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Relative weaknesses in visual-motor skills und visual-spatial perception as risk factors inhibiting the development of gifted children and adolescents: an analysis of AID 3 intelligence-test profiles for children with superior intelligence

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Abstract

In spite of highly gifted children's and adolescents' enormous cognitive potential, it is well-known that their schooling can fail. Concerning this matter, gifted underachievers – that means those who noticeably perform below their capabilities regarding school/academic achievements despite their evident high intellectual gift – are of high research interest. Hereof, so-called twice-exceptionals – students who are gifted and have a learning disability – appear as particular risk group as they often show relative weaknesses in lower order processing abilities apart from their high cognitive skills. In the present study, we aim to shed led light on these lower order processing abilities of highly gifted students without diagnosed learning disability. Therefore, we compare the intelligence profiles of the intelligence test AID 3 (*Adaptive Intelligence Diagnosticum 3rd Edition,* Kubinger & Holocher-Ertl, 2014) of 81 highly gifted children who presented at an University's psychological outpatient clinic during the past two years with a non-clinical, highly gifted sample of 42 children and a non-clinical, non-highly gifted sample of 389 children of the standardization sample of the intelligence test AID 3. Whereas in the non-clinical, non-gifted sample no content-related differences between the particular sub-tests – and therefore the measured abilities – were identified, analyses by means of dependent ANOVA reveal systematically occurring, comparably low values in those sub-tests that examined the children's visual-motor processing speed, visual-spatial perception and social abilities in the sample of the clinical, highly gifted children. Interestingly, these abilities are also lowest developed in the non-clinic, highly gifted sample, whereas the abilities' distribution is distinctly more homogeneous. Thus, the results suggest that highly gifted children show individual weaknesses in very specific areas that can become development-inhibiting within the framework of the school. Why these weaknesses find expression in the mentioned range of

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abilities and how this correlates with high cognitive abilities is discussed by applying empirical findings as well as our observations from clinical practice. This discussion appears to be crucial in view of developing further future research projects.

Keywords: gifted children, fine motor skills, twice-exceptionals, AID 3

Introduction

A substantial body of research recently focusses on school encouragement and assistance of highly gifted students/pupils with the aim of further developing the potential of highly gifted children and youth in the context of education, and of preventing boredom and the resulting loss of motivation by appropriately stimulating encouragement. Particularly in view of highly gifted underachievers, it becomes obvious that the school careers of highly gifted children and youth are often marked by great difficulties despite their high resources. Their school paths are often characterized by problems in adjusting successfully to educational demands and the general school set-up. Therefore, underachievement is the most common presenting issue at university-based clinics geared to gifted youth and their families (Colangelo, 2003). In addition, the extensive review of the literature conducted by Robinson et al. (2002) suggested that not only underachievement but even most of the social and emotional concerns of gifted children and adolescents have their roots in school environments that are not adapted to their unique learning needs. Gifted students may have various personality characteristics, such as perfectionism, excitability, sensitivity, questioning of rules or authority, a strong sense of justice, and idealism (Lovecky, 1993; Sowa, McIntire, May, & Bland, 1994; VanTassel-Baska, 1998) that may create behavioral problems in traditional school settings. Accordingly, they benefit from differentiated counselling that addresses their social and emotional needs and helps them cope with the stress created by being different (Peterson, 2006; Yoo & Moon, 2006).

In one of the Sigmund Freud University's psychological outpatient departments, we have a centre for the diagnosis of high giftedness which offers consultation. There, it is often necessary to stimulate educational incentive measures in addition to identifying cognitive giftedness. However, it is also noticeable that many highly gifted children do not suffer from the lack of educational support and resulting boredom, but also from that they cannot cope with the demands of school because of relative weaknesses in some very basal abilities in the range of visual-motor skills and tactile-kinaesthetic perception. Despite the very high cognitive giftedness, systematically occurring weaknesses therefore stand in the way of a successful educational development.

