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Interests and intelligence: A meta-analysis

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ABSTRACT

The purpose of this article is to examine the nature and magnitude of the relationship between cognitive abilities and vocational interests — two important measures of individual differences. Our meta-analysis of 27 studies with 29 independent samples and an overall sample size of 55,297 participants demonstrated meaningful relations between cognitive abilities and vocational interests. Meta-analytic coefficients ranged from −0.29 to 0.47; their strength and direction were comparable for females and males. Furthermore, we established both age and birth cohort as moderators of the relation between interests and cognitive abilities. Limitations and implications for future research are discussed.

1. Introduction

Vocational interests are established predictors of educational choice (Hansen & Neuman, 1999), degree completion (Webb, Lubinski, & Benbow, 2002), occupational choice (Hansen & Dik, 2005), and occupational satisfaction (Tsabari, Tziner, & Meir, 2005). Their importance in personnel selection and their relevance for understanding performance has often been questioned in past research (Barrick & Mount, 2005; Hunter & Hunter, 1984). However, recent meta-analyses (Nye, Su, Rounds, & Drasgow, 2012; Van Iddekinge, Roth, Putka, & Lanivich, 2011) called for a reconsideration of interests for predicting performance-relevant criteria. Van Iddekinge, Roth, et al. (2011) demonstrated the importance of interests for predicting job and training performances as well as turnover. Nye et al. (2012) showed that interests are related to performance and tenure not only in work but also in academic contexts. In addition, prediction of performance was strongest when academic or work environment matched individuals' interests. Thus, these meta-analyses provide critical evidence for the predictive validity of interests for performance criteria in both work and academic settings.

This renewed attention to vocational interests also raises the question of how vocational interests relate to established predictors of job performance (i.e., cognitive abilities and personality). Whereas the relation between interests and personality received considerable attention in both personnel selection and vocational choice literature (Barrick, Mount, & Gupta, 2003; Larson, Rottinghaus, & Borgen, 2002; Staggs, Larson, & Borgen, 2007), no comprehensive quantitative summary has thus far been conducted to analyze the relationship between vocational interests and cognitive abilities. Therefore, the main purpose of this study is to address this gap and systematically examine the nature and magnitude of the relation between these two constructs.

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2. Vocational interests

According to Lowman (2010), interests can be defined as "relatively stable psychological characteristics of people [that] identify the personal evaluation … attached to particular groups of occupational or leisure activity clusters" (p. 477). Holland's (1959, 1997) theory of vocational interests and career choices is the most prevalent taxonomy of vocational interests and has received robust empirical support. Holland supposed that individuals seek and enter environments that allow them to express their interests and values and exercise their abilities and skills. Satisfaction with educational and occupational choices as well as performance and persistence is determined by the degree of fit between an individual's interest type and environmental requirements. Holland's theory assumes that most individuals and environments can be categorized into one of six types: Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising (E), and Conventional (C), collectively referred to as RIASEC. Each type can be distinguished by specific interests, abilities, competencies, values, and life goals. According to Holland, the Realistic type prefers activities that involve working with tools, machines, or outdoor; the Investigative type shows a preference for sciences; the Artistic type is interested in the creative expression of ideas through writing or visual and performing arts; the Social type prefers working with people; the Enterprising type is interested in leading and persuading others; and the Conventional type prefers activities that involve dealing with structured data. Holland's assumptions have been widely validated (e.g., in a meta-analysis by Tracey & Rounds, 1993) and are generalizable across gender (Darcy & Tracey, 2007), age (Darcy & Tracey, 2007), and culture (e.g., Darcy, 2005; Nagy, Trautwein, & Lüdtke, 2010). Given its wide proliferation and profound empirical support, we referred to Holland's RIASEC framework to examine vocational interests.

3. Cognitive abilities

The nature and structure of cognitive abilities were highly debated in the last century. In 1994, a group of experts in the field of cognitive ability research and related disciplines consented on the following definition of intelligence:

> "Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test taking smarts. Rather it reflects a broader and deeper capability for comprehending our surroundings — 'catching on', 'making sense' of things, or 'figuring out' what to do" (Gottfredson, 1997, p. 13).

Furthermore, in the last decades, an understanding has emerged that cognitive abilities are organized hierarchically with a general factor, labeled *g* or intelligence or general mental ability (GMA), and a series of specific or primary cognitive abilities that are moderately correlated with the general factor (Carroll, 1993). Measures of general intelligence are effective predictors of job and academic performance (Kuncel, Hezlett, & Ones, 2004; Schmidt & Hunter, 2004). Specific abilities such as verbal, quantitative, and spatial abilities possess psychological importance beyond *g*, especially for predicting educational and vocational choices (Achter, Lubinski, Benbow, & Eftekhari-Sanjani, 1999; Humphreys, Lubinski, & Yao, 1993). The Cattell–Horn–Carroll (CHC) theory of cognitive abilities is viewed as an influential contemporary theory of cognitive abilities (Flanagan & Dixon, 2013; Schneider & McGrew, 2012). By merging Horn–Cattell's extended *Gf*–*Gc* theory (Horn & Noll, 1997) – on fluid (*Gf*) and crystallized intelligence (*Gc*) – with Carroll's three-stratum theory (Carroll, 1993), CHC theory is effectively an amalgam of more than 60 years of factor-analytical research in the domain of cognitive abilities. In accordance with Carroll's three-stratum theory, CHC theory assumes a hierarchical model of cognitive abilities with three strata: General intelligence (*g*) is located at the apex (Stratum III), 16 broad cognitive abilities (e.g., fluid reasoning, visual processing, psychomotor abilities) are located at Stratum II, and more than 80 narrow abilities (e.g., perceptual speed, working memory capacity) at Stratum I (see Schneider & McGrew, 2012, for detailed descriptions of broad and narrow abilities).

According to Carroll (1993), broad abilities represent "characteristics of individuals that govern and influence a great variety of behaviors in a given domain," whereas narrow abilities represent "specializations of abilities … that reflect the effects of experience and learning, or the adoption of particular strategies to perform" (p. 634). Recent studies highlight the invariance of CHC broad ability factors across different intelligence batteries (Reynolds, Vannest, & Fletcher-Janzen, 2013) and its usefulness as a framework for classifying intelligence and achievement batteries (Flanagan, Alfonso, & Ortiz, 2012). Moreover, the CHC model is perceived as the most empirically supported and theoretically sound model of the structure of human cognitive abilities (Alfonso, Flanagan, & Radwan, 2005; Stankov, 2000), thus emphasizing the CHC model's advantage as a classification system for meta-analyses.

4. Relations between interests and cognitive abilities

Interests are perceived as antecedents of performance. In his investment theory, Cattell (1971, 1987) assumed that individuals differ in their initial level of fluid intelligence that is genetically- and neurophysiologically-based. Hence, fluid intelligence is the main determinant of performance in infancy. Across the lifespan, individuals invest their fluid intelligence in the development of skills and acquisition of knowledge (i.e., crystallized intelligence). According to Cattell, this development is not only driven by availability and quality of education, family resources, effort, motivation, and ambition but also by an individual's interests. Or as Strong (1943) suggested, "the relationship among abilities, interests, and achievement may be linked to a motor boat with a motor and a rudder. The motor (abilities) determines how fast the boat can go, the rudder (interests) determines which way the boat goes" (p. 17). Thus, whereas cognitive abilities predict performance because they determine what individuals "can do," interests direct where one's intellectual potential is invested. In line with Cattell (1971, 1987), Ackerman (1996) proposed in his process, personality, interests, and knowledge (PPIK) theory that the development of intelligence (i.e., the transition from intelligence-as-process to intelligence-as-knowledge) is guided by motivation, personality, and also interests. Further, intelligence-as-knowledge is thought to form the core of adult intelligence.

In his integrative theoretical model of individual differences, Schmidt (2014) highlighted that both general interests, such as typical intellectual engagement (TIE), and specific interests, such as Holland's occupational interests, should predict academic and occupational performance by guiding the development of crystallized intelligence (i.e., general and specific knowledge and skills). Recent empirical findings support these assumptions. In their meta-analysis, both Van Iddekinge, Roth, et al. (2011) and Nye et al. (2012) demonstrated that specific interests predict academic and occupational performance. Furthermore, recent research showed that various investment traits such as TIE or need for cognition positively correlate with crystallized intelligence, academic performance, and acquired knowledge (von Stumm & Ackerman, 2013; von Stumm, Hell & Chamorro-Premuzic, 2011). However, the relation between what Schmidt (2014) defined as specific interests and both fluid and crystallized intelligence should be investigated more closely.

Despite some efforts to consider the relationship between intelligence and vocational interests (e.g., Carson, 1998a; Lowman & Leeman, 1988; Proyer, 2006; Randahl, 1991), most studies addressed the issue from the perspective of self-estimated abilities. However, self-ratings of abilities are susceptible to self-presentational biases and are only moderately correlated with objectively assessed or measured cognitive abilities (Zell & Krizan, 2014). Furthermore, the reported overlap between interests and self-estimated abilities may partly be explained by common-method variance (Lowman & Carson, 2013). In their meta-analysis, Ackerman and Heggestad (1997) focused on the overlap between cognitive abilities, vocational interests, and personality. Due to the small number of studies that reported correlations between vocational interests and cognitive ability measures, Ackerman and Heggestad had to rely on a qualitative review. Summarizing patterns in interest–ability correlations from five studies, they concluded that there are only moderate correlations between specific cognitive abilities and vocational interests.

5. Expected relations between Holland's occupational themes and cognitive abilities

5.1. Holland's RIASEC types and general intelligence (g)

Although Holland (1973) proposed that different occupational types have developed a characteristic repertoire of skills, competencies, and abilities, there are relatively few references on the precise relationship between vocational interests and cognitive abilities in his work. However, some additional indications can be drawn from Holland's (1959) earlier work where the six occupational types were still labeled motoric, intellectual, esthetic, supportive, persuasive, and conforming. For example, Holland (1959) described persons with an intellectual orientation as "task-oriented people who generally prefer to 'think through', rather than to 'act out', problems. They have marked needs to organize and understand the world." (p. 36). Later Holland (1973, 1985) referred to the Investigative type as scholarly and intellectual and proposed that the Investigative type has higher levels of general intelligence than the Realistic and Artistic types. Contrary, persons with a supportive orientation are assumed to "avoid situations requiring intellectual problem solving" (Holland, 1959, p. 37).

In his interdomain career assessment model, Lowman (1991) made a first attempt to systematically review the relationship between interest themes and cognitive abilities. Lowman related high levels of intelligence with the Investigative type, moderate levels of intelligence with the Social and Enterprising types, and low to average intelligence levels with the Realistic and Conventional types. Empirically, there is strong evidence for a positive relation between Investigative interests and *g* (Carson, 1998a; Proyer, 2006; Reeve & Heggestad, 2004). Additionally, analyses of occupational data showed that investigative occupations require the highest level of *g* (Gottfredson, 1986). Empirical evidence further points to a positive correlation between Artistic interests and *g* (Carson, 1998a; Proyer, 2006; Reeve & Heggestad, 2004). Unfortunately, evidence from past research is less definite regarding the relation between *g* and Realistic, Social, Enterprising, and Conventional interests. In line with Holland's (1959, 1973, 1985) assumptions, we proposed that Investigative interests will be positively related to *g* (Hypothesis 1a) and that the relation between Investigative interests and *g* will be stronger than the relationship with any other interest type (Hypothesis 1b).

