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Review

The co-occurrence of intellectual giftedness and Autism Spectrum Disorders: A literature review

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ABSTRACT

This systematic literature review explored the state of the art concerning the theoretical and empirical knowledge of the twice-exceptionality of Intellectual Giftedness and Autism Spectrum Disorders (IG + ASD)[3], in relation to diagnostic and assessment issues. After searching and examining publications in peer-reviewed journals and dissertations, we encountered a variety of methodologies being used. The results showed the absence, until now, of theoretical conceptualisations of the phenomenon IG + ASD. Nevertheless, this contribution revealed some converging tendencies concerning both personal characteristics and diagnostic and assessment issues, between publications with and without Systematic Identification Measures (SIM). Some findings, like the 'superior non-verbal abilities', are discussed in relation to (controversial) image formation of IG and IG + ASD. Altogether, the results indicated the need for an in-depth exploration and conceptualisation of the phenomenon IG + ASD. Meanwhile, future research should also address the practical psychological-educational need for both classification-based and needs-based assessment procedures, regarding students with (suspicion of) IG + ASD.

Contents

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[3] All abbreviations are explained below Table 1 in 'abbreviations Tables 1 and 2'.

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1. Introduction

This article systematically explored the state of the art concerning the theoretical and empirical knowledge of the twice-exceptionality of Intellectual Giftedness and Autism Spectrum Disorders (IG + ASD) in relation to diagnostic and assessment issues. The rationale for this review stemmed from our educational and clinical experiences with diagnoses and assessments of intellectually gifted children and adolescents who suffered from problems with learning strategies and/or social interactions with peers. It was found difficult to differentiate whether or not these kinds of problems could be attributed to the individual student's Intellectual Giftedness (IG) or that they were merely symptoms of an Autism Spectrum Disorder (ASD). This was because some cognitive and social features often ascribed to giftedness, like language precocity or social isolation, resembled certain behavioural characteristics of children with Asperger's Syndrome (Burger-Veltmeijer, 2003). While doing second opinion assessments, it was noticed that these similar characteristics often were one-sidedly ascribed by diagnosticians in educational and clinical institutions to either IG or an ASD. This led to mis- and missed diagnoses concerning students with (suspicion of) IG + ASD and to improper one-sided interventions or no interventions at all.

So far, these practical experiences have been supported by the findings of a preliminary literature study of Burger-Veltmeijer (2006): According to the reviewed authors, misidentification often occurred whereas correct diagnosis was essential to provide adequate psychological and educational treatment and facilities. This literature search, summarised in Burger-Veltmeijer (2007, 2008), was limited however to articles published before 2005, in which the authors selectively compared literature of ASD to publications of giftedness, and interwove their findings with clinical opinions and anecdotal reports (Barber, 1996; Cash, 1999; Donnelly & Altman, 1994; Gallagher & Gallagher, 2002; Grandin, 1992; Henderson, 2001; Little, 2002; Neihart, 2000). Moreover, the search was methodologically limited, because of the narrow scope of search terms used, and because until a few years ago, the relatively few discussions of IG + ASD mainly appeared in non-peer-reviewed journals and were limited by lack of systematic data collection and statistical analysis (Huber, 2007).

In the current literature review, these limitations are dealt with. We added relevant search terms and aimed at publications in peer-reviewed journals and dissertations published until 2009. Next the theoretical outlines of the core concepts ASD, IG and IG + ASD are presented.

1.1. Autism Spectrum Disorders (ASD)

In this study, the dimensional concept of ASD was chosen, rather than the static-categorical approach used in classification systems such as the revised fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) (APA, 2000). This approach was used because the border between the specific ASD-categories might not always be clear-cut and, up to now, no differences in cause or treatment were reported. Therefore, we did not focus on classification *per se*, but on the core characteristics that described the phenomenon of autism in a broad perspective. These were the triad of impairments of social interaction, communication, and imagination, together with a marked preference for a rigid, repetitive pattern of activities (Wing, 1992). The autistic continuum ranged from the severe diagnosis Autism (AU) to the 'lesser variants', Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS), Asperger's Syndrome (AS) and High Functioning Autism (HFA).

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Individuals with such 'lesser variants' were cognitively more able and show fewer, less severe or qualitatively different symptoms (Huber, 2007). We agreed with Serra, Minderaa, Geert, and Jackson (1999) that 'lesser' referred only to the severity or the amount of symptoms, and not to the consequences for daily functioning.

1.2. Intellectual giftedness (IG)

Educational and psychological literature offered a wide variety of definitions of giftedness. The criteria varied from study to study, from IQ score to creative products to teacher recommendations (Clinkenbaerd, 1991). Definitions accentuated performance or the potential to perform. Traditionally, researchers have defined giftedness in a one-dimensional way, as high general intelligence estimated upon a high global IQ score (Winner, 1997). In the last three decades, the focus of theories of giftedness became multidimensional, thus explaining that identification of giftedness, along with success or failure in education and life did not exclusively result from an individual's general intelligence. In 1978, Renzulli identified three factors important for the development of gifted behaviour: above-average ability, creativity, and task commitment (Mönks, 1985). Mönks (1985) expanded this three-ring model with three environmental conditions: school, peers and family. Subsequently, multi-factor models were developed in which interactions between various environmental conditions and personality characteristics were emphasised to be crucial to the way in which various talents or gifts develop into talented performances (Gagné, 2004; Heller, 2004). Sternberg (2000) perceived an analytical, creative and practical component in his theory of successful intelligence. According to Reis and Renzulli (2004), current research suggested that gifted and talented students were a very diverse group of individuals who had ability in one or more domains, that was sufficiently advanced and that required changes in the school environment, such as the instructional curriculum and teacher behaviour. These domains were, for example, academic, creative and artistic areas, or leadership capacities. In Gardner's (1983) theory of Multiple Intelligences, initially seven (later expanded to eight) domains were identified. Gardner's ideas are today widely applied in educational settings and useful in gifted education (Bianco, Carothers, & Smiley, 2009). They were not, however, specifically constructed to conceptualise giftedness. According to Mönks and Mason (2000), it was next to impossible to define giftedness in a concise manner, because it depended on the specific research goal or educational context in which it was used. Moreover, definitions seemed more related to practical considerations than to developmental theories.

In this article, the concept of giftedness is embedded in the context of child and youth education and mental health, and in the domain of academic intelligence and/or performance. We will not focus on other domains of giftedness, such as arts or leadership, because our rationale stems from practical experiences with intellectually gifted and academically talented children, and second, unlike creative or leadership qualities, intellectual talents can be measured rather validly, given that intelligence tests have the highest known levels of reliability in talent assessment (Ziegler & Ziegler, 2009).

In order to serve the explorative aim, an open-minded approach is used to any publications in peer-reviewed journals and dissertations on giftedness in the academic domain. Because of the fact that even IQ tests do generate certain types of miscalculations (Ziegler & Ziegler, 2009), we made no restrictions concerning any cut-off points of IQs or academic performances in the inclusion criteria (see Section 2), as long as authors were able to demonstrate that their target group or cases had cognitively intellectual capacities and/or academic achievements at a supreme level (see inclusion criteria, Section 2.2).

1.3. IG in co-occurrence with ASD (IG + ASD)

Nowadays, IG and ASD are concepts that are well-known to many child and youth psychologists and special educationalists, as well as in educational and psychological research. Until a few years ago, systematically obtained, empirically based, knowledge of the co-occurrence IG + ASD was hardly available (Cash, 1999; Huber, 2007). The two conditions differed in that ASD referred to developmental pathology, which focused on impairments and disabilities, whereas IG referred to abilities and/or performances. ASD referred to disorders whereas IG did not and consequently, from a psychopathological point of view, one could not define the co-occurrence of both as co-morbidity. However, from the psychological and educational points of view, these conditions do have something in common. Not only ASD-students but also IG-students differ from the norm, which may require special educational needs. Fiedler (1999), for instance, argued that gifted children needed special education because they required services that differed from those provided for typical students. Therefore, in the literature on gifted students, the co-occurrence of giftedness and ASD was usually termed a 'twice-exceptionality' (Cash, 1999), despite the fact that, because of the widening range of clinical presentations in ASD, autism was considerably more common than was previously believed (Gillberg & Wing, 1999).

Over the past four decades, the ASD prevalence rates of children increased considerably from about 0.05% (Gillberg & Wing, 1999) to 0.3–0.9% (Baird et al., 2006). According to Posserud, Lundervold, Atle Lie and Gillberg (2010), a large part of the variability across studies is nonaetiologic, and can be explained by differences in diagnostic criteria and issues of study design. These authors found an estimated prevalence rate of 0.87%, in the population of 7–9 year old children. Prevalence figures of IG are even more controversial, because the field has not agreed on how to define the term gifted. Pfeiffer (2002) noted that rates may vary from 1%, using an IQ cut-off of 135, to about 20%, using multiple talent domains. We did not find any prevalence figures of IG + ASD. The hypothetical overlap between the aforementioned percentages might give some insight: Choosing the commonly used IG threshold of an IQ cut-off of 130, the prevalence estimate of IG is approximately 2.3%. Multiplied with the aforementioned ASD-estimates, the estimated rates of IG + ASD children would be about 0.7 up to

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2%. These figures, although speculative, show that the number of children that could be affected and that could be in need of special educational provisions, is large enough to justify exploration of this twice-exceptionality.

