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ADHD and personality: A meta-analytic review

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HIGHLIGHTS

- The potential for an integrated five-factor personality model and ADHD was examined.
- ADHD symptom groups are inattention (IA) and hyperactivity/impulsivity (HI).
- Conscientious inhibition had stronger negative associations with IA than HI.
- Agreeable inhibition had stronger negative associations with HI than IA.
- IA and HI were about equally associated positively with negative emotionality.

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ABSTRACT

We report a meta-analysis of up to 40 data sets that examined the personality dimensions in the Five-Factor Model (FFM) and the integrated Five-Factor Model (IFFM) in relation to ADHD symptom domains of inattention (IA) and hyperactivity/impulsivity (HI). The IFFM incorporated the dimensions of other personality models (in particular, those of Eysenck, Tellegen, and Cloninger, as well as the FFM). Major findings were: (1) IA and HI were both associated with low conscientious inhibition/conscientiousness, and low agreeable inhibition/agreeableness, and with high negative emotionality/neuroticism; (2) conscientious inhibition and conscientiousness were more strongly related to IA than HI; (3) agreeable inhibition and agreeableness were more strongly related to HI than IA; and (4) the association of conscientious inhibition and conscientiousness with HI was moderated by age group and source from where participants were recruited (associations were stronger in children than adults, and clinical samples than community samples). These findings are discussed in relation to single and multiple pathway theories, underlying factors and processes for the personality–ADHD link, and clinical implications.

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1. Introduction

It is generally accepted that establishing links between psychological disorders and personality (and temperament) dimensions is valuable in improving our understanding of clinical diathesis, cause, progression, prognosis, and treatment. Despite current theoretical models that can link Attention-Deficit/Hyperactivity Disorder (ADHD; DSM-5, American Psychiatric Association, APA, 2013; DSM-IV-TR, APA, 2000) to personality, and also a growing number of studies examining relationships between ADHD and the major dimensions proposed in several personality models, the personality–ADHD literature has yet to be summarized and synthesized. In this paper, we report the results of a meta-analysis that examines the relationships of personality and ADHD in terms of the Five-Factor Model (FFM; Costa & McCrae, 1985), as well as the integrated Five-Factor Model (IFFM; Markon, Krueger, & Watson, 2005). To appreciate and justify our goal, we will present a brief overview of ADHD research germane to the present review.

2. A selective overview of ADHD

2.1. ADHD symptoms and diagnosis, comorbidity, and other relevant characteristics

The symptoms, subtypes, and diagnosis proposed for ADHD in DSM-IV-TR (APA, 2000) are identical to those in DSM-IV (APA, 1994), which lists eighteen symptoms under two separate groups, namely inattention (IA) and hyperactivity/impulsivity (HI), with nine symptoms for each group. DSM-IV and DSM-IV TR indicate that there are three subtypes of ADHD: ADHD inattentive type (presence of at least six IA symptoms); ADHD hyperactive/impulsivity type (presence of at least six HI symptoms); and ADHD combined type (presence of at least six IA and six HI symptoms). Although DSM-5 has retained the same symptoms and groups as DSM-IV/DSM-IV TR, subtypes have been replaced with presentation specifiers that map directly to the prior subtypes.

While ADHD is viewed in categorical terms in DSM-IV/DSM-IV-TR and DSM-5, there is support for a dimensional (continuous) view of it (Coghill & Sonuga-Barke, 2012; Marcus & Barry, 2011). There is also evidence that ADHD is fairly stable from childhood to adulthood (Biederman et al., 1993; Kessler et al., 2005). Family, twin and adoption studies have shown that ADHD is highly influenced by genetic factors (Faraone & Doyle, 2001). Biederman (2005) estimated the mean heritability of ADHD to be .77. Thus, like personality dimensions, ADHD can be viewed dimensionally, stable across time, and is highly heritable. Another common feature of ADHD, in both children and adults, is the high comorbidity with other externalizing (Oppositional Defiant Disorder [ODD], Conduct Disorder [CD]) and internalizing (anxiety and mood disorders) disorders (Biederman, 2005; Biederman et al., 1993; Spencer, Biederman, & Wilens, 1999).

2.2. Major theoretical models of ADHD

Theoretical models of ADHD can be grouped as either single pathway (implicating a single core deficit) or multiple pathway (implicating two or more core deficits) models. The more influential single pathway models contain deficits of cognition (Barkley, 1997) or motivation (Sonuga-Barke, Taylor, Sembi, & Smith, 1992). According to Barkley (1997), inhibitory control is a superordinate function that contributes to various executive functions (working memory, planning, regulation of arousal, emotion, and motivation), and ADHD results from deficient executive functions, with poor inhibitory control as a core deficit. In contrast, Sonuga-Barke et al.'s delay aversion model suggests that ADHD results from intolerance for delayed rewards, thereby implicating deficits in motivation rather than executive functions as the primary deficit.

A major multiple pathway model is the dual pathway model proposed by Sonuga-Barke (2003), which postulates that ADHD is associated with deficits in both motivation (related to delay aversion) and executive (related to response inhibition) functions, with these deficits contributing independently to ADHD. Martel, von Eye, and Nigg (2010) (see also Nigg, 2010) have referred to the executive control processes and motivational processes as "top-down" and "bottom-up", respectively. Top-down control behaviors are goal-directed, resource-demanding and planful, whereas bottom-up control behaviors, which include affective responses, are strongly influenced by immediate incentives. Unlike single pathway models, which attempt to explain ADHD without differentiating the IA and HI symptom groups, multiple pathways implicate different processes for the two groups. In the dual pathways model proposed by Sonuga-Barke (2003), deficits in motivation are linked to HI, whereas deficits in executive functions are linked to IA (Sonuga-Barke, 2005). In a similar manner, in the Martel, Goth-Owen, Martinez-Torteya, and Nigg (2010) and Martel, von Eye, and Nigg (2010) model, top-down and bottom-up control processes are differentially related to IA and HI, respectively.

2.3. Relevance for ADHD models for understanding ADHD–personality links

According to Martel, Goth-Owen, et al. (2010), Martel, von Eye, et al. (2010) personality traits related to low effortful control, conscientiousness and resiliency reflect top-down control processes, whereas personality traits related to high reactive control, negative emotionality, neuroticism, extraversion, and low agreeableness reflect bottom-up control processes. As top-down and bottom-up control processes are differentially related to IA and HI, respectively, it follows that low effortful control, conscientiousness and resiliency should be associated with IA, whereas high reactive control, negative emotionality, neuroticism, extraversion, and low agreeableness should be associated with HI symptoms (Martel, Goth-Owen, et al., 2010; Martel, von Eye, et al., 2010). Overall, therefore, there are good theoretical grounds to assume

that a comprehensive understanding of how personality dimensions are related to ADHD would improve our understanding of ADHD, especially relating to behavioral criteria, heterogeneity and development of ADHD (De Pauw & Mervielde, 2010), and simpler biologically-linked markers (endophenotypes) of ADHD (Nigg, 2010).

In terms of processes, four models have been proposed to explain the relations between personality and psychopathology: spectrum (normal and abnormal fall at different points on the same continuum, such that psychopathology is primarily a clinical manifestation of personality, with shared etiological determinants); vulnerability (certain personality traits predispose individuals to certain kinds of psychopathology); pathoplastic (temperament alters the course of disorder once it occurs); and scar (psychopathology influence personality) (Tackett, 2006). Thus, it can be speculated that the relations between ADHD (and its domains) and personality may involve one or more of these processes.

3. Justification for a meta-analysis

The personality models most used in ADHD research are Cloninger's biopsychosocial model (Cloninger, 1987; Cloninger, Svrakic, & Przybeck, 1993), including the child/adolescent version of this model (Luby, Svrakic, McCallum, Pryzbeck, & Cloninger, 1999), and various versions of the Big Five model, especially the Five-Factor Model (FFM; Costa & McCrae, 1985; Goldberg, 1993). Personality models of Eysenck (Eysenck & Eysenck, 1975), Tellegen (2000), and Gray (1975, 1982) have also been applied. Table 1 provides descriptions of all the dimensions in these models.