6. Holland's RIASEC themes and specific cognitive abilities

Holland (1959, 1973) proposed that each RIASEC type is characterized not only by specific interests but also by specific abilities and competencies. Holland assumed persons with a motoric orientation to "enjoy activities requiring physical strength, aggressive action, motor coordination and skill" (Holland 1959, p. 36), and further related the Realistic type with mechanical abilities and a lack of social skills. According to Lowman's (1991) review, Realistic interests should further be positively related to spatial abilities, and negatively related to verbal abilities. Furthermore, Ackerman and Heggestad (1997) concluded that positive relations tend to be found between Realistic interests and spatial, mathematical, and mechanical abilities. Recent research supports the positive correlation between Realistic interests and spatial abilities (Carson, 1998b; Proyer, 2006) as well as mathematical abilities (Carson, 1998b). Based on Holland's (1959, 1973) assumptions, we hypothesized that Realistic interests are positively related to mechanical abilities (Hypothesis 2a) as well as motor coordination (Hypothesis 2b).

Investigative interests were found to have positive correlations with spatial, mathematical, and also verbal abilities (Ackerman & Heggestad, 1997); assumptions supported by recent research (Carson, 1998b; Proyer, 2006). Furthermore, Lowman (1991) proposed that Investigative interests are associated with high levels of reasoning and convergent thinking. Holland (1959, 1973) associated the Investigative type with mathematical and scientific abilities but also a lack of leadership abilities. Therefore, we hypothesized that Investigative interests are positively related to numerical abilities (Hypothesis 3) and induction (Hypothesis 3b).

Holland (1959) assumed that persons with an esthetic orientation "prefer dealing with environmental problems through self-expression in artistic media" and highlighted that they "avoid problems requiring interpersonal interactions, a high degree of structuring, or physical skills" (p. 37). Later Holland (1973) associated the Artistic type with verbal abilities as well as divergent thinking. Lowman (1991) further proposed a positive relationship between artistic interests and spatial abilities. Neither of these assumptions was supported by a recent research (Carson, 1998b; Proyer, 2006). Again, following Holland's assumptions, we hypothesized that Artistic interests are positively related to verbal abilities (Hypothesis 4).

Holland (1959) assumed that persons with a supportive orientation have verbal and interpersonal skills and "avoid situations requiring intellectual problem-solving, physical skills or highly ordered activities" (p. 37). Holland (1973) further related the Social type with a lack of mechanical and scientific abilities. Empirically, Social interests were found to be uncorrelated or negatively correlated with specific cognitive abilities (Ackerman & Heggestad, 1997). Ackerman (1997) proposed that cognitive ability measures insufficiently capture domains such as social or interpersonal abilities. Recent research reported negative relations with verbal, numerical, and spatial abilities (Carson, 1998b; Proyer, 2006). Based on Holland's assumptions, we hypothesized that Social interests will be positively related to verbal abilities (Hypothesis 5a) but negatively related to mechanical abilities (Hypothesis 5b).

Holland (1959) indicated that persons with a persuasive orientation "prefer to use their verbal skills … for dominating, selling, or leading others". Lowman (1991) assumed positive relations with interpersonal as well as management abilities. Ackerman and Heggestad (1997) concluded in their review that negative associations tend to be found between ability measures and Enterprising interests. This assumption is further supported by a recent research (Carson, 1998b; Proyer, 2006). In line with Holland, we hypothesized that Enterprising interests will be positively related to verbal abilities (Hypothesis 6).

The Conventional type is associated with clerical and numerical abilities (Holland, 1973) as well as with computational abilities and perceptual speed (Lowman, 1991), but avoids "ambiguous situations or problems involving interpersonal relationships and physical skills" (Holland, 1959, p. 37). Ackerman and Heggestad (1997) as well as Carson (1998a) confirmed a positive relation between Conventional interests and mathematical computation as well as perceptual speed. We hypothesize that Conventional interests will be positively related to numerical abilities (Hypothesis 7a) as well as perceptual speed (Hypothesis 7b).

7. Moderators

7.1. Gender differences in interests and cognitive abilities

Despite gender invariance in interest structure (Darcy & Tracey, 2007), considerable mean gender differences are found for the RIASEC scales (Lippa, 1998; Su, Rounds, & Armstrong, 2009). Meta-analytical results revealed that women tend to report stronger Social, Artistic, and Conventional interests than men, whereas men are more likely than women to prefer Realistic and Investigative activities (Su et al., 2009). Research suggests that gender differences in vocational interests are among the largest differences in the field of individual differences (Lubinski, 2000). Furthermore, there is evidence that these gender differences remain relatively stable over time (Bubany & Hansen, 2011) and are not attributable to test bias (e.g. Pässler, Beinicke & Hell, 2014; Wetzel & Hell, 2013).

Although research showed negligible gender differences in general intelligence (Deary, 2003; Strand, Deary, & Smith, 2006), males tend to perform better in some subtests and females on others. Meta-analyses on verbal abilities (Hedges & Nowell, 1995; Hyde & Linn, 1988) found small to moderate differences favoring females on reading comprehension, writing, and speech production but not on all tests of verbal ability. Likewise, meta-analyses on mathematical abilities (Hedges & Nowell, 1995; Lindberg, Hyde, Petersen, & Linn, 2010) found negligible to small overall differences with females performing better at measures of mathematical computation and males performing better at mathematical problem solving tasks. Moderate to large differences favoring males were found on measures of mental rotation, spatial perception, and mechanical reasoning (Lemos, Abad, Almeida, & Colom, 2013; Schmidt, 2011; Voyer, Voyer, & Bryden, 1995). Furthermore, research suggested that (a) gender differences in cognitive abilities vary by age (Lindberg et al., 2010), and (b) males show greater variability than females on most cognitive ability measures (Deary, 2003; Strand et al., 2006).

Further, gender differences in vocational interests are perceived as antecedents of gender differences in the development of skills, knowledge, and aptitudes: Schmidt (2011), for example, proposed that gender differences in technical interests lead to differences in technical experiences and technical knowledge acquisition, which in turn, lead to gender differences in technical aptitude. Similarity of verbal and quantitative aptitudes, in contrast, results from common experiences during formal education. Although few studies (Carless, 1999; Reeve & Heggestad, 2004) examined the relationship between interests and cognitive abilities by gender, results suggested that the direction and magnitude of correlation coefficients differ to some extent for females and males. Further, Johnson and Bouchard (2008) found that gender differences in cognitive abilities partially explained differences in vocational interests. In light of presented findings and the fact that Ackerman and Heggestad (1997) noted not considering gender differences as a specific limitation of their review on intelligence, interests, and personality, we investigated gender as a possible moderator in the relationship between vocational interests and cognitive abilities.

Recent research further indicated that vocational interests are influenced by cohort effects (Bubany & Hansen, 2011; Su et al., 2009). Investigating change across birth cohorts of college students, Bubany and Hansen (2011) found that although Enterprising and Social interests increased from earlier generations to more recent generations for both females and males, the increase in Enterprising interests was especially great in females. Further, for males, Bubany and Hansen (2011) reported a decrease in Realistic, Investigative, and Artistic interests. Moreover, gender differences in Investigative, Enterprising, and Conventional interests decreased from earlier generations to more recent generations. Similarly, Su et al. (2009) revealed that gender differences in Artistic and Enterprising interests were smaller for younger generations than older generations. These birth cohort changes are assumed to result from changes in the labor market, especially a steady increase in the number of women entering the workforce as well as an increase in college and graduate degrees earned by women (Bubany & Hansen, 2011). Thus, we considered birth cohort changes a potential moderator between interests and cognitive abilities, especially when relations are investigated separately for females and males.

8. Age differences in interests and cognitive abilities

In their meta-analysis of longitudinal studies on rank-order and profile stability, Low, Yoon, Roberts, and Rounds (2005) demonstrated that vocational interests are relatively stable, even at early adolescence. Moreover, interest stability greatly increases in early adulthood and then remains stable for the next two decades. This marked stability increase in early adulthood is assumed to result from fewer environmental constraints since individuals at this age typically leave their familiar surrounding for novel settings such as college or work places (Low & Rounds, 2007), thus enabling individuals to choose environments and activities that match their vocational interests.

Although general intelligence (*g*) remains stable over time (Deary, Pattie, & Starr, 2013), there are some cognitive abilities that are more stable than others. Fluid intelligence has been found to increase throughout young adulthood, peaking in middle adulthood, and afterwards declining steadily (Kaufman et al., 2008). This decline in fluid intelligence has been attributed to declines in processing speed and working memory (Kaufman et al., 2008). In contrast, crystallized ability has been found to increase with age throughout adulthood (Schaie, 2013). As highlighted previously, Cattell's (1971, 1987) investment theory assumes an age-related differentiation of cognitive abilities such that fluid intelligence is invested in the elaboration and formation of crystallized intelligence. Environmental and non-cognitive variables (e.g., motivation and interests) guide this knowledge acquisition. Therefore, we assumed that vocational interests and measures of crystallized intelligence should become more closely related as individuals grow older, and the relation between vocational interests and those cognitive abilities that are highly influenced by experience and knowledge acquisition in the course of parental upbringing and education would be more pronounced in older samples than in younger samples. Within the CHC theory framework, domain-specific knowledge (e.g., mechanical knowledge or foreign language proficiency), quantitative knowledge, reading and writing, as well as language development are perceived as acquired knowledge constructs (Schneider & McGrew, 2012). Thus, we investigated individuals' age as a possible moderator in the relationship between vocational interests and cognitive abilities.

9. Method

9.1. Literature search

To identify relevant (published or unpublished) literature for this meta-analysis, we searched the following databases: PsycINFO, PSYNDEX, ERIC, Academic Search Premier, and Business Source Premier. We searched titles, abstracts, or keywords of articles using combined keywords including the following terms and Boolean operators: (vocational preference OR vocational preferences OR vocational interest OR vocational interests OR occupational interest OR occupational interests OR occupational preference OR occupational preferences OR Holland* OR RIASEC* OR hexagon*) AND (cognitive ability OR cognitive abilities OR general mental ability OR general mental abilities OR aptitude* OR intelligence* OR ability*). Since the 1970s, interest literature has primarily used Holland's RIASEC taxonomy to organize research results on vocational interests (Armstrong, Su, & Rounds, 2011). Thus, only articles published after 1970 were investigated. We further reviewed the reference sections of those articles obtained by database search to identify additional articles. Finally, we contacted authors in the research field of vocational interests for unpublished data or work in progress.

10. Inclusion criteria

All primary studies were reviewed for meeting the following inclusion criteria: (a) a vocational interest inventory using Holland's RIASEC taxonomy, (b) cognitive ability measures based on objectively assessed (not self-reported) data, and (c) sufficient data (e.g., sample size, correlation coefficients) provided to compute effect sizes. If possible, we contacted the authors to obtain missing information. As Ackerman and Beier (2003) highlighted, vocational interest measures traditionally generate either similarity indexes or dominant typological themes. Thus, measures seldom yield continuous scores for individuals, making it impossible to compute correlations between vocational interests and cognitive abilities. Relatively few studies examine the association between objective cognitive abilities and vocational interests; instead they rely on self-estimated abilities. Overall, 27 studies representing 29 independent samples met all criteria of inclusion (see Table 1). All but two studies were published in peer-reviewed journals.

11. Coding of primary studies

We coded the following data from each primary study: (a) full reference details, (b) study location, (c) year of publication, (d) year of data acquisition, (e) sample age, (f) gender distribution, (g) career level, (h) measured constructs, (i) reliability of constructs, and (j) correlations' effect size and direction.

11.1. Cognitive abilities

Cognitive ability (sub-)tests were classified using the CHC taxonomy. Thus, ability tests were coded to represent either general intelligence (*g*) or specific broad and narrow abilities. Detailed descriptions of each type of broad and narrow abilities as presented by Schneider and McGrew (2012) were used as a guideline for coding. Each ability test was coded independently by two of the authors. Few disagreements were discussed and resolved.

11.2. Gender

The gender distribution of the sample was identified. For moderator analyses, all-female, all-male, and those samples

Table 1
Overview of the meta-analysis database.