Burger-Veltmeijer (2006) concluded that in the few publications on IG + ASD, the authors supposed that mis- and missed diagnoses of gifted students with (suspicion of) an ASD could be ascribed to mutual traits of both exceptionalities, and/or to a mutually-camouflaging effect of both conditions. This means that characteristics of both giftedness and an ASD tended to look alike and/or modified or masked one another, thus making identification of either more difficult. This was particularly the case when professionals were trained in either giftedness or ASDs but rarely in both (Henderson, 2001). From clinical experience, Gallagher and Gallagher (2002) stressed that characteristics of giftedness and of AS can combine and collide in complex ways, and therefore impede correct identification, as illustrated in their following remarks "A small number of gifted children suffer from social isolation – isolation that may be exacerbated by the presence of AS." and "*Consider combining the social inattention, motor clumsiness, and high verbal skill of Asperger's Syndrome with such traits as independent thinking, constant questioning, and heightened emotional sensitivity (. . .). It is the perfect formula for a social pariah." (p. 9).*

This camouflaging effect[4] might lead to the formulation of an inappropriate educational plan (Neihart, 2000), since it troubles the correct identification of IG and/or ASD, as well as correct assessment of strengths as well as weaknesses. For instance, advanced rote skills of a student with an ASD might be mistaken for advanced comprehension (Huber, 2007) while *vice versa*, the advanced comprehension and creative thinking of an IG student might be overlooked because of weak learning strategies. Moreover, if talents were subordinated to limitations, the student might receive improper intellectual challenges, suffer from low self esteem, low motivation and depression (Cash, 1999). In the literature on gifted students, the camouflaging effect was supposed to be a general characteristic of twice-exceptional gifted students, and not simply related to IG + ASD. For instance, Reis and Renzulli (2004) stated that gifted students with learning disabilities often were misunderstood because their giftedness could mask their disabilities and their disabilities could camouflage their talents. Moon (2002) claimed that because some symptoms of AD/HD overlapped with characteristics of giftedness, scholars in the field of gifted education theorised that a gifted child – while not actually having the disorder – might be labelled and treated for AD/HD.

1.4. Research questions

The objective of this literature review was to explore the phenomenon of the twice-exceptionality IG + ASD, in relation to its diagnostic issues, by means of the following research question. 'What is the state of the art in empirical and theoretical literature, that is, in dissertations and publications in peer-reviewed journals, concerning personal characteristics of the phenomenon *intellectual giftedness in co-occurrence with an autism spectrum disorder* (IG + ASD), in relation to identification and diagnostic and assessment issues?' To facilitate systematic comparison of publications, the research addressed the following sub questions:

1. How is IG + ASD defined and/or identified?
2. Are any general characteristics ascribed to IG + ASD?
3. What are the similarities between the characteristics of IG and of ASD?
4. What are the differences between the characteristics of IG and of ASD?
5. In the case of IG + ASD, do characteristics of IG and of ASD influence one another in a camouflaging way?
6. What diagnostic and assessment issues are mentioned, concerning IG + ASD?

2. Method

2.1. Search

The electronic databases Web of Science, PsychInfo, ERIC and MedLiner were systematically searched for relevant publications up to and including December 2008, by means of the following combination of search terms: ("Gifted*" or "talent*" or "genius" or "intelligen*" or "high ability" or "highly able" or "high IQ") and ("autism" or "Asperger*" or "PDD" or "ASD"). Most of these search terms were applied to search throughout the whole texts of publications. Because, in the first instance, the term 'intelligen*' resulted in an overwhelming number of irrelevant hits, this term was subsequently restricted only to 'titles'. The search was systematically aimed at publications in peer-reviewed journals and dissertations, and generated 382 hits.

2.2. Inclusion criteria

Included were publications in which one or more IG + ASD-cases or IG + ASD-groups were described, and/or aspects of the phenomenon IG + ASD were described and/or conceptualised. For the purpose of this study, we defined IG + ASD as an

[4] Camouflage means any form of pretence or hiding. If the ASD-symptom of 'social isolation' is exacerbated, as described in the quote of Gallagher and Gallagher (2002), it might mask traits of giftedness, like supreme cognitive intelligence. In other words, in that case, the weaknesses obscure the strengths. It can also be the other way around, however: For example, if gifted traits like extensive (verbal) knowledge base are intensified, this might modify and obscure ASD-traits like a lack of reciprocal non-verbal communication.

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Table 1
Publications containing Systematic Identification Measures of IG and/or ASD (SIM publications).

Author	Aim of study (where appropriate: *n* and/or age and/or gender of all cases, including non-IG + ASD ones)	*n* + age + gender of IG + ASD cases	Definitions of IG + ASD	Identification of IG + ASD	Identification level
Correlational studies					
Goldstein et al. (2008)	Confirmatory factor analyses of the commonly used 11 subtests of the Wechsler child and adult scales. Objective: to determine whether structure of intelligence in HFA groups was similar to that found in normative samples and whether a separate 'social context' factor would emerge unique to HFA (IQ 70+). Sample 137 children (age $M = 11.04$); 117 adults (age $M = 27, 58$). Highest IQ group: IQ 120+	$n = 30$ 16 children, age $M \approx 11$; 14 adults, age $M \approx 27$; gender no info	HFA in co-occurrence with highest IQ-level.	Autism diagnosis through ADOS and ADI-R cut-offs for autism (not Autism Spectrum Disorder and AS excluded) plus verification by expert opinion. Plus Wechsler IQ 120+ (WISC-R, WISC-III, WAIS-R, WAIS-III)	Norm referenced plus criterion referenced
(Multiple) Case studies					
Baron-Cohen et al. (1999)	Descriptive multiple case study: three cases of very high functioning individuals described and compared to control group of men ($n = 14$, age $M = 28$; predicted full-scale IQ score 130.9)	$n = 3$ male adults, age 18, 19, 38	Very high functioning individuals with self evident academic achievements plus diagnosis AS	FSIQ proves to be ≥130 and PIQ > VIQ. Plus diagnosis AS/HFA, but no info about frame of reference (e.g. DSM-IV) nor instruments	Norm referenced plus (implicitly) criterion referenced
Huber (2007)	Dissertation: multiple case study: systematic, empirically based descriptions of 10 IG-students (school-age) with ASDs. No control group. Introduction part serves as a selective literature study	$n = 10$ school-age students, age range 7–11 (1 girl)	Intellectual giftedness in co-occurrence with an ASD (i.e. AU, AS, PDD-NOS)	Inclusion criteria: highest IQ score in 95% confidence interval of FSIQ, or VCI or PRI (WISC-IV), or FSIQ, or VIQ or NVIQ (SB-5) ≥ 130. Plus DSM-IV diagnosis AS, AU or PDD-NOS (among others via ADOS-G, ADI-R)	Norm referenced plus criterion referenced
Nass and Gutman (1997)	Five boys with both Asperger's disorder and Tourette syndrome, exceptional verbal intelligence, and clumsiness are reported. Each presented at early elementary school age with a prominent complaint of social difficulties with peers	$n = 5$ boys, early elementary school age	AD plus verbal IQ in the very superior range	Mean and range Wechsler IQs: FSIQ 131 (121–154), VIQ 140 (129–156), PIQ 115 (108–134), VC 138 (124–146), PO 118 (110–135), FFD 125 (115–131 over 4 boys). No id. criteria concerning AD	IQ: norm referenced, AD?
Njiokiktjien et al. (2001)	Multiple case study: exploration, through anamnesis, observation and neuropsychological test data, of severe deficits in facial affect recognition in 3 boys (aged 6, 7, 10) with AS and prosopagnosia (=disorder of face perception). 1 boy is highly gifted in physics and mathematics	$n = 1$ school boy, age 10	Highly gifted in physics and mathematics plus AS criteria DSM-IV and literature	Selection of WISC-III scores at age 8: FSIQ = 115, VIQ = 110, PIQ = 120, FFD = 145, PS = 125. arithmetic ss = 19, picture arrangement ss = 6, block design ss = 17, object assembly ss = 15. Plus AS diagnosis, but no info on instruments	IQ: norm referenced, AS?
Implictly meeting inclusion criteria					
Boggs et al. (2006)	IG ($n = 20$), AS ($n = 21$), AU ($n = 14$) and TD ($n = 21$) children compared as control groups in AS diagnostic instrument validation study, age $M = 9.42$ (1.61)	$n = 0$	IG: having an IG educational eligibility ruling	IG: IQ and achievement scores > P90, +A average, +char. of giftedness and either creativity or leadership'	IQ: norm referenced, ASD?
Caron et al. (2006)	Explaining the mechanism responsible for BDT-peak in AU ($n = 8$) and disentangle the effects of IG ($n = 8$), AU ($n = 8$) and general IQ ($n = 10$) in BDT. Adolescents, age $M = 16$, 88 (2.0)	$n = 0$	'autistic giftedness' = 'HFA-P' = a relative (savant) ability (BDT-peak) in individuals with mean IQ)	Mean IQ scores HFA-P research group prove to be: FSIQ 103, 1 (15.0), VIQ 98, 9 (21.5), PIQ 108, 9 (10.0) BDT ss 16, 6 (2.0)	IQ: Norm referenced ASD: criterion referenced (ADI-R + ADOS-G)

ADI-R = Autism Diagnostic Interview-Revised; ADOS(-G) = Autism Diagnostic Observation Schedule (-Generic); AD = Asperger's disorder; AS = Asperger's syndrome; ASD = Autism Spectrum Disorder(s); AU = Autism; BDT = Block-Design Task; char. = characteristics; def. = defined/definition; expl. = explicitly mentioned in text.; FFD = Freedom From Distractibility factor (Wechsler scales); FSIQ = full-scale IQ; GT = gifted(ness); GT/LD = Gifted/Learning Disabled; HFA = High Functioning Autism; HFA-(n)P = High Functioning Autism with(out) visuo-spatial Peak; id. (instr.) = identification (instrument(s)); IG = intellectually gifted; IG + ASD = co-occurrence of IG plus ASD; impl. = implicitly derived from text.; LD = Learning Disability/Learning Disabled; non-SIM = without systematically obtained identification measures of IG and/or ASD; NVIQ = Non Verbal IQ (SB-5); PDD(-NOS) = Pervasive Developmental Disorder(s) (-Not Otherwise Specified); PIQ = Performance IQ/Perceptual IQ; PO = Perceptual Organisation factor (WISC, WAIS, -R and -III); PRI = Perceptual Reasoning Index (WISC-IV); PS = Processing Speed factor (WISC, WAIS, -R and -III); SB-5 = Stanford-Binet Intelligence Scales, fifth edition; SC = Social Context factor (WISC, WAIS, -R and -III); SIM = systematically obtained identification measures of IG and/or ASD; TD = typically developing; TD-P = typically developing gifted comparison participants with visuo-spatial Peak; VC = Verbal Comprehension factor (WISC, WAIS, -R and -III); VCI = Verbal Comprehension Index (WISC-IV); VIQ = Verbal IQ; WAIS-R = Wechsler Adults Intelligence Scale Revised; WAIS-III = Wechsler Adults Intelligence Scale 3rd edition; WISC-R = Wechsler Intelligence Scale for Children Revised; WISC-III = Wechsler Intelligence Scale for Children 3rd edition; WISC-IV = Wechsler Intelligence Scale for Children 4th edition.