Scientific evidence for this is found in a body of research on twice-exceptionals. It concerns those pupils who are identified as gifted/talented in one or more areas while also possessing a learning, emotional, physical, sensory and/or developmental disability (Yewchuk & Lupar, 1988). Studies show that particularly in this group of highly gifted students, relative deficits in processing speed, short-term memory, working memory, or other basic psychological processes (Hale et al., 2010; Schiff, Kaufman, & Kaufman, 1981; Silverman, 1989; Waldron & Saphire, 1990) depress overall cognitive performance (Assouline, Foley Nicpon & Whiteman, 2010; Foley Nicpon, Assouline & Colangelo, 2013). But not only twice-exceptionals seemed to show such basal cognitive, relative weaknesses in their achievement profile. In several publications, which are devoted strictly speaking to the question of which intelligence test scores in general are suitable for identifying highly gifted students, it is pointed out that because of relative weaknesses in processing speed and working memory, measures should be used that are less influenced by these abilities. For example, Watkins et al. (2002) applied a factor analysis of the WISC-III to evaluate the construct validity in the population of gifted students. Results showed a negative loading of the Coding subtest and the four verbal subtests. Consequently, researchers recommend that Coding Subtest scores should not be used to determine eligibility for gifted programming. This outcome is similar to the results reported by Macmann et al. (1991) regarding the factor analysis of the WISC-R, and Rowe et al. (2014) regarding the WISC-IV. In fact, the General Ability Index, a measure that minimizes the impact of working memory and processing speed, is frequently referenced as the most appropriate composite for the use of gifted students (NACS, 2010; Rimm et al., 2008).

With the research subject matter in mind, the results of a study by Doobay et al. (2014) that examined the cognitive, adaptive and psychosocial differences between high ability youth with and without autism spectrum disorder (ASD) are also of interest. Analyses showed a statistically significant difference between the ASD group and the Non-ASD group on the Processing Speed Index. Students with ASD scored significantly lower on the Processing Speed Index than the control group. Observing the results more closely, large differences (more than one standard deviation) between the mean scores of Processing Speed Index and Working Memory Index and the General Ability Index were observed in the ASD group as well as in the group of gifted students without ASD. These great intra-individual differences are not interpreted in the publication, but they do in fact show that there are systematic, relative weaknesses in the group of the highly gifted. Extreme discrepancies in abilities are more common among the most able students than among average ability children. This is also stated by Lohmann et al. (2008) and they introduce a method for categorizing score profiles for identifying gifted children instead of an IQ cut-off score.

Contribution of the present study

Against this backdrop, we conducted a comprehensive study to compare and contrast intelligence profiles of the intelligence test AID 3 of a group of highly gifted children who presented at Sigmund Freud University's psychological outpatient clinic during the past two years with a non-clinical, highly gifted group and a non-clinical, non-highly gifted control group. We hypothesized that highly gifted children would demonstrate systematic, relative weaknesses in visual-motoric processing speed and working memory. Thus, the relative weaknesses would be greater in the clinical highly gifted group. Taking into consideration empirical findings as well as our experiences with highly gifted children, possible mechanisms will be presented for discussion.

Methods

Participants

Three groups of children participated in this study: 81 highly gifted children who presented at Sigmund Freud University´s psychological outpatient clinic for assessment and psychological consultation and do not meet criteria for any psychological disorder; 42 highly gifted children and 389 non-highly gifted children of the standardization sample of the intelligence test AID 3. Sample sizes differ as in the standardization sample of the AID 3 only 431 students were presented all 12 mandatory subtests. Out of these 431 students, 42 fit an IQ > 123, they were assigned to the non-clinical, highly gifted sample. The 431 students is a quota sample, within which region, age, sex and kind of school were considered (Kubinger & Holocher-Ertl, 2014). Due to its representativity, in the present study, we didn´t minimize this non-clinical sample, even though sample sizes differ as consequence.

Regarding the "highly gifted" classification in our sample, the cut-off score was an IQ > 123, considering the standard error of the IQ-measurement (if a child has an IQ score of 130, the "true score" should fall between 123.4 and 136.6 points at a 95% confidence interval). On the one hand, this procedure makes it possible to rule out the possibility that children and adolescents are classified as not-highly gifted only because of the standard error common in intelligence tests. On the other hand, a reduction of the cut-off value is of particular importance to the content of the present study: if children actually show the assumed weaknesses in lower order processing abilities as mentioned above, the global IQ score will be lower. As a result, with a cut-off value of 130, exactly those cases that are actually the subject of interest are excluded from the investigation.