ID	Author(s)[a]/article	Country	Sample size			Population	Moderator values			Vocational interest measure	Cognitive ability measure
			N	Male	Female		Age	Sex	Cohort		
1	Ackerman (2000)	United States	228	78	150	2	0	1	1960s	UNIACT	Ability battery
2	Ackerman et al. (2001)	United States	320			2	1	0	1980s	UNIACT	Ability battery
3	Ackerman et al. (1995)	United States	93	42	51	2	2	1	1970s	UNIACT	Ability battery
4	Bergmann (2013)*	Austria	5134	2269	2866	1	1	1	1980s	GIST-R	KFT 4-12 + R
5	Carless (1999a)	Australia		669	206	4	2	1	1960s	SDS	PL-PQ
6	Carless (1999b)	Australia		48	91	4	0	1	1970s	SDS	WAIS-R
7	Carson (1996)	United States	117			4	0	0	1970s	SII	DAT-A
8	Carson (1998a)	United States	547			4	0	0	1950s	SII	BAB
9	Carson (1998b)	United States	198			1	1	0	1970s	SDS	BAB
10	Fritzsche et al. (1999)	United States	90			4	0	0	1970s	SDS	WPT
11	Kanfer et al. (1996)	United States	158			2	0	0		UNIACT	Ability battery
12	Kaub et al. (2012)	Germany	219	71	148	2	2	1	1980s	GIST-R	LPS-K
13	Kelso et al. (1977)	United States			192	1	0	1	1960s	SDS	ASVAB
14	Kirchler (1990)	Germany	86			4	0	0		GIST	BIST
15	Krapic et al. (2008)	Croatia	132			4	0	0	1970s	SDS**	APM
16	Lowman et al. (1985)	United States			149	2	0	1	1960s	SDS	Ability battery
17	Marcus et al. (2009)	Germany	268			3	1	0	1990s	GIST	WPT
18	Mussel (2013)	Germany	250	92	158	5	0	1	1980s	VPI	S&F
19	Pässler and Hell (2012)	Germany	1.990	809	1.181	2	2	1	1980s	WSI	Ability battery
20	Proyer (2006)	Austria	138	39	99	2	2	1	1970s	GIST	ISA
21	Randahl (1991)	United States	846			4	0	0	1940s	SVIB-SCII	GATB
22	Reeve and Heggestad (2004)	United States		16,010	20,443	4	0	1	1940s	VPI, SDS	Ability battery
23	Rolfhus and Ackerman (1996)	United States	180			2	1	0	1970s	UNIACT	Ability battery
24	Schmidt et al. (1998)	United States	695			1	0	0	1980s	SVIB-SCII	Ability battery
25	Stanley et al. (1999)	United States		188	90	1	0	1	1960s	HOC	DAT
26	Toker and Ackerman (2012)	United States	184	82	102	2	0	1	1990s	UNIACT	ETS KIT
27	Toker and Ackerman (2012)	United States	240	123	117	2	0	1	1990s	UNIACT	ETS KIT
28	Van Iddekinge, Putka and Campbell (2011)	United States	418			4	2	0	1980s	WPS	AFQT
29	Vock et al. (2013)	Germany	4680	2123	2557	1	1	1	1980s	GIST	KFT 4-12 + R

In the coding of the population, 1 represents high school samples, 2 represents college or university samples, 3 represents apprentices, 4 represents workers, and 5 represents mixed samples. In the coding for age as a moderator, 1 represents a mean sample age smaller than 20 years with standard deviation less or equal than 5 years, 2 refers to a mean sample age greater or equal than 20 years with standard deviation less or equal than 5, and 0 represents either data with standard deviations greater than 5 or no available data. For sex as a moderator, female- or male-specific samples were coded as 1, whereas data with only the total sample available was coded as 0.
Interest measures: GIST = General Interest Structure Test, GIST-R = General Interest Structure Test-Revised, HOC = Holland Occupations Checklist, SDS = Self-Directed Search, SII = Strong Interest Inventory, SVIB-SCII = Strong Vocational Interest Blank-Strong Campbell Interest Inventory, UNIACT = Unisex Edition of the American College Testing, VPI = Vocational Preference Inventory, WPS = Work Preferences Survey, WSI = was-studiere-ich.de [what should I study]; ability measures: AFQT = Armed Forces Qualification Test, APM = Advanced Progressive Matrices, ASVAB = Armed Services Vocational Aptitude Scales, BAB = Ball Aptitude Battery, BIST = Berlin Intelligence Structure Test, DAT = Differential Aptitude Test, DAT-A = Differential Aptitude Tests-Adaptive, ETS KIT = Kit of Factor-Referenced Cognitive Tests, GATB = General Aptitude Test Battery, ISA = Intelligence-Structure-Analysis, KFT 4-12 + R = Cognitive Ability Test-Revision, LPS-K - = Leistungsprüfsystem-Short Version, PL-PQ = Australian Council of Educational Research Higher Test PL-PQ, WAIS-R = Wechsler Adult Intelligence Scale-Revised, WPT = Wonderlic Personnel Test. For detailed correlations of each study, see Appendix A.

[a] Complete references can be found in the reference section. *Unpublished data. **Croatian version of the SDS. Sample sizes are presented for (total, male, female) samples that are included in the analyses.

that provided correlation coefficients by gender were included, thus enabling comparisons between correlational patterns for females and males.

11.3. Age

The majority of studies reported a mean age of the sample ($k = 27$). Due to the small amount of studies that reported both mean age and correlations between interest types and specific cognitive abilities ($k = 1$ to $k = 11$), we decided to investigate age as a categorical moderator. For this purpose, samples with an average age below 20 years were compared to those with an average age of 20 years and older. This cut-off was chosen for theoretical reasons: Meta-analytical longitudinal research (Low et al., 2005) on change and stability of interests demonstrated that stability estimates from age 12 to age 18 (i.e., prior to graduation from high school) remained remarkably unchanged. However, during college years, interest stability increases dramatically. In the U.S., in Australia, and in Europe, individuals generally graduate from high school between 17 and 19 years of age. In order to compare high school and early adulthood samples, we split samples with an average age below 20 years from those with an average age of 20 years and older. Furthermore, samples showing great heterogeneity of age ($SD > 5$) were excluded from analyses ($k = 4$ with $SD > 5$ and $k = 3$ with missing SD_{age}).

11.4. Cohort

For each sample, we calculated an index for cohort by subtracting mean age from year of sample acquisition. If year of sample acquisition was not available, we used year of publication instead. Studies were subsequently assigned to one of six cohort groups: 1940s, 1950s, 1960s, 1970s, 1980s, and 1990s.

12. Statistical analyses

Analyses were conducted according to the validation generalization approach (Raju, Burke, Normand, & Langlois, 1991). This method is rooted in the meta-analytic approach by Hunter, Schmidt, and Jackson (1982) and corrects effect sizes individually for artifacts (i.e., sampling error, unreliability of measures) as opposed to using artifact distributions. Following recommendations by Hunter and Schmidt (2000), meta-analytic estimates were computed in a random-effects (RE) model using a software program by Raju and Fleer (2003). The fixed-effects (FE) model postulates that all included studies are homogenous, sharing a common effect size, and all between-variance is caused by sample error, measurement error, or other adulterant or moderating influences. In contrast, the RE model allows the possibility for effect sizes to vary randomly from study to study.

Correlation coefficients were corrected for both sampling error and attenuation due to unreliability of both vocational interest and cognitive ability measures. Reliabilities were either obtained from the study or, if not reported, substituted by reliabilities stated in the test manuals. If neither approach was possible, we substituted scale reliabilities with a reliability estimate that was calculated based on the reliability information given in other studies for the specific construct.

Generally, only bivariate relationships between interests and cognitive ability measures that were drawn from three or more studies were retained for overall analyses. If studies reported two or more correlation coefficients for the same interest–ability-relation derived from one sample, these correlations were pooled. The reliability of the pooled predictors was estimated with Mosier's formula (Hunter & Schmidt, 2004). In accordance with Hunter and Schmidt (2004), we resigned from Fisher's z-transformations to pool correlations.

13. Results

We first present results for the interest–intelligence relation and then turn to the relation between interest themes and specific cognitive abilities. Gender, age, and cohort will be investigated as possible moderators. To interpret the magnitude of correlations (ρ), we applied Cohen's guideline: According to Cohen (1992), $\rho = 0.10$ is small, $\rho = 0.30$ is medium, and $\rho = 0.50$ is large. Correlations (ρ) are reported together with lower and upper bounds of both 90% credibility value (CV) and 95% confidence interval (CI).

14. Holland's RIASEC types and general intelligence

We performed analyses for the RIASEC types and general intelligence. Results are shown in Table 2; if the 90% credibility value did not include zero, correlations are presented in bold. As expected, Investigative interests showed a positive correlation with g ($\rho = 0.28$, 95% CI [0.24, 0.33]), and this relation was the strongest for all interest types. However, we also found a small positive correlation with Realistic interests ($\rho = 0.23$, 95% CI [0.17, 0.29]) and the 95% CIs for Investigative and Realistic interests overlapped. Further, results indicated a small negative correlation with social interests ($\rho = -0.19$, 95% CI [-0.23, -0.15]). For all above findings, neither the 90% CVs nor the 95% CIs included zero. The remaining correlations were close to zero. Thus, only Hypothesis 1a - Investigative interests will be positively related to g- was supported. Noticeably, statistical artifacts (i.e., sampling error and measurement error) accounted for no more than 44% of variance in the correlations. Based on the 75%-rule by Hunter and Schmidt (2004), this indicates that the remaining variance is likely to be caused by additional artifacts that we have not yet taken into account, and moderator analyses are recommended.

15. Moderator analyses

15.1. Gender

Moderator analyses were conducted to determine whether the strength and direction of correlations between interests and general intelligence varied as a function of gender. In a first step, we included all studies that met the inclusion criterion. However, artifacts accounted for no more than 15% of variance in all correlation coefficients, thus indicating strong heterogeneity, while directions and magnitudes of ρ deviated considerably from those found for total samples. As highlighted by Kepes, McDaniel, Brannick, and Banks (2013), results and conclusions of meta-analyses can be heavily influenced by one or more effect sizes of deviant magnitude or by a single, large sample. In this case, Hunter and Schmidt (2004) recommended a specific-sample-removed analysis, where meta-analytic results with and without excluded samples are compared to assess robustness of results. A close inspection of included studies in our meta-analysis revealed that data by Reeve and Heggestad (2004) deviated considerably both in magnitude and direction of correlation coefficients. Moreover, due to its large sample size, it strongly influenced the estimates of overall effect sizes. Thus, we decided to remove this sample from analyses and report results with and without data by Reeve and Heggestad (2004) to assess robustness of results. Moderator analyses including data from Reeve and Heggestad (2004) are reported in Appendix A.

As indicated in Table 3, when excluding data by Reeve and Heggestad (2004), we found positive correlations with Investigative ($\rho_{males} = 0.22$, 95% CI [0.15, 0.29], $\rho_{females} = 0.23$, 95% CI [0.20, 0.27]) and Realistic interests ($\rho_{males} = 0.11$, 95% CI [0.03, 0.19], $\rho_{females} = 0.20$, 95% CI [0.14, 0.25]) as well as a small negative correlation with Social interests ($\rho_{males} = -0.11$, 95% CI [-0.14, -0.09], $\rho_{females} = -0.15$, 95% CI [-0.17, -0.13]) and g for both genders. However, for males the 90% CV for Realistic interests included zero. Relations between g and Artistic, Enterprising, and Conventional interests were negligible. With the exception of Conventional interests, all CIs for females and males overlapped. In sum, results by gender closely represented those found for total samples. Thus, the relationship between interests and general intelligence was not moderated by gender. However, mean variance accounted for by artifacts was larger for gender-specific analyses than for mixed samples (50.6% vs. 23.1%, respectively).