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Table 2
Publications lacking Systematic Identification Measures of IG and/or ASD (non-SIM publications).

Author	Aim of study (where appropriate: *n* and/or age and/or gender of all cases, including non-IG + ASD ones)	*n* + age + gender of IG + ASD cases	Definitions of IG + ASD	Identification of IG + ASD	Identification level
Case reports					
Boucher (2007)	Unsystematic case report: Analytical account of the atypical memory abilities and memorizing and learning strategies of a highly able person with AS, whose language and intellectual abilities are superior	*n* = 1 male adult	Superior intellectual abilities plus AS	No info	No info
Ward and Alar (2000)	Article, autobiographic case report	*n* = 1 male adult, age 22	Very smart and talented young man with autism, highly developed visual spatial skills	At age 14: PIQ = 144, top score on high school scale of visual spatial skills	IQ: norm referenced ASD no info
Selective literature reviews					
Cash (1999)	Article: description of behaviours, impacts, educational needs and implications for future growth of the twice exceptionality of autism and giftedness	*n* = 0 individuals, children	Gifted individuals with AU, AS or PDD-NOS are 'twice exceptional' or 'dual labelled' learners. Mainly but not exclusively referring to domain of intellectual giftedness	No info	No info
Donnelly and Altman (1994)	Article: this article focuses attention on the underserved population of *gifted* students with autism and advocates for special educational opportunities for these children	*n* = 0 children, youngsters	Gifted students with autism, also defined as 'autistic savants'. Meaning: 'not mentally retarded autists' or 'above average in general intelligence' and/or 'having abilities and IQ-subtest scores in the gifted range'	No info	No info
Neihart (2000)	Article: discusses ways in which AS might be missed in gifted children, and proposes guidelines for differentiating characteristics of giftedness from characteristics of AS	*n* = 0 children	Gifted children with AS (DSM-IV diagnosis). Gifted implicitly meaning: 'those who should be participating in special educational programs'	No info	No info
Book reviews					
Barber (2005)	Fitzgerald, M. (2004). *Autism and creativity. Is there a link between autism in men and exceptional ability?*	*n* = 6 male adults	Creative genius	No info	No info
Davies (2004)	Fitzgerald, M. (2004). *Autism and creativity. Is there a link between autism in men and exceptional ability?*	*n* = 6 male adults	Genius with clinical features of HFA/AS	No info	No info
Dosani (2005)	Fitzgerald, M. (2004). *Autism and creativity. Is there a link between autism in men and exceptional ability?*	*n* = 6 male adults	Genius with HFA/AS	No info	No info
Geller and Haynes (2004)	Mont, D. (2001): *A different kind of boy: A father's memoir of raising a gifted child with autism*	*n* = 1 boy (age 11)	A gifted boy with AU, mathematics whiz.	Implicitly: IQ > 150	No info
Holmes (2007)	Grandin, T., Scariano, M. (2005). *Emergence: Labeled autistic*	*n* = 1 female adult	Most gifted High Functioning Autists. Nonverbal thinkers with fluid intelligence	No info	No info
Kuss (2007)	Weinfeld, R., Barnes-Robinson, L., Jeweler, J., Roffman Shevitz, B. (2006). *Smart kids with learning difficulties: Overcoming obstacles and realizing potential*	*n* = 0 students/kids	Gifted autists, being a subgroup of the gifted and talented learning disabled	Implicitly: IQ ≥ 130 plus AU.	IQ: norm referenced, AU: no info
Rapin (2002)	Sowell, Th. (2001): *The Einstein syndrome*	*n* = 46 children	Sowel's 'Einstein children' are extraordinarily gifted children in whom exceptional visual/spatial reasoning skills mature much earlier than language skills. Rapin presumes that part of these Einstein children are actually IG-children with ASD	No info other than assumed IQ range of 140-180.	IQ: norm referenced ASD no info

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Wolff (2005)	Fitzgerald, M. (2004). *Autism and creativity. Is there a link between autism in men and exceptional ability?*	n = 6 male adults	Creative genius = brilliant people with autistic traits	No info	No info
Letters to editor					
Fitzgerald (2002)	Discusses the presentation of Asperger's disorder in mathematicians of genius	n = 12 male adults	Mathematicians of genius and originality over the past 2300 years for whom there are adequate data which meet the criteria for Asperger's disorder	Well-known geniuses with DSM-IV criteria	IG: no info AS: criterion referenced
Grandin (2004)	Response to the ongoing discussion about the links between autism and genius	n = 0 children, adults	Intellectually gifted engineers and scientists who seem to have mild autism or Asperger's traits	No info	No info
Implicitly meeting inclusion criteria					
Casanova et al. (2007)	Report of neuroanatomical findings in the post mortem brains of three eminent scientists and six normative controls. Post-mortem brains, 3 male adults, age of death: 58, 84, 89	n = 0	'intellectual achievement', 'scientists of high distinction' with 'wide range of knowledge (polymaths) and divergent thinking'	IG: personal history and interviews with acquaintances	No info
Chiang and Lin (2007)	Article: systematic review of empirical studies investigating cognitive ability and academic achievement, of students (adults, children, adolescents, age 3-51 years) with AS/HFA. Questions amongst other things. 'do individuals with AS/HFA have mathematical giftedness?'	n = 0	Mathematically gifted individuals with AS/HFA	Mathematics scores are above the 99th percentiles on the norm	Partly norm-, partly criterion referenced.
Wallace (2008)	Article: selective review of neuropsychological research on savant skills of children, adolescents and adults is highlighted; results are compared to extant results within the giftedness literature	n = 0	No info (savant skill)	No info	No info

ADI-R = Autism Diagnostic Interview-Revised; ADOS(-G) = Autism Diagnostic Observation Schedule (-Generic); AD = Asperger's disorder; AS = Asperger's syndrome; ASD = Autism Spectrum Disorder(s); AU = Autism; BDT = Block-Design Task; char. = characteristics; def. = defined/definition; expl. = explicitly mentioned in text.; FFD = Freedom From Distractibility factor (Wechsler scales); FSIQ = full-scale IQ; GT = gifted(ness); GT/LD = Gifted/Learning Disabled; HFA = High Functioning Autism; HFA-(n)P = High Functioning Autism with(out) visuo-spatial Peak; id. (instr.) = identification (instrument(s)); IG = intellectually gifted; IG + ASD = co-occurrence of IG plus ASD; impl. = implicitly derived from text.; LD = Learning Disability/Learning Disabled; non-SIM = without systematically obtained identification measures of IG and/or ASD; NVIQ = Non Verbal IQ (SB-5); PDD(-NOS) = Pervasive Developmental Disorder(s) (-Not Otherwise Specified); PIQ = Performance IQ/Perceptual IQ; PO = Perceptual Organisation factor (WISC, WAIS, -R and -III); PRI = Perceptual Reasoning Index (WISC-IV); PS = Processing Speed factor (WISC, WAIS, -R and -III); SB-5 = Stanford-Binet Intelligence Scales, fifth edition; SC = Social Context factor (WISC, WAIS, -R and -III); SIM = systematically obtained identification measures of IG and/or ASD; TD = Typically Developing; TD-P = Typically Developing gifted comparison participants with visuo-spatial Peak; VC = Verbal Comprehension factor (WISC, WAIS, -R and -III); VCI = Verbal Comprehension Index (WISC-IV); VIQ = Verbal IQ; WAIS-R = Wechsler Adults Intelligence Scale Revised; WAIS-III = Wechsler Adults Intelligence Scale 3rd edition; WISC-R = Wechsler Intelligence Scale for Children Revised; WISC-III = Wechsler Intelligence Scale for Children 3rd edition; WISC-IV = Wechsler Intelligence Scale for Children 4th edition.

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ASD diagnosis (either AU, HFA, AS or PDD-NOS), with or without co-morbidity, in co-occurrence with cognitive intelligence and/or academic performances at a gifted level. In order to serve the explorative aim of this review, we included any publications in peer-reviewed journals, and dissertations, on giftedness in the academic domain. In so doing, we did not place restrictions concerning the document-type or quantitative level of any IQ-scores or academic performances, as long as authors mentioned or justified their target group or case(s) to have cognitive intellectual capacities and/or intellectual functioning and/or academic achievements at a gifted, talented, supreme or very high ability level. In this way, publications containing systematically obtained IG and/or ASD identification measures (SIM publications, Table 1) as well as publications without systematically obtained identification measures (non-SIM publications, Table 2) were included. Identification Measures means, that either IG or ASD or both can be measured quantitatively, for instance with IQ's or percentages. SIM means that Identification Measures were studied in a Systematic, planned way. Non-SIM means that quantitative Identification Measures were not studied by plan, but found by coincidence or just mentioned or suggested, or not provided at all. One of our goals was to analyse whether or not the results from both fields of contributions, that is SIM and non-SIM, were in line with or contradictory to each other.

Four book reviews (Barber, 2005; Davies, 2004; Dosani, 2005; Wolff, 2005) of the same book (Fitzgerald, 2004) were included, because per se they belonged to the inclusion criteria.