A qualitative examination of existing findings suggests that, in general, ADHD has positive associations with Gray's (1975) behavioral inhibition system (BIS) and Cloninger's harm avoidance. Also, ADHD has negative associations with Tellegen's constraint, FFM agreeableness and conscientiousness, and Cloninger's persistence, cooperation, and self-directedness (see Gomez, 2009 for a narrative review). Also, mixed findings (positive, negative, and no associations) have been reported for Eysenck's and FFM extraversion, Tellegen's positive emotionality, Cloninger's reward dependence and self-transcendence/spirituality, and FFM openness. Studies that have examined the relations of personality dimensions with IA and HI have generally mirrored the findings for ADHD symptoms taken together (e.g., Gomez & Corr, 2010; Gomez, Woodworth, Waugh, & Corr, 2012; Hundt, Kimbrel, Mitchell, & Nelson-Gray, 2008; Nigg et al., 2002; Parker, Majeski, & Collin, 2004; Salgado et al., 2009).

Existing data also show that the relationships of personality with ADHD, IA and HI are likely to be moderated by other variables. There are data showing that associations are stronger: in clinical samples than community samples; when ADHD samples are not screened or not excluded for other externalizing and conduct problems (and, therefore, these samples are most likely to have externalizing and conduct problems since these problems are high correlations with ADHD); and among younger children (Cukrowicz, Taylor, Schatschneider, & Iacono, 2006; Gomez & Corr, 2010). Thus, a better understanding of personality–ADHD links would require a systematic evaluation of these moderating associations.

Although qualitative examination of past findings can provide useful information about the relations of ADHD, IA and HI with the major personality dimensions, this approach has limitations. First, as ADHD, IA and HI have shown somewhat similar relations with the same personality dimensions, it would be useful to examine the magnitude of these relations as this should provide a more comprehensive picture and would help to synthesize the extant literature. Second, as there are data that age, source from where participants are recruited, and the presence of other externalizing/conduct problems, may influence personality relations with ADHD, IA, and HI, their effects need to be jointly considered for a clearer interpretation of findings. This work has not yet been conducted.

Table 1
Dimensions of personality models in ADHD studies.

Gray (1975, 1982)	
Behavioral approach system (BAS)	Underlies impulsivity, sensitivity to reward, increases approach and impulsive responses
Behavioral inhibition system (BIS)	Underlies anxiety, sensitive to punishment, increases avoidance responses
Eysenck and Eysenck's (1975)	
Extraversion	Being sociable, outgoing, optimistic, sensation seeking versus being quiet, unsociable, passive and careful
Neuroticism	Tendency for proneness to unpleasant experience and maladjustment versus being less prone to unpleasant experience and maladjustment
Psychoticism	Egocentric, lacking empathy and impulsive
Tellegen's (2000) multidimensional personality model (MPM)	
Positive emotionality	Tendency to experience positive emotions, including traits of sociability, assertiveness, and achievement orientation
Negative emotionality	Tendency to experience negative emotions and ability handle stress
Constraint	Tendency for cautious, restrained and inhibitory behaviors
Cloninger's model (1987); Cloninger et al. (1993)	
Novelty seeking	Tendency to engage and be excited/exhilarated experiencing novel situations
Harm avoidance	Tendency to intensely inhibit responses to aversive cues
Reward dependence	Tendency to intensely maintain responses rewarded previously
Persistence	Tendency to be persevering, despite frustration and fatigue
Self-directedness	Ability to control, regulate and adapt one's behavior to fit the situation in accord with one's chosen goals and values
Cooperativeness	Tendency to be agreeable and acceptance of others
Self-transcendence	Being spiritual
Five-Factor Model (FFM; Costa & McCrae, 1985)	
Extraversion	Being sociable, outgoing, optimistic, sensation seeking versus being quiet, unsociable, passive and careful
Neuroticism	Tendency for proneness to unpleasant experience, and maladjustment versus being less prone to unpleasant experience and maladjustment; including being impulsive
Agreeableness	Tendency to be agreeable, trustworthy, friendly and cooperative with others
Conscientiousness	Tendency to be well organized, responsible and task-focused in pursuing goals
Openness to experience	Tendency for being imaginative, creative, and interested in cultural and educational experiences

An appropriate way to synthesize past findings, and at the same time determine relationships and moderating effects, is to perform a quantitative meta-analysis. More specifically, meta-analysis would allow us to provide summary statistics of the effect size of the relationships between personality and ADHD, IA, and HI; and, importantly, to discover the nature and magnitude of the moderators of these relationships. The findings from a meta-analysis can, therefore, provide a more comprehensive and reliable understanding of how personality dimensions are related to ADHD. Also, it would provide more reliable data that can facilitate better understanding of the biological underpinning and heterogeneity of ADHD, and this, in turn, may have implications for theory, assessment, and treatment of ADHD.

4. Aims of current meta-analysis

The overall aim of this study was to use meta-analytic techniques to examine the relationships of personality dimensions with ADHD, IA,

and HI. In addition, we examined if the relationships were moderated by: (1) source of the sample (clinical versus community); (2) age group (child/adolescent versus adult); and (3) whether participants were screened for other externalizing problems. For such analyses to be viable there is a need for a sufficiently large number of independent studies. Our search (described later) indicated that this was the case for the FFM, but not the other models. Given this fact and also because there is now considerable empirical support for the FFM in terms of its construct validity, temporal stability, and cross-cultural relevance in children, adolescents and adults (Costa & McCrae, 1988; John, Caspi, Robins, Moffit, & Stouthamer-Loeber, 1994; McCrae, Terracciano, & 78 members of the Personality Profiles of Cultures Project, 2005), we examined these relations within two different FFM frameworks, namely the original FFM model, and the integrated FFM (IFFM) proposed by Markon et al. (2005).

Based on meta-analysis, these IFFM researchers grouped the personality dimensions of the FFM, Eysenck, Tellegen, and Cloninger models into five major dimensions corresponding to the original FFM. Table 2 provides this grouping. As shown, the factors are positive emotionality (comparable to extraversion in the FFM), negative emotionality (comparable to neuroticism in the FFM), conscientious inhibition (originally called conscientious disinhibition, but reversed keyed and renamed here to align with the FFM conscientiousness), agreeable inhibition (originally called agreeable disinhibition, but reverse keyed and renamed here to align with the FFM agreeableness), and openness (similar to FFM openness). Given that the IFFM includes all the personality dimensions used in past ADHD research (except the BIS and BAS dimensions of Gray's model — but these dimensions are largely reflected in the dimensions; e.g., negative and positive emotionality, respectively), and as it corresponds closely with the well validated FFM of personality, the IFFM can be seen as a relevant, useful and meaningful framework for integrating past studies of personality and ADHD. Since the IFFM proposed by Markon et al. (2005) does not incorporate temperament models, we did not include past studies that have examined the associations between temperament dimensions and ADHD. This was to allow us to constrain the meta-analysis clearly to the IFFM. This was not seen as problematic as there were very few such studies (three when we conducted the meta-analysis).

Based on existing findings, we expected the meta-analyses to show significant effect size associations for negative emotionality/neuroticism, conscientious inhibition/conscientiousness, and agreeable inhibition/agreeableness with ADHD, IA, and HI. We also expected moderating effects since past studies have suggested that these relationships are influenced by the source from where participants are recruited, the presence of other externalizing/conduct problems, and age. More specifically, significant associations were generally more strongly associated with clinic-referred samples, and among those not screened for other externalizing/conduct problems, and children more than adults.

Table 2
Scales from the EPQ, MPQ, TCI and NEO measures loading in the 5-Factor Model reported by Markon et al. (2005).