Table 2
Mean effect size estimates and confidence intervals for the correlations between Holland's RIASEC types and general intelligence.

	k	N	r	ρ	σ^2_ρ	% VE	90% CV	95% CI
Realistic	13	13,999	0.20	**0.23**	0.010	9.9	[0.10, 0.36]	[0.17, 0.29]
Investigative	13	13,991	0.25	**0.28**	0.005	17.8	[0.20, 0.46]	[0.24, 0.33]
Artistic	13	13,993	−0.02	−0.03	0.006	16.5	[−0.14, 0.08]	[−0.07, 0.02]
Social	11	13,584	−0.16	**−0.19**	0.004	21.0	[−0.27, −0.11]	[−0.23, −0.15]
Enterprising	12	13,909	−0.07	**−0.08**	0.001	43.5	[−0.13, −0.03]	[−0.11, −0.05]
Conventional	12	13,908	0.01	0.01	0.003	29.7	[−0.06, 0.08]	[−0.02, 0.05]

Note. k = number of independent samples; N = total sample size; r = sample size weighted mean correlation; ρ = estimated true score correlation (corrected for sample error and unreliability); $\sigma^2\rho$ = estimated variance for true score correlation; % VE = percentage of variance in ρ accounted for by statistical artifacts; 90% CV = lower and upper bounds of the 90% credibility value for true score correlation; 95% CI = lower and upper bounds of 95% confidence interval. Correlations are presented in boldface if the 90% credibility interval excludes zero.

15.2. Cohort

Analyses for cohort as a continuous moderator were conducted using weighted multiple regression with inverse variance weights. Analyses were performed in SPSS using a module given by Wilson (2005). Results indicated that the relation between interests and g indeed varied by birth cohort. For males, the correlation between Realistic interests and g was positive for younger cohorts and negative for older cohorts ($\beta = 0.72$, $p = 0.024$), the reversed trend was found for Social interests ($\beta = -0.78$, $p = 0.035$). For females, younger cohorts showed stronger positive relations between Realistic interests and g than older cohorts ($\beta = 0.57$, $p = 0.027$). For Enterprising interests, younger cohorts showed small negative relations with g, whereas the correlations were negligible for older cohorts ($\beta = -0.84$, $p = 0.021$). In general, this moderator analysis must be interpreted with caution since the number of independent samples was distributed unequally among the cohorts. For the 1960s, only one study was available, whereas the 1970s and 1980s were overrepresented ($k = 3$ and $k = 4$, respectively).

16. Holland's RIASEC types and specific cognitive abilities

In a next step, we performed analyses for the RIASEC types and narrow cognitive abilities. Analyses were conducted when data from a minimum of three independent samples were available (see Table 4, for descriptions of those narrow cognitive ability measures for which sufficient data were allocated). Some notations in the CHC framework differ from notations generally applied in cognitive ability research. To enhance interpretation of results and comparability of findings, we summarized findings on language development, quantitative reasoning, and visualization as findings on verbal, numerical, and spatial abilities, respectively. The results are presented in Table 5, and each of the six interest themes will be discussed. Again, correlations are marked in bold if the 90% credibility value did not include zero.

Small to moderate positive correlations were found between Realistic interests and spatial abilities (ρ = 0.34, 95% CI [0.30, 0.40]), numerical abilities (ρ = 0.26, 95% CI [0.18, 0.35]), and mechanical knowledge (ρ = 0.31, 95% CI [0.23, 0.40]). All 90% credibility values excluded zero. Thus, Hypothesis 2a -

Table 3
Mean effect size estimates and confidence intervals for the correlations between Holland's RIASEC types and general intelligence by sex.
Excluding data by Reeve and Heggestad (2004).

	k	N	r	ρ	σ^2_ρ	% VE	90% CV	95% CI
Males								
Realistic	8	6072	0.10	0.11	0.011	13.1	[−0.03, 0.14]	[0.03, 0.19]
Investigative	8	6070	0.19	**0.22**	0.003	34.8	[0.15, 0.29]	[0.17, 0.26]
Artistic	8	6070	0.03	0.03	0.002	43.5	[−0.03, 0.06]	[−0.01, 0.08]
Social	8	6068	−0.10	**−0.11**	0.000	100.0		[−0.14, −0.09]
Enterprising	8	6068	−0.08	**−0.09**	0.003	36.6	[−0.11, −0.02]	[−0.14, −0.04]
Conventional	8	6069	−0.05	**−0.06**	0.000	96.6	[−0.07, −0.05]	[−0.09, −0.03]
Females								
Realistic	8	7183	0.17	**0.20**	0.005	22.5	[0.11, 0.29]	[0.14, 0.25]
Investigative	9	7326	0.20	**0.23**	0.002	47.4	[0.18, 0.28]	[0.20, 0.27]
Artistic	8	7179	0.03	0.04	0.007	18.2	[−0.07, 0.15]	[−0.03, 0.10]
Social	8	7178	−0.13	**−0.15**	0.000	100.0		[−0.17, −0.13]
Enterprising	8	7183	−0.03	−0.04	0.002	49.3	[−0.09, 0.01]	[−0.08, 0.00]
Conventional	8	7181	−0.06	**0.07**	0.002	45.1	[0.01, 0.13]	[0.03, 0.11]

Note. k = number of independent samples; N = total sample size; r = sample size weighted mean correlation; ρ = estimated true score correlation (corrected for sample error and unreliability); $\sigma^2\rho$ = estimated variance for true score correlation; % VE = percentage of variance in ρ accounted for by statistical artifacts; 90% CV = lower and upper bounds of the 90% credibility interval for true score correlation; 95% CI = lower and upper bounds of 95% confidence interval. Correlations are presented in boldface if the 90% credibility interval excludes zero.

Table 4
Classification of the ability measures: Broad and narrow cognitive abilities and definitions according to Schneider and McGrew (2012).

Broad cognitive ability	Narrow cognitive ability	Definition
Verbal knowledge	Language development	General understanding of spoken language at the level of words, idioms, and sentences. *Core ability of verbal knowledge and crystallized intelligence* (g_c)
Fluid reasoning	Induction	The ability to observe a phenomenon and discover the underlying principles or rules that determine its behavior. *Core ability of fluid intelligence* (g_f)
	Quantitative reasoning	The ability to reason, either with induction or deduction, with numbers, mathematical relations, and operators.
Visual processing	Visualization	The ability to perceive complex patterns and mentally simulate how they might look when transformed (e.g., rotated, changed in size, partially obscured). *Core ability of visual processing* (G_v)
Processing speed	Perceptual speed	The speed at which visual stimuli can be compared for similarity or differences. *Core ability of processing speed* (G_s)
Domain specific knowledge	Mechanical knowledge	Knowledge about the function, terminology, and operations of ordinary tools, machines, and equipment.

Realistic interests are positively related to mechanical abilities-was supported. Further, a small positive correlation for Realistic interests and induction was revealed (ρ = 0.13, 95% CI [0.08, 0.19], %VE = 100%). Due to an insufficient number of primary studies (k = 1) we were unable to investigate the relation between Realistic interests and motor coordination (Hypothesis 2b).

For Investigative interests, we found positive correlations with verbal (ρ = 0.21, 95% CI [0.16, 0.27]), numerical (ρ = 0.25, 95% CI [0.19, 0.30]), and spatial abilities (ρ = 0.27, 95% CI [0.23, 0.31]). Furthermore, analyses revealed a small positive correlation with induction (ρ = 0.22, 95% CI [0.14, 0.30]) and mechanical knowledge (ρ = 0.17, 95% CI [0.02, 0.32]). All 90% credibility values excluded zero. Thus, Hypotheses 3a and 3b were supported.

As expected, we found a small positive correlation between Artistic interests and verbal abilities (ρ = 0.22, 95% CI [0.18, 0.25]). Thus, Hypothesis 4 was supported. Further, analyses revealed a negative correlation with numerical abilities (ρ = −0.18, 95% CI [−0.24, −0.12]).

For Social interests, we found negative relations with mechanical knowledge (ρ = −0.28, 95% CI [−0.37, −0.19]) as well as with spatial (ρ = −0.22, 95% CI [−0.26, −0.18]) and numerical abilities (ρ = −0.21, 95% CI [−0.27, −0.14]). Thus, Hypothesis 5b was supported. Contrary to our expectation, the relation between social interests and verbal abilities was very small negative (ρ = −0.06, 95% CI [−0.09, −0.03]). Thus, Hypothesis 5a was not supported.

Correlations between Enterprising interests and narrow ability measures were negligible to small negative. Small negative correlations were found with spatial abilities (ρ = −0.13, 95% CI [−0.16, −0.11]) and mechanical knowledge (ρ = −0.14, 95% CI [−0.16, −0.12]). Deviant from expectation, we found no positive relation between Enterprising interests and verbal abilities (ρ = −0.08, 95% CI [−0.14, −0.03]). Thus, Hypothesis 6 was not supported.

For Conventional interests, correlations with all narrow ability measures were negligible. Although the correlation with numerical abilities was positive (ρ = 0.08, 95% CI [0.03, 0.12]), the 90% credibility interval included zero. Thus, Hypothesis 7a was not supported. In line with our hypotheses, we found a positive albeit very small relation with perceptual speed (ρ = 0.06, 95% CI [0.02, 0.13]). Thus, Hypothesis 7b was supported.

In sum, 6 out of 8 hypotheses resulting from Holland's (1959, 1973, 1985) assumptions on the relationship between interest types and specific cognitive abilities were supported by our findings. Since statistical artifacts accounted for more than 75% of variance in only 9 out of 36 correlations between RIASEC themes and narrow ability measures, we conducted moderator analyses in a next step.

17. Moderator analyses

17.1. Gender

As in previous analyses, correlation coefficients by gender were included in this moderator analysis to examine gender as a possible moderator of the relationship between interest types and narrow cognitive abilities. Correlations (ρ) are reported when at least three independent samples were available for this moderator analysis. Results are presented in Table 6; again, correlations in bold indicate that the 90% credibility interval excluded zero.

For verbal abilities, in line with previous findings, analyses showed a small positive correlation with Investigative (ρ = 0.19, 95% CI_{males} [0.13, 0.26], 95% $CI_{females}$ [0.12, 0.25], respectively) and Artistic interests (ρ = 0.23, 95% CI_{males} [0.17, 0.30], 95% $CI_{females}$ [0.18, 0.28], respectively) for females and males. Both 90% CVs and 95% CIs overlapped for both genders. All other correlations between interest types and verbal abilities were negligible for both genders.

For numerical abilities, we found a positive relation with Investigative interests ($ρ_{males}$ = 0.15, 95% CI [0.10, 0.21], $ρ_{females}$ = 0.17, 95% CI [0.11, 0.23]) for both genders. Again, both 90% CVs and 95% CIs overlapped. For realistic interests, albeit positive for both, the correlation with numerical abilities was stronger for females ($ρ_{females}$ = 0.19, 95% CI [0.12, 0.27]) than for males ($ρ_{males}$ = 0.07, 95% CI [−0.03, 0.21]). However, the 95% CIs overlapped. Similarly, we found a small positive correlation with Conventional interests for females ($ρ_{females}$ = 0.10, 95% CI [0.05, 0.15]) but not for males ($ρ_{males}$ = 0.02, 95% CI [−0.02, 0.06]). Again, however, 95% CIs overlapped slightly.

For spatial abilities, analyses showed a small positive correlation with Realistic ($ρ_{males}$ = 0.25, 95% CI [0.18, 0.33], $ρ_{females}$ = 0.27, 95% CI [0.21, 0.33]) and Investigative interests ($ρ_{males}$ = 0.21, 95% CI [0.16, 0.26], $ρ_{females}$ = 0.22, 95% CI [0.18, 0.26]), and small negative correlations with Social ($ρ_{males}$ = −0.16, 95% CI [−0.22, −0.10], $ρ_{females}$ = −0.18, 95% CI [−0.21, −0.15]) and Enterprising interests ($ρ_{males}$ = −0.15, 95% CI [−0.20, −0.10], $ρ_{females}$ = −0.11, 95% CI [−0.14, −0.09]) for males and females. All 90% CVs and 95% CIs overlapped. Correlations with Artistic and Conventional interests were overall negligible.

