carroll, 1993). In addition, many intelligence test batteries, such as the Wechsler Adult Intelligence Scales (Wechsler, 1955) or the Differential Aptitude Test Battery (Bennett, Seashore, & Wesman, 1972), include designated information and knowledge scales to assess crystallized ability, which possibly require a greater amount of culture-specific knowledge than vocabulary or synonym tests. Nonetheless, crystallized ability measures typically follow psychological rather than pedagogical test designs (e.g., they are often speeded). Furthermore, most crystallized ability tests assess consensus or core cultural knowledge, and thus, they are suboptimal measures of adult intellect because of their lack of depth and breadth (Ackerman, 1996). By contrast, knowledge tests constitute better makers of adult intelligence, because of their pedagogical nature that assesses the "dark matter" of adult intelligence: domain-specific knowledge including aspects of academic study, active engagement in society (e.g., government functioning), occupational knowledge (e.g., specific skills and technical understanding), and knowledge associated with avocational hobbies (e.g., literature or music; Ackerman, 2000; Rolfhus & Ackerman, 1999). Few research studies have employed pedagogical knowledge tests, possibly because they require considerable time and effort in development and in administration (see Rolfhus & Ackerman, 1999).

In summary, markers of adult intellect differ in the extent to which they follow psychological or pedagogical methods and, with that, in how accurately they allow inferences of adult intellectual capability and maturity. College entry tests closely resemble maximum performance measures, and one might speculate that individual differences in corresponding test scores are best explained by general intelligence. Conversely, academic performance, crystallized intelligence, and knowledge are more closely related to intelligence as typical performance, as they capture intellect that

has been developed and built over time, not during a few weeks of extensive rehearsals. That said, these intellect markers are also known to be influenced by a number of other variables, such as effort and zeal, and prior (fluid) intelligence. Therefore, it is likely that associations between investment and intellect are only of small or medium effect sizes because of the multitude of alternative factors that impact adult intellect.

The Current Meta-Analysis

Here we aimed to review and meta-analyze associations between investment traits and markers of adult intellect. Thus, literature searches were conducted to identify research studies that reported bivariate correlations between the previously listed investment traits (see Table 1) and intellect markers including crystallized intelligence, academic performance, college entry tests, and knowledge tests. We excluded studies that reported on Openness to Experience as higher order factor and focused on those that reported associations with Openness facets.

Method

Database Search

We searched PsycINFO and ERIC databases for investment traits in relation to indicators of adult intellect using a Boolean search term: *Investment trait AND (intelligence OR ability OR knowledge OR academic performance).* General search terms were purposefully chosen to identify all studies that reported on associations of investment traits and indicators of adult intellect. When the respective investment trait was a subcomponent of a more comprehensive personality model or taxonomy, searches were run for (a) the trait (i.e., Absorption), (b) the full model or taxonomy name (i.e., Multidimensional Personality Questionnaire), and (c) the abbreviated model or taxonomy name (i.e., MPQ). The obtained hits included journal articles, dissertations, reports, books, and test manuals, whose references were also screened to ensure the completeness of the review. The searches were originally run between July and September 2008, and they were updated in December 2011. The searches returned 59,000 publications dated from 1900 to 2011, whose abstracts were evaluated for their relevance to the current research. Some of the current search terms are used in many research abstracts (e.g., *knowledge* and *ability*), resulting in a comparatively high number of returned hits. However, only a small fraction of the studies was relevant in the current research context; initially, 198 hits were retained, and full-text copies were obtained.[4] They were subsequently reevaluated with reference to the inclusion criteria outlined below.

Inclusion Criteria

Criteria for study inclusion in the meta-analysis were that (a) the target study reported bivariate correlations, in line with Hunter and Schmidt (1990), who stated that "for multiple regression, factor analysis, and canonical correlation analysis, the zero-order correlation matrices are essential for accumulations across studies" (p. 505). Two selection criteria referred to sample characteristics; that is, (b) study samples had to be aged 16 years and above, excluding, for example, Harris, Vernon, and Jang's (2005) differentiation study with a sample of 516 twins ranged in age from 13 and 45 years; and (c) samples were not drawn from clinical or artificial or extremely restricted populations, such as new sect members (Delay, Pichot, Sadoun, & Perse, 1955), drug users (Holroyd & Kahn, 1974), and schizophrenics (Langevin, 1976). Finally, (d) investment traits were assessed with self-rating personality measures but not implicit or association-based tests. For example, Hafeez (1952) employed a projective test of curiosity, and in Rossing's (1978) dissertation, individual differences in epistemic curiosity were assessed based on participants' ratings of surprise and desire for further knowledge in response to 10 brief accounts of psychology experiments; both studies were excluded.

With regard to the operationalization of the outcome variables, that is, indicators of adult intellect, inclusion criteria were less stringent. That is, studies of self-reported grade point average (e.g., Tolentino, Curry, & Leak, 1990) were included if the study's conditions made high validity of the self-report plausible (Kuncel, Credé, & Thomas, 2005). Also, studies using self-reported general knowledge (e.g., Rolfhus & Ackerman, 1996; Woo et al., 2007) were included because of the exceptional psychometric properties of the respective self-report scales (Paulhus & Harms, 2004; Rolfhus & Ackerman, 1996). Other studies were excluded, however, because the employed indicator of adult intellect proved inadequate after careful examination; for example, P. O'Connor's (1952) set of familiar, symbolic, and tricky syllogisms did not fit definitions of adult intellect and was excluded.

Studies were included regardless of their publication language; that is, most articles were published in English, but also non-English reports were incorporated (e.g., Angleitner, 1973; Brengelmann & Brengelmann, 1960). All studies were coded for investment traits, type of sample (student, adult, mixed, older adults and twins), and indicators of adult intellect. For the latter, vocabulary, information, and related ability tests were categorized as markers of crystallized intelligence in line with Carroll (1993). Academic performance spanned measures of grade point average, course grades, exam marks, and dissertation project grades, and the category of college entry tests included ACT, SAT, and related college or university admission tests. Here coefficients from the verbal component of college entry tests were included when possible. Finally, assessments of knowledge included several test formats of subjective and objective knowledge; this category excluded, however, any tests or measures that are typically employed in intelligence test batteries strictly as markers of crystallized intelligence.

[4] Target articles, books, and manuals were downloaded directly from the PsycINFO and ERIC databases. If electronic copies were unavailable, print copies were obtained. If neither electronic nor print copies were available, the articles' first authors were contacted to obtain a copy of their work. This strategy was not always successful because some authors were deceased, had left academia and were untraceable, or did not respond to repeated inquiries. For example, Bendig and Meyer (1963) published on the factorial structure of the Primary Mental Abilities and the Guilford–Zimmerman Temperament Survey stating that the intercorrelation matrix was available on request from the first author. However, neither Bendig nor his coauthor could be located, and no contact details were available, which is hardly surprising considering that half a century has passed since Bendig and Meyer published. Overall, the number of unavailable articles was small.