Factors	Scales
Positive emotionality	Eysenck/Extraversion, FFM/Extraversion, Tellegen/Positive Affect, Cloninger/Reward Dependence
Negative emotionality	Eysenck/Neuroticism, FFM/Neuroticism, Tellegen/Negative Affect, Cloninger/Harm Avoidance, Cloninger/Self-Directedness(−)
Conscientious inhibition	FFM/Conscientiousness, Tellegen/Positive Affect, Tellegen/Constraint, Cloninger/Novelty Seeking (−), Cloninger/Persistence
Agreeable inhibition	Eysenck/Psychoticism(−), FFM/Agreeableness, Tellegen/Negative Affect(−), Cloninger/Cooperation
Openness	FFM/Openness, Cloninger/Self-transcendence

Note: Negative sign indicates that the scale loaded negatively. In the original proposed model, conscientious inhibition and agreeable inhibition were called unconscientious disinhibition and disagreeable disinhibition, respectively. To reflect correspondence with the five-factor model, the signs of the dimensions in these factors have been reversed to reflect conscientious inhibition and agreeable inhibition.

4.1. Inclusion criteria for studies

To be included, a study had to either (1) compare an ADHD group with a control group without any known disorder (the control group being either one specific to the study or a group with preestablished normative scores) in terms of the relevant personality dimensions, or (2) provide the correlations for ADHD, and/or IA and/or HI domains with the relevant personality dimensions. For the current study, personality dimensions were restricted to the following models: Eysenck, Tellegen, Cloninger, and the FFM. These models included various versions of the child (junior) and adult versions of Eysenck Personality Inventory and Eysenck Personality Questionnaire (EPQ and EPQ—Revised [EPQ-R], Eysenck & Eysenck, 1975, 1994); the Multidimensional Personality Questionnaire (MPQ; Tellegen, 2000); the Temperament and Character Inventory (TCI) and its predecessor, the Tridimensional Personality Questionnaire (TPQ; Cloninger, 1987; Cloninger et al., 1993); the Junior Temperament and Character Inventory (JTCI; Luby et al., 1999); variants of the NEO Personality Inventory (NEO-PI, NEO-PI—Revised [NEO–R], and NEO Five-Factor Inventory [NEO-FFI]; Costa & McCrae, 1985, 1992), including the Hierarchical Personality Inventory for Children (HiPIC; Mervielde & De Fruyt, 2002), and California Child Q-Sort (CCQ; Caspi et al., 1992).

Group comparison studies were based on categorically diagnosed ADHD groups, whereas correlational studies were based on ADHD rating scales that assume continuous or dimensional scores for ADHD, IA, and HI. For the group comparison studies, the ADHD groups had to be diagnosed using DSM-IV/DSM-IV TR or DSM-III (American Psychiatric Association, 1987, or DSM-III-R, 1986). For the correlation studies, ratings of ADHD had to comprise the symptoms listed either in DSM-IV/DSM-IV TR/DSM-5, DSM-III or DSM-IIIR. Our initial search found no study that had examined how related constructs of inattention and hyperactivity, such as the attention problems scale of the Child Behavior Checklist (Achenbach & Rescorla, 2001), were related to traits relevant to the FFM. To be included in the current study it was also necessary for the current study to have had, or for the authors (upon request) to provide, all data needed to calculate the weighted effect sizes. Excluded from this meta-analysis were data reflecting personality dimensions in Gray's model (for a summary of this literature, see Gomez & Corr, 2010; Hundt et al., 2008; Luman, van Meel, Oosterlann, & Geurts, 2012) as these dimensions were not included in the IFFM proposed by Markon et al. (2005).

4.2. Literature search and sample of studies

To identify all relevant studies, our initial strategy was to conduct searches in the following database: Academic Search Premier (EBSCO), Expanded Academic ASAP (Gale), JSTOR, Web of Science (ISI), Proquest (unpublished dissertations), PsycINFO, and MEDLINE. For this search, we used the key phrases “ADHD or ADD or ADDH and personality traits or personality dimensions”; “ADHD or ADD or ADDH and Eysenck's Personality Questionnaire or EPQ or EPQ—Revised”; ADHD or ADD or ADDH and MPQ or Multidimensional Personality Questionnaire”; “ADHD or ADD or ADDH and NEO Personality Inventory or NEO-PI or NEO-PI—Revised or NEO Five-Factor Inventory or NEO-FFI or Big Five” or “Five-Factor Model”; “ADHD or ADD or ADDH and Temperament and Character Inventory or TCI or Tridimensional Personality Questionnaire or TPQ or Junior Temperament and Character Inventory or JTCI”. This search provided 236 abstracts. The introduction and reference sections of all relevant studies in this set, as well as a recent narrative review (Gomez, 2009), were examined for additional studies. In order to

identify additional data, we also contacted authors who had published in the area of personality and ADHD.

Where a study provided multiple data for a personality dimension from different raters, we used the data from only one of these sources (the mother) so as to ensure statistical independence. Where a study provided multiple data for a personality dimension, we used the mean effect size for the meta-analysis. Since the self-transcendence dimension in the JTCI is split into the dimensions for fantasy and spirituality (Luby et al., 1999), we used the spirituality dimension in the meta-analysis. When samples were used in more than one publication, effects were included for only one study. Thus, each sample contributed only one effect size per construct. However, when a study contained multiple independent samples the correlations from all samples were included. Details, including the study and participant characteristics coded that were included in the meta-analysis are presented in Table 3.

As shown in Table 3, there were 31 studies that contributed 40 independent data sets for ADHD. There were 17 independent data sets for questionnaires related to the FFM (e.g., NEO-PI-R, NEO-FFI, HiPIC, and CCQ), 16 for measures relevant to Cloninger's model, 5 for Tellegen's measures, and 2 for measures relevant to Eysenck's model. Overall, scores were available to compute effect sizes for IA in 14 studies and HI in 13 studies. In relation to the FFM, 11 and 10 studies provided scores that allowed effect sizes to be computed for IA and HI, respectively, for the FFM. Many studies did not include all the relevant personality dimensions of the models they examined.

Table 3
Characteristics of studies examining the relationships of personality with ADHD, IA and HI included in the different meta-analyses.