Table 5
Mean effect size estimates and confidence intervals for the correlations between Holland's RIASEC types and specific cognitive abilities.

	k	N	r	ρ	σ^2_ρ	% VE	90% CV	95% CI
Language development (verbal ability)								
Realistic	14	10,097	0.04	0.05	0.004	35.4	[−0.03, 0.13]	[0.01, 0.09]
Investigative	14	10,090	0.17	**0.21**	0.008	18.6	[0.10, 0.32]	[0.16, 0.27]
Artistic	14	10,092	0.17	**0.22**	0.003	40.1	[0.15, 0.29]	[0.18, 0.25]
Social	14	9769	−0.05	**−0.06**	0.001	76.7	[−0.09, -0.03]	[−0.09, −0.03]
Enterprising	14	10,094	−0.07	−0.08	0.009	18.8	[−0.20, 0.04]	[−0.14, −0.03]
Conventional	14	10,093	−0.04	−0.05	0.005	31.1	[−0.14, 0.04]	[−0.09, −0.01]
Induction								
Realistic	5	1616	0.10	**0.13**	0.000	100.0		[0.08, 0.19]
Investigative	5	1616	0.16	**0.22**	0.004	58.6	[0.14, 0.30]	[0.14, 0.30]
Artistic	5	1616	0.05	0.07	0.009	38.5	[−0.05, 0.19]	[−0.03, 0.18]
Social	4	1296	−0.04	−0.05	0.001	80.6	[−0.10, 0.00]	[−0.13, 0.03]
Enterprising	5	1616	−0.09	−0.12	0.010	36.0	[−0.25, 0.01]	[−0.23, −0.01]
Conventional	5	1616	0.04	0.06	0.009	39.6	[−0.06, 0.18]	[−0.05, 0.16]
Quantitative reasoning (numerical ability)								
Realistic	10	9076	0.21	**0.26**	0.017	8.2	[0.10, 0.42]	[0.18, 0.35]
Investigative	10	9068	0.20	**0.25**	0.006	19.7	[0.15, 0.35]	[0.19, 0.30]
Artistic	10	9070	−0.14	**−0.18**	0.009	15.5	[−0.30, −0.06]	[−0.24, −0.12]
Social	10	9067	−0.17	**−0.21**	0.008	15.9	[−0.33, −0.09]	[−0.27, −0.14]
Enterprising	10	9072	−0.07	**−0.08**	0.001	65.1	[−0.12, −0.05]	[−0.12, −0.05]
Conventional	10	9071	0.06	0.08	0.004	27.9	[−0.01, 0.17]	[0.03, 0.12]
Visualization (spatial ability)								
Realistic	12	9985	0.28	**0.34**	0.006	21.2	[0.25, 0.43]	[0.30, 0.40]
Investigative	12	9978	0.21	**0.27**	0.003	35.2	[0.19, 0.35]	[0.23, 0.31]
Artistic	12	9980	−0.06	−0.08	0.006	23.8	[−0.18, 0.02]	[−0.13, −0.03]
Social	12	9977	−0.17	**−0.22**	0.002	44.4	[−0.28, −0.16]	[−0.26, −0.18]
Enterprising	12	9982	−0.11	**−0.13**	0.000	81.5	[−0.15, −0.11]	[−0.16, −0.11]
Conventional	12	9981	−0.02	−0.02	0.001	61.8	[−0.06, 0.02]	[−0.05, 0.01]
Perceptual speed								
Realistic	6	1613	−0.04	−0.05	0.014	29.4	[−0.20, 0.10]	[−0.16, 0.07]
Investigative	6	1613	0.06	0.08	0.002	76.6	[0.03, 0.13]	[0.01, 0.15]
Artistic	6	1613	0.05	0.07	0.012	32.8	[−0.08, 0.22]	[−0.04, 0.17]
Social	6	1613	0.03	0.03	0.003	63.4	[−0.04, 0.10]	[−0.05, 0.11]
Enterprising	6	1613	**−0.04**	−0.06	0.000	100.0		[−0.09, −0.02]
Conventional	6	1613	**0.06**	0.08	0.000	100.0		[0.02, 0.13]
Mechanical knowledge								
Realistic	3	992	0.27	**0.31**	0.003	54.7	[0.25, 0.37]	[0.23, 0.40]
Investigative	3	992	0.15	**0.17**	0.014	19.2	[0.01, 0.33]	[0.02, 0.32]
Artistic	3	992	−0.11	−0.12	0.022	14.5	[−0.31, 0.07]	[−0.30, 0.06]
Social	3	992	−0.24	**−0.28**	0.003	54.7	[−0.35, −0.21]	[−0.37, −0.19]
Enterprising	3	992	−0.12	**−0.14**	0.000	100.0		[−0.16, −0.12]
Conventional	3	992	−0.06	−0.06	0.000	93.4	[−0.14, 0.01]	[−0.14, 0.01]

Note. k = number of independent samples; N = total sample size; r = sample size weighted mean correlation; ρ = estimated true score correlation (corrected for sample error and unreliability); $\sigma^2\rho$ = estimated variance for true score correlation; % VE = percentage of variance in ρ accounted for by statistical artifacts; 90% CV = lower and upper bounds of the 90% credibility interval for true score correlation; 95% CI = lower and upper bounds of 95% confidence interval. Correlations are presented in boldface if the 90% credibility interval excludes zero.

For induction, analyses indicated moderate positive relations with Investigative ($\rho_{males} = 0.31$, 95% CI [0.15, 0.48], $\rho_{females} = 0.33$, 95% CI [0.24, 0.42]), and small negative relation with Enterprising interests ($\rho_{males} = -0.22$, 95% CI [−0.46, 0.03], $\rho_{females} = -0.13$, 95% CI [−0.26, −0.01]). However, the 90% CV included zero for Enterprising interests. Again, the 95% CIs overlapped for males and females.

Thus, in general, the relationships between interests and specific cognitive abilities were not moderated by gender. However, mean variance accounted for by artifacts was larger for gender-specific analyses than for mixed samples: For verbal abilities 46.5% vs. 36.8%, for numerical abilities 53.9% vs. 25.4%, for spatial abilities 61.1% vs. 44.7%, and for induction 80.5% vs. 58.9%, respectively.

17.2. Age

Meta-analyses were conducted to determine whether the strength of correlations between interests and general intelligence varied as a function of sample age. Results of this moderator analysis are presented in Table 7. Unfortunately, we had to rely on a very small number of independent samples, especially for the younger age group with a mean age younger than 20 years (k = 2 to 3). With few exceptions, correlations

Table 6
Mean effect size estimates and confidence intervals for the correlations between Holland's RIASEC types for selected specific abilities by sex.

	k	*N*	*r*	ρ	σ^2_ρ	% VE	90% CV	95% CI	*k*	*N*	*r*	ρ	σ^2_ρ	% VE	90% CV	95% CI
	Males								Females							
Language development (verbal ability)																
Realistic	10	4344	−0.04	−0.05	0.008	30.3	[−0.17, 0.07]	[−0.11, 0.02]	10	5007	0.04	**0.05**	0.001	74.9	[0.01, 0.09]	[0.01, 0.09]
Investigative	10	4342	0.16	**0.19**	0.008	28.0	[0.08, 0.30]	[0.13, 0.26]	10	5002	0.15	**0.19**	0.008	26.3	[0.07, 0.31]	[0.12, 0.25]
Artistic	10	4342	0.18	**0.23**	0.006	35.0	[0.13, 0.33]	[0.17, 0.30]	10	5004	0.18	**0.23**	0.003	46.0	[0.16, 0.30]	[0.18, 0.28]
Social	10	4340	−0.02	−0.03	0.002	64.4	[−0.09, 0.03]	[−0.07, 0.02]	10	5003	−0.05	**−0.06**	0.000	100.0		[−0.09, −0.03]
Enterprising	10	4340	−0.03	−0.04	0.010	23.7	[−0.17, 0.09]	[−0.11, 0.03]	10	5008	−0.04	−0.05	0.008	26.8	[−0.17, 0.07]	[−0.12, 0.02]
Conventional	10	4341	−0.05	−0.07	0.003	57.7	[−0.14, 0.00]	[−0.12, −0.02]	10	5006	−0.02	−0.02	0.004	44.7	[−0.10, 0.06]	[−0.07, 0.03]
Quantitative reasoning (numerical ability)																
Realistic	7	4033	0.06	0.07	0.018	12.3	[−0.10, 0.24]	[−0.03, 0.18]	8	4809	0.16	**0.19**	0.009	20.2	[0.07, 0.31]	[0.12, 0.27]
Investigative	7	4031	0.12	**0.15**	0.003	46.1	[0.08, 0.22]	[0.10, 0.21]	8	4803	0.14	**0.17**	0.005	29.8	[0.08, 0.26]	[0.11, 0.23]
Artistic	7	4031	−0.07	**−0.09**	0.001	74.9	[−0.13, −0.05]	[−0.13, −0.04]	8	4805	−0.09	**−0.11**	0.005	35.4	[−0.19, −0.03]	[−0.17, −0.06]
Social	7	4029	−0.10	**−0.12**	0.000	100.0		[−0.14, −0.10]	8	4804	−0.10	**−0.13**	0.003	44.1	[−0.20, −0.06]	[−0.18, −0.08]
Enterprising	7	4029	−0.05	−0.06	0.005	35.0	[−0.15, 0.03]	[−0.13, 0.00]	8	4809	−0.04	**−0.05**	0.000	100.0		[−0.08, −0.03]
Conventional	7	4030	0.02	**0.02**	0.000	95.3	[0.01, 0.03]	[−0.02, 0.06]	8	4807	0.08	**0.10**	0.002	53.7	[0.04, 0.14]	[0.05, 0.15]
Visualization (spatial ability)																
Realistic	9	3673	0.20	**0.25**	0.008	29.0	[0.14, 0.36]	[0.18, 0.33]	10	4925	0.21	**0.27**	0.007	30.1	[0.16, 0.38]	[0.21, 0.33]
Investigative	9	3671	0.17	**0.21**	0.003	58.2	[0.15, 0.27]	[0.16, 0.26]	10	4920	0.17	**0.22**	0.001	69.0	[0.17, 0.27]	[0.18, 0.26]
Artistic	9	3671	−0.03	−0.04	0.003	57.4	[−0.11, 0.03]	[−0.09, 0.02]	10	4922	0.02	0.03	0.007	32.8	[−0.08, 0.14]	[−0.03, 0.09]
Social	9	3669	−0.12	**−0.16**	0.005	44.9	[−0.25, −0.07]	[−0.22, −0.10]	10	4921	−0.14	**−0.18**	0.000	100.0		[−0.21, −0.15]
Enterprising	9	3669	−0.12	**−0.15**	0.002	62.2	[−0.21, −0.09]	[−0.20, −0.10]	10	4,9626	−0.09	**−0.11**	0.000	100.0		[−0.14, −0.09]
Conventional	9	3670	−0.06	−0.08	0.003	53.5	[−0.16, 0.00]	[−0.13, −0.02]	10	4924	0.01	0.02	0.000	95.8	[0.00, 0.04]	[−0.02, 0.06]
Induction																
Realistic	3	284	0.04	0.06	0.005	79.4	[−0.03, 0.15]	[−0.12, 0.25]	3	333	0.02	**0.03**	0.000	100.0		[−0.12, 0.18]
Investigative	3	284	0.22	**0.31**	0.005	78.6	[0.23, 0.39]	[0.15, 0.48]	3	333	0.23	**0.33**	0.000	100.0		[0.24, 0.42]
Artistic	3	284	0.12	0.18	0.030	40.5	[−0.04, 0.40]	[−0.07, 0.43]	3	333	0.07	0.09	0.013	56.8	[−0.05, 0.16]	[−0.10, 0.29]
Social	3	284	−0.07	−0.10	0.024	44.8	[−0.30, 0.10]	[−0.33, 0.14]	3	333	−0.05	**−0.07**	0.000	100.0		[−0.21, 0.06]
Enterprising	3	284	−0.15	−0.22	0.029	39.1	[−0.44, 0.01]	[−0.46, 0.03]	3	333	−0.09	**−0.13**	0.000	100.0		[−0.26, −0.01]
Conventional	3	284	0.01	0.01	0.029	41.5	[−0.21, 0.23]	[−0.24, 0.26]	3	333	−0.02	−0.03	0.048	26.3	[−0.31, 0.25]	[−0.32, 0.26]

Note. k = number of independent samples; N = total sample size; r = sample size weighted mean correlation; ρ = estimated true score correlation (corrected for sample error and unreliability); $\sigma^2\rho$ = estimated variance for true score correlation; % VE = percentage of variance in ρ accounted for by statistical artifacts; 90% CV = lower and upper bounds of the 90% credibility interval for true score correlation; 95% CI = lower and upper bounds of 95% confidence interval. Correlations are presented in boldface if the 90% credibility interval excludes zero.