The excluded publications dealt with the following topics: 1. 'Savant abilities' or HFA without justification of any IQ scores and/or intellectual functioning and/or academic performances at a gifted, talented, superior or very high ability level 2. Domains of giftedness other than academic intelligence or performance (viz. arts, music or leadership) 3. Disorders other than ASD 4. IG and/or ASD separately but not explicitly with the co-occurrence IG + ASD. To this last exclusion rule we made an exception for two SIM publications (Boggs, Gross & Gohm, 2006; Caron, Mottron, Berthiaume, & Dawson, 2006) and three non-SIM publications (Casanova, Switala, Trippe, & Fitzgerald, 2007; Chiang & Lin, 2007; Wallace, 2008) in which the discussions explicitly shed light on (controversial image formation of) the phenomenon IG + ASD. Finally, therefore, 25 publications were included, summarised in Tables 1 and 2, comprising one dissertation, 14 articles, eight book reviews, and two 'letters to the editor'.

3. Results

Here, we compared the included publications by means of the sub-research questions, grouped together in Section 3.1 (*Definitions and identification*), Section 3.2 (*Characteristics of IG + ASD*), and Section 3.3 (*Diagnostic and assessment issues*).

3.1. Definitions and identification

Tables 1 and 2 show per publication the aim of study, the age and gender of the target group, and the definition and identification data of IG + ASD used in the study in question. Tables 1 and 2 summarise the SIM publications respectively the non-SIM publications (see Section 2.2). In both tables, all publications are grouped per study type. The five publications that did not explicitly meet the inclusion criteria are grouped under 'implicitly meeting inclusion criteria'.

3.1.1. SIM publications

The SIM publications that explicitly met the inclusion criteria are one confirmatory factor analysis (Goldstein et al., 2008) and four multiple case studies (Baron-Cohen, Wheelwright, Stone & Rutherford, 1999; Huber, 2007; Nass & Gutman, 1997; Njiokiktjien, Verschoor, & Sonneville, 2001). Table 1 shows that across these five studies, the concept of IG + ASD was defined differently in each study. According to the identification data, norm-referenced intelligence measures co-occurred with criterion-referenced ASD-diagnoses. Only Nass and Gutman (1997) gave no identification data of AD. Intelligence-levels and intelligence-profiles differed among these studies. The full-scale IQs of all 19 cases in the four case studies ranged from 115 to 154. Virtually all cases showed significant discrepancies among the various IQ and subtest scores. Baron-Cohen et al. (1999) and Njiokiktjien et al. (2001) described giftedness in the 'non-verbal' realm, that is mathematics, physics, computer science, visual-spatial capacities, whereas Nass and Gutman (1997) described verbal giftedness. Goldstein et al. (2008) mentioned full-scale IQs and did not differentiate between verbal and performance IQs. Huber (2007) found no specific pattern of intelligence or academic profile. Furthermore, the first five publications in Table 1 differed in respect of their research questions and the age of the participants. One study included both children and adults, another examined male adults, while the rest of the studies mentioned school-age children. The subjects in the studies were male, only Huber (2007) mentioned one girl. Of the two publications that implicitly met the inclusion criterion, only Caron et al. (2006) gave (more or less) a definition of IG + ASD. They defined 'autistic giftedness' as a mean full-scale IQ score with a relative peak on the Block design task and mentioned high abilities in the non-verbal area.

3.1.2. Non-SIM publications

Table 2 shows one unsystematic case report (Boucher, 2007) and one autobiographical case report (Ward & Alar, 2000). Boucher (2007) defined IG + ASD as 'superior intellectual abilities plus AS' without information about IQ-scores. The meaning of 'superior' therefore remains fuzzy. Ward and Alar (2000) mentioned high capacities in the non-verbal area, and one outdated performance IQ score. Because their text lacked information on other IQs (e.g. FSIQ or VIQ), it remains unclear whether or not the intelligence profile had any discrepancies.

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In the three selective literature reviews that explicitly met the inclusion criteria (Cash, 1999; Donnelly & Altman, 1994; Neihart, 2000) the authors mainly, but not exclusively, referred to giftedness in the domain of intelligence. For this reason, and because there is no information on identification levels, the definitions remain indefinite. This is especially the case in the study of Donnelly and Altman (1994), who inconsistently used the name 'gifted students with autism' throughout the text of their publication.

The four authors who reviewed Fitzgerald's book (Fitzgerald, 2004) used the names 'creative geniuses' or 'geniuses with AS/HFA' (Barber, 2005; Davies, 2004; Dosani, 2005; Wolff, 2005). Only from the text of Davies' (2004) can one derive that it is about geniuses in philosophy, politics, literature and mathematics. None of these four authors gave any identification data. Of the eight book reviews and two 'letters to the editor', only Kuss (2007), Geller and Haynes (2004) and Rapin (2002) added some identification information to their definitions, indicating full-scale IQs $\geq$ 130. The definitions of Fitzgerald (2002), Geller and Haynes (2004), Grandin (2004), Holmes (2007), and Rapin (2002) all included giftedness in the broad non-verbal realm (viz. visual-spatial skills, mathematics, physics computer science or engineering). Fitzgerald (2002) added the divergent aspect of 'original thinking'.

Of the three publications that implicitly met the inclusion criteria, only Wallace (2008) gave no definition. Chiang and Lin (2007) gave a definition in the non-verbal realm, namely mathematical giftedness, which they defined in absolute terms and not in relation to the rest of an individual's own intelligence. Casanova et al. (2007) mentioned high abilities in the non-verbal area and explicitly mentioned 'divergent thinking'.

3.2. Characteristics of IG + ASD

In the 25 publications, 59 personal characteristics (Table 3) were found ascribing the co-occurrence IG + ASD. According to the exploratory aim of this study, these characteristics were grouped without having any *a priori* hypotheses. This resulted in ten comprehensive clusters, based on the following content analysis. Many characteristics seemed to share a core developmental and/or (neuro)psychological feature or principle. Six of these clusters were more or less based on core resemblances in the field of cognitive information processing, namely: 'uneven development', 'superior non-verbal capacities', 'verbal/language issues', 'compensation through reasoning', 'memory issues' and 'executive functions (EF) issues'. Three of the clusters were more or less based on resemblances in the social-emotional realm, named 'social issues', 'behaviour/rigidity' and 'hypersensitivity'. One characteristic showed no resemblance with any other and therefore it could not be grouped and was classified on its own as the cluster 'neurobiological'. In Table 3 the marked characteristics per publication are shown. Characteristics are marked in four ways: 'G' means that the authors found or considered this characteristic to be a *general* feature of (their definition of) IG + ASD, or it was a *general* characteristic of (almost) all cases in a multiple case study. 'I' means that this characteristic was ascribed to one *individual* case, in either multiple or one-case studies. 'S' means that the author(s) found or considered this characteristic to be a *similar* trait of typically developing IG and of ASD. 'D' means that the author(s) found or considered this characteristic to *differentiate* between IG and ASD. 12 characteristics have a double mark, a combination of G and/or S and/or D. This means, for instance, that the author(s) of a specific publication considered the marked characteristic to be a general trait (G) as well as a similar trait (S), or a similar trait with differential potentialities (D). The double mark 'II', only indicated at Baron-Cohen et al. (1999), means that this specific characteristic was ascribed to two of the cases in a multiple case study.

In Table 4, the second column shows the distribution of the types of marks (G, I, S and D) per cluster. The third column shows the sum of marks per cluster in terms of percentages related to the total 150 marks (of Table 3). This was done in order to gain an insight into an inter-cluster weight. Another way to weigh the clusters in relation to each other is presented in the fourth column, which shows the number of publications in which the authors mentioned each cluster at least once.

In the next section, the information included in Tables 3 and 4 is "analysed".

3.2.1. Distribution of characteristics across publications

The distribution of marks in Table 3 is exhibiting various profiles of characteristics among the publications. Moreover, the same characteristic might be marked differently among publications as well as within publications. For example, Donnelly and Altman (1994) identified the characteristic 'verbal fluency/precocity' as a general characteristic (G) of IG + ASD, while Huber (2007) and Neihart (2000) ascertained this to be a similar trait (S) of both IG and ASD. An example of 'double naming' within a publication is shown by Baron-Cohen et al. (1999), who found that their three clinical cases showed greater VIQ–PIQ discrepancies than IQ-matched controls. According to our definitions of 'general', we marked this characteristic as G. Meanwhile these authors also found this characteristic to be a differential trait between their IG + ASD cases and their typical developing IG-controls. This characteristic is therefore double marked. Table 3 shows 12 double marks, seven of which occur in non-SIM publications (i.e., Cash, 1999; Donnelly & Altman, 1994; Neihart, 2000). Since these authors merely compared publications on giftedness with those on ASD, and partly referred to each other, these double-marked characteristics are not derived empirically from an IG + ASD research group but are generated theoretically.

The last column of Table 3 shows the number of publications in which each characteristic is mentioned. The following characteristics stand out the most, in that they show up in at least five publications: uneven development of 'social versus cognitive capacities', 'significant reasoning-motor discrepancies', capacities in the field of 'mathematics, physics computer', 'creative/divergent thinking', 'formal/pedantic speech with nearly absent prosody', 'intense focus/obsession to detail', 'deficits in social adjustment, isolation', 'unawareness of social rules', 'general hypersensitivity'.

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Table 3
Characteristics mentioned per publication.