	Participants					ADHD	Personality		
Study	#	Age group	% of males	Source	Study design	DSM version	Scale	Dimensions	Outcomes
Anckarsater et al. (2006)	400	Adult	NR	Clinical	IG	IV	TCI	HA, NS, RD, P, SD, Cop, Sp	ADHD
Braaten and Rosén (1997)	127	Adult	46	Community	IG	IIIR	EPQ	N, E	ADHD
Cho et al. (2008)/parent	102	Child	90	Clinical	IG	IV	JTCI	HA, NS, RD, P, SD, Cop, Sp	ADHD
Cho et al. (2009)	261	Child	74	Clinical	IG	IV	JTCI	HA, NS, RD, P, SD, Cop, Sp	ADHD
Cukrowicz et al. (2006)									
Female (Adol)	589	Child	0	Clinical	IG	IIIR	MPQ	NA, PA, Const	ADHD
Male (Adol)	360	Child	100	Clinical	IG	IIIR	MPQ	NA, PA, Const	ADHD
Female (Child)	802	Child	0	Clinical	IG	IIIR	MPQ	NA, PA, Const	ADHD
Male (Child)	628	Child	100	Clinical	IG	IIIR	MPQ	NA, PA, Const	ADHD
De Pauw and Mervielde (2010)		Child	52	Clinical	IG	IV	HiPIC	N, E, C, A, O	ADHD, IA, HI
Downey, Pomerleau, and Pomerleau (1996)	35	Adult	100	Clinical	IG	III	TPQ	HA, NS, RD, P	ADDH
Downey, Stelson, Pomerleau, and Giordani (1997)	341	Adult	78	Clinical	IG	III	TPQ	HA, NS, RD	ADDH
Faraone, Kunwar, Adamson, and Biederman (2009)	250	Adult	49	Clinical	IG	IV	TCI	HA, NS, RD, P, SD, Cop, Sp	ADHD
Gomez and Corr (2010)	214	Adult	46	Community	Cor	IV	MPQ	NA, PA, Const	ADHD, IA, HI
Gomez et al. (2012)	231	Adult	39	Community	Cor	IV	TCI	HA, NS, RD, P, SD, Cop, Sp	ADHD, IA, HI
Gudjonsson, Sigurdsson, Young, Newton, and Peersen (2009)	46	Adult	93	Clinical	Cor	IV	EPQ	E, N, P	ADHD
Jacob et al. (2007)	806	Adult	38	Clinical	IG	IV	TPQ	HA, NS, RD, SD, Cop, Sp	ADHD
	796	Adult	38	Clinical	IG	IV	NEO-PIR	N, E, C, A, O	ADHD
Lynn et al. (2005)	171	Adult	51	Clinical	IG	IV	TCI	HA, NS, SD, Cop, Sp	ADHD
Martel, Nigg, and Lucus (2008)									
Adolescent	184	Child	59	Community	IG	IV	CCQ	N, E, C, A	ADHD, IA, HI
Child	179	Child	63	Community	IG	IV	CCQ	N, E, C, A	ADHD, IA, HI
Martel, Nigg, and von Eye (2009)									
Adolescent	184	Child	59	Clinical	Cor	IV	CCQ	N, C, A	ADHD, IA, HI
Child	179	Child	63	Clinical	Cor	IV	CCQ	N, C, A	ADHD, IA, HI
Martel, Goth-Owen, et al. (2010), Martel, von Eye, et al. (2010)	501	Child	59	Community	IG	IV	CCQ	N, E, C, A, O	ADHD
Martel et al. (20111)	501	Child	309	Community	IG	IV	CCQ	N, E, C, A, O	ADHD, IA
Miller, Miller, Newcorn, and Halperin (2008)		Child	88	Clinical	IG	III-R	NEO-PIR	N, E, C, A, O	ADHD
Nigg et al. (2002)									
Clinical ADHD	88	Adult	38	Clinical	Cor	IV	NEO-FFI	N, E, C, A, O	ADHD, IA, HI
Adult self-ratings	529	Adult	36	Community	Cor	IV	NEO-FFI	N, E, C, A, O	ADHD, IA, HI
Parent ratings	142	Adult	48	Community	Cor	IV	NEO-FFI	N, E, C, A, O	ADHD, IA, HI
Parker et al. (2004)	587	Adult	21	Community	Cor	IV	NEO-FFI	N, E, C, A, O	ADHD, IA, HI
Purper-Ouakila et al. (2010)	162	Adult	100	Clinical	IG	IV	TCI	HA, NS, SD, Cop, Sp	ADHD
Ranseen, Campbell, and Baer (1998)	48	Adult	38	Clinical	IG	IIIR	NEO-FFI	N, E, C, A, O	ADHD
Rettew, Copeland, Stanger, and Hudziak (2004)	83	Child	68	Clinical	IG	IV	JTCI	HA, NS, RD, P, SD, Cop, Sp	ADHD
Retz et al. (2004)	129	Adult	100	Clinical	Cor	IV	NEO-FFI	N, E, C, A, O	ADHD
Rösler et al. (2004)	250	Adult	?	Clinical	Cor	IV	NEO-FFI	N, E, C, A, O	ADHD, IA, HI
Sizoo, van den Brink, van Eenige, and van der Gaag (2009)	353	Adult	75	Clinical	IG	IV	TCI	HA, NS, RD, P, SD, Cop, Sp	ADHD
Smalley, Loo, Hale, Shrestha, and McGough (2009)	105	Adult	47	Community	IG	IV	TCI	HA, NS, RD, P, SD, Cop, Sp	ADHD
Tillman, Geller, and Craney (2003)	133	Child	70	Clinical	IG	IV	JTCI	HA, NS, RD, P, SD, Cop, Sp	ADHD
Weinstein, Apfel, and Weinstein (1998)	20	Adult	0	Clinical	IG	III-R	NEO-PIR	N, E, C, A, O	ADHD
Yoo et al. (2006)	104	Child	49	Community	IG	IV	JTCI	HA, NS, RD, P, SD, Cop, Sp	ADHD, IA, HI

For *% of males*, NR = not reported.
For *Study design*, IG = independent group; Corr = correlation.
For *Source*, when underlined, ADHD based on interview, otherwise rating scales.
For *Scales*, CCQ = California Child Q-Sort, EPQ = Eysenck Personality Questionnaire, HiPIC = Hierarchical Personality Inventory for Children, JTCI = Junior Temperament and Character Inventory, MPQ = Multidimensional Personality Questionnaire, NEO-FFI = NEO Five Factor Inventory, NEO-PIR = NEO Personality Inventory–Revised, TCI = Temperament and Character Inventory, and TPQ = Tridimensional Personality Questionnaire.
For *Dimensions*, A = agreeableness, C = conscientiousness, Const = constraint, Cop = cooperation, E = extraversion, HA = harm avoidance, N = neuroticism; NA = negative emotionality; NS = novelty seeking, O = openness to experience, P = persistence, PA = positive emotionality, RD = reward dependence, SD = self-directedness, and ST = self-transcendence/spirituality.
For *Outcome*, ADHD = attention deficit/hyperactivity disorder, HI = hyperactivity/impulsivity, IA = inattention; when underlined, screened for conduct problems, otherwise not screened for conduct problems.

4.3. Variables coded from each research report

To allow us to run the meta-analysis, the following characteristics were coded for each study: study name (authors and year published) and subgroup within study (if any); type of study design (whether the findings involved comparison of ADHD and control groups [independent group design], or correlations between personality dimensions and ADHD, IA or HI [correlation design]); the personality questionnaire(s) and their dimensions used to measure personality; and in the case of correlational data, if the coefficients were reported for overall ADHD (IA + HI), IA, and HI. For studies involving group comparisons, we recorded the number of participants and mean and standard deviation scores in the clinical and comparison groups. The total number of participants and the coefficients were recorded for correlation studies.

For moderation analyses, the following information was coded for each study: age group of participants; whether participants included clinical groups or were from the general community; in the case of a clinical study, whether participants were screened for other externalizing disorders; and in the case of a correlational data, if other externalizing problems were controlled in the analysis. The age group of participants were coded in terms of child, adolescent, and adult. However, because of the limited number of studies involving children and adolescents, the child and adolescent data were coded into a single group (henceforth referred as 'child'). We also included two studies involving prisoners (Gudjonsson et al., 2009; Rösler et al., 2004), and coded them as clinical samples. For descriptive purposes, we coded the DSM version used for clinical diagnosis or for obtaining dimensional scores for ADHD and its symptom domains. As already noted, ratings of ADHD had to comprise the symptom listed in either DSM-IV or DSM-IV-TR or DSM-III or DSM-III-R. Coding was done independently by two raters and disagreements were checked against the original published data and corrected as needed, before the analyses.

4.4. Meta-analytic procedures

Meta-analysis was conducted using the Comprehensive Meta-Analysis (CMA) computer software (Borenstein, Hedges, Higgins, & Rothstein, 2007). For each study, Cohen's *d* was used as the effect size estimate. Whenever possible, we derived an effect size from the difference in personality dimension between the ADHD and control groups, and the estimate of their pooled standard deviation score. For studies that provided only correlations, these were converted to *d* effect sizes. The formulae for these computations can be found in Borenstein, Hedges, Higgins, and Rothstein (2009). All effect sizes computed were weighted by the study sample size.

Initially, the distributions of the effect size estimates were examined for outliers since these can distort findings (Bettencourt & Miller, 1996). Outliers were defined as a *d* value that was four standard deviations above or below the mean of the *d* values in the analysis (in accordance with Huffcutt & Arthur, 1995). For all analyses, there were no extreme outliers. Thus we used all the studies listed in Table 2 in the meta-analysis.

The variability of the overall effect size or *d* in the current study was examined in terms of 95% confidence intervals (CI). Cohran's *Q* and I^2 indices were used to evaluate the heterogeneity of mean effect sizes (Higgins, Thompson, Deeks, & Altman, 2003). A significant ($p < .05$) Cochran's *Q* value or an I^2 value above 50% can be interpreted as heterogeneity for the mean effect size (Higgins et al., 2003). We also report tau, which can be interpreted as similar to the standard deviation of the point estimate of the effect size.