Table 7
Mean effect size estimates and confidence intervals for the correlations between Holland's RIASEC types and specific cognitive abilities by age.

	k	N	r	ρ	σ^2_ρ	% VE	90% CV	95% CI	k	N	r	ρ	σ^2_ρ	% VE	90% CV	95% CI
	Age (<20 years)								Age (≥20 years)							
Language development (verbal ability)																
Realistic	3	5634	0.02	0.02	0.002	34.7	[−0.03, 0.07]	[−0.03, 0.08]	4	2440	0.11	**0.13**	0.000	92.7	[0.11, 0.15]	[0.08, 0.18]
Investigative	3	5627	0.13	**0.16**	0.000	94.6	[0.15, 0.17]	[0.13, 0.19]	4	2440	0.25	**0.31**	0.008	21.5	[0.20, 0.42]	[0.21, 0.41]
Artistic	3	5629	0.17	**0.22**	0.000	100.0		[0.20, 0.24]	4	2440	0.12	**0.15**	0.005	33.6	[0.07, 0.23]	[0.07, 0.24]
Social	3	5306	−0.06	**−0.07**	0.000	100.0		[−0.10, −0.04]	4	2440	−0.07	**−0.10**	0.001	79.3	[−0.14, −0.06]	[−0.15, −0.04]
Enterprising	3	5631	−0.01	−0.01	0.000	77.8	[−0.03, 0.01]	[−0.04, 0.03]	4	2440	−0.13	**−0.17**	0.004	39.0	[−0.25, −0.09]	[−0.24, −0.09]
Conventional	3	5630	−0.02	−0.03	0.002	28.7	[−0.09, 0.03]	[−0.09, 0.03]	4	2440	−0.03	−0.03	0.005	32.3	[−0.12, 0.06]	[−0.12, 0.05]
Quantitative reasoning (numerical ability)																
Realistic	2	5310	0.18	**0.22**	0.000	100.0		[0.20, 0.25]	3	2221	0.38	**0.47**	0.004	29.9	[0.39, 0.55]	[0.39, 0.55]
Investigative	2	5302	0.18	**0.23**	0.000	100.0		[0.21, 0.24]	3	2221	0.28	**0.35**	0.000	98.5	[0.34, 0.36]	[0.30, 0.39]
Artistic	2	5304	−0.13	**−0.16**	0.003	18.5	[−0.22, −0.10]	[−0.24, −0.08]	3	2221	−0.23	**−0.30**	0.002	57.7	[−0.35, −0.25]	[−0.37, −0.24]
Social	2	5301	−0.16	**−0.20**	0.000	100.0		[−0.21, −0.18]	3	2221	−0.26	**−0.34**	0.000	100.0		[−0.38, −0.30]
Enterprising	2	5306	−0.08	**−0.10**	0.000	100.0		[−0.13, −0.07]	3	2221	−0.03	**−0.04**	0.000	100.0		[−0.09, 0.01]
Conventional	2	5305	0.03	0.04	0.001	40.9	[0.00, 0.08]	[−0.01, 0.09]	3	2221	0.09	**0.12**	0.005	30.0	[0.03, 0.21]	[0.02, 0.21]
Visualization (spatial ability)																
Realistic	3	6000	0.23	**0.29**	0.000	100.0		[0.27, 0.31]	4	2440	0.38	**0.47**	0.000	100.0		[0.44, 0.51]
Investigative	3	5993	0.20	**0.25**	0.001	41.2	[0.21, 0.29]	[0.20, 0.30]	4	2440	0.25	**0.31**	0.000	100.0		[0.29, 0.34]
Artistic	3	5995	−0.04	−0.06	0.003	23.0	[−0.13, 0.01]	[−0.12, 0.01]	4	2440	−0.14	**−0.18**	0.002	53.2	[−0.24, −0.12]	[−0.25,-0.11]
Social	3	5992	−0.17	**−0.21**	0.000	100.0		[−0.24, −0.18]	4	2440	−0.23	**−0.29**	0.000	100.0		[−0.33, −0.24]
Enterprising	3	5997	−0.10	**−0.13**	0.000	100.0		[−0.15, −0.10]	4	2440	−0.11	**−0.14**	0.000	100.0		[−0.16, −0.11]
Conventional	3	5996	−0.04	**−0.05**	0.000	100.0		[−0.07, −0.03]	4	2440	0.03	**0.03**	0.000	100.0		[0.01, 0.05]

Note. k = number of independent samples; N = total sample size; r = sample size weighted mean correlation; ρ = estimated true score correlation (corrected for sample error and unreliability); $\sigma^2\rho$ = estimated variance for true score correlation; % VE = percentage of variance in ρ accounted for by statistical artifacts; 90% CV = lower and upper bounds of the 90% credibility interval for true score correlation; 95% CI = lower and upper bounds of 95% confidence interval. Correlations are presented in boldface if the 90% credibility interval excludes zero.

between specific cognitive abilities and interests were slightly higher for the older age group.

For verbal abilities, we found a stronger positive relation with Investigative interests for the older age group ($\rho = 0.31$, 95% CI [0.21, 0.41]) than for the younger group ($\rho = 0.16$, 95% CI [0.15, 0.17]). Neither the 90% CVs nor the 95% CIs overlapped for either age group. Further, the relation between Enterprising interests was negative for the older age group ($\rho = -0.17$, 95% CI [−0.24, −0.09]) but negligible for younger samples ($\rho = -0.01$, 95% CI [−0.03, 0.01]).

For numerical abilities, older samples showed stronger relations between interest types and numerical abilities for Realistic, Investigative, Artistic, and Social interests. Neither the 95% CIs nor the 90% CVs overlapped for either age group.

For spatial abilities and realistic interests, we established stronger relations for older samples ($\rho = 0.47$, 95% CI [0.44, 0.51]) than for younger samples ($\rho = 0.29$, 95% CI [0.27, 0.31]). Neither the 90% CVs nor the 95% CIs overlapped for either age group.

Thus, results also indicated stronger relations for Investigative, Artistic, and Social interests for older samples. However, the CIs for older and younger samples slightly overlapped. With $\rho = 0.47$ for Realistic interests and numerical as well as spatial abilities, we found one of the highest correlations between any interest type and cognitive ability measures. Further, for 17 out of 36 correlations, statistical artifacts explained 100% of variance in the correlation, thereby indicating homogeneity of the relations. Thus, we found evidence for age-specific differences in the relation between vocational interests and specific cognitive abilities.

17.3. Cohort

As for general intelligence, results indicated that the relation between interests and specific cognitive abilities partly varied by birth cohort. For verbal abilities, older male cohorts showed small negative correlations with Social interests whereas the correlations were negligible for younger male cohorts ($\beta = 0.68$, $p = 0.020$). For numerical abilities, the relation with Investigative interests for females was negative for more recent cohorts but positive for older cohorts ($\beta = -0.70$, $p = 0.006$); the reversed trend was found for Conventional interests ($\beta = 0.76$, $p = 0.013$). For spatial abilities, analyses indicated that for males, younger cohorts showed a stronger negative relation with Enterprising interests than older cohorts ($\beta = -0.68$, $p = 0.016$). For Conventional interests, results indicated that whereas for males the relation with spatial abilities was negative in younger cohorts, but positive in older cohorts ($\beta = -0.67$, $p = 0.006$), the reversed trend was found for females ($\beta = 0.75$, $p = 0.021$). Moreover, for females, the relation with Realistic interests became stronger in more recent cohorts ($\beta = 0.53$, $p = 0.031$). Again, this moderator analysis must be interpreted with caution since the number of independent samples was small and distributed unequally among the cohorts. For the 1960s, 1970s, and 1990s, a maximum of two studies was available, whereas the 1980s were slightly overrepresented ($2 \leq k \leq 4$).

18. Follow-up analysis

Publication bias is a possible danger to the validity of any meta-analysis. Thus, we investigated the presence of potential bias against small or nonsignificant findings with a funnel graph that plots sample sizes against effect sizes. From visual inspections of the plot, no exclusion of small or negative results from small samples was detectable. It should be mentioned that many correlation matrices were drawn from studies that did not explicitly investigate the relation between vocational interests and cognitive abilities. Thus, withdrawing from reporting nonsignificant correlations between both measures had not been a problem in these studies.

19. Discussion

The main goal of the present meta-analysis was to investigate the relation between Holland's RIASEC themes and cognitive abilities. Specifically, we were interested in whether (a) the relation between interests and cognitive abilities varies by gender, (b) the relation between interests and cognitive abilities becomes more pronounced by age, and (c) the findings from Ackerman and Heggestad's (1997) review could be supported by our quantitative analyses. We analyzed results from 27 primary studies (and 29 independent samples) and believe that our findings provide important insights into the relation between vocational interests and cognitive abilities.

Our results support the notion of small to medium correlations between vocational interests and cognitive abilities. In accordance with Holland's (1959, 1973, 1985) assumptions, we found (a) positive relations between Realistic interests and mechanical knowledge, (b) positive relations between Investigative interests and g as well as numerical abilities and induction, (c) positive relations between Artistic interests and verbal abilities, (d) negative relations between Social interests and mechanical knowledge, and (e) positive albeit very small relations between Conventional interests and perceptual speed. Deviant from Holland's assumptions, we found negative relations between Enterprising and Social interests and verbal abilities. We further established (a) positive relations between Realistic interests and spatial as well as numerical abilities, and (b) positive relations between Investigative interests and spatial as well as verbal abilities. All findings are in accordance with Ackerman and Heggestad's (1997) review. In sum, whereas Realistic, Investigative, and Artistic interests were linked to cognitive abilities, we found only negligible or negative relations for Enterprising and Social interests and specific cognitive abilities. Armstrong et al. (2011) pointed out two reasons to account for these findings: First, this may reflect a lack of traditional cognitive ability measures to map abilities used to work effectively with others (i.e., social or management skills) or second, cognitive abilities may not be critical for job performance in environments that strongly emphasize interpersonal relations. However, in her work on an occupational aptitude patterns map, Gottfredson (1986) assigned at least average levels of g, verbal, and numerical abilities to jobs that involved dealing with social and economic relations. In sum, interests and cognitive abilities were found to be modestly correlated with cognitive abilities. This limited overlap between interests and cognitive abilities suggests that the assessment of each individual difference measure provides unique information about an individual.

Thus, neither measure should be replaced by the other in both research and practice.[3]

Past research suggested that gender moderates the relation between RIASEC types and cognitive abilities (Carless, 1999; Reeve & Heggestad, 2004). However, examining gender as a moderator, we found that the direction and magnitude of correlations between vocational interests and cognitive abilities were comparable for females and males. Thus, counter to expectations, the relation between cognitive abilities and interests was not moderated by gender. Likewise, gender was not found to be a substantial moderator of the relation between interests and personality (Staggs et al., 2007).