Statistical Analysis

Hunter and Schmidt (1990) listed 11 study artifacts that alter the size of a given study correlation in comparison to its true correlation or effect, referring to sampling error as the "most damaging artifact" (p. 44), which causes the study validity to vary randomly from the population value. A second, highly problematic artifact is measurement error, which refers to the systematic underestimation of bivariate associations because of measuring traits or constructs with imperfect reliability. Therefore, we corrected for both sampling and measurement error, and subsequently meta-analytic estimates were computed in fixed- and random-effects models.

To correct for measurement error in both investment trait and indicator of adult intellect, we corrected correlation coefficients for scale reliabilities. For investment traits and tests of crystallized intelligence, reliabilities were either obtained from the given study or, if not reported, substituted with reliability estimates from the original validation studies, as stated in test manuals, research articles, and test guidance booklets. Of course, studies are likely to differ with regard to the reliability of their employed measures; however, when no reliability estimate is reported, substituting the value from original construct development studies is most adequate. Similarly for markers of academic performance, such as general point average and exam grades, and college entry tests, reliability estimates were obtained from various additional research sources. Typically, research studies do not report reliabilities or internal consistency values for academic performance measures. That said, Bacon and Bean (2006) reported college grade point average reliability at .90, whereas Stricker, Rock, Burton, Muraki, and Jirele (1994) estimated its internal consistency ranged from .64 to .99. Also, Kuncel et al. (2005) found that college grade point correlated with self-reported grade point average at .90. Thus, the reliability of grade point average was estimated here at .90. For other academic assessment markers, including continuous assessment, essay, and exam grades, Chamorro-Premuzic, Furnham and Ackerman (2006b) reported reliabilities of .78, .82, and .72, respectively. For various college entry tests, the reliability coefficient was estimated to be .90, based on Frey and Detterman's (2004) and Koenig et al.'s (2008) results as well as the official college exam reports.

Fixed-effects analysis requires the assumption that all included studies share a common effect size, whose variance primarily depends on each study's sample size (Borenstein, Hedges, & Rothstein, 2007). That is, the fixed-effects model recognizes one level of sampling and of sampling error; because all studies are presumably sampled from the same population, sampling error must exclusively lie within studies. Therefore, weights are assigned to each study based on the inverse variance, which is proportional to the sample size but a more nuanced measure (Borenstein et al., 2007). By contrast, a random-effects model assumes a distribution of true effects, representing the mean of a population of true effects (Borenstein et al., 2007). Here two levels of sampling identify within-studies and between-studies sampling error. Therefore, the observed variance is decomposed into two components of sampling error, both of which are used to assign study weights. Borenstein et al. (2007) concluded that the relative weights assigned in a random-effects analysis would be more balanced and accurate than weights in a fixed-effects analysis. In the current review, the included studies are not functionally identical, and the assumption that sampling error lies only within studies cannot hold. If the number of included studies is small, however, it may not be viable to estimate the between-studies variance with any precision. According to Schulze (2004), random-effects model estimations are not reliable until at least 32 coefficients are included. As this number of studies is presently not given for any investment trait and indicator of adult intellect (see below), both random- and fixed-effects estimates are reported.

Cochran's Q refers to the weighted sum of squared differences between the effect of an individual study and the pooled effect across studies (Hunter & Schmidt, 1990). A significant Q statistic suggests that more than one distribution may underlie the sample of correlations and that pooling the data into a single estimate may be inappropriate. The Q statistic is, however, sensitive to the number of participants, and even small variations among the sample correlations can result in significant heterogeneity in large samples (Hedges & Olkin, 1985).

Results

Database Search

Overall, 112 studies satisfied the aforementioned inclusion criteria, resulting in 234 bivariate coefficients and a total sample size of 60,097. Overall, 192 coefficients were derived from student samples, whereas 32 were from general adult populations including twins, 11 came from elderly samples, and four samples were not defined in any way. In Appendix B, we summarize all included studies according to investment trait, reporting authors, sample size, and outcome variable (i.e., indicator of adult intellect).

Research studies reporting investment–intellect associations were found for 28 out of 34 previously identified investment trait constructs (i.e., Table 2). The number of identified, adequate studies for a given investment trait ranged from a minimum of one (e.g., the Analytical Cluster from the Jackson Personality Inventory; Jackson, 1976) to a maximum of 42 studies for Need for Cognition (Cacioppo & Petty, 1982). Overall, Intolerance for Ambiguity, Need for Cognition, Intellectual Efficiency, Thoughtfulness, and Typical Intellectual Engagement were the most frequently studied traits with reference to intellect. The most often employed indicators of adult intellect were crystallized intelligence tests and academic performance, whereas knowledge measures were comparatively rarely studied.

Meta-Analysis Results

In Table 3, we report the meta-analytic associations of investment traits with indicators of adult intellect. Out of 112 possible associations (28 investment traits $\times$ 4 indicators of intellect), only 64 cells were filled, and of those, 43 comprised aggregated coefficients. The number of identified studies was too scarce to compute meta-analytic coefficients for any given trait and all four indicators of intellect separately. However, bivariate associations of Intellectual Efficiency, Intolerance for Ambiguity, Need for Cognition, and Typical Intellectual Investment could be meta-analyzed with reference to three indicators of adult intellect, whereas for all remaining trait scales only one or two adult intellect correlations were supported by a satisfactory number of studies.

Table 2
Frequencies and Totals of Identified Correlations Between Investment Traits and Indicators of Adult Intellect

Trait	Gc	CET	AP	K	Total
Absorption	4	1	3	1	9
Academic curiosity	1		2		3
Analytical Cluster[a]	1				1
Intolerance for Ambiguity	10	3	2		15
CCTDI		3	2		5
Curiosity	3	1	1		5
Intellectance	1				1
Intellectual Efficiency	11	7	19		37
Intellectual Disposition	2	7	1		10
Need for Closure	2	1			3
Need for Cognition	16	13	12	1	42
Novelty Experiencing EC		2			2
Novelty Experiencing IC		2			2
Novelty Experiencing ES		2			2
Novelty Experiencing IS		2			2
Openness to Experience–Fantasy	2	1	5		8
Openness to Experience–Aesthetics	2	1	6		9
Openness to Experience–Feelings	2	1	5		8
Openness to Experience–Actions	2	1	5		8
Openness to Experience–Ideas	2	1	6		9
Openness to Experience–Values	2	1	6		9
School Success	1				1
Sensation Seeking	1	4			5
Sentience	2				2
Stimulus Variation Seeking Scale		2			2
Thoughtfulness	1	4	8		13
Typical Intellectual Engagement	7	1	3	7	18
Understanding	3				3
Total	78	61	86	9	234

Note. Empty cells represent associations for which no empirical evidence was identified in the research literature. Gc = crystallized intelligence; AP = academic performance; CET = college entry tests; K = knowledge tests; CCTDI = California Critical Thinking Disposition Inventory; EC = External Cognitive; IC = Internal Cognitive; ES = External Sensation; IS = Internal Sensation.
[a] Breadth of Interests, Complexity, and Innovation.