25 publications → / **59** characteristics, grouped in **10** clusters ↓	Goldstein et al. (2008)	Baron-Cohen et al. (1999)	Huber, (2007)	Nass & Gutman (1997)	Njiokiktjien et al. (2001)	Boucher (2007)	Ward (2000)	Cash (1999)	Donnelly & Altman (1994)	Neihart (2000)	Barber (2005)	Davies 2004)	Dosani (2005)	Geller (2004)	Holmes (2007)	Kuss (2007)	Rapin (2002)	Wolff (2005)	Fitzgerald (2002)	Grandin (2004)	Boggs et al. (2006)	Caron et al.. (2006)	Casanova et al. (2007)	Chiang & Lin (2007)	Wallace (2008)	Totals without doubles
Neurobiological																										
Minicolumnar morphometry																							**S**			**1**
Uneven development																										
Social versus cognitive capacities	**G D**	**G**	**G S**						**G**	**G S**																**5**
Precocity of higher cognitive functions (memory, language)										**G**																**1**
Strengths+weaknesses within (academic) ability profiles			**G**						**G**	**S**																**3**
Very irregular intelligence profile			**G**		**I**																					**2**
Significant VIQ-PIQ discrepancies		**G D**	**G**	**G**																						**3**
Relatively slower maturing language skills, speechless kids																	**G**									**1**
Significant reasoning-motor discrepancies, clumsiness		**I**	**G**	**G**	**I**					**D**																**5**
Superior nonverbal capacities																										
PIQ>VIQ		**G**	**G**																							**2**

Mathematics, physics, computer (games, science)		**G**					**I**							**I**			**G**		**S**	**G**						**6**
Visual(-spatial)/non-verbal thinking								**S**	**G**						**I**											**3**
Creative/divergent thinking, fluid intelligence; nonverbal problem solving											**S**	**S**	**S**		**I**		**G**	**S**	**S**				**S**			**8**
Verbal/language issues																										
VIQ>PIQ			**G**	**G**																						**2**
Verbal fluency/precocity			**S**						**G**	**S**																**3**
Slow verbalisation in subjects outside of interest					**I**																					**1**
Formal, pedantic, monotonous speech with nearly absent prosody			**D**	**G**	**I**					**D**					**I**											**5**
(Annoying) lengthy + specific detailed responses, endless questions, overfocused conversation			**S**	**G**						**S**																**3**
(Humor, understands jokes but sometimes) take things literally		**I**								**D**																**2**
Miss unspoken messages, cannot infer from context				**G**					**G**					**I**												**3**
Compensation through reasoning																										
(Reduced) mathematical view of the (social) world		**I**																	**G**							**2**
Use single visual facial de-tails to interpret emotions					**I**																					**1**
Adaptation only possible if things can be reasoned logically					**I**																					**1**
Event memory through analytical reasoning form fact to fact						**I**																				**1**
Memory issues																										
Excellent rote/factual memory			**S D**				**I**		**G**	**S**																**4**
Relative weakness of working memory			**G**																							**1**
Relative weakness of inforrmation processing speed			**G**																							**1**

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Table 3 (*Continued*)

Poor memory for names					**I**		**I**							**I**												**3**
Factual knowledge influenced by preferences					**I**																					**1**
Superior perceptual memory						**I**																				**1**
Superior but atypical semantic memory						**I**																				**1**
Superior auditory/verbal sequential working memory					**I**	**I**			**G**																	**3**
Poor (autobiographical) event memory						**I**																				**1**
Cannot recall or recognise faces or people		**I**				**I**																				**2**
Executive functions (EF) issues																										
Fascination , preoccupied absorbing (restricted) special interest			**S**	**G**						**G S**								**G**								**4**
Intense focus/obsession to detail/perfectionism			**S D**		**I**			**S D**	**G**			**S**													**S**	**6**
Excellent planning skills					**I**																					**1**
Attention disturbance			**D**							**D**																**2**
Relative weakness of processing speed			**G**																							**1**
Social issues																										
Deficits in social adjustment, isolation, few friends, withdrawn		**G**	**G**	**G**	**I**		**I**	**S D**	**S D**								**D**	**G**		**D**						**10**
Limitless talk about own interests, lack of reciprocal communication				**G**	**I**												**G**	**G**								**4**
Communicates, though about his interests and/ or via internet		**I**			**I**		**I**																			**3**
Cannot understand why he does not fit in socially		**I I**								**D**																**3**
Unaware of social rules and (one's own) interactions			**D**		**I**		**I**		**G**	**D**																**5**
Rather impassive body language and mimicry, no eye-contact					**I**		**I**		**G**																	**3**
Being bullied		**G**					**I**																			**2**
Transition to junior high school stressful							**I**																			**1**

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Malemployment (underemployment or unsuitable work)			**D**																							**1**
Inappropriate affect										**D**																**1**
Behaviour/rigidity																										
Negative behaviour								**S D**																		**1**
Temper tantrums														**I**	**I**											**2**
Vocal and/or motor tics				**G**																						**1**
Various strategies to deal with stress (head banging, strange noises)							**I**	**I**							**I**											**3**
Difficulty with change, rigidity			**D**																							**1**
Response to routines										**D**																**1**
Stereotyped/repetitive behaviour				**G**						**D**																**2**
Low play and leisure skills			**G**											**I**												**2**
Intense need for stimulation								**S**																		**1**
hypersensitivity																										
General hypersensitivity			**S**				**I**	**S**		**G S**					**I**											**5**
Auditory stimuli										**G**					**I**											**2**
Totals	**1**	**13**	**23**	**11**	**16**	**6**	**11**	**7**	**11**	**18**	**1**	**2**	**1**	**5**	**7**	**0**	**5**	**1**	**6**	**1**	**1**	**0**	**2**	**0**	**1**	**150**

G = general characteristic of IG + ASD; I = individual characteristic of IG + ASDl; S = similar characteristic of IG and of ASD; D = differential characteristic of IG and of ASD; EF = executive functions.

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Table 4
Distribution of characteristics per cluster.

Column 1	Column 2					Column 3		Column 4
10 characteristic clusters	Absolute number of G, I, S or D					Total amount of marks (G + I + S + D)		Total number of publications
	Gs	Is	Ss	Ds	Doubles (G + S, G + D, or S + D)	Per cluster, minus doubles	Percentage related to 150 marks	Mentioning each cluster at least once (G, I, S and/or D)
Neurobiological	0	0	1	0	0	1	1%	1
Uneven development	15	3	3	3	4	20	13%	8
Superior non-verbal abilities	7	4	8	0	0	19	13%	15
Verbal/language issues	7	5	4	3	0	19	13%	8
Compensation through reasoning	1	4	0	0	0	5	3%	4
Memory issues	4	12	2	1	1	18	12%	8
EF issues	5	2	6	4	3	14	9%	9
Social issues	10	14	2	9	2	33	22%	11
Behaviour/rigidity	3	6	2	4	1	14	9%	7
Hypersensitivity	2	3	3	0	1	7	5%	5
Total	54	53	31	24	12	150	100%	
Percentage related to 150 marks	36%	35%	21%	16%	8%	100%		

G = general characteristic of IG + ASD; I = individual characteristic of IG + ASDl; S = similar characteristic of IG and of ASD; D = differential characteristic of IG and of ASD; EF = executive functions.

Besides, the characteristics that are mentioned in four publications are: 'Excellent rote/factual memory', 'fascination/preoccupation to absorbing and restricted special interests', 'limitless talk about ones own interests'.

The bottom row of Table 3 indicated that four SIM publications (Baron-Cohen et al., 1999; Huber, 2007; Nass & Gutman, 1997; Njiokiktjien et al., 2001) and three non-SIM publications (Donnelly & Altman, 1994; Neihart, 2000; Ward & Alar, 2000) contain the highest total (more than 10) of the marked characteristics. Within these seven publications, general characteristics (Gs) are mentioned in three multiple case studies as well as in two selective literature reviews. Furthermore, due to their individual case descriptions, Njiokiktjien et al. (2001) and Ward and Alar (2000) mentioned only individual traits (Is). The similarities and differentials mentioned by Huber (2007) are theoretical conclusions of her selective literature review in the introductory part of her publication.

3.2.2. Distribution of mark-types across clusters

The bottom row of column 2 in Table 4 shows that the majority of the 150 characteristics are marked a general trait (36%) or individual trait (35%), whereas the minority are marked a differential trait (15%), and similar traits fall in between (21%). As shown in Table 3, the many individual traits are concentrated in five (book reviews of) individual case descriptions. So the amount of Gs and Is are about equal, but the Gs are based on more cases than the Is. Moreover, in the (book reviews of) $n = 1$ case-descriptions in which the authors displayed many Is, the descriptions are more concrete and detailed, which generated more marks. This is contrary to the way we marked data of multiple case studies. For instance, in the case of Huber (2007), merely common conclusions were marked because we intend to look for general tendencies of the phenomenon IG + ASD. All of this means that the total sum of Gs in proportion to the total sum of Is might not be very relevant in the explorative context of this study. Distribution across clusters might reveal information that is more relevant.

Considering the clusters with a relatively average or high number of marks as summed up in column 3 (i.e. about 14 marks or more), reveals the following tendencies: Only in the cluster 'uneven development', are the Gs a majority. These Gs are mainly marked in multiple case studies and in selective literature reviews. 'Memory issues' as well as 'compensation through reasoning' scored mainly Is, which are dominated by two cases.

All of this means that analysing the distribution of the different mark-types, either in total or across clusters, did not provide relevant information.

3.2.3. Distribution of marks across clusters

Table 4 column 3 shows the total number of marked characteristics per cluster. Related to the total of 150 marks in Table 3, the cluster of social issues stands out most. This is not surprising, since social deficits are the core problem of ASD (Robertson, Tanguay, L'Ecuyer, Sims, & Waltrip, 1999). Second are the clusters 'uneven development', 'superior non-verbal abilities' and 'verbal/language issues', and 'memory issues'. Contrary to what might be expected, the 'EF issues', 'behaviour/rigidity' and 'hypersensitivity', which are common issues in general ASD-literature, score relatively low. Contrary to the theoretical idea of the 'camouflaging effect', the cluster 'compensation through reasoning' has a small number of marks, mainly individual ones. Since we found only one neurobiological publication (Casanova et al., 2007), the neurobiological cluster scores the lowest.