Publication bias (tendency for publication or non-publication of studies to depend on the direction and statistical significance of the results, leading to a situation that the studies identified for inclusion in the meta-analysis do not represent all studies on the topic of interest) was assessed using Rosenthal's Z or fail-safe number. This measure indicates the number of unpublished or omitted studies with non-significant results that would be needed in the meta-analysis to change the results from significant to non-significant (Borenstein et al., 2009).

Meta-analysis is generally conducted using either the fixed-effects (FE) or random-effects (RE) model (Cooper & Hedges, 1998). These models make different assumptions for the differences between study mean effect size and the population mean. The FE model assumes that this is due to only subject-level sampling error, whereas the RE model assumes that this is due to both subject-level sampling error and randomly distributed sources of variance (Lipsey & Wilson, 2000). Given these considerations, the results from the FE model limit inferences about the effect size to the set of reviewed studies, whereas the results from the RE model allow generalization beyond the set of reviewed studies to a broader population of studies (Hedges & Vevea, 1998). This property renders the RE model more desirable for a meta-analysis, when there is a reasonable number of data set, such as five or more (Field, 2001; Hafdahl & Williams, 2009). As the number of data sets for the FFM and the IFFM were well above this number, it was decided to interpret our meta-analysis results using the RE model.

Moderator analysis was conducted for all effect sizes. This used mixed effects analysis. Categorical moderators of age group, source, and whether participants were screened for other externalizing problems, were examined by computing between-groups *Q* statistic or Q_B. This procedure is analogous to analysis of variance. The difference between groups is distributed as a chi-square test, with a *df* value of number of groups − 1. A significant Q_B denotes significant moderation effect.

We also interpreted the magnitude of the effect sizes using the cut-off scores proposed by Cohen (1988). For *d* effect sizes, Cohen's recommended magnitudes are as follows: <.20 = negligible; ≥.20 and <.50 = small; ≥.50 and <.80 = medium; ≥.80 = large.

5. Results

5.1. Integrated Five-Factor Model

Table 4 shows the mean effect sizes for the relationships of the IFFM dimensions with ADHD, IA, and HI. The effect sizes for negative emotionality, conscientious inhibition, and agreeable inhibition with ADHD, IA, and HI, and the effect size for the association of positive emotionality with IA, were significant. All other associations were non-significant. As can be seen in Table 4, the fail safe numbers suggest that a large number of studies with null findings would be required to challenge the significant effects found.

All associations for ADHD, IA, and HI with negative emotionality were positive, and all associations with conscientious inhibition and agreeable inhibition were negative. The positive emotionality–IA association was also negative. For ADHD, the effect sizes for negative emotionality ($d = 0.85$) and conscientious inhibition ($d = -0.95$) were both large and the effect size for agreeable inhibition ($d = -0.64$) was medium. For IA, the effect sizes for negative emotionality ($d = 0.75$), conscientious inhibition ($d = -1.21$), and agreeable inhibition ($d = -0.46$) were medium, large, and small, respectively. The effect size for the association of positive emotionality with IA was negligible ($d = -0.16$). For HI, the effect sizes for negative emotionality ($d = 0.36$), conscientious inhibition ($d = -0.75$), and agreeable inhibition ($d = -0.62$) were small, medium, and medium, respectively.

Table 4 shows that, with the exception of the effect size for openness with HI, all other effect sizes showed heterogeneity (as indexed by the large 95% CI of the effect sizes, significant Cohran's *Q*, and I^2 value above 50%). The possible sources for the heterogeneity were examined via moderation analyses. The results for these analyses are presented in Table 5.

As shown, for the significant associations involving ADHD, the effect size for negative emotionality with ADHD was moderated by source (as indexed by the significant Q_B value). The effect size was significant, positive, and large for clinical samples ($d = 0.97$), and significant, positive, and medium for community samples ($d = 0.68$). The effect size for

Table 4
Summary of the unbiased standardized mean difference effect sizes (d) for the personality factors in the Integrated Five-Factor Model.

Dimension	k	N	d	95% CI	Q	df	I^2 (%)	Tau	FSN
ADHD									
Positive emotionality	34	10790	−0.11	−0.23/−0.01	216.13***	33	84.73	.32	164
Negative emotionality	40	12060	0.85***	0.72/0.98	320.57***	39	87.83	.38	2019
Conscientious inhibition	36	12199	−0.95***	−1.21/−0.84	529.42***	35	93.39	.55	3783
Agreeable inhibition	34	10172	−0.64***	−0.79/−0.50	276.46***	33	88.06	.39	5130
Openness	23	6696	0.02	−0.19/.0.23	295.32***	22	92.55	.47	0
Inattention									
Positive emotionality	11	3229	−0.16*	−0.29/−0.03	32.53**	10	69.23	.18	47
Negative emotionality	13	3592	0.75***	0.62/0.88	36.08***	12	66.74	.19	1342
Conscientious inhibition	13	3592	−1.21***	−1.47/−0.95	134.65***	12	91.09	.46	2652
Agreeable inhibition	13	3592	−0.46***	−0.60/−0.32	47.19***	12	74.62	.23	505
Openness	7	2343	0.10	−0.23/0.16	31.31*	6	80.72	.23	0
Hyperactivity/impulsivity									
Positive emotionality	10	2920	0.20	−0.01/0.44	74.41**	9	87.96	.23	5
Negative emotionality	12	3283	0.36**	0.15/0.57	89.44***	11	97.44	.33	247
Conscientious inhibition	12	3283	−0.75***	−0.90/−0.53	98.00***	11	88.77	.36	911
Agreeable inhibition	12	3283	−0.62***	−0.77/−0.47	42.51**	11	74.12	.22	722
Openness	7	2343	0.04	−0.08/0.16	11.05	6	45.68	.10	0

Note: k = number of ds; N = combined sample size; d = unbiased standardized mean difference effect size; CI = confidence interval for d; Q = Cohran's Q; I^2 = Higgins & Thompson's (2002) I^2 index.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 5
Moderation of the effect sizes of the personality factors in the Integrated Five-Factor Model by age group, source and screened for conduct problems.

Dimension	ADHD			ADHD symptom domains					
				IA			HI		
	$K(N)$	d	Q_B ($df = 1$)	$K(N)$	d	Q_B ($df = 1$)	$K(N)$	d	Q_B ($df = 1$)
Moderator = age group (Adult vs Child/adolescent)									
PE: Adult	20 (5497)	−0.19*	1.91	7 (2041)	−0.29**	10.23**	7 (2041)	0.18	0.39
Child	14 (5293)	−0.02		4 (1188)	0.01		3 (879)	0.36	
NE: Adult	22 (5830)	0.95*	1.97	7 (2041)	0.80***	0.64	7 (2041)	0.47***	0.21
Child	18 (6369)	0.76*		6 (1551)	0.69***		5 (1242)	0.36***	
CI: Adult	20 (5657)	−0.92***	0.87	7 (2041)	−1.05***	1.70	7 (2041)	−0.39***	10.41***
Child	16 (5512)	−1.01***		6 (1551)	−1.42***		5 (1242)	−1.14***	
AI: Adult	17 (4521)	−0.59***	0.54	7 (2041)	−0.48***	0.10	7 (2041)	0.53***	1.87
Child	16 (5512)	−0.70***		6 (1551)	−0.43*		5 (1242)	0.77***	
O: Adult	15 (4284)	0.12	1.69	Only one child sample					
Child	8 (2412)	−0.14							
Moderator = source (clinical [Clinic] vs community [Com])									
PE: Clinic	22 (7578)	−0.23**	5.78*	4 (701)	0.08	12.02***	4 (701)	0.46***	3.38
Com	12 (3212)	0.06		7 (2528)	−0.27***		6 (2219)	0.08	
NE: Clinic	26 (8269)	0.97***	5.11*	6 (1064)	0.86***	2.15	6 (1064)	0.46*	0.09
Com	14 (3930)	0.68***		7 (2528)	0.68**		6 (2219)	0.39*	
CI: Clinic	25 (8223)	−1.01***	0.04	6 (1064)	−1.59***	4.36*	6 (1064)	−1.09***	8.10**
Com	11 (3085)	−1.06***		7 (2528)	−0.94***		6 (2219)	−0.46***	
AI: Clinic	23 (7211)	−0.68***	0.23	6 (1064)	−0.51***	2.82	6 (1064)	−0.80***	5.86*
Com	11 (3085)	−0.62***		7 (2528)	−0.37***		6 (2219)	−0.47***	
O: Clinic	16 (4497)	−0.10	0.33	2 (338)	−0.00	0.00	2 (338)	0.09	0.26
Com	7 (2199)	0.10		5 (2005)	−0.05		5 (2005)	−0.02	
Moderator = screened for conduct problems (Yes vs No)									
PE: No		26 (7698)			−0.12*				0.03
Yes		8 (2953)			−0.10				
NE: No		32 (9249)			0.88***				0.74
Yes		8 (2953)			0.74***				
CI: No		28 (8355)			−1.16***				11.89**
Yes		8 (2953)			−0.55***				
AI: No		26 (7375)			−0.70***				3.98*
Yes		7 (2612)			−0.45***				
O: No		20 (6463)			0.03				0.45
Yes		4 (233)			−0.10				