Out of 43 aggregated coefficients, 9 were nonsignificant ($p < .05$), with the corresponding confidence intervals of 95% including 0, whereas all others were significant and in a positive direction. Note that meta-analytic correlations of intellect indicators and Need for Closure and Intolerance for Ambiguity were negative, which is owed to the reverse meaning of these two scales compared to the other investment traits; corresponding results are herein interpreted as positive effects.

Aggregated coefficients ranged from approximating 0 to a maximum value of above .50 (for the relationships of the Openness to Experience facets of Ideas and Values with crystallized intelligence). Estimates were generally invariant across fixed- and random-effects conditions, with a maximum difference of .06 between both corrected mean coefficients (e.g., Need for Cognition and crystallized intelligence). Confidence intervals of 95% were also similar in fixed- and random-effects models; in cases where the models differed, the confidence intervals in random-effects models tended to be wider than intervals from fixed-effects models, in line with previous research (Hunter & Schmidt, 2000). Out of 43 meta-analytic estimates, 19 were associated with a significant Q statistic ($p < .05$), which suggested that it may be inappropriate to pool the data in order to obtain overall estimates (Hedges & Olkin, 1985).

For crystallized intelligence as marker of intellect, significant associations were observed with Intolerance for Ambiguity, Intellectual Efficiency, Intellectual Disposition, Need for Cognition, Typical Intellectual Engagement, Understanding, and all Openness facets except Actions, which centered around the $\rho = .30$ mark in fixed- and random-effects models, ranging from .13 to .58. Smaller but significant effects were observed for Need for Closure with $\rho = -.13$ in fixed- and random-effects models. For Sentience, Curiosity, and Absorption, however, nonsignificant correlations were observed (see Table 3).

Investment traits were also positively associated with academic performance with significant estimates ranging from .08 to .29 for Absorption, Academic Curiosity, Intellectual Efficiency, Intellectual Disposition, Need for Cognition, Thoughtfulness, Typical Intellectual Engagement, and the Openness facets of Aesthetics, Feelings, and Ideas. Nonsignificant estimates were found for Intolerance for Ambiguity, the California Critical Thinking Inventory, and the Openness facets of Actions, Fantasy, and Values.

Regarding college entry tests, significant correlations around .30 were found for Intolerance for Ambiguity, Intellectual Efficiency, Intellectual Disposition, Need for Cognition, Novelty Experiencing Internal Cognition, Sensation Seeking, and Thoughtfulness. Less strong, but still significantly positively associated investment traits included Novelty Experiencing Internal Sensation, Stimulus Variation Seeking, Absorption, and the California Critical Thinking Inventory. Nonsignificant correlations were estimated for the Novelty Experiencing scales of External Cognition and External Sensations. Note that the modest magnitude and nonsignificant estimates occurred mostly when pooling only two coefficients.

Knowledge has been most frequently studied with regard to Typical Intellectual Engagement; across seven studies, a significant meta-analytic estimate of .38 was observed in fixed- and random-effects models. For no other trait construct did we find multiple studies that reported on associations with knowledge. Overall, the results suggested positive, moderate associations between investment traits and indicators of adult intellect.

Discussion

With the current meta-analysis, we sought to quantify the association between investment traits and adult intellect across studies and intellect markers, including college entry tests, academic performance, measures of crystallized intelligence, and assessments of knowledge. Before discussing the substantive findings of the meta-analysis, it is important to note that a comparatively small number of research studies was identified that reported investment–intellect correlations. Therefore, it was impossible to conduct a complete meta-analysis of the previously identified investment traits (see Table 1) in relation to adult intellect. This scarcity of data is somewhat counterintuitive considering the large number of identified investment trait constructs. It is, however, consistent with the traditional perspective that intelligence and personality constitute independent entities that are best studied by distinctive methods, in separate contexts, and following different research agendas (e.g., Penke et al., 2007; von Stumm, Chamorro-Premuzic, & Ackerman, 2011; Zeidner & Matthews, 2000). Because the small number of pooled meta-analytic estimates makes it

Table 3
Meta-Analytic Results for Investment Traits and Indicators of Adult Intellect

Trait	Gc	AP	CET	K
Absorption				
ρ_{FE}/ρ_{RE}	.04/.04	.15/.14	−.03	.02
k (*N*)	4 (627)	3 (1,661)	1 (174)	1 (228)
CI_{FE}/CI_{RE}	[−.04, .12]/[−.04, .12]	[.10, .19]/[.07, .21]		
Q	0.69	4.35		
Analytical Cluster (JPI)				
Breadth of Interest				
ρ_{FE}/ρ_{RE}	.16			
k (*N*)	1 (405)			
CI_{FE}/CI_{RE}				
Q				
Complexity				
ρ_{FE}/ρ_{RE}	.22			
k (*N*)	1 (405)			
CI_{FE}/CI_{RE}				
Q				
Innovation				
ρ_{FE}/ρ_{RE}	.21			
k (*N*)	1 (405)			
CI_{FE}/CI_{RE}				
Q				
CCTDI				
ρ_{FE}/ρ_{RE}		.03/.03	.10/.10	
k (*N*)		2 (452)	3 (616)	
CI_{FE}/CI_{RE}		[−.07, .12]/[−.07, .12]	[.02, .18]/[.02, .18]	
Q		0.23	0.40	
Curiosity[a]				
ρ_{FE}/ρ_{RE}	.11/.07	.42	.05	
k (*N*)	3 (172)	1 (484)	1 (954)	
CI_{FE}/CI_{RE}	[−.04, .26]/[−.33, .44]			
Q	13.94*			
Academic Curiosity				
ρ_{FE}/ρ_{RE}	.36	.21/.22		
k (*N*)	1 (170)	2 (435)		
CI_{FE}/CI_{RE}		[.12, .30]/[.11, .33]		
Q		1.39		
Intellectance				
ρ_{FE}/ρ_{RE}	.24			
k (*N*)	1 (49)			
CI_{FE}/CI_{RE}				
Q				
Intellectual Efficiency				
ρ_{FE}/ρ_{RE}	.31/.42	.22/.24	.33/.32	
k (*N*)	11 (2,730)	19 (5,801)	7 (1,994)	
CI_{FE}/CI_{RE}	[.28, .35]/[.32, .51]	[.19, .24]/[.20, .29]	[.29, .37]/[.25, .39]	
Q	74.10*	40.83*	12.95	
Intellectual Disposition				
ρ_{FE}/ρ_{RE}	.37/.37	.31	.27/.29	
k (*N*)	2 (152)	1 (154)	7 (602)	
CI_{FE}/CI_{RE}	[.23, .50]/[.20, .53]		[.19, .34]/[.18, .39]	
Q	1.44		10.72*	
Intolerance for Ambiguity				
ρ_{FE}/ρ_{RE}	−.38/−.34	−.13/−.16	−.30/−.30	
k (*N*)	10 (1,306)	2 (224)	3 (476)	
CI_{FE}/CI_{RE}	[−.43, −.34]/[−.46, −.20]	[−.26, 0]/[−.46, .17]	[−.38, −.22]/[−.38, −.22]	
Q	53.78*	6.07*	0.44	
Need for Closure				
ρ_{FE}/ρ_{RE}	−.13/−.13		−.05	
k (*N*)	2 (315)		1 (180)	
CI_{FE}/CI_{RE}	[−.23, −.02]/[−.23, −.02]			
Q	0.01			