Giftedness in our sample is defined as high general intelligence. In our outpatient clinic, multidimensional measures are applied for psychological assessment and consultation as well as placement decisions. However, the standardization sample was anonymous and there was no demographic data for this sample, as well as no additional multidimensional measurements. As a consequence, we reduced high giftedness in the present study to a high score on an IQ test. Students of the clinical gifted sample were not identified as gifted beforehand. For the highly gifted sample of the standardization sample, this information is not available. The children ranged in age between 6 to 15 years with a mean age of 9.75 (SD = 2.51) years and showed a nearly balanced gender ratio with 271 male (52.9 %) and 241 female (47.1 %) children.

Instruments

The *Adaptive Intelligence Diagnosticum - AID 3* (Kubinger & Holocher-Ertl, 2014) is an individually administered test of intellectual ability for children aged 6 to 15 years. It contains 12 mandatory subtests that contribute to one global IQ-score.

Concerning the contents, the intelligence test-battery AID partly follows David Wechsler's world-wide known test concepts, dating back to the year 1939. However, even content similar subtests clearly bear conceptual modifications (Kubinger, 2017). As the AID aims to measure wide-spread basal and complex abilities that are assumed to be responsible for intellectual behavior, a screening for special developmental disorders or learning disabilities is offered since the second edition AID 2 (Kubinger, 2009). In this respect, the AID 3 distinguishes between the basal cognitive operations perception, memory and reasoning. All three apply to several modalities, e.g. visual, auditory, and tactile-kinaesthetic, and affect complex cognitive abilities. Systematic, intra-individual low scores in particular subtests can therefore be interpreted as an indication of basal deficits. As a consequence, the AID 3 provides the opportunity to assess a child as having a high cognitive potential although simultaneously suffering from a specific core deficit. This model is consistent with findings from research informed by the well-validated Cattell-Horn-Carroll (CHC) theory of intelligence (Schneider & McGrew, 2012). CHC theory postulates a higher order model of intelligence with a first-order general intelligence factor (g) and second-order broad ability factors that represent more specific areas of cognitive ability such as fluid reasoning, crystallized knowledge, processing speed, and others. A large body of CHC-informed research has illustrated that broad cognitive abilities (e.g., auditory and sensory processing) affect school performance (see e.g. Flanagan, Ortiz, & Alfonso, 2013).

The AID 3 offers 14 test characters for twelve subtests in T-scores. Subtest *1 Everyday Knowledge* measures crystallized intelligence; questions about biological, historical and geographical contents are to be answered. By subtest *2 Competence in Realism,* missing parts of objects are to be detected; it shows how children comprehend their everyday life. Subtest *3 Applied Computation* offers textual numeric problems and measures quantitative knowledge. Subtest *4 Social and Material Sequencing* is a measure of social comprehension; testees should arrange picture cards. Subtests *5 Immediately Reproducing-numerical* offers two test characters; sequences of digits should be repeated forward (measurement of auditory short-term memory) and backward (measurement of auditory working memory). Subtests *6 Producing Synonyms* and *9 Verbal Abstraction* cover facets of verbal intelligence, the former verbal fluency and the latter verbal reasoning. Subtest *7 Coding and Associating* consists of two tasks and test characters: *Coding* is a measurement of visual-motor processing speed; the individual is presented with a key in which figures (f.e. apple, umbrella, pear) are each paired with a different symbol; his/her task is then to use this key to put in the appropriate symbols for a list of figures pressed for time. Afterwards he/she should reproduce those symbols he/she could remember (*Associating*: measurement of visual working memory). By subtest *8 Anticipating and Combining-figural,* pieces of objects should be combined; besides fine motor skills, visual-spatial perception is needed to solve this task. Subtest *10 Analysing and Synthesising-abstract* is a measurement of the intelligence factor visual processing; children have to detect and form patterns. The subtest´s *12 Formal Sequencing* task accomplishment requires fluid reasoning. Subtest *11 Social Understanding and Material Reflection* is a measure of crystallized, social knowledge.