Some characteristics may overlap each other, either within or between clusters, for example, 'precocity of higher cognitive functions' in cluster 'uneven development' might overlap 'excellent (rote) memory.' in cluster 'memory issues'. Therefore, we constructed an additional way of analysis in column 4 of Table 4, which displays, per cluster, the number of publications in which the cluster is mentioned at least once. The main difference with column three is that cluster 'superior non-verbal abilities' stands out quite clearly over the rest. 'Social issues' scores second and also quite high, followed by 'EF issues', 'uneven development', 'verbal/language issues' and 'memory issues'. 'Behaviour/rigidity' scores next. In this analysis, the clusters 'compensation through reasoning' and 'hypersensitivity' score lowest, just like in the aforementioned analysis (see column 3 of Table 4).

3.2.4. SIM publications with $n > 1$

The publication of Huber (2007) is the only empirically based study in which the author aimed at a systematic clinical description of an IG-group, ten school-age students, diagnosed with ASDs. Huber (2007) found significant differences across cases concerning profiles of capacities, academic capabilities and motor skills. She found the following few general characteristics: (moderately) low scores for interpersonal relationships, aspects of uneven development, a slight tendency of relative weaknesses of working memory and processing speed within the intelligence profiles and significant reasoning-motor discrepancies. The majority of her cases showed significant discrepancies between verbal and perceptual capacities. Since Huber (2007) made no comparison with any control group, it remained unclear whether or not these characteristics distinguish IG + ASD from IG or ASD. Baron-Cohen et al. (1999) compared their cases to an IQ-matched control group. Unlike Huber, however, these authors aimed more specifically at high 'non-verbal' intellectual skills of adults and seemed to have chosen their subjects selectively, that is, the publication lacks information on the selection procedure of participants. Nass and Gutman (1997) aimed at exceptional verbal intelligence, plus co-morbidity with Tourette syndrome, and did not compare their findings to any control group. Goldstein et al. (2008) compared the Wechsler factor scores of children and adults with autism in different IQ-groups. They found across child IQ samples that a Social Context (SC) factor, consisting of the subtests Picture arrangement and Picture completion, scored the lowest of four Wechsler-scale factors in the 120+ IQ group. In the other child IQ groups (120−) the Freedom From Distractibility (FFD) factor score (Digit span, Arithmetic and Coding/Digit

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symbol) was the lowest. Across adult autism samples the SC factor scored lower at almost all normal and above normal IQ groups (IQs 90–119), but the difference between this SC-factor score and other factor scores was particularly evident for adults in the highest 120+ IQ group. Apart from the methodological differences, the four aforementioned empirical studies also differed concerning the reported full-scale IQs, as shown in Table 1 under identification. In these four publications, the authors did not find 'similar characteristics' (Ss), probably due in part to the fact that this was not the main focus of their empirical study. The similar and differential characteristics marked for Huber's (2007) publication in Table 3 resulted from her selective literature review, which served as a theoretical introduction to the case study – and were not hypothesised in the actual case study. Baron-Cohen et al. (1999) received one differential characteristic (D) because they found that the research group had greater VIQ–PIQ discrepancies than the IG-control group. Goldstein et al. (2008) also received one D because they found that a Social Context factor scored the lowest of four Wechsler-scale factors in the highest IQ-group (120+), compared to ASD-control groups. Since Goldstein et al. (2008) and Baron-Cohen et al. (1999) used different sorts of control groups, in which either IG or ASD was constant, the aforementioned two Ds indicate different sorts of differential potentiality. Even though these four empirical studies of IG + ASD were difficult to compare, they scored many Gs in the clusters 'uneven development', 'superior non-verbal abilities', 'verbal/language issues' and 'social issues' (see Table 3). Furthermore, the characteristics 'uneven development of social versus cognitive capacities' as well as 'VIQ versus PIQ', and 'deficits in social adjustment' stand out with at least three Gs.

3.2.5. Link between IG and ASD

Fitzgerald (2002) argued in a letter to the editor that there might be a link between genius and Asperger's syndrome, which can be summarised as a mathematical view of the world. He also linked the 'creative thinking' of the geniuses to Asperger traits. In the four reviews of one of Fitzgerald's books (Fitzgerald, 2004) on this topic (Barber, 2005; Davies, 2004; Dosani, 2005; Wolff, 2005) this link between creative geniuses and Asperger's syndrome was also mentioned and critically discussed. *Inter alia*, these four reviewers argued that Fitzgerald's premises are not substantiated in a methodologically robust way, because of the selective choice of (only male) geniuses and the lack of a control group. The work of Casanova et al. (2007), of which Fitzgerald is co-author, might put this discussion in another perspective. In a controlled post-mortem brain study, these researchers expose an anatomical similarity between autistic brains and brains of eminent scientists, concerning the morphometry of the cell minicolumn. This is a vertical column through the cortical layers, which is the smallest module capable of information processing in the brain. Casanova et al. (2007) suggested that a minicolumnar phenotype that provides for discrimination and/or 'focused attention' may help explain the savant abilities observed in some autistic people and in the intellectually gifted. This focused attention, especially on details, is also mentioned in the literature review of Wallace (2008) as an ability that is shared by talented individuals with and without ASD. Cash (1999) also concluded this to be a similarity. Following a selective literature review, she argued that individuals with autism, as well as gifted learners, might intensely focus on their activities. Cash (1999) argued this similarity also has differential potentiality, saying that gifted learners more selectively filter out information.

3.2.6. Similarities between IG and ASD

The previously mentioned similarities 'focused attention' and 'creative thinking' are aspects of the characteristics 'intense focus/obsession to detail' and 'creative/divergent/fluid intelligence'. These two stand out quantitatively, because they are marked as a similarity in at least four publications. Apart from these, Table 3 revealed similarities in the clusters 'uneven development', 'verbal/language issues', 'memory issues', 'social issues' and 'hypersensitivity'. These are concentrated in four selective literature reviews (Cash, 1999; Donnelly & Altman, 1994; Huber, 2007; Neihart, 2000). This can be explained by the fact that these authors specifically compared literature on ASD with publications on IG (interweaved with clinical opinions and case descriptions) and that they referred to each other. All other publications reviewed in this study have no such study-design and might be less suitable for finding affirmations or contradictions of any similarities.

3.3. Diagnostic issues

This section examined diagnostic issues explicitly mentioned by the authors, as well as remarks that might support or refute the possibility of a camouflaging effect. Moreover, the differential characteristics of Table 3 have been analysed in relation to the possibility of differential diagnosis.

3.3.1. Age of initial diagnoses

Huber (2007) reported that the ages of initial parental concern ranged from 8 months to 5 years, and that the ages of initial ASD-diagnosis ranged from 5 years and 3 months, to 11 years and 7 months. She concluded that this variation could not be explained by variation of full-scale IQ. Nonetheless, Huber (2007) found a slight trend that children with higher verbal IQs were older at the time of diagnosis. Some other authors also mentioned the age of initial diagnosis, these varied from 18 months (Ward & Alar, 2000), to toddler age (Geller & Haynes, 2004), primary school age (Baron-Cohen et al., 1999) and adult age (Baron-Cohen et al., 1999). None of the authors explicitly mentioned any age of initial diagnosis of IG.

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3.3.2. Misdiagnoses

It is mainly in the selective literature reviews of Cash (1999), Donnelly and Altman (1994), Huber (2007) and Neihart (2000) that the authors either suggested or concluded that IG + ASD is vulnerable to misidentification or misdiagnosis. Neihart (2000) emphasised that ASD might be missed, whereas Donnelly and Altman (1994) suggested that it is the gifted skills that could be missed. Cash (1999) and Huber (2007) displayed no such direction to either giftedness or ASD. Of all other authors, only Grandin (2004) mentioned the issue of misidentification. One of her great concerns was that if a child is diagnosed with Asperger's or mild autism, this label can hold back development of the gifted talents, scientific or otherwise. In her book review, Kuss (2007) noted that general screening in education will miss many gifted students with a learning disability, including ASD.

Apart from these dual misdiagnoses, only Huber (2007) explicitly reported aspects of differential misdiagnoses of ASD in IG-individuals. Huber (2007) found that eight of her ten participants had prior diagnoses of which ADHD was the most common.

3.3.3. Camouflaging effect

The camouflaging effect, meaning that characteristics of IG and of ASD could mask or distort each other, was only explicitly mentioned in non-SIM publications, especially in the selective literature reviews of Cash (1999), Huber (2007) and Neihart (2000), and the book review of Kuss (2007). Neihart (2000) proposed that gifted children with Asperger's Syndrome might not be identified because their unusual behaviour might be wrongly attributed to either their giftedness or to a learning disability. She warned that identification only as gifted or learning disabled could contribute not only to misunderstandings about the true nature of the child's difficulties, but also to the formulation of an inappropriate educational plan. Cash (1999) emphasised that strengths and weaknesses might often mask each other or might confuse uninformed peers and teachers. She warned that if talents are subordinated to limitations, the twice-exceptional learner might receive inappropriate intellectual opportunities, may suffer from low self-esteem, depression, and might have a weakened motivation to succeed. Huber (2007), who referred to Cash (1999) and Neihart (2000), argued that this camouflage might be attributed to the fact that professionals typically have training in one area (i.e. gifted education or autism) but not in both. In her review, Kuss (2007) mentioned Weinfeld's opinion, that general screening for giftedness will miss many gifted students with learning disabilities, including ASD, because the disability and giftedness will mask each other.

Furthermore, the camouflaging effect could implicitly be derived from the following data: Based on five highly verbally intelligent boys, Nass and Gutman (1997) proposed that the diagnosis of Asperger's disorder should be considered and the appropriate evaluation undertaken when a verbal child fared poorly in school. In Ward's autobiographic case report, Ward and Alar (2000) mentioned that he did communicate with other people, though it was about mathematics. Rapin (2002) emphasised the very broad range of severity of the autistic spectrum and argued that many people did not know that being gifted did not preclude a diagnosis of an ASD. Grandin (2004) remarked that she told one mother that, before Asperger's syndrome became widely accepted, her child would have received a label of 'intellectually gifted'.