(*table continues*)

Table 3 (*continued*)

Trait	Gc	AP	CET	K
Need for Cognition				
ρ_{FE}/ρ_{RE}	.33/.27	.20/.22	.26/.26	.29
k (*N*)	16 (5,164)	12 (2,998)	13 (2,683)	1 (81)
CI_{FE}/CI_{RE}	[.30, .35]/[.20, .34]	[.16, .23]/[.17, .27]	[.23, .30]/[.22, .30]	
Q	78.14*	18.29	12.95	
Novelty Experiencing EC				
ρ_{FE}/ρ_{RE}			.10/.11	
k (*N*)			2 (248)	
CI_{FE}/CI_{RE}			[−.03, .22]/[−.09, .30]	
Q			2.47	
Novelty Experiencing IC				
ρ_{FE}/ρ_{RE}			.23/.24	
k (*N*)			2 (248)	
CI_{FE}/CI_{RE}			[.11, .35]/[.05, .41]	
Q			2.20	
Novelty Experiencing ES				
ρ_{FE}/ρ_{RE}			−.02/−.02	
k (*N*)			2 (248)	
CI_{FE}/CI_{RE}			[−.14, .11]/[−.14, .11]	
Q			0.29	
Novelty Experiencing IS				
ρ_{FE}/ρ_{RE}			.17/.17	
k (*N*)			2 (248)	
CI_{FE}/CI_{RE}			[.05, .29]/[.04, .31]	
Q			1.26	
Openness to Experience–Fantasy				
ρ_{FE}/ρ_{RE}	.16/.17	−.02/−.02	.24	
k (*N*)	3 (830)	4 (991)	1 (407)	
CI_{FE}/CI_{RE}	[.09, .22]/[.04, .28]	[−.08, .05]/[−.08, .05]		
Q	4.72	2.83		
Openness to Experience–Aesthetics				
ρ_{FE}/ρ_{RE}	.25/.25	.08/.08	.12	
k (*N*)	5 (2,081)	4 (991)	1 (407)	
CI_{FE}/CI_{RE}	[.21, .29]/[.19, .31]	[.02, .14]/[.02, .14]		
Q	6.99	2.08		
Openness to Experience–Feelings				
ρ_{FE}/ρ_{RE}	.25/.25	.09/.09	.18	
k (*N*)	3 (830)	4 (991)	1 (407)	
CI_{FE}/CI_{RE}	[.19, .31]/[.19, .31]	[.03, .15]/[.01, .16]		
Q	0.15	3.91		
Openness to Experience–Actions				
ρ_{FE}/ρ_{RE}	.05/.09	−.08/−.08	.01	
k (*N*)	3 (830)	4 (991)	1 (407)	
CI_{FE}/CI_{RE}	[−.02, .12]/[−.04, .21]	[−.14, −.02]/[−.16, .01]		
Q	4.84	5.32		
Openness to Experience–Ideas				
ρ_{FE}/ρ_{RE}	.55/.52	.08/.08	.23	
k (*N*)	5 (2,081)	4 (991)	1 (407)	
CI_{FE}/CI_{RE}	[.52, .58]/[.41, .61]	[.01, .14]/[.01, .14]		
Q	33.06*	1.20		
Openness to Experience–Values				
ρ_{FE}/ρ_{RE}	.58/.53	.10/.14	.26	
k (*N*)	5 (2,081)	4 (991)	1 (407)	
CI_{FE}/CI_{RE}	[.55, .61]/[.30, .70]	[.03, .16]/[−.01, .28]		
Q	155.01*	14.73*		
School Success				
ρ_{FE}/ρ_{RE}	.44			
k (*N*)	1 (49)			
CI_{FE}/CI_{RE}				
Q				
Sensation Seeking				
ρ_{FE}/ρ_{RE}	.24		.26/.28	
k (*N*)	1 (691)		4 (369)	
CI_{FE}/CI_{RE}			[.16, .35]/[.10, .43]	
Q			8.63*	

Table 3 (*continued*)

Trait	Gc	AP	CET	K
Sentience				
ρ_{FE}/ρ_{RE}	.03/.04			
k (*N*)	2 (690)			
CI_{FE}/CI_{RE}	[−.05, .10]/[−.16, .24]			
Q	7.39*			
Stimulus Variation Seeking Scale				
ρ_{FE}/ρ_{RE}			.20/.22	
k (*N*)			2 (283)	
CI_{FE}/CI_{RE}			[.09, .31]/[.18, .56]	
Q			11.85*	
Thoughtfulness				
ρ_{FE}/ρ_{RE}	−.06	.20/.22	.29/.26	
k (*N*)	1 (100)	8 (2,059)	4 (1,677)	
CI_{FE}/CI_{RE}		[.16, .24]/[.13, .31]	[.24, .33]/[.04, .45]	
Q		29.58*	55.35*	
Typical Intellectual Engagement				
ρ_{FE}/ρ_{RE}	.37/.38	.28/.29	.21	.38/.38
k (*N*)	7 (1,487)	3 (425)	1 (138)	7 (1,276)
CI_{FE}/CI_{RE}	[.32, .41]/[.29, .46]	[.19, .37]/[.05, .50]		[.33, .43]/[.30, .44]
Q	19.67*	12.62*		12.21
Understanding				
ρ_{FE}/ρ_{RE}	.39/.41			
k (*N*)	3 (729)			
CI_{FE}/CI_{RE}	[.33, .45]/[.19, .58]			
Q	15.16*			

Note. Complexity here is taken from the Jackson Personality Inventory (JPI; Jackson, 1976), not from F. Barron's (1953) measure. Intolerance for Ambiguity also refers to studies of Tolerance for Ambiguity (MacDonald, 1970); corresponding coefficients were reversed in sign. Empty cells mark associations that were not empirically reported on in the literature. ρ_{FE}/ρ_{RE} refers the meta-analytic coefficient corrected for sampling and measurement error in fixed- and random-effects models, except for cases in which only one coefficient was identified for a given association. In those cases, the one study's coefficient was corrected for measurement error. *k* refers to the number of studies, with the overall sample size in parentheses. CI_{FE}/CI_{RE} refers to confidence intervals of 95% in fixed- and random-effects models, respectively. *Q* is the *Q* statistic value. Gc = crystallized intelligence; AP = academic performance; CET = college entry tests; K = knowledge tests; CCTDI = California Critical Thinking Disposition Inventory; EC = External Cognitive; IC = Internal Cognitive; ES = External Sensation; IS = Internal Sensation.