A detailed profile interpretation of these 14 test characters is only possible because the AID 3 offers comparably high measurement accuracy as a result of its Rasch model-based adaptive testing. The range of reliabilities for the subtests varies from .70 for subtest *2 Competence in Realism* to .95 for subtest *1 Everyday Knowledge*, subtest *3 Applied Computation* and subtest *10 Analysing and Synthesising-abstract.* Low or medium measurement accuracy entails large confidence intervals for the scores, and therefore hardly justifies the interpretation of most score differences. Adaptive testing offers many more items for every subtest at any ability level, so that there are enough items to differentiate between gifted children with high levels of cognitive ability; the advantage of adaptive testing with respect to high ability assessment has recently been emphasized by Kubinger and Holocher-Ertl (2010).

Procedure

81 participants in this study presented at Sigmund Freud University´s psychological outpatient clinic for assessment and psychological consultation in the years 2017-2018. They were tested individually during the course of one or two visits using standardized procedures. 431 students participated in the standardization sample of the intelligence test AID 3 that was carried out in the years 2011-2012 in Austria and Germany. They were also tested individually, albeit all subtests were administered during one appointment.

Statistical analysis

As a first step, we used a multivariate analysis of variance (MANOVA) followed by post-hoc univariate variance analyses, to compare the AID 3 intelligence profiles between highly gifted clinical children, highly gifted non-clinical children and non-highly gifted, non-clinical children.

Subsequently, in order to discover possible weaknesses regarding certain intellectual abilities, we examined the AID 3 intelligence profile regarding differences in mean values within the three samples using repeated measures analyses of variance (rANOVA). Statistical analyses were performed using IBM SPSS Version 24.

Results

Descriptive statistics for the three groups (clinical, highly gifted; non-clinical, highly gifted; non-clinical, non-highly gifted) are presented in Table 1. In terms of gender (chi^2 (df = 2, n = 512) = 19.03, p = .000) and age (F (2, 509) = 14.68, p = .000, η^2 = .05), statistically significant differences were found between the groups. Whereas the non-clinical, non-highly gifted control group showed a nearly balanced gender ratio, boys are clearly overrepresented in the highly gifted samples. The clinical, highly gifted sample also consisted of younger children in comparison to the non-highly gifted control group. As highly gifted children often experience problems when entering school, this representation is not surprising. Because of these difficulties, children at the age of six to seven

Table 1:
Means and Standard Deviations for the demographic variables and the IQ

Variable	NHG		HG		CHG				
	M	SD	*M*	SD	*M*	SD	*F* (2, 509)	*P*	Eta-squared
Age	10.07	2.42	9.19	2.38	8.52	2.58	14.68	.000	.05
IQ	101.35	12.88	129.18	4.75	133.79	7.67	326.01	.000	.56

Note. NHG (185 males, 204 females) non-clinical, non-highly gifted control group; HG (28 males, 14 females) non-clinical, highly gifted children; CHG (58 males, 23 females) clinical, highly gifted children

years are usually attending our outpatient clinic. As a consequence, the clinical sample contains comparatively many young children. Univariate ANOVA demonstrated that there was a significant difference in IQ between the three groups (F (2, 509) = 326.01, p = .000, η^2 = .56). Mean IQ and subtests scores for the gifted samples were considerably above the normative mean as well as above the scores of the non-gifted sample. There were no significant differences in the mean IQ between the clinical and non-clinical highly gifted samples.

Overall and considering the 14 AID 3 test characters, statistically significant differences can be observed between the three groups (Λ = .38, F (28, 992) = 21.94, p = .000). Subsequent univariate variance analyses revealed significant differences in all AID 3 subtests. As shown in Table 2, non-highly gifted, non-clinical children displayed significantly lower AID 3 subtest values compared to clinical, highly gifted children as well as non-clinical, highly gifted children. A smaller number of significant differences were found between the two highly gifted samples. The largest discrepancy was found in AID 3 subtest *6 Producing Synonyms* (Verbal Fluency) (p = .000, d = 1.04), in which the clinical, highly gifted children (M = 66.33 (SD = 7.43)) showed significantly higher values than the non-clinical, highly gifted children (M = 59.43 (SD = 5.15)). Furthermore, significant differences were found in subtest *11 Social Understanding and Material Reflection* (Social Knowledge) (p = .008, d = .73) and subtest *1 Everyday Knowledge* (Crystallized Knowledge) (p = .003, d = .65), in which the clinical, highly gifted group also showed higher values. In regard to the other subtests, no significant differences were found.