Note: PE = positive emotionality; NE = negative emotionality; CI = conscientious inhibition; AI = agreeable inhibition; O = openness; IA = inattention; HI = hyperactivity/impulsivity; k = number of correlations; N = combined sample size; d = unbiased standardized mean difference effect size; Q_B = Cohran's Q between. Moderation for "screened" was not done as there was no study that screened conduct problems.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

conscientious inhibition with ADHD was moderated by whether other externalizing problems were screened. The effect size was significant, negative, and large for samples not screened for other externalizing problems ($d = -1.16$) and significant, negative, and medium for screened samples ($d = -0.55$). The effect size for agreeable inhibition was also moderated by whether other externalizing problems were screened. The effect size was significant, negative, and medium for unscreened ($d = -0.70$) and significant, negative, and small for screened ($d = -0.45$) samples. The effect size for positive emotionality was moderated by source. The effect size was significant, negative, and small for clinical samples ($d = -0.23$) and it was not significant for community samples.

For significant effect sizes involving IA, for conscientious inhibition this was moderated by source. The effect size was significant, negative, and large for both clinical ($d = -1.59$) and community ($d = -0.92$) samples. The association of positive emotionality with IA was moderated by age and source. It was significant, negative, and small for adults ($d = -0.29$) but not significant for children. They were significant, negative, and small for community samples ($d = -0.27$) but not significant for clinical samples. There was no other moderating effect for the relations involving IA.

The significant effect of HI with conscientious inhibition was moderated by age and source. For age, the effect size was significant, negative, and small for adults ($d = -0.39$) and significant, negative, and large for children ($d = -1.14$). For source, the effect size was significant, negative, and large for clinical samples ($d = -1.09$) and significant, negative, and small for community samples ($d = -0.46$). The effect size for agreeable inhibition with HI was moderated by source. The effect size was significant, negative, and large for clinical samples ($d = -0.80$) and significant, negative, and small for community samples ($-d = 0.47$). There was no other moderating effect for the relations involving HI.

5.2. Five-Factor Model

As the findings were similar to those found in the IFFM, we focus here on the differences between them. Due to space limitation, we have not presented detailed tables of results (these tables are available from the first author). With two exceptions, the findings for significant associations were the same for the IFFM and the FFM. Although there was a negligible ($d = -0.16$) negative association between positive emotionality and IA, there was no association for extraversion and IA. While there was no association between positive emotionality and HI, there was small (0.27) positive association between extraversion and HI. In relation to the magnitude of the significant associations there was only a single difference. The association for HI with conscientiousness was large ($d = -0.87$), whereas the association of HI with conscientious inhibition was medium ($d = -0.75$) — although this difference was small (0.12). As there was only a single study (Ranseen et al., 1998) that screened for other externalizing problems, moderation analysis involving this variable was not conducted for the FFM. Keeping this in mind, with the exception of the finding that the effect size for conscientious inhibition with IA was moderated by source, all other moderating effects were the same in the FFM and IFFM. Thus, overall there was high degree of comparability in the findings across these two personality models.

6. Discussion

6.1. Summary of findings

As there was a high degree of comparability in the findings across the FFM and IFFM, and as the IFFM included additional moderation analyses (whether individuals were screened for other externalizing problems), we base our discussion on the findings for the IFFM. These findings showed significant associations for ADHD, IA, and HI with negative emotionality, conscientious inhibition, and agreeable inhibition. The effect sizes for all subgroups for these associations were, at least, of reasonable magnitude (small or above), suggesting that the relations of ADHD, IA, and HI with negative emotionality, conscientious inhibition, and agreeable inhibition are robust, and theoretically and practically meaningful.

The findings showed large associations for conscientious inhibition with ADHD, IA and HI, with the associations being generally stronger for IA than HI; large, medium and small associations for negative emotionality with ADHD, IA and HI; and medium associations for agreeable inhibition with ADHD and HI, and small association with IA. As we applied a meta-analytic review, we were able to show differential magnitude of associations between the personality dimensions with ADHD, IA, and HI; and we showed also how participant characteristics (age, screened or not screened for other externalizing problems, and whether they were recruited from clinics or from communities) moderated these associations. For ADHD, the effect size for negative emotionality was moderated by source, and the effect sizes for conscientious inhibition and agreeable inhibition were moderated by whether other externalizing problems were screened. For IA, the effect size for conscientious inhibition was moderated by source, and for HI, the effect size for conscientious inhibition was moderated by age and source. Overall, the findings suggest that although, from a personality viewpoint, ADHD, IA, and HI could reflect traits tapping inhibition control difficulties coupled with high negative emotional reactivity, these traits have different magnitudes of relationships with ADHD, IA, and HI. Also, despite the moderation effects, the effect sizes for all subgroups for the associations of ADHD, IA, and HI with negative emotionality, conscientious inhibition, and agreeable inhibition were, at least, of reasonable magnitude (small or above), suggesting that the relations of ADHD, IA, and HI with negative emotionality, conscientious inhibition, and agreeable inhibition are robust.

6.2. Implications of findings for single and dual pathway models of ADHD

Single pathway ADHD models implicate a single core deficit for ADHD, with deficits in motivation related to delay aversion (Sonuga-Barke et al., 1992) and executive functions related to core deficits in response inhibition (Barkley, 1997) being the more influential ones. Multiple pathway models implicate core deficits in both of these areas (Martel, Goth-Owen, Martinez-Torteya, & Nigg, 2010; Martel, von Eye, & Nigg, 2010). Sonuga-Barke (2003) points to deficits in motivation contributing uniquely to HI, and deficits in executive functions contributing uniquely to IA — conscientious inhibition and agreeable inhibition are the primarily personality markers for top-down cognitive control processes and bottom-up reactive control processes, respectively (Martel & Nigg, 2006; Nigg, Goldsmith, & Sachek, 2004).

Since conscientious inhibition and agreeable inhibition were associated negatively with both IA and HI, our findings suggest that deficits in both top-down and bottom-up control processes are associated with both symptom groups. This is congruent with predictions from single pathway models of ADHD. However, the findings also showed large associations for conscientious inhibition with IA and HI, with the associations generally being stronger for IA than HI, small associations for agreeable inhibition with IA, and medium associations with HI. Thus, it can be argued that while both top-down and bottom-up deficits are associated with IA and HI, compared to HI, IA is more associated with deficits in top-down control processes, whereas, compared to IA, HI is more associated with deficits in bottom-up control processes. Our hypothesis of relative differences is consistent with the well-established findings that IA and HI are highly correlated and, also, that top-down and bottom-up control processes are also highly correlated (Martel, von Eye, & Nigg, 2010; Martel et al., 2009; Toplak et al., 2009). Therefore, it seems that both dual and multiple pathway models have merit.

6.3. Implications for a personality model of ADHD

As there were differential associations for personality dimensions with IA and HI, the personality model that we propose relates to the associations with IA and HI symptom groups separately, and not to overall ADHD. Fig. 1 shows a representation of the personality model of ADHD as suggested by the major findings in this meta-analysis. As shown, the model proposes (1) large associations for conscientious inhibition with IA and HI, with the associations being generally stronger for IA than HI; (2) medium associations for negative emotionality with IA, and small associations with HI; and (3) small associations for agreeable inhibition with IA, and medium associations with HI.