[a] Studies included under curiosity all employed self-report measures that emphasized exploration and absorption. The studies included were Day and Langevin (1969) and Poortinga and Foden (1975) for GC; Fulcher (2004) for CET; Kashdan and Yuen (2007) for AP.

* $p < .05$.

difficult to interpret the current results, we focus our discussion on the four investment traits that have been most frequently studied with regard to adult intellect, that is, Intolerance for Ambiguity[5] (e.g., Frenkel-Brunswik, 1949), Intellectual Efficiency (Gough, 1953), Need for Cognition (Cacioppo & Petty, 1982), and Typical Intellectual Engagement (Goff & Ackerman, 1992). Their meta-analytic associations with crystallized intelligence ranged from .28 to .42, for academic performance from .13 to .29, and for college entry tests from .26 to .33. For knowledge, a sufficient number of studies reporting associations were only published for Typical Intellectual Engagement with an overall estimate of .38. These results suggest that investment traits and adult intellect markers have a sizable, positive relationship. That said, adult intellect is likely to be affected by a number of determinants, such as general ability, motivation, and effort. Also, contextual factors—such as school quality, discrimination, and stereotype threat—may play an important role when interpreting the current findings with regard to the nature of adult intellect. Therefore, although the estimated effects of individual differences in investment on adult intellect appear modest on a first look, they may be considered quite substantial when reflecting on other determinants of adult intellect.

In summary, our findings lead to three main conclusions: (a) investment personality traits are significantly positively associated with markers of adult intelligence; (b) associations of investment traits and intellect indictors differ in strength but not in direction; and (c) investment traits are conceptually diverse and multifaceted.

Limitations

The first limitation refers to the question whether the observed relationship between investment and intellect is merely a by-product of general intelligence. It is possible that intelligent behaviors, such as reading, attending cultural events, and practicing one's cognitive ability, are consequences of being intelligent rather than of an investment personality trait (Gow et al., 2005). Our analysis does not allow for conclusions about the extent to which intelligence may explain the association between investment traits and intellect markers. Although meta-analytic studies, like the current one, have inadequate designs to control for confounding variables (especially when the number of relevant articles is as small as here), several empirical studies have demonstrated independence of effects of investment and intelligence intellect or markers thereof (e.g., Ackerman et al., 1995; Chamorro-Premuzic, Furnham, & Ackerman, 2006a; Chamorro-Premuzic et al., 2006b; Goff & Ackerman, 1992). In addition, von Stumm, Hell, and Chamorro-Premuzic (2011) recently demonstrated the importance

[5] Intolerance for Ambiguity is here treated as Tolerance for Ambiguity.

of investment for academic performance, based on a large-scale literature review. Testing a series of structural equation models based on a meta-analytic correlation matrix derived from 200 studies with more than 50,000 participants, they reported that intelligence and investment were positively but modestly correlated predictors of academic achievement, and after controlling for their interrelation, investment sustained a significant direct effect. Other studies suggest that this observation also holds true for crystallized intelligence, college entry tests, and knowledge (e.g., Goff & Ackerman, 1992; Rolfhus & Ackerman, 1999). Even though the current review does not lend itself to explore the confounding effect of intelligence for investment–intellect associations, our results are consistent with previous findings. We do not mean to say that general intelligence and intellectual curiosity are completely independent; by contrast, we suspect that they develop and operate in relation to one another. However, most research on investment theories (including ours) is cross-sectional, and therefore, ideas about longitudinal developments remain speculative.

A second limitation refers to the included markers of intellect that spanned crystallized intelligence, academic performance, college entry tests, and knowledge measures but omitted others, such as professional performance and occupational and avocational knowledge (see Ackerman, 1996, 2000; Cattell, 1943). However, we concluded that extending the selection of markers of adult intellect even further was not going to meaningfully substantiate the current findings because of a general scarcity of studies that explore investment traits.

A third limitation is the observed heterogeneity between studies, which principally warrants a cautious interpretation of the current findings. One reason for the observed heterogeneity may be that some investment traits have been assessed by different scales with different foci despite supposedly assessing the same trait dimension. For example, three psychometric instruments assessed Intolerance for Ambiguity, including Brengelmann and Brengelmann's (1960), Budner's (1962), and MacDonald's (1970) scales, although the construct was originally introduced and defined by Frenkel-Brunswik (1949). Brengelmann and Brengelmann's measure is rather distinct from Budner's and MacDonald's with regard to the scale items and content. In turn, Budner and MacDonald included very similar items in their Intolerance for Ambiguity scales. That is, Budner and MacDonald addressed individual differences in black-and-white perspectives, discomfort in social situations with strangers, preference for universal rules and regulations, and pleasure in cognitively exploring ideas. By contrast, Brengelmann and Brengelmann's measure resembles more a conservative values scale with items referring to respect for the elderly, gender equality, and the uncertainty of modern times. To date, no study has investigated the empirical overlap of these three measures,[6] and therefore the extent of their divergence remains unknown.

Alternatively, the observed between-studies heterogeneity may have resulted from systematic differences between studies. Potential moderating variables include sex, sample type, degree level, and date of publication. However, the scarcity of studies that reported investment–intellect associations, as well as incomplete sample and study descriptions, provided a small number of data points upon which no meaningful moderator analysis could be conducted.

Finally, the current meta-analysis did not correct for range restriction, which is likely to affect the intellect markers rather than investment trait scales. Although no previous study has addressed this issue in particular, investment trait scales typically show stable standard deviations across student and adult samples of mixed ages and origins and have no floor or ceiling effects. Thus, it is possible that the derived meta-analytic coefficients are somewhat underestimated because of range restriction; such effects appear to apply to the intellect markers rather than the investment measures.