Contrary to what might be expected if a camouflaging effect were to exist, the findings in Tables 3 and 4 indicate that characteristics in the cluster 'compensation through reasoning' were not often mentioned.

3.3.4. Differential possibilities

Table 3 revealed that 16 characteristics are marked with D at least once. These are distributed in the clusters 'uneven development', 'verbal/language issues', 'memory issues', 'EF-issues', 'social issues' and 'behaviour/rigidity'. Hence, we elaborated on the two most remarkable characteristics with differential potentiality, Social issues and VIQ–PIQ discrepancies, subsequently followed by the remaining D's.

Social issues. As a by-product of their validation study of an AS-instrument, Boggs et al. (2006) found that IG-children scored significantly lower than AS-children on AS-symptomathology and higher on social skills. These authors repeatedly emphasised that this was contrary to anecdotal observations of similarities between IG-children and AS-children. Although this result is interesting, it is questionable, because of the small research groups. Moreover, the AS group was not IQ-matched with the IG-group and the IG-sample was not taken from the total IG-population, but composed of IG-children with a gifted educational eligibility ruling. This raises questions such as whether or not IG-children who do not stand out as such, for instance because of underachievement or social non-conformism, might not be included. Nevertheless, this is an interesting issue, also mentioned by Rapin (2002), whose clinical opinion was that IG-children without ASD generally had no deficits in social skills or behavioural inflexibilities.

Goldstein et al. (2008), who used larger HFA samples, found a Social Context factor, consisting of Picture arrangement and Picture completion, that scored the lowest in the highest IQ groups (120+) of their subjects with autism. These findings were restricted, however, to the three Wechsler scales WISC-R, WISC-III and WAIS-III, and to individuals with the diagnosis autism that displayed developmental problems before the age of three. Despite these restrictions, the finding of Goldstein et al. (2008) in combination with the aforementioned finding of Boggs et al. (2006) and the clinical experiences of Rapin (2002), might generate the hypothesis that IG-individuals with significant discrepancies between aspects of cognitive and social information processing, should be considered suspicious of IG + ASD and urges for further assessment and diagnosis. Cash (1999) and Donnelly and Altman (1994) considered 'deficits in social adjustment . . .' as a similar and at the same time a differential trait of ASD and IG. They argued that the social skill deficits and problems in establishing friendships in gifted

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autistic children were neurologically caused, whereas among typically gifted students these were assumed to result from other factors.

VIQ–PIQ discrepancies. Baron-Cohen et al. (1999) found significant VIQ–PIQ discrepancies (PIQ > VIQ). This is the only D of which the differential possibility was empirically found in comparison with an IQ-matched control group. Goldstein et al. (2008) found no VIQ–PIQ discrepancies in comparison with AU-matched controls. Nass and Gutman (1997) found significant VIQ–PIQ discrepancies, VIQ > PIQ, but did not match this with any controls. Huber (2007) also found significant VIQ–PIQ discrepancies, VIQ > PIQ as well as PIQ > VIQ, without comparison to controls. VIQ–PIQ discrepancies were not mentioned in the non-SIM publications. Recapitulating, one could speculate that VIQ–PIQ discrepancies did exist among selected groups of IG + ASD individuals, but did not seem to be a common characteristic.

Remaining Ds. The characteristics 'intense focus . . .' and 'excellent rote memory . . .' are marked double with S and D in Table 3. Cash (1999) argued that individuals with autism are often preoccupied and appeared compelled to focus intensely on activities, behaviours and objects, while non-autistic learners might be focused but they also more selectively filter out information. Concerning 'excellent (rote) memory. . . .', Huber (2007) suggested that in some cases advanced rote skills of individuals with ASD might be mistaken for the advanced comprehension displayed by typically gifted children.

Huber (2007) found 'significant reasoning-motor discrepancies' in her IG + ASD group that were not, however, compared to an IQ-matched or ASD-matched control group. Neihart (2000) proposed that motor clumsiness be used to differentiate between IG and ASD because it is characteristic of ASD and not characteristic of most gifted children.

Huber (2007) and Neihart (2000) argued that 'formal, pedantic, monotonous speech . . .' of the ASD-group was different from the precocious language of typically-gifted children, who might have the language of an older child. These two authors mentioned that children with ASD had poor 'awareness of social rules and (their own) interactions', which differentiated them from typically-gifted children. Huber (2007) mentioned that individuals with ASD lacked awareness regarding their eccentricity, and Neihart (2000) emphasised their poor awareness of how others saw them.

3.3.5. Diagnostic suggestions

Some authors proposed ways to diagnose the co-occurrence of IG + ASD. Huber (2007) suggested that the diagnostic procedure used in her case study provided a means of assessing ASD-symptoms that made misattribution of gifted characteristics highly unlikely. Her test battery included a combination of ASD-instruments, an adaptation checklist, a behavioural checklist, individual intelligence tests, tests of visual-motor integration, plus some academic achievement scales. Since Huber (2007) only included already-diagnosed children, and started to analyze test data afterwards without comparison to any control group, her suggestion was based on a circular argument. Huber's (2007) publication was the only one in which a diagnostic procedure was described quite explicitly, and might be useful from an explorative point of view. Some other authors also gave diagnostic suggestions. Nass and Gutman (1997) suggested that the diagnosis of Asperger's disorder should be considered and the appropriate evaluation undertaken when a verbal child fared poorly in school. Rapin (2002) emphasised that (early) diagnosis of gifted children with ASD should be done by a combination of parental reports, tests, checklists, and direct observation in everyday life. Neihart (2000) stressed that assessment should be performed in an interdisciplinary team, and that parents should be actively involved. Moreover, she presented a table with characteristics that had at the same time both similar and differential potentiality. She emphasised also that one should look for the motivation behind certain forms of behaviour in order to differentiate between the superficial similarities of giftedness and ASD. Cash (1999) suggested that perhaps the discussion concerning discreet classification should be pursued with an analysis of the effects of being dual-labelled as both autistic and gifted. One should, for example, examine how these students manage their environment and what barriers impact on their adjustments. Chiang and Lin (2007), and to some extent Kuss (2007), mentioned that in individual assessment, information should be collected on personal relative strengths and weaknesses.

4. Conclusion and discussion

To summarise the results of this study, the next sections focus upon definitions and identification (Section 4.1), on characteristics (Section 4.2) and on diagnostic and assessment issues (Section 4.3) of IG + ASD. Furthermore, the methodological limitations of this study (Section 4.4), the differences between classification-based versus needs-based procedures (Section 4.5) as well as the controversial issues of 'VIQ–PIQ discrepancies' (Section 4.6) and 'superior non-verbal abilities' (Section 4.7) are highlighted. Finally, some implications for future research are discussed (Section 4.8).

4.1. Definitions and identification

Most of the non-SIM publications lacked a well-defined description of IG + ASD because definitions were restricted to names or the conceptualisation was inconsistent. The definitions of the core concepts IG and ASD were rather specific in six SIM publications and two non-SIM publications. Of these eight publications, the six SIM publications provided general intelligence(-scores) and were the only ones where the identification levels were clearly a combination of norm-referenced and criterion-referenced data. An exception is the publication of Nass and Gutman (1997), who gave no identification criteria of AD. All other reviewed publications lacked (full) information on this issue, which makes it impossible to compare

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definitions. Regardless of the way IG + ASD was defined, Tables 1 and 2 show that in about half of the 25 publications the described cases showed giftedness in the non-verbal realm. Except for Huber (2007), and Nass and Gutman (1997), no authors specifically mentioned verbal giftedness.

In general, it is concluded that, if present at all, study aims, age of target group, definitions and identification data were very diverse, and often provided in an inconsistent or only implicit way. Moreover, in SIM as well as non-SIM publications, conceptualisation of IG + ASD, if present, was restricted to a mere summary of behavioural descriptions and identification criteria of IG next to those of ASD, which were not interwoven into a unique synthesised IG + ASD entity.

4.2. Characteristics of IG + ASD

Across SIM as well as non-SIM publications, we found manifold distribution-profiles of IG + ASD-characteristics between and within clusters (Table 3). Moreover, many characteristics were qualified variously among publications, namely as a general trait or as an individual case feature of IG + ASD, and/or as a similar and/or differential trait of ASD and IG. This means that this literature review does not provide a clear-cut pattern of general characteristics concerning IG + ASD. The data in Tables 3 and 4 reveal, however, some slight tendencies towards some clusters and characteristics, which stand out in SIM publications as well as non-SIM publications. The characteristic 'significant VIQ–PIQ discrepancies' stands out qualitatively, being the only significant one found in comparison with an IQ-matched control group (Baron-Cohen et al., 1999). The characteristics that stand out quantitatively are those that show up repeatedly in the various analyses of Tables 3 and 4, and that are at the same time mentioned in at least 4 of the included publications. These are: Uneven development ('social versus cognitive capacities', 'significant reasoning-motor discrepancies'), superior non-verbal capacities ('mathematics, physics computer', 'creative/divergent thinking'), verbal/language issues ('formal/pedantic speech with nearly absent prosody'), memory issues ('excellent rote/factual memory'), EF-issues ('fascination, preoccupied absorbing (restricted) special interests', 'intense focus/obsession to detail'), social issues ('deficits in social adjustment, isolation', 'limitless talk about own interests, lack of reciprocal communication', 'unawareness of social rules and (one's own) interactions'), hypersensitivity ('general hypersensitivity').