Analyzing birth cohorts from the 1940s to 1990s, moderator analyses indicated some cohort effects for the relation of interests and cognitive abilities. Cohort effects in vocational interests are in general attributed to changes in the labor market. First, there has been a steady increase in the number of women entering the workforce as well as an increase in college and graduate degrees earned by women (Bubany & Hansen, 2011). Second, there has been a general decline in individuals working in the Realistic area (occupations such as auto mechanic, aircraft controller, surveyor, or farmer) and a steady increase in individuals employed in the Enterprising area (i.e., occupations such as business executive, salesperson, supervisor, and manager) as reported by Reardon, Bullock, and Meyer (2007). Third, there has been a pronounced decline in manual and cognitive routine tasks and a marked increase in complex cognitive tasks, such as planning, selling, and doing research, in recent decades particularly due to technological changes (Spitz-Oener, 2006). Altogether, these shifts in the labor market may help to explain why we found indications of cohort effects in our analyses. Our results, however, must be interpreted with caution since we relied on very few samples for these moderator analyses. Further, samples were distributed unequally among the decades with considerably more samples from the 1970s and 1980s.

Cognitive investment theories (Cattell, 1987; Schmidt, 2011) propose that personality and interests guide the development of crystallized intelligence, specifically the acquisition of knowledge, skills, and aptitudes. Recently, Von Stumm and Ackerman (2013) found that general interest in knowledge acquisition is positively correlated with crystallized intelligence, academic performance, and acquired knowledge. We examined age as potential moderator and hypothesized that we would find stronger relations between specific cognitive abilities that are highly influenced by experience and knowledge acquisition, that is, measures of crystallized intelligence and related vocational interests. Within the CHC framework, domain-specific knowledge, language development, and quantitative knowledge are perceived as acquired knowledge constructs (Schneider & McGrew, 2012). For both language development as well as quantitative knowledge, we indeed found evidence for more pronounced relations with various interest types for older samples than for younger samples.

In summary, our findings lead to three main conclusions: (a) we found empirical support for small to moderate correlations between vocational interests and cognitive abilities providing evidence for Holland's assumptions on the relation between interest types and cognitive abilities; (b) deviant from past research, we established that relations between interests and cognitive abilities were comparable for females and males; and (c) we further found support for the notion that the relation between vocational interests and specific cognitive abilities, especially those that are influenced by experience and knowledge acquisition, becomes more pronounced with age.

20. Limitations

First, due to the comparably small number of studies that reported correlation coefficients between vocational interests and specific cognitive abilities as well as information on mean sample age, we were unable to consider age as a continuous moderator and instead relied on group comparisons.

Second, by focusing on Holland's RIASEC framework, we indeed based our analyses on the most prevalent model of vocational interests. Nevertheless, we had to exclude studies that relied on other theoretical frameworks such as basic interest markers. Basic interest scales measure interests on a lower level of generality than Holland's RIASEC framework such as interests in specific fields of work (e.g., engineering, teaching, physics, and theology).

Third, we decided upon the CHC framework as a classification system for our analyses since this taxonomy of cognitive abilities is widely accepted and empirically well validated (Alfonso et al., 2005). Further, it enabled us to classify the diverse specific cognitive ability measures administered in the primary studies. However, our results may be influenced by our choice of cognitive ability taxonomy since the CHC theory was not developed to implement relations among cognitive abilities and other individual difference measures such as vocational interests or personality.

Fourth, although primary studies offered a wide range of cognitive ability measures, we focused our analyses on a small selection of specific cognitive abilities due to the small number of primary studies. The majority of primary studies have been conducted in the field of career counseling. Measures of specific abilities are especially important in career counseling since they help individuals to match their educational and occupational choices to their individual constellation of abilities (Humphreys et al., 1993). In this setting, measures of verbal, numerical, and spatial abilities are often administered and are therefore overrepresented in our meta-analysis. However, especially the Artistic type is associated with abilities such as divergent thinking and artistic abilities that are not captured by our meta-analysis. The same accounts for social or interpersonal skills and management abilities which are associated with the Social and the Enterprising type.

Last, the current study did not correct for range restriction which is likely to affect cognitive ability measures rather than

[3] In vocational counseling instead of focusing on the level of a particular type of interest, individuals are characterized by a two or three-letter-code (i.e., by the two or three interest types that resemble the person most in descending order). Educational and occupational environments are similarly characterized. By matching an individual's three-letter-code to occupational characteristics potential career choices are identified.

vocational interest measures. Several primary studies included in this meta-analysis were based on college or university samples where admission is usually based on aptitude test scores. Thus, it is possible that our meta-analytic correlation coefficients are underestimated because of range restriction.

21. Implications for future research

As Lowman and Carson (2013) highlighted, it may be important to investigate not only the relationship between specific cognitive abilities and vocational interests but also between *g*-free specific abilities and vocational interests. Generally, measures of specific cognitive abilities (i.e., measures of broad and narrow cognitive abilities) correlate strongly with measures of general intelligence (*g*). Thus, to get an accurate understanding of the relation between specific cognitive abilities and interests, correlations should be controlled for *g*. Both Carson (1996, 1998a) as well as Pässler (2011) showed that the relation between Holland's RIASEC types and specific cognitive abilities alters once *g* is controlled for. Overall, the correlation between vocational interests and specific cognitive abilities is considerably reduced. Pässler (2011) reported negligible to small relations between Investigative interests and verbal, numerical, and spatial abilities when controlling for *g*. Further, the negative correlation between Social interests and numerical and spatial abilities diminished considerably. Thus, variability of past research on the relation between interests and cognitive abilities may be partly attributed to not considering differences in samples' *g*-level. Most research on the relationship between vocational interest and cognitive abilities relies on either high school students applying for college or college students. However, college samples generally display above average *g*-levels. This notion is important since research showed that at higher levels of *g*, specific cognitive abilities become more differentiated – generally referred to as Spearman's law of diminishing returns or differentiation hypothesis (see Deary et al., 1996, for a comprehensive review). Further, individuals with higher levels of intelligence were found to show broader vocational interests (Johnson & Bouchard, 2008). Broad interests and high levels of general intelligence may lead to crystallization of intelligence and knowledge acquisition in a wide range of content areas. Thus, samples' *g*-level may influence the correlational pattern of interests and specific abilities.

As summarized, we established negligible relations only between both Enterprising and Social interests and cognitive ability measures. As proposed by Armstrong et al. (2011), this may reflect a lack of traditional cognitive ability measures to map abilities used to work effectively with others such as social or emotional intelligence. Investigating the relation between Holland's RIASEC types and social intelligence, Lowman and Leeman (1988), for example, found that social and interpersonal skills were positively related with Enterprising but not Social interests. However, as pointed out by Mackintosh (2011), measures of social and emotional competence tend to show only moderate correlations with traditional measures of intelligence and are best characterized as a blend of both ability and personality. Thus, further research is needed to establish how measures of social and emotional competencies can be integrated in a framework of interests, cognitive abilities, and personality.

Finally, although we found an indication that the relation between interests and specific cognitive abilities becomes more pronounced with age, our meta-analysis was based only on cross-sectional data. Thus, no causal inferences can be drawn. To further investigate the question whether interests guide the development of crystallized intelligence (i.e., the acquisition of knowledge, skills, and aptitudes), analyses of longitudinal data are necessary. For such studies, we recommend the investigation of possible moderators such as specialization in education and reinforcement as well as deprivation and discouragement during socialization.

Appendix A. Mean effect size estimates and confidence intervals for the correlations between Holland's RIASEC types and general intelligence by sex

	k	*N*	*r*	ρ	σ^2_ρ	% VE	90% CV	95% CI
Males								
Realistic	9	22,082	−0.06	−0.07	0.015	3.3	[−0.16, 0.09]	[−0.15, 0.01]
Investigative	9	22,080	0.36	**0.42**	0.016	2.8	[0.26, 0.58]	[0.33, 0.50]
Artistic	9	22,080	0.13	**0.15**	0.006	8.6	[0.05, 0.25]	[0.10, 0.20]
Social	9	22,078	0.10	0.12	0.020	2.6	[−0.06, 0.30]	[0.02, 0.21]
Enterprising	9	22,078	0.02	0.03	0.006	8.5	[−0.07, 0.13]	[−0.03, 0.08]
Conventional	9	22,079	0.02	0.03	0.003	17.2	[−0.04, 0.10]	[−0.01, 0.06]
Females								
Realistic	9	27,626	0.13	**0.15**	0.002	16.2	[0.09, 0.21]	[0.11, 0.18]
Investigative	10	27,769	0.28	**0.32**	0.003	11.4	[0.25, 0.39]	[0.28, 0.36]
Artistic	9	27,622	0.22	**0.25**	0.018	2.3	[0.08, 0.42]	[0.16, 0.34]
Social	9	27,621	0.15	0.17	0.036	1.2	[−0.07, 0.41]	[0.05, 0.30]
Enterprising	9	27,626	0.04	0.04	0.003	14.0	[−0.03, 0.11]	[0.00, 0.08]
Conventional	9	27,624	−0.07	−0.08	0.008	5.4	[−0.20, 0.04]	[−0.14, −0.02]

Note. *k* = number of independent samples; *N* = total sample size; *r* = sample size weighted mean correlation; ρ = estimated true score correlation (corrected for sample error and unreliability); $\sigma^2\rho$ = estimated variance for true score correlation; % VE = percentage of variance in ρ accounted for by statistical artifacts; 90% CV = lower and upper bound of the 90% credibility interval for true score correlation; 95% CI = lower and upper bound of 95% confidence interval. Correlations are presented in boldface if the 90% credibility interval excludes zero.