Implications and Future Directions

Several large-scale longitudinal studies have been dedicated to understanding and exploring individual differences in cognitive development across adulthood and the life span (e.g., Bayley, 1955; Schaie, 2005; Terman & Oden, 1959). However, they tended to focus on age-related changes in cognitive performance but did not address influences from personality traits (see Salthouse, 1991, for a review). Thus, the relationship between personality (i.e., investment traits) and intelligence (i.e., adult intellect) to date has been mostly explored in cross-sectional studies. The few exceptions to this have employed highly selected samples, such as very old populations (Gow et al., 2005; von Stumm & Deary, 2012).

Because intelligence–personality associations are likely to have complex relationships, the previous correlational evidence may be suggestive, rather than definitive (von Stumm, Chamorro-Premuzic, & Ackerman, 2011). In particular, the interplay of intelligence and personality must be studied with longitudinal research designs that include a wide range of psychological, social, and demographic variables, to disentangle interaction, mediation, and moderation mechanisms in trajectories of cognitive development (Bayley, 1955; Schaie, 2005). Presumably because of the historical premises of intelligence research (i.e., the innateness and life-span stability of cognitive ability), contemporary study efforts mostly focus on the identification of biological and genetic underpinnings of individual differences in intelligence (e.g., Plomin et al., 2008). Even so, intelligence and, for that matter, any other psychological traits are influenced by environmental factors, and they are more or less malleable across the life span—more so at younger ages, and less so in adolescence and beyond (Nisbett et al., 2012).

Akin to the idea that intelligence follows a life-span developmental process and is subject to change, investment-related behaviors and attitudes are likely to develop and change. That is, they may be susceptible to encouragement and stimulation. Although there is no doubt that genetic factors partly explain variances in the tendency to engage in and seek effortful cognitive activity, the expression of such biological differences in investment—just like those in intelligence—is likely to depend greatly on the given environmental provisions (Hayes, 1962; Nisbett et al., 2012; Plomin et al., 2008; Scarr, 1996). For example, a tree might have the genes to grow 100 m high, but if it does not get enough sunshine and water, it will only grow half the way. Similarly, a boy with the genetic potential to come first in a spelling competition may fall short of such an accomplishment if he is raised in a household

[6] Furnham (1994) studied correlations of four Intolerance for Ambiguity measures, but only one of them—Budner's (1962) scale—was also relevant to the current meta-analysis.

without books. Obviously, these are extreme examples of environmental deprivation, and the degree to which environmental provision differs between families is debatable (especially in Western society; cf. Scarr, 1996). However, a series of recent studies suggested that comparable mechanisms apply to intellectual development in children and adolescents; that is, families vary with regard to the amount and quality of learning opportunities they offer and, hence, in the extent to which children have chances to actually invest (Nisbett et al., 2012; Tucker-Drob & Harden, 2011). For example, children who are offered a diverse range of engagement opportunities (e.g., piano lessons, reading clubs, museum visits) tend to grow intellectually because of the experience and simultaneously to develop an appetite for more (e.g., B. Barron, Martin, Takeuchi, & Fithian, 2009). Such children are more likely to establish a competence in exploration and curiosity. Here the disposition to seek out and engage in effortful cognitive activities becomes a force of intellectual maturity itself that continues to benefit cognitive growth, even long after stopping to play the piano (as most people do). As outlined before, investment traits represent a tendency to engage, but such traits do not suggest a prescribed set of investment behaviors, like going to the theater or attending evening classes. In line with this, future (longitudinal) research must focus on the nature and malleability of investment trait dispositions and behaviors, as well as their relative contributions to intellectual development and growth across the life span.

Conclusions

This review article sought to quantify the extent to which personality traits, in particular investment traits, are associated with adult intellect. The results suggested that although several investment trait constructs exist in the psychological literature, their associations with indicators of intellect have not been a core research interest to date. The strength of association varied markedly across investment trait scales and indicators of intellect. However, overall, investment traits were found to be positively and moderately associated with markers of adult intellect at about .30. Combining our current and other research findings, it appears as if investment comprised a crucial, presently overlooked factor in life-span cognitive development.

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(*Appendices follow*)

Appendix A

Investment Trait Categories

Investment
Need for Cognition
Typical Intellectual Engagement
Intellectual Curiosity
Analytical Cluster
Inquiring Intellect
Understanding
Love of Truth
Epistemic Curiosity
Academic Curiosity
Need for Cognition (Cohen)
School Success
Novelty Experiencing–External Cognitive
Intellect
Intellectance
Intellectual Efficiency
Intellectual Disposition
Openness—Ideas
Abstract Thinking
Intellectence
California Critical Thinking
Liking for thinking
Thoughtfulness
Thinking Introversion–Extraversion
Information needs
Intellectual Disposition
Novelty Experiencing–Internal Cognitive
Novelty Sensation Seeking
Novelty Seeking
Novelty Experiencing–External Sensation
Sensation Seeking
Stimulus Variation Seeking Scale
Openness–Actions
Openness
Sentience
Perceptual Curiosity
Mindfulness
Openness–Feelings, Aesthetics
Ambiguity
Intolerance for Ambiguity
Need for Closure
Complexity (R)
Openness–Values
Absorption
Absorption
Novelty Experiencing–Internal Sensation
Openness–Fantasy
Social Curiosity
Social Curiosity

Note. R = reversed.

(*Appendices continue*)

Appendix B

Studies Reporting Bivariate Associations Between Investment Traits and Indicators of Adult Intellect

Author	*N*	Type	Outcome	*R*
Absorption				
Ackerman (2000)	228	G	Gc	.05
	228	G	K	.02
Hunt et al. (1993)	25	S	College vocabulary test	.08
McGregor & Elliot (2002)	174	S	SAT	−.03
Rader & Tellegen (1987)	170	S	Mill Hill vocabulary test	−.01
	204	S	Mill Hill vocabulary test	.05
Schaufeli et al. (2002)	623	S	Exam ratio	.16
	727	S	Exam ratio	.09
	311	S	Exam ratio	.08
Academic Curiosity				
Vidler & Rawan (1974)	170	S	Verbal ability	.36
Vidler & Rawan (1975)	314	S	Course grades	.16
Vidler (1980)	121	S	Course grades	.27
Analytic Cluster				
Breadth of Interest				
Harris (2004)	405	S	Information	.16
Complexity				
Harris (2004)	405	S	Information	.22
Innovation				
Harris (2004)	405	S	Information	.19
California Critical Thinking Disposition Inventory				
Nelson (2008)	320	S	GPA	.03
Broadbear et al. (2005)	283	S	ACT	.12
	144	S	ACT	.06
Elam (2001)	189	S	CET	.08
McDade (2000)	132	S	GPA	−.01
Curiosity				
Fulcher (2004)	954	S	SAT	.05
Day & Langevin (1969)	75	S	Verbal ability	.33
Poortinga & Foden (1975)	50	S	Verbal ability	−.19
	47	S	Verbal ability	.06
Kashdan & Yuen (2007)	484	S	Exams	.33
Intellectance				
Hogan & Hogan (1992)	49	G	Reading comprehension	.24
Intellectual Efficiency				
Gough & Weiss (1981)	90	G	General vocabulary test	.60
Griffin & Flaherty (1964)	154	S	Quality point ratio	.26
Martin et al. (1981)	39	S	Shipley vocabulary test	.50
Pfeifer & Sedlacek (1974)	79	S	GPA	.28
	193	S	GPA	.23
Shealy (1978)	102	G	WAIS Verbal	.42
Sirigatti et al. (1992)	98	S	GPA	.43
Durtow & Houston (1981)	172	M	GPA	.11
Gough & Hall (1964)	34	S	GPA	.40
Rosenberg et al. (1962)	98	S	GPA	.37
	64	S	GPA	.31
J. D. Evans (1969)	51	S	GPA	.01
	51	S	GPA	.03
	51	S	SAT	.31
	51	S	SAT	.32