With the research subject matter in mind, analyses of the intelligence profiles were of peculiar interest: repeated measures variance analyses revealed overall significant differences between the 14 AID 3 subtests within all groups. The largest discrepancy was found within the clinical, highly gifted group of children (F (9.14, 730.78) = 19.21, p = .000, η^2 = .19), followed by non-clinical, highly gifted (F (8.23, 337.24) = 2.94, p = .003, η^2 = .07) and non-clinical, non-highly gifted children (F (10.66, 4137.72) = 7.30, p = .000, η^2 = .02). The mean profiles of each group are shown in Figure 1, where it becomes evident that the highly gifted samples showed more heterogeneous intelligence

Table 2:
Descriptive Statistics and Univariate ANOVA results for the AID 3 Subtests

Subtests		NHG (n = 389)	HG (n = 42)	CHG (n = 81)	*F*	*df1*	*df2*	*p*	η^2
1 Everyday Knowledge	*M*	49.54	63.62	69.84	159.58	2	509	.000	.39
	SD	10.14	8.52	10.03					
2 Competence in Realism	*M*	52.06	62.79	66.17	86.22	2	509	.000	.25
	SD	9.39	9.99	10.55					
3 Applied Computation	*M*	50.15	64.00	65.18	122.75	2	509	.000	.33
	SD	9.34	8.53	7.65					
4 Social and Material Sequencing	*M*	50.46	60.00	55.19	19.70	2	509	.000	.07
	SD	10.77	10.02	10.16					
5 Immediately Reproducing-numerical forward	*M*	51.96	63.50	61.67	69.05	2	509	.000	.21
	SD	7.83	11.47	9.97					
5 Immediately Reproducing-numerical backward	*M*	53.02	60.67	60.22	32.29	2	509	.000	.11
	SD	8.51	10.12	9.75					
6 Producing Synonyms	*M*	50.45	59.43	66.33	132.33	2	509	.000	.34
	SD	8.78	5.15	7.43					
7 Coding	*M*	48.87	59.29	60.09	47.24	2	509	.000	.16
	SD	11.28	8.31	10.14					
7 Associating	*M*	50.05	56.67	57.39	30.93	2	509	.000	.11
	SD	9.00	5.91	8.68					
8 Anticipating and Combining-figural	*M*	49.48	57.60	58.27	41.43	2	509	.000	.14
	SD	9.48	8.02	7.66					
9 Verbal Abstraction	*M*	50.83	64.12	65.60	116.10	2	509	.000	.31
	SD	9.55	8.83	6.32					
10 Analysing and Synthesising-abstract	*M*	49.16	60.45	63.01	75.01	2	509	.000	.23
	SD	10.48	9.16	9.95					
11 Social Understanding and Material Reflection	*M*	50.90	62.36	67.83	122.16	2	509	.000	.32
	SD	10.04	7.33	7.55					
12 Formal Sequencing	*M*	50.23	60.74	62.93	78.19	2	509	.000	.24
	SD	9.46	10.67	7.50					

Note. NHG = non-clinical, non-highly gifted control group; HG = non-clinical, highly gifted children; CHG = clinical, highly gifted children.