Our findings suggest that some of the paths depicted in Fig. 1 are moderated by age and source (community vs clinic samples). The relations for conscientious inhibition with HI were moderated by age and source: it being significant and large in children and significant, and small in adults; and significant and large in clinical samples, and significant and small in community samples: the relation for agreeable inhibition with HI was moderated by source. For agreeable inhibition, the effect size was significant and large in clinical samples and significant and small in community samples. The association of positive emotionality with IA was moderated by age and source: the effect size was significant, negative, and small for adults and not significant for children; and significant, negative, and small for community samples and not significant for clinical samples. These moderation findings raise the possibility that the association for conscientious inhibition with HI is stronger for children and clinical samples than adults and community samples. Also, the association for agreeable inhibition with HI is stronger for clinical samples than community samples. Further, the association of positive emotionality with IA is evident for only adults and community samples.

Fig. 1 also includes the key features in the personality dimensions that can be speculated to be responsible for the associations with IA and HI. In line with dual pathway models of ADHD, the key features for agreeable inhibition and conscientious inhibition were hypothesized to be responsible for the associations with both IA and HI are top-down and bottom-up control processes, respectively (Martel et al., 2009; Nigg et al., 2004). As negative emotionality is associated with being hyperreactive to environmental demands and stress (Eysenck & Eysenck, 1975; Tellegen, 2000), it can be speculated that these responses can interfere with all forms of attention, cognition, and motivation control processes, thereby contributing directly to problems in inattention, impulsivity, and hyperactivity. Of relevance also is the attentional control theory that links trait anxiety, which is closely related to neuroticism and negative emotionality, with intrusive thoughts and worry. The theory proposes that such thoughts interfere with attention control by detracting individuals from the resources available for performance (Eysenck & Calvo, 1992; Eysenck, Derakshan, Santos, & Calvo, 2007).

6.4. Possible underlying factors and processes for the personality–ADHD link

Our findings have implications for understanding the underlying factors and processes involved in ADHD. As noted earlier, relations between personality and psychopathology can be explained in terms of four models: spectrum, vulnerability, pathoplastic, and scar. According to Nigg (2006) it is unlikely that the personality–psychopathology links can be explained in terms of the pathoplastic and scar models. The spectrum model suggests that normal and abnormal fall at different points on the same continuum, such that psychopathology is primarily a clinical manifestation of personality, with shared etiological determinants. Thus, the model should predict similar relations for ADHD symptoms with personality for those with and without a clinical diagnosis of ADHD. As this prediction was revealed in the meta-analysis, the findings can be interpreted as supportive of the spectrum model. Although the magnitudes of relations were different for those with ADHD diagnosis and those without, the findings are still consistent with the spectrum

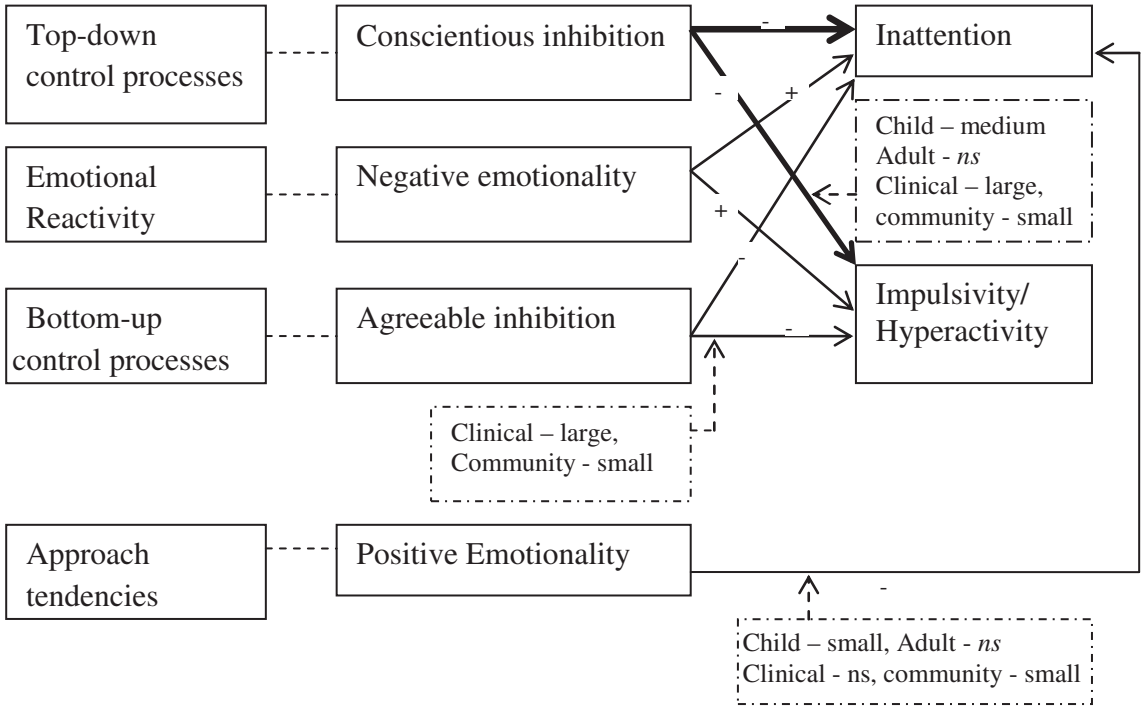

Fig. 1. Personality model of ADHD suggested by the meta-analysis. *Note*. The relative weights of the solid lines indicate the relative magnitude of the associations found in the meta-analysis. Signs "+" and "−" indicate positive and negative associations, respectively. There were (1) large associations for conscientious inhibition with IA and HI, with the associations being generally stronger for IA than HI; (2) medium associations for negative emotionality with IA, and small associations with HI; (3) small associations for agreeable inhibition with IA, and medium associations with HI; and (4) small negative associations for positive emotionality with IA. Dashed lines link key processes in the personality dimensions hypothesized to be critical in the associations. Dashed boxes and dashed lines with arrows show moderating effects.

model as this reflects quantitative difference and not a qualitative difference in relations (Van Leeuwen, Mervielde, De Clercq, & De Fruyt, 2007).

From a process point of view, it is possible to speculate that extreme levels of the relevant personality dimensions (that is, at the "dysfunctional end") may lead to difficulties in developing and exercising effective control that are manifested as observable ADHD symptoms. Although there was support for the spectrum model, our findings reveal that the amount of shared variance for all significant relations between personality and ADHD was never more that 50%, suggesting that the spectrum model alone does not provide sufficient explanation for the association between personality and ADHD. The vulnerability model predicts that certain personality traits predispose individuals to certain kinds of psychopathology, under certain circumstances. This model would predict quantitative differences between different subgroups, or moderation effects for relations between ADHD and personality dimensions. Thus, the findings in this study that the association between positive emotionality and IA was present for adults but not for children provide some support for the vulnerability model. More specifically, being a clinical sample (relative to being a community sample) increases the strength of the associations for conscientious inhibition and agreeable inhibition with HI,

Overall, our meta-analysis found support for the spectrum model and, to a lesser degree, support for the vulnerability model. Evaluation of the pathoplastic and scar models would require data from long-term longitudinal studies of personality–ADHD relations. Such studies have yet to be conducted, therefore the findings from this current meta-analysis cannot address this issue. Clearly more studies are needed in this area to enable a more comprehensive understanding of the processes linking ADHD and personality.

6.5. Clinical implications

The major finding that personality dimensions and ADHD are associated has clinical implications for ADHD types or specifiers, assessment, diagnosis and treatment.