(*Appendices continue*)

Appendix B (*continued*)

Author	*N*	Type	Outcome	*R*
Gough (1953)	40	S	Miller's Analogies	.42
Gough (1987)	99	S	GPA	.32
	99	S	GPA	.20
	995	S	GPA	.16
	441	S	GPA	.17
	735	S	College vocabulary test	.28
	452	S	College vocabulary test	.22
	608	n/k	Miller's Analogies	.11
	379	n/k	Miller's Analogies	.25
	158	n/k	WAIS Verbal	.36
	27	n/k	WAIS Verbal	.34
	99	S	SAT	.25
	99	S	SAT	.19
Gandhi (2002)	808	S	ACT	.30
Himaya (1973)	471	S	ACT	.16
Watkins & Astilla (1981)	1,149	S	GPA	.14
Stroup & Eft (1969)	968	S	GPA	.18
	970	S	GPA	.19
Demos & Weijola (1966)	42	S	GPA	−.05
	44	S	GPA	.21
Gough (1957)	100	G	Wesman Personal Classification	.46
Gowan (1960)	415	S	ACE	.30
Intellectual Disposition				
Eno (1978)	80	S	Lorge–Thorndike Verbal	.25
Elton & Rose (1970)	118	S	ACT	.07
	137	S	ACT	.18
	35	S	ACT	.39
	111	S	ACT	.22
	85	S	ACT	.38
	44	S	ACT	−.33
Weissman (1970)	72	S	College vocabulary test	.40
	72	S	SAT	.30
	72	S	GPA	.36
Intolerance for Ambiguity				
Angleitner (1973)	196	G	WAIS Verbal	−.50
	197	G	WAIS Verbal	−.44
Blanchard-Fields et al. (2001)	96	S	Shipley vocabulary test	−.34
	219	G	Shipley vocabulary test	−.32
Ladd (1967)	54	S	ACT	−.20
Leoke & Dalton (1988)	87	S	Course grades	−.29
Sypher & Applegate (1982)	285	S	WAIS Verbal	−.28
	285	S	ACT	−.28
Feather (1967)	53	S	Verbal ability	−.08
	31	S	Verbal ability	−.43
Seitz (1971)	47	S	Watson–Glaser	.03
	45	S	Watson–Glaser	−.02
Taube (1995)[a]	137	S	SAT	−.22
	137	S	Watson–Glaser	−.07
	137	S	GPA	−.00
Need for Cognition				
Blanchard-Fields et al. (2001)	96	S	Shipley vocabulary test	.35
	219	G	Shipley vocabulary test	.27
Bors et al. (2006)	453	S	Course grades	.16
	650	S	Mill Hill vocabulary test	.23
Gough & Weiss (1981)	650	S	Course grades	.13
Cacioppo & Petty (1982)	104	S	ACT	.39
Cacioppo et al. (1986)	185	S	Shipley vocabulary test	.32
Cacioppo et al. (1983)[b]	>100	S	Shipley vocabulary test	.15
Morris et al. (1982)[b]	>100	S	Shipley vocabulary test	.21
Chang & McDaniel (1995)	32	S	SAT	.31

(*Appendices continue*)

Appendix B (*continued*)

Author	*N*	Type	Outcome	*R*
Crowson (2003)	180	S	ACT	.25
Elias & Loomis (2002)	135	S	GPA	.31
Fletcher et al. (1986)	81	S	ACT	.20
Hambrick et al. (2008)	579	S	Shipley vocabulary test	.30
	579	S	ACT	.26
Jensen (1998)	81	S	CET	.19
Kardash & Noel (2000)	83	S	Vocabulary test	.48
Kardash & Scholes (1996)	68	S	Vocabulary test	.06
McCutcheon et al. (2003)	102	S	Information	.28
Olson et al. (1984)	88	S	ACT	.31
Wolfe & Grosch (1992)	162	S	SAT	.22
	193	S	SAT	.10
Sadowski & Gülgöz (1992)	51	S	Project grade	.24
Sadowski & Gülgöz (1996)	51	S	Course grades	.28
Stuart-Hamilton & McDonald (2001)	40	O	Mill Hill vocabulary test	.06
Taube (1995)	137	S	SAT	.26
	137	S	Watson–Glaser	.15
	137	S	GPA	.30
Tidwell et al. (2000)	220	S	Shipley vocabulary test	.33
Tolentino et al. (1990)	57	S	GPA	.34
Waters & Zakrajsek (1990)	207	S	ACT	.18
	207	S	GPA	.21
Wang & Newlin (2000)	28	S	Course grades	.48
Dollinger & McMorrow (1992)	46	S	ACT	.11
Woo et al. (2007)	81	S	K	.29
Epstein et al. (1996)	853	S	GPA	.13
Heijne-Penninga et al. (2010)	239	S	Course grades	.20
Ku & Ho (2010)	137	S	WAIS Verbal	.13
	137	S	GPA	.11
Mussel (2010)	191	G	Gc composite	.07
West et al. (2008)	793	S	SAT	.24
Soubelet & Salthouse (2010)	2,257	G	Gc composite	.33
Novelty Experiencing				
External Cognitive				
Waters (1974)	137	S	SAT	−.04
	111	S	SAT	.02
Internal Cognitive				
Waters (1974)	137	S	SAT	.09
	111	S	SAT	.21
External Sensation				
Waters (1974)	137	S	SAT	.01
	111	S	SAT	.18
Internal Sensation				
Waters (1974)	137	S	SAT	.13
	111	S	SAT	.29
Need for Closure				
Crowson (2003)	282	S	ACT	−.04
Blanchard-Fields et al. (2001)	96	S	Shipley vocabulary test	−.10
	219	G	Shipley vocabulary test	−.11
Openness to Experience				
Fantasy				
Noftle & Robins (2007)	256	S	GPA	.05
	414	S	GPA	−.04
	407	S	SAT	.24
Wainwright et al. (2008)	556	T	Verbal Ability	.11
Saggino & Balsamo (2003)	100	O	WAIS Verbal	.05
Chamorro-Premuzic & Furnham (2003)	247	S	Exams	−.05
Detrick et al. (2004)	74	S	Class average	.05
DeYoung et al. (2005)	174	S	Gc composite	.24
Aesthetics				
Noftle & Robins (2007)	256	S	GPA	.10
	414	S	GPA	.08