Table 3:
Bonferroni post-hoc tests with effect sizes

AID 3 subtests	group	group	*p*	*d*
1 Everyday Knowledge (Crystallized Knowledge)	NHG	HG	.000	-1.41
	NHG	CHG	.000	-2.01
	HG	CHG	.003	.65
2 Competence in Realism (Everyday Comprehension)	NHG	HG	.000	-1.13
	NHG	CHG	.000	-1.47
	HG	CHG	.195	.33
3 Applied Computation (Quantitative Knowledge)	NHG	HG	.000	-1.50
	NHG	CHG	.000	-1.66
	HG	CHG	1.000	.15
4 Social and Material Sequencing (Social Comprehension)	NHG	HG	.000	-.89
	NHG	CHG	.001	-.44
	HG	CHG	.053	-.48
5 Immediately Reproducing-numerical forward (Auditory Short-Term Memory)	NHG	HG	.000	-1.41
	NHG	CHG	.000	-1.18
	HG	CHG	.780	-.17
5 Immediately Reproducing-numerical backward (Auditory Working Memory)	NHG	HG	.000	-.88
	NHG	CHG	.000	-.83
	HG	CHG	1.000	-.05
6 Producing Synonyms (Verbal Fluency)	NHG	HG	.000	-1.07
	NHG	CHG	.000	-1.86
	HG	CHG	.000	1.04
7 Coding (Visual-motor Processing Speed)	NHG	HG	.000	-.95
	NHG	CHG	.000	-1.01
	HG	CHG	1.000	.08
7 Associating (Visual Working Memory)	NHG	HG	.000	-.76
	NHG	CHG	.000	-.82
	HG	CHG	1.000	.09
8 Anticipating and Combining-figural (Spatial-visual Perception)	NHG	HG	.000	-.87
	NHG	CHG	.000	-.96
	HG	CHG	1.000	.09
9 Verbal Abstraction (Verbal Reasoning)	NHG	HG	.000	-1.40
	NHG	CHG	.000	-1.64
	HG	CHG	1.000	.21
10 Analysing and Synthesising-abstract (Visual Processing)	NHG	HG	.000	-1.09
	NHG	CHG	.000	-1.33
	HG	CHG	.576	.26
11 Social Understanding and Material Reflection (Social Knowledge)	NHG	HG	.000	-1.17
	NHG	CHG	.000	-1.76
	HG	CHG	.008	.73
12 Formal Sequencing (Fluid Reasoning)	NHG	HG	.000	-1.10
	NHG	CHG	.000	-1.39
	HG	CHG	.642	.26

Note. NHG = non-clinical, non-highly gifted control group; HG = non-clinical, highly gifted children; CHG = clinical, highly gifted children.

Table 4:
rANOVA post-hoc bonferroni test results (p values) for both highly gifted groups

Variables	group	Sub 1	Sub 2	Sub 3	Sub 4	Sub 5a	Sub 5b	Sub 6	Sub 7a	Sub 7b	Sub 8	Sub 9	Sub 10	Sub 11	Sub 12
Sub 4	CHG	**0.000**	**0.000**	**0.000**		**0.013**	0.181	**0.000**	0.181	1.000	1.000	**0.000**	**0.000**	**0.000**	**0.000**
	HG	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Sub 5a	CHG	**0.000**	0.720	1.000	**0.013**		1.000	0.109	1.000	0.645	1.000	0.368	1.000	**0.009**	1.000
	HG	1.000	1.000	1.000	1.000		1.000	1.000	1.000	0.163	0.704	1.000	1.000	1.000	1.000
Sub 5b	CHG	**0.000**	**0.033**	**0.048**	0.181	1.000		**0.009**	1.000	1.000	1.000	**0.008**	1.000	**0.000**	1.000
	HG	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Sub 7a	CHG	**0.000**	**0.035**	**0.035**	0.181	1.000	1.000	**0.002**		1.000	1.000	**0.009**	1.000	**0.000**	1.000
	HG	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000
Sub 7b	CHG	**0.000**	**0.000**	**0.000**	1.000	0.645	1.000	**0.000**	1.000		1.000	**0.000**	0.062	**0.000**	**0.001**
	HG	**0.006**	0.276	**0.006**	1.000	0.163	1.000	1.000	1.000		1.000	**0.002**	1.000	0.060	1.000
Sub 8	CHG	**0.000**	**0.000**	**0.000**	1.000	1.000	1.000	**0.000**	1.000	1.000		**0.000**	**0.011**	**0.000**	**0.010**
	HG	0.351	0.594	0.203	1.000	0.704	1.000	1.000	1.000	1.000		**0.044**	1.000	1.000	1.000

Note: Significant differences are printed in bold. HG = non-clinical, highly gifted children; CHG = clinical, highly gifted children. Sub 1 = 1 Everyday Knowledge; Sub 2 = Competence in Realism; Sub 3 = 3 Applied Computation; Sub 4 = 4 Social and Material Sequencing; Sub 5a = 5 Immediately Reproducing-numerical forward; Sub 5b = 5 Immediately Reproducing-numerical backward; Sub 6 = 6 Producing Synonyms; Sub 7a = 7 Coding; Sub 7b = 7 Associating; Sub 8 = 8 Anticipating and Combining-figural; Sub 9 = 9 Verbal Abstraction; Sub 10 = 10 Analysing and Synthesising-abstract; Sub 11 = 11 Social Understanding and Material Reflection; Sub 12 = 12 Formal Sequencing.