6.5.1. ADHD types or specifiers

Our personality model of ADHD has implications for understanding the different ADHD types (DSM-IV TR, APA, 2000) or presentation specifiers (DSM-5, APA, 2013). As conscientious inhibition and agreeable inhibition were associated negatively with both IA and HI, these findings raise the possibility that deficits in both top-down and bottom-up control processes involved these two types/specifiers. However, since the findings showed that IA had larger associations with conscientious inhibition and smaller associations with agreeable inhibition, and HI had medium associations with conscientious inhibition and agreeable inhibition, it can be speculated that the ADHD inattentive type/specifier is more associated with deficits in top-down control processes, whereas the ADHD hyperactive/impulsive type/specifier is more associated with deficits in bottom-up control processes. In addition, as negative emotionality was linked to both IA and HI, but stronger with IA than with HI, it can be speculated that while both these types/specifiers of ADHD are associated with hyper-reactivity to environmental demands and stress, the inattentive type/specifier can be expected to be more reactive to environmental demands and stress and, therefore, more susceptible to interference with attention control than the hyperactive/impulsive type/specifier.

As the ADHD combined type has high levels of both IA and HI symptoms, it can be speculated that ADHD combined type/specifier would have the characteristics of both the ADHD inattention and hyperactive/impulsivity types. This means that the combined type may be related to deficits in top-down control (as this is linked to IA symptoms) and bottom-up (as this is linked to HI symptoms) control processes. In addition, it would be associated with hyper-reactivity to environmental demands and stress (as this is associated with IA symptoms). Clearly this is an area that requires further examination.

6.5.2. Assessment

We illustrate assessment implications with reference to the FFM. Our findings suggest that all types/specifiers of ADHD individuals will have high scores for neuroticism, and low scores for conscientiousness and agreeableness. This conclusion implies there is a potential to use FFM measures for screening ADHD. Individuals who are likely to have ADHD can be distinguished from less likely in terms of high scores for neuroticism and low scores for conscientiousness and agreeableness. This profile involving these scales can also be used to distinguish individuals with elevated levels of inattention, hyperactivity and impulsivity who have "true" ADHD from those without this disorder (e.g., like many with traumatic brain injury).

In relation to the different ADHD types, individuals with inattentive type should have relatively higher scores for neuroticism, and individuals with combined and hyperactive–impulsive types will have relatively higher scores for disagreeableness. The latter type can be distinguished by extraversion scales: the hyperactive–impulsive type will have relatively higher extraversion scores. It needs to be noted that despite the fact the FFM measures (and by extension other personality measures) could be useful for screening ADHD, at this point this may not be practical. This is because appropriate cut-off scores (based on sensitivity and specificity statistics) are currently not available for this purpose. Clearly it would be useful for future studies to establish such cut-off scores in order to facilitate the differential diagnosis of ADHD.

6.5.3. Diagnosis

At a more general level, our findings suggest that, despite the differences in the strength of relations, both the IA and HI are associated with the same personality dimensions (conscientious inhibition, agreeable inhibition, and negative emotionality). This finding can be taken to imply that the same group of underlying biological and environmental factors are responsible for both the IA and HI symptom groups (although the relative influence played by these factors may vary across the symptom groups). Viewed in this light, the implication for diagnosis is that only a single ADHD type rather than different ADHD types (as in DSM-IV-TR, 2000) or presentation specifiers (as in DSM-5, 2013) is appropriate. This conclusion implies that, unlike DSM-IV TR and DSM-5, all the IA and HI symptoms could be grouped together under a single list of ADHD symptoms and considered together when making an ADHD diagnosis. This suggests that ADHD be diagnosed as a single disorder without subtypes — a suggestion that is consistent with existing data showing weak evidence for discriminant validity of the different ADHD types in terms of etiology, academic and cognitive functioning, treatment response, and longitudinal instability (for a recent review, see Willcutt et al., 2012). It is however important to note that our suggestion for a single disorder is not in support of the single pathway ADHD model. To capture the heterogeneity of ADHD and to concur with the findings here supporting the dual and multiple pathway models, we agree with the model proposed by Lahey and Willcutt (2010). They have suggested that ADHD be diagnosed as a single disorder with dimensional modifiers that indicate the number or severity (mild, moderate or severe) of IA and HI symptoms at the time of assessment.

6.5.4. Treatment

Our general findings are that ADHD is associated with low conscientious inhibition and agreeable inhibition, and high negative emotionality which implies that ADHD is associated with dysfunctions in both top-down and bottom-up control processes. These processes cover resource demanding goal-directed responses, effortful and executive control, affective responses that are strongly influenced by immediate incentives and rewards, and inhibitory control. The management implications are that a comprehensive training program for ADHD needs directly to focus on improving these areas of deficit. Currently, most intervention programs for ADHD do not include these components. In addition, as the associations for personality and ADHD were stronger

in participants not screened for other externalizing problems, it can be speculated that for better treatment outcomes of ADHD it would be necessary to manage these other externalizing problems concurrently.

6.6. Limitations of study

The findings in this study must be viewed with a number of limitations in mind. First, as the studies included were all cross-sectional, causal relations cannot be inferred. Second, this study is limited by the fact that it examined broad personality dimensions. This is because currently very few studies have examined the lower-order facets in these dimensions as they relate to ADHD and its two symptom groups. As it can be expected that facet level analyses would provide more finely tuned associations, it is suggested that such studies should be conducted in the future. Third, we used the guidelines proposed by Cohen (1988) to interpret the magnitude of our effect sizes. As noted by others, these cut-off scores are arbitrary and cut-off scores need to be specific to the goals of the meta-analysis (e.g., Fern & Monroe, 1996). However, as the steps for this statement have not been clearly articulated, we decided to use Cohen's criteria as they are the most frequently used guidelines for interpreting the magnitude of effect sizes. We believe that this choice has not compromised our findings because our conclusions are theoretically consistent with the literature. Fourth, relative to most other published meta-analytic studies, the analyses included relatively few studies, especially for the analyses involving moderation effects. In view of this fact, a question may hang over the usefulness of our results. We argue that despite the small numbers, these findings provide a more objective integration of past studies than a purely qualitative review. Fifth, it is possible that the positive emotionality and extraversion dimensions of the IFFM and FFM, respectively, may be measuring different personality dimensions. This is because the findings showed that while there was a negligible negative association between positive emotionality and IA, there was no association for extraversion and IA. Also, while there was no association between positive emotionality and HI, there was small positive association between extraversion and HI. Thus, our interpretations are based on the IFFM and this may not be directly applicable to extraversion as conceptualized in the FMM. Sixth, virtually all studies in this area involving children have used information provided by parents. The absence of data from teachers, and consequently the inability to conduct analysis of moderation effects across parents and teachers, can be seen as a further limitation since the consistency of information about ADHD symptoms across these respondents is generally low (e.g., Gomez, 2007).

6.7. Summary and conclusions

The confluence of findings for the associations observed between the various personality dimensions with IA and HI leads to the strong inference that some personality variables are closely intertwined with ADHD. Since the IFFM is conceptually similar to the FFM, and as there were minimal differences in the meta-analysis findings for these models, our conclusions can be considered also to be applicable to the FFM. The major findings were that overall ADHD, IA, and HI were associated positively with traits reflecting negative emotionality/neuroticism, and negatively with traits reflecting agreeable inhibition/agreeableness, and conscientious inhibition/conscientiousness. The findings showed that compared to HI, IA has relatively stronger association with conscientious inhibition/conscientiousness and relatively less association with agreeable inhibition/agreeableness. In contrast, compared to IA, HI has relatively stronger association with agreeable inhibition/agreeableness and relative less association with conscientious inhibition/conscientiousness.

When considered collectively our findings suggest that, although in both IA and HA symptom groups, top-down cognitive control processes are more problematic than bottom-up ones, the distinction between IA and HI may be related to the relative degree of deficits in these two sets of control processes. Specifically, compared to HI, IA has relatively more deficits in top-down processes and relatively fewer deficits in bottom-up processes. Furthermore, compared to IA, HI has relatively more deficits in bottom-up processes and relatively fewer deficits for top-down processes. As discussed, these findings may have significant implications for the theory, diagnosis and treatment of ADHD. In conclusion, this field of research would benefit from more studies, taking into consideration the limitations highlighted here. Despite these limitations, our findings clarify existing data, provide new information, and open up new theoretical perspectives and clinical implications related to the personality bases of ADHD.

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