(*Appendices continue*)

Appendix B (*continued*)

Author	*N*	Type	Outcome	*R*
	407	S	SAT	.12
Wainwright et al. (2008)	556	T	Verbal Ability	.16
Saggino & Balsamo (2003)	100	O	WAIS Verbal	.20
Chamorro-Premuzic & Furnham (2003)	247	S	Exams	.06
Detrick et al. (2004)	74	S	Class average	−.06
DeYoung et al. (2005)	174	S	Gc composite	.28
Zimprich et al. (2009)	679	G	Gc composite	.18
	572	O	Gc composite	.26
Feelings				
Noftle & Robins (2007)	256	S	GPA	.12
	414	S	GPA	.10
	407	S	SAT	.18
Wainwright et al. (2008)	556	T	Verbal Ability	.20
Saggino & Balsamo (2003)	100	O	WAIS Verbal	.19
Chamorro-Premuzic & Furnham (2003)	247	S	Exams	.01
Detrick et al. (2004)	74	S	Class average	−.02
DeYoung et al. (2005)	174	S	Gc composite	.18
Actions				
Noftle & Robins (2007)	256	S	GPA	−.04
	414	S	GPA	−.10
	407	S	SAT	.01
Wainwright et al. (2008)	556	T	Verbal Ability	0
Saggino & Balsamo (2003)	100	O	WAIS Verbal	.09
Chamorro-Premuzic & Furnham (2003)	247	S	Exams	.02
Detrick et al. (2004)	74	S	Class average	−.13
DeYoung et al. (2005)	174	S	Gc composite	.13
Ideas				
Noftle & Robins (2007)	256	S	GPA	.09
	414	S	GPA	.07
	407	S	SAT	.23
Wainwright et al. (2008)	556	T	Verbal Ability	.40
Saggino & Balsamo (2003)	100	O	WAIS Verbal	.41
Chamorro-Premuzic & Furnham (2003)	247	S	Exams	.02
Detrick et al. (2004)	74	S	Class average	.04
DeYoung et al. (2005)	174	S	Gc composite	.29
Zimprich et al. (2009)	679	G	Gc composite	.50
	572	O	Gc composite	.54
Values				
Noftle & Robins (2007)	256	S	GPA	.17
	414	S	GPA	.02
	407	S	SAT	.26
Wainwright et al. (2008)	552	T	Verbal Ability	.26
Saggino & Balsamo (2003)	100	O	WAIS Verbal	.39
Chamorro-Premuzic & Furnham (2003)	247	S	Exams	−.01
Detrick et al. (2004)	74	S	Class average	.29
DeYoung et al. (2005)	174	S	Gc composite	.24
Zimprich et al. (2009)	679	G	Gc composite	.60
	572	O	Gc composite	.49
School Success				
Hogan & Hogan (1992)	49	G	Reading comprehension	.44
Sensation Seeking				
Ripa et al. (2001)	691	G	WAIS Verbal	.24
Kish & Donnenwerth (1972)	64	S	ACT	.43
	57	S	ACT	.11
Waters (1974)	137	S	SAT	.17
	111	S	SAT	.16
Sentience				
Harris (2004)	405	S	Information	−.05
Harris et al. (1998)	285	G	Verbal ability	.12

(*Appendices continue*)

Appendix B (*continued*)

Author	*N*	Type	Outcome	*R*
Understanding				
Lukey & Baruss (2005)	39	S	Verbal ability	.35
Harris (2004)	405	S	Information	.25
Harris et al. (1998)	285	G	Verbal ability	.44
Stimulus Variation Seeking				
Penney & Reinher (1966)	155	S	CET	.02
	128	S	CET	.36
Thoughtfulness				
Watley (1964)	114	S	GPA	.25
	158	S	GPA	.37
	63	S	GPA	.22
Wagner & Sober (1964)	776	S	CET	.22
	776	S	GPA	.16
Grimsley & Jarrett (1973)	100	G	Verbal ability	−.06
Bendig & Sprague (1954)	155	S	Course grades	−.02
Long (1964)	416	S	College quality point average	.12
	416	S	SCAT	.45
Watley & Merwin (1964)	148	S	SAT	.05
	148	S	GPA	.33
Witherspoon & Melberg (1959)	229	S	GPA	.10
Gowan (1960)	337	S	ACE	.12
Typical Intellectual Engagement				
Ackerman (2000)	228	G	Gc	.29
	228	G	K	.22
Ackerman et al. (2001)	320	S	Gc	.42
	320	S	K	.4
Ackerman et al. (1995)	93	S	Verbal ability	.49
Beier & Ackerman (2001)	153	G	Gc	.42
Chamorro-Premuzic et al. (2006a)	201	S	K	.36
Chamorro-Premuzic et al. (2006b)	104	S	Course grades	.36
Dellenbach & Zimprich (2008)	364	O	Vocabulary test	.27
Furnham et al. (2008)	101	S	K	.22
Goff & Ackerman (1992)	138	S	Gc	.22
	138	S	ACT	.20
	138	S	GPA	.04
Rolfhus & Ackerman (1999)	202	S	K	.37
Rolfhus & Ackerman (1996)	143	S	K	.25
Woo et al. (2007)	81	S	K	.45
Wilhelm et al. (2003)[c]	183	S	GPA	−.32
Mussel (2010)	191	G	Gc	.20

Note. *N* refers to the number of subjects included in each correlation computation; Type refers to the sample type (G = general adult population; S = students; M = mixed sample; O = older adults; T = twins; n/k = not known); *R* refers to the uncorrected correlation coefficient reported in the respective study. Gc = crystallized intelligence; K = knowledge; SAT = Scholastic Aptitude Test; GPA = grade point average; ACT = American College Test; CET = college entry test; WAIS = Wechsler Adult Intelligence Scale; ACE = American Council on Education Psychological Examination; SCAT = School and College Ability Test.

[a] In this study, the Ambiguity Tolerance Scale (MacDonald, 1970) was used, and thus correlations were reversed. [b] Sample sizes were described as at least 100 participants; for both studies, we determined the sample size to be 100. [c] In the German education system, lower numbers represent better grades; the sign of the coefficient, which was calculated from the mean of humanities and science school GPA, was therefore reversed.

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