Of the relatively few characteristics that are marked as a similar trait of IG and ASD, 'creative/divergent thinking' and 'intense focus/obsession to detail' are the most remarkable, because they stand out quantitatively. These might hypothetically be linked to a possible neurobiologically based overlap between IG and ASD (Casanova et al., 2007). The most outstanding clusters are those that quantitatively stand out in Table 4 and at the same time possess more than one remarkable characteristic. These are 'uneven development', 'superior non-verbal capacities', 'EF issues', and 'social issues'.

4.3. Diagnosis and assessment issues

Across some SIM as well as some non-SIM publications, the age of initial concern and diagnosis varies from (early) childhood and puberty to adulthood. Adolescence, however, was not mentioned.

Misdiagnoses were mentioned in non-SIM publications, especially the selective literature reviews in which gifted-literature was compared to ASD-literature, interweaved with clinical opinions and illustrated with case reports. The camouflaging effect was mentioned in non-SIM publications. This might partly be because in all SIM publications the IG + ASD groups or individual cases were already diagnosed as such. Therefore, at least at the time of the case description, symptoms were not camouflaged by definition. Diagnostic and assessment suggestions were discussed rather briefly.

Most of the differential possibilities in the non-SIM publications were not derived from empirically-controlled studies but stem from IG and ASD literature, interweaved with clinical opinions and case descriptions. These findings therefore remain hypothetical.

4.4. Methodological limitations

The variety of empirical and theoretical research methods from different disciplines, education, (neuro)psychology and neurobiology, brings about a large variation of definitions and characteristics of IG + ASD. This made comparison of data laborious and somewhat troublesome. It was sometimes not obvious, for instance, whether a particular characteristic belonged to the IG + ASD case(s) or merely was mentioned to illustrate ASD in general. This indicated that some marks might be improperly included or excluded in Table 3. Moreover, the clusters in Table 3 are not mutually exclusive. For example, 'precocity of higher cognitive functions', grouped in the cluster 'uneven development', implies a possible precocity of memory, which should also be grouped in the cluster 'memory issues'. This also applies, for instance, to the characteristic 'significant VIQ-PIQ discrepancies', grouped in cluster 'uneven development', which overlaps the characteristics 'PIQ > VIQ' and 'VIP > PIQ', respectively grouped in 'superior non-verbal capacities' and 'verbal capacities/language'.

Many of the methodologies used in both SIM and non-SIM publications lack robustness because of the small number of cases, lack of control groups, biased circular arguments and inconsistently or vaguely defined core concepts. The lack of control groups in particular gives rise to scepticism concerning the uniqueness of the IG + ASD-characteristics, in relation to typical IG or typical ASD. On the other hand, the different perspectives resulting from various study approaches within and across SIM and non-SIM publications, appear to reveal two converging tendencies, which should not be ignored in the light of the explorative objective of this literature review. These are: (1) The clusters and characteristics that are frequently marked

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(see summary in Section 4.2); (2) Diagnostic and assessment suggestions, if present, include not only classification-based but also needs-based procedures, as we will explain in the next section.

4.5. Classification-based versus needs-based

The diagnostic and/or assessment suggestions, as shown in Section 3.3.5, can be divided into two categories: First, *Classification-based* suggestions, aimed at identification of IG + ASD. These were mentioned in a few SIM and non-SIM publications. In sum, authors proposed the use of a combination of parental reports, tests, checklists, and direct observation in everyday life, in a multidisciplinary team. The few empirically-controlled findings in this literature review suggest that it is obvious to use an appropriate IQ-test, like Wechsler scales, if there is any suspicion of IG + ASD, and to assess comprehensively after finding a rather large discrepancy between VIQ and PIQ and/or between the SC-factor score and other factor scores. Second, *needs-based* suggestions, in which the assessment process is not primarily aimed at classification, but at recommendations for educational or psychological interventions. A needs-based procedure targets relevant risks as well as protective factors, like weaknesses and strengths, concerning the individual students as well as the educational and home environments (Pameijer, 2006). Elements of needs-based suggestions were mentioned in non-SIM publications (Cash, 1999; Chiang & Lin, 2007; Kuss, 2007).

In either of these two assessment procedures, it might be useful to search for the motivation behind certain behaviours in order to differentiate (superficial) similarities between IG and ASD (Neihart, 2000). This seems especially obvious in the case of the differential potentialities of the rather frequently marked characteristics 'deficits in social adjustment', 'intense focus', 'excellent (rote) memory', 'formal, pedantic speech' and 'awareness of social rules and interactions'.

4.6. VIQ–PIQ discrepancies

VIQ–PIQ discrepancies seemed to exist among selected groups of IG + ASD individuals, but did not seem to be a common characteristic. We found no evidence that it might differentiate between AU individuals with IQs > 120 and <120 (Goldstein et al., 2008). It might, however, differentiate between IG-individuals with and without an ASD (Baron-Cohen et al., 1999). As such, these speculations might be interesting in the context of individual assessments and diagnoses of IG-students, because, from literature on giftedness, we already assume that IG-children have greater VIQ–PIQ discrepancies than average intellectual children (Sweetland, Reina, & Tatti, 2006; Wilkinson, 1993). Therefore, it seems necessary to use an appropriate IQ-test if there is any suspicion of IG + ASD, and to assess individual cases in a comprehensive way in case of a rather large VIQ–PIQ discrepancy.

These VIQ–PIQ discrepancies are also interesting in relation to the slight trend found by Huber (2007) that IG + ASD children with higher verbal IQs were older at the time of the diagnosis. In combination with the fact that only already-diagnosed individuals are mentioned in the 25 publications, this might partly explain why the cluster 'superior non-verbal abilities' stands out quite clearly above the rest. This group, with relatively fewer verbal abilities, might show up earlier and more clearly than the group of highly-verbal learners, who might fit more easily into the verbal/language demands of education. This speculation corresponds with the warning of Nass and Gutman (1997), based on their five cases with exceptional verbal intelligence, that the diagnosis of AD should be considered and the appropriate evaluation undertaken when a verbally high functioning child fares poorly in school.

4.7. Superior non-verbal abilities

Some of the findings concerning the outstanding cluster 'superior non-verbal abilities' generate a special point of discussion. Caron et al. (2006) used the name 'autistic giftedness', aiming at a savant ability (block design peak) with average IQ. Chiang and Lin (2007) suggested that some individuals with AS/HFA are mathematically gifted. Since they defined mathematical giftedness in an absolute way, meaning that maths scores are not related to overall intelligence scores, this suggestion is likely to devalue the meaning of giftedness. In other words, it includes the possibility of averagely intelligent individuals with a 'maths peak', and also general, intellectually-gifted individuals whose maths scores do not exceed the rest of their very high cognitive/academic scores. This last group would better be called 'generally gifted' than 'mathematically gifted'. It is concluded that studies like these might generate vagueness and contribute to a controversial image formation of the twice-exceptional phenomenon IG + ASD. On the other hand, these publications lend support to the idea that 'superior non-verbal capacities', which involve reasoning with symbols, figures and shapes, and which is characteristic to reasoning in engineering and physical science, might be a crucial link between IG and ASD. This is especially so because the current study revealed many characteristics of IG + ASD to be in this cluster. This sheds another light on the suggestion in giftedness-literature that visual-spatial ability might be an overlooked and unappreciated dimension of cognitive ability, which might go along with underachievement (Chan, 2008).

4.8. Implications

This review reveals the lack – until now – of a profoundly developed conceptualisation of IG + ASD, and its diagnostic and assessment issues. This is the more valid due to the very few number of dissertations and publications in peer-reviewed jour-

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nals, that directly or indirectly aim at the co-occurrence IG + ASD. Nonetheless, the results show some converging tendencies concerning characteristics and diagnostic issues. This justifies the need for further theory development and research.

In order to develop conceptualisation of IG + ASD an extensive cluster analysis is recommended, aiming at large groups of IG-children, including drop-outs and underachievers as well as successful students. This may or may-not generate subgroups with ASD-like profiles. Furthermore, the rather obvious personal characteristics, as summed up in Section 4.2, may serve as a starting point for future research of *classification-based* as well as *needs-based* assessment.

To decide whether these characteristics are unique to IG + ASD, studies on dual and differential *classification-based* diagnoses should include control groups such as typically developing IG-students and/or average intelligent ASD-students. Research should not only aim at already diagnosed individuals, but also try to focus systematically on students with missed or misdiagnoses. In other words, the camouflaging effect, which was mentioned in the selective literature reviews, but neither verified nor invalidated in any of the empirical studies, should be researched in the future. Creative study designs to detect such 'undercover' students are required. One could, for example, systematically study the motivation behind certain behavioural characteristics, in order to differentiate (superficial) similarities between IG and ASD, as supposed by Neihart (Huber, 2007; Neihart, 2000). Alternatively, one could concentrate on underachievers, such as underachieving visual-spatial gifted students, as mentioned in Section 4.6. It will be interesting and useful to study whether these students might be not just 'gifted' but also suffer from characteristics of an ASD. Moreover, the presumed neurobiological similarity between autistic and gifted brains (Casanova et al., 2007), which might hypothetically be linked to the similar characteristics 'creative thinking' and 'intense focus to detail', might generate interesting hypotheses regarding the conceptualisation of IG + ASD and the camouflaging effect.

Meanwhile, research should address the practical psychological-educational needs of individuals with (suspicion of) IG + ASD. To realise this, *needs-based* assessment procedures should be studied systematically. For example by constructing a theory based and intervention directed protocol, aimed at identifying profiles of strengths and weaknesses regarding the characteristics as summed up in Section 4.2. When such studies are performed through the methodology of educational design research (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006), they might run alongside, or even preceed, studies aimed at identification and conceptualisation of IG + ASD. That is because design research serves both theory formation as well as practical applications at the same time. This implies the development and systematic and continuous evaluation of theoretically based systems, to determine the effectiveness in educational practice (Van den Akker et al., 2006; Walker, 2006). Therefore, we do not agree with Ziegler and Ziegler (2009), who argued that it is impossible to develop effective programs for gifted students as long as their talents and gifts cannot reliably be identified.

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