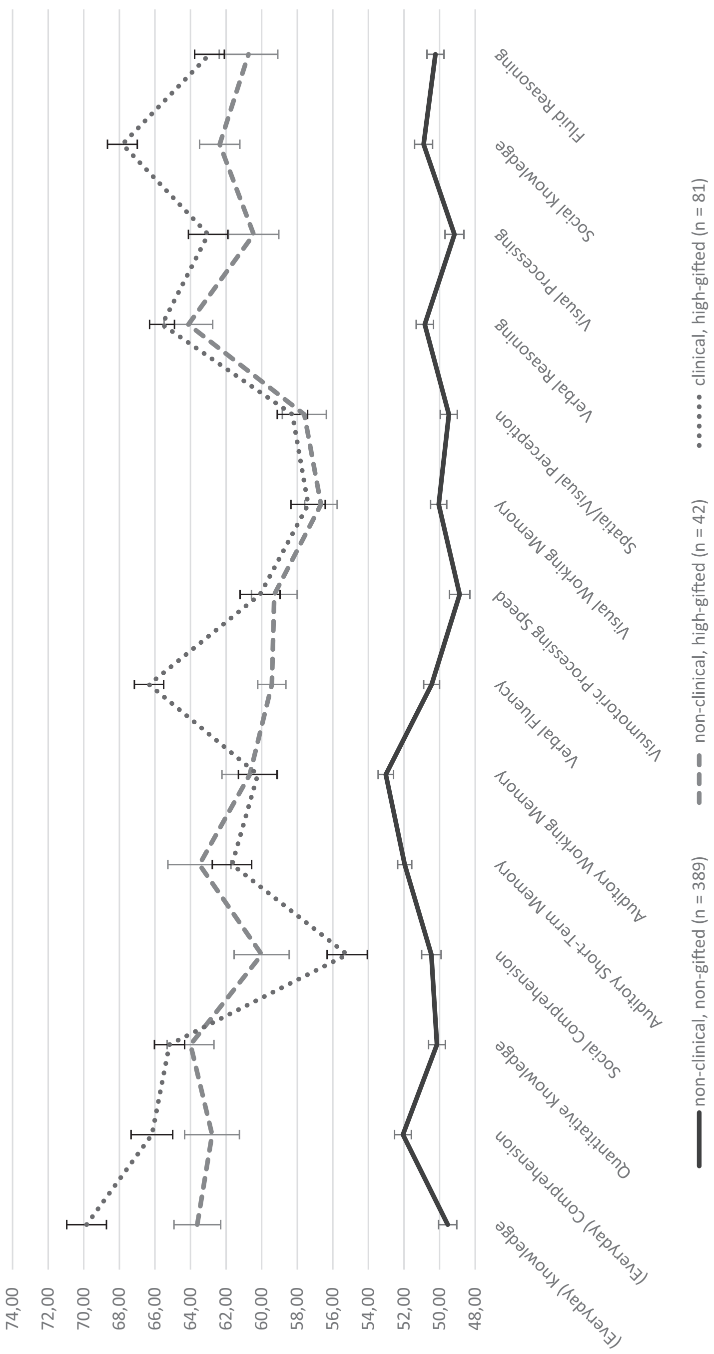

Figure 1:
AID 3 intelligence profiles (t mean values and error bars) for each group

profiles compared to the non-highly gifted control group. In the clinical, highly gifted sample the subtests *4 Social and Material Sequencing*, *5 Immediately Reproducing-numerical*, *7 Coding and Associating* and *8 Anticipating and Combining-figural* were comparatively low. Statistically significant discrepancies of the mean scores of those four subtests, compared to the mean scores of subtests that examine verbal intelligence, crystallized knowledge and logical reasoning were found in post-hoc tests (see Table 3). Descriptive statistics of the mean scores (see Table 2) in the non-clinical, highly gifted sample showed only two comparatively low measures. Those were subtests *7 Associating* and *8 Anticipating and Combining-figural*. Mean scores of these two subtests were 6-7 t-values lower than the mean scores of the verbal and knowledge subtests, even though post-hoc tests showed that these differences were not statistically significant. The significant differences in the non-clinical, non-highly gifted sample were different than in the highly gifted samples. A significantly higher mean score in subtest *5 Immediately Reproducing – numerical* compared to almost all other subtest scores was found.