Appendix B. Summary of studies and samples included in the meta-analysis

ID	Author(s)[a]/ article		Total								Males								Females						
			G	LD	I	QR	V	PS	MK		G	LD	I	QR	V	PS	MK		G	LD	I	QR	V	PS	MK
1	Ackerman (2000)	R		0.09	0.02	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.02	−0.08	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.11	0.05	−0.00	−0.00	−0.00	−0.00
		I		0.28	0.14							0.30	0.06							0.28	0.18				
		A		0.14	−0.08							0.13	−0.06							0.17	−0.07				
		S		−0.05	−0.16							−0.09	−0.31							−0.02	−0.05				
		E		−0.19	−0.26							−0.30	−0.40							−0.13	−0.18				
		C		−0.14	−0.08							−0.20	−0.24							−0.11	0.02				
2	Ackerman et al. (2001)	R	0.08	0.02	0.12																				
		I	0.17	0.21	0.09																				
		A	0.10	0.20	−0.02																				
		S																							
		E	−0.16	−0.11	−0.16																				
		C	−0.15	−0.20	−0.07																				
3	Ackerman et al. (1995)*	R		0.14		0.38	0.24	0.35			0.18	−0.05		0.29	0.18	0.24			0.36	0.26		0.37	0.24	0.44	
		I		0.33		0.34	0.13	0.31			0.31	0.31		0.29	0.13	0.26			0.30	0.34		0.31	0.07	0.32	
		A		0.37		−0.20	0.01	−0.08			0.00	0.34		−0.36	0.02	−0.24			0.30	0.46		0.13	0.11	0.24	
		S		−0.08		−0.14	−0.04	0.02			−0.10	−0.08		−0.16	−0.01	0.02			0.05	−0.05		0.12	0.05	0.17	
		E		−0.32		−0.15	−0.15	−0.06			−0.36	−0.51		−0.17	−0.16	−0.04			−0.16	−0.21		−0.06	−0.11	−0.03	
		C		−0.32		0.18	−0.01	0.14			−10	−0.46		0.24	−0.01	0.21			−0.07	−0.24		0.12	−0.02	0.06	
4	Bergmann (2013)**	R	0.20	0.01		0.18	0.23				0.04	−0.10		0.03	0.16				0.17	0.04		0.13	0.19		
		I	0.25	0.12		0.19	0.21				0.17	0.09		0.10	0.17				0.19	0.11		0.13	0.16		
		A	0.00	0.17		−0.14	−0.03				0.08	0.22		−0.07	0.00				0.10	0.20		−0.06	0.05		
		S	−0.18	−0.06		−0.16	−0.16				−0.09	0.00		−0.10	−0.08				−0.13	−0.06		−0.08	−0.14		
		E	−0.09	0.00		−0.08	−0.10				−0.08	0.01		−0.08	−0.10				−0.05	0.02		−0.04	−0.07		
		C	−0.02	−0.01		0.03	−0.05				−0.03	−0.02		0.02	−0.07				0.04	0.01		0.08	0.00		
5	Carless (1999a)	R									−0.09	−0.07		−0.09					0.10	0.03		0.16			
		I									0.15	0.18		0.10					0.18	0.18		0.16			
		A									0.03	0.07		−0.02					−0.10	−0.01		−0.13			
		S									−0.11	−0.12		−0.07					−0.04	−0.02		−0.05			
		E									0.07	0.05		0.09					0.04	0.06		0.01			
		C									−0.08	−0.13		−0.02					−0.03	−0.14		0.02			
6	Carless (1999b)	R									0.07		−0.10		0.01				−0.12		0.11		−0.08		
		I									0.40		0.35		0.33				0.33		0.29		0.22		
		A									0.05		−0.04		0.14				0.24		0.21		0.16		
		S									0.10		0.01		0.17				−0.18		−0.17		−0.10		
		E									−0.07		−0.15		0.05				−0.05		−0.05		−0.02		
		C									0.18		0.17		0.15				−0.15		−0.29		0.06		
7	Carson (1996)	R	0.26	0.21		0.09	0.30	0.02	0.39																
		I	0.40	0.39		0.27	0.33	0.16	0.43																
		A	0.18	0.19		0.07	0.06	0.08	0.11																
		S	0.03	0.08		−0.04	0.02	−0.01	−0.06																
		E	−0.23	−0.16		−0.26	−0.17	−0.13	−0.11																
		C	−0.14	−0.19		−0.04	−0.18	0.01	−0.17																
8	Carson (1998a)	R	0.15																						
		I	0.29																						
		A	0.21																						

(continued on next page)

Appendix B (*continued*)

ID	Author(s)[a]/article		Total							Males							Females						
			G	LD	I	QR	V	PS	MK	G	LD	I	QR	V	PS	MK	G	LD	I	QR	V	PS	MK
		S	0.01																				
		E	−0.07																				
		C	0.12																				
9	Carson (1998b)	R	−0.09																				
		I	0.49																				
		A	0.13																				
		S	0.10																				
		E	0.13																				
		C	0.09																				
10	Fritzsche et al. (1999)	R	0.02																				
		I	0.11																				
		A	0.07																				
		S	0.06																				
		E	0.09																				
		C	−0.02																				
11	Kanfer, Ackerman and Heggestad (1996)	R		−0.12		0.05	0.27	0.03															
		I		−0.05		0.11	0.17	0.02															
		A		0.19		0.01	0.16	−0.03															
		S		−0.10		−0.11	−0.01	−0.10															
		E		−0.30		−0.17	−0.17	−0.02															
		C		−0.22		−0.06	−0.12	0.16															
12	Kaub et al. (2012)	R	0.14	−0.02			0.35	0.01		0.12	−0.10			0.39	0.04		0.14	−0.15			0.27	0.09	
		I	0.06	0.03			0.23	−0.05		−0.03	−0.07			0.14	−0.06		0.10	−0.01			0.24	0.00	
		A	−0.15	0.06			−0.30	−0.17		−0.02	0.25			−0.21	−0.20		−0.22	0.08			−0.32	−0.24	
		S	−0.12	−0.06			−0.19	−0.10		−0.20	−0.07			−0.21	−0.19		−0.05	0.05			−0.12	−0.11	
		E	−0.04	0.03			−0.11	−0.07		−0.08	0.10			−0.11	−0.20		−0.01	0.02			−0.08	−0.01	
		C	0.06	−0.05			0.07	0.02		0.02	−0.11			0.04	−0.09		0.08	−0.05			0.07	0.10	
13	Kelso et al. (1977)***	R																		−0.01	0.11	0.04	0.14
		I																		0.27	0.35	0.02	0.29
		A																		0.00	0.14	−0.13	0.02
		S																		−0.03	−0.30	−0.04	−0.15
		E																		−0.03	−0.12	0.06	−0.08
		C																		−0.09	−0.12	0.15	−0.07
14	Kirchler (1990)	R	−0.19																				
		I	0.29																				
		A	0.22																				
15	Krapic et al. (2008)	R			0.25																		
		I			0.25																		
		A			0.22																		
		S			−0.05																		
		E			0.02																		
		C			0.18																		
16	Lowman et al. (1985)	I															0.28						
		C																				0.14	
17	Marcus et al. (2009)	R	0.08																				

		I	0.12																						
		A	0.07																						
		S	−0.07																						
		E	0.05																						
		C	0.07																						
18	Mussel (2013)	R		0.05	0.08							−0.08	−0.12							0.14	0.14				
		I		0.24	0.28							0.26	0.27							0.25	0.26				
		A		0.28	0.17							0.23	0.14							0.32	0.26				
		S		0.06	−0.01							0.01	0.05							0.09	0.03				
		E		−0.02	−0.01							0.00	0.01							−0.03	−0.03				
		C		0.00	0.12							0.04	0.18							−0.02	0.08				
19	Pässler and Hell (2012)	R	0.31	0.12		0.39	0.39				0.24	0.08		0.26	0.34				0.26	0.08		0.27	0.30		
		I	0.31	0.28		0.28	0.26				0.27	0.27		0.22	0.20				0.26	0.26		0.18	0.20		
		A	−0.04	0.12		−0.24	−0.13				0.07	0.20		−0.07	−0.09				−0.01	0.15		−0.18	−0.04		
		S	−0.18	−0.06		−0.27	−0.24				−0.09	0.01		−0.11	−0.21				−0.14	−0.05		−0.19	−0.15		
		E	−0.09	−0.14		−0.02	−0.11				−0.11	−0.14		−0.10	−0.17				−0.11	−0.16		−0.05	−0.12		
		C	0.05	0.00		0.10	0.02				−0.04	−0.04		0.00	−0.08				0.08	0.01		0.12	0.06		
20	Proyer (2006)	R	0.22	0.06		0.15	0.40				0.28	0.33		0.00	0.44				0.16	−0.08		0.16	0.37		
		I	0.20	0.10		0.16	0.25				0.37	0.34		0.19	0.49				0.09	−0.01		0.10	0.14		
		A	−0.05	−0.04		−0.06	−0.07				−0.23	−0.24		0.01	−0.42				0.13	0.09		0.04	0.12		
		S	−0.26	−0.26		−0.26	−0.21				−0.31	−0.35		−0.10	−0.34				−0.18	−0.20		−0.11	−0.13		
		E	−0.04	−0.13		−0.13	−0.02				−0.10	−0.22		0.07	0.01				−0.03	−0.10		0.01	−0.05		
		C	−0.07	−0.16		−0.16	0.05				0.22	0.03		0.18	0.39				−0.20	−0.23		−0.14	−0.08		
21	Randahl (1991)	R		−0.03		0.09	0.34	−0.13																	
		I		0.22		0.23	0.27	0.08																	
		A		0.28		−0.02	−0.01	0.13																	
		S		−0.01		0.01	−0.13	0.06																	
		E		−0.17		−0.04	−0.06	−0.04																	
		C		−0.08		0.15	0.06	0.04																	
22	Reeve and Heggestad (2004)	R									−0.12								0.11						
		I									0.43								0.31						
		A									0.17								0.28						
		S									0.18								0.25						
		E									0.06								0.06						
		C									0.05								−0.11						
23	Rolfhus and Ackerman (1996)	R		0.23		0.27	0.28	0.10	0.35																
		I		0.20		0.14	0.16	0.02	0.21																
		A		0.24		0.11	0.06	0.05	0.11																
		S		0.03		−0.20	−0.08	0.14	−0.21																
		E		−0.03		0.01	−0.16	0.02	−0.15																
		C		−0.05		0.19	0.01	0.15	0.04																
24	Schmidt et al. (1998)	R			0.09		0.20		0.23																
		I			0.14		0.11		0.08																
		A			0.06		−0.17		−0.20																
		S			0.00		−0.21		−0.28																
		E			−0.04		−0.07		−0.11																
		C			0.08		0.00		−0.06																
25	Stanley et al. (1995)	R													0.13		0.16						−0.09		0.11
		I													0.08		0.13						0.11		−0.08

(continued on next page)

Appendix B (*continued*)

ID	Author(s)[a]/ article		Total G	Total LD	Total I	Total QR	Total V	Total PS	Total MK	Males G	Males LD	Males I	Males QR	Males V	Males PS	Males MK	Females G	Females LD	Females I	Females QR	Females V	Females PS	Females MK
		A												−0.01		0.00					0.04		−0.01
		S												−0.20		−0.06					−0.01		−0.08
		E												−0.07		0.03					−0.09		−0.08
		C												0.06		0.12					−0.03		0.11
26	Toker and Ackerman (2012)	R		0.00		−0.02	0.21				0.04		0.00	0.15				−0.03		−0.14	0.15		
		I		0.09		−0.03	0.11				0.16		−0.03	0.14				0.04		−0.04	0.14		
		A		0.13		−0.16	−0.03				0.05		−0.18	−0.01				0.19		−0.12	−0.01		
		S		0.06		−0.07	−0.10				0.00		−0.05	−0.06				0.12		−0.07	−0.06		
		E		−0.10		−0.11	−0.23				−0.20		−0.05	−0.23				−0.03		−0.16	−0.23		
		C		−0.05		0.15	0.00				−0.10		0.18	−0.10				−0.02		0.13	−0.10		
27	Toker and Ackerman (2012)	R		−0.03		0.12	0.25				−0.01		0.11	0.12				0.04		0.00	0.30		
		I		0.10		−0.05	−0.01				0.23		0.12	−0.06				0.01		−0.20	0.00		
		A		0.16		−0.19	−0.10				0.09		−0.21	−0.05				0.34		−0.14	−0.10		
		S		−0.05		−0.14	−0.22				−0.01		−0.05	−0.21				−0.03		−0.17	−0.17		
		E		−0.16		−0.05	−0.27				−0.08		0.05	−0.38				−0.22		−0.16	−0.17		
		C		−0.21		0.13	−0.03				−0.12		0.11	−0.19				−0.26		0.15	0.15		
28	Van Iddekinge, Putka, et al. (2011)	R	−0.11																				
		I	0.07																				
		A	−0.09																				
		S	−0.12																				
		E	−0.08																				
		C	−0.15																				
29	Vock et al. (2013)	R	0.22							0.15							0.13						
		I	0.24							0.18							0.18						
		A	−0.09							−0.04							−0.02						
		S	−0.19							−0.11							−0.13						
		E	−0.04							−0.10							0.01						
		C	0.03							−0.08							0.09						

Note: [a]Complete references can be found in the reference section. Cognitive abilities: G = General Intelligence. LD = Language Development. I = Induction. QR = Quantitative Reasoning. V = Visualization. PS = Perceptual Speed. MK = Mechanical Knowledge. *PS complex is reported, PS simplex is also included in the analyses (Total: 0.08, 0.12, −0.04, 0.07, −0.05, −0.07; Males: 0.04, 0.17, −0.18, −0.09, −0.05, 0.08; Females: 0.15, 0.11, 0.10, 0.23, −0.08, −0.20). **Unpublished data. ***For MK Mechanical Comprehension is reported. Tool Knowledge, Space Perception, Shop Information, Automotive Information, Electronic Information are also included in the analyses.

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