Discussion

The focus of this study rests on the hypothesis that gifted children have intra-individual weaknesses in some basic cognitive abilities that may become development-inhibiting within the framework of the school. Based on previous research, we hypothesized that gifted children show systematic, relative weaknesses in visual-motor processing speed and working memory. Therefore, we compared the intelligence profiles of highly gifted students who presented at an psychological outpatient clinic for assessment and psychological consultation with highly gifted and non-highly gifted children of the standardization sample of the intelligence test AID 3. We confirmed our hypothesis regarding the sample of highly gifted children who asked for psychological assessment and consultation. In this sample, in fact significantly clear differences between the various individual subtests of the intelligence test were revealed, and as we expected, the value test scores of those subtests that measure visual-motor processing speed and visual and auditory working memory were low in comparison. Additionally, two further subtests were significantly low: subtest *4 Social and Material Sequencing* and subtest *8 Anticipating and Combing-figural*. The former is a measure of social comprehension, the latter of fine motor skills and visual-spatial perception. In the non-clinical, highly gifted sample, the abilities' distribution was distinctly more homogeneous, the differences were therefore lower, and the measurements of social comprehension and auditory working memory were much more highly pronounced in comparison to the clinical sample. However, even this sample showed comparatively low abilities in visual working memory, fine motor skills and visual-spatial perception, although the deficits were not statistically significant. This non-clinical, highly gifted sample had a rather small sample size; thus, results are interpreted with caution in the following discussion. In the non-highly gifted control-sample these distinct intra-individual differences within the intelligence profile did not appear.

Comparing the two highly gifted samples, it becomes apparent that the intelligence profiles of those children who are highly gifted and in need of psychological assessment and consultation were more heterogeneous. Even if these children do not yet have any clinical disorder such as ADHD, dyslexia or dyscalculia, it may be concluded that the simultaneous presence of particularly high abilities and individual, basal deficits make psychological consultation necessary. If they are not identified and then supported in time, the intra-individual, relative weaknesses can contribute to underachievement or learning disorders in the further course, as shown by research on twice-exeptionals (Hale et al., 2010; Schiff, Kaufman, & Kaufman, 1981; Silverman, 1989; Waldron & Saphire, 1990). In our highly gifted samples, the deficits related to three basic cognitive abilities: visual-motoric (fine motor) skills, (visual) working memory, and visual-spatial perception.

Subtest *7 Coding* that turned out to be comparatively low in the clinical, highly gifted sample, measures visual-motoric processing speed. The processing speed is strongly influenced by the fine motor skills. *Subtest 8 Anticipating and Combining-figural* also requires fine motor skills to solve the tasks. In a number of publications Stoeger and Ziegler (Ziegler & Stoeger, 2010; Stoeger & Ziegler, 2013; Stoeger, Suggate, & Ziegler, 2013) already drew attention to the fact that deficits in fine motor skills may occur in highly gifted children and that these deficits contribute to underachievement in highly gifted children. Consequently, researchers strongly advise including the assessment of motor skills as an explanation of underachievement in the diagnostic process. Intelligence tests like WISC-IV or AID 3 contain subtests that require fine motor skills, deficits in these are then reflected in a low processing speed. It could be argued that these are only relative weaknesses – after all, the test scores in the corresponding subtest are usually still in the average range. However, it is known from self-concept research that (in addition to social and temporal comparisons) dimensional comparisons also play a central role in one's own (ability) self-concept (see e.g. Möller & Köller, 2001). In dimensional comparisons, two different dimensions of performance of a person are related to each other, whereby high performance in one dimension can contribute to a significant devaluation of performance in another dimension. This inevitably results in a negative self-concept in the worse domain and a positive self-concept in the better domain (Möller & Marsh, 2013). The highly gifted child has a very high aspiration level for assessing his or her own performance due to the outstanding talent in one domain, even average fine motor skills can then lead to a low ability self-concept in this area. Thus, the motivation to engage in fine motor activities is lost, and the persistence is low. In this context, it should also be noted that giftedness often goes hand in hand with a high degree of perfectionism (see e.g. Neihart, Reis, Robingson & Moon, 2001). Applying this perfectionism to „just" average fine motor skills can quickly contribute to frustration and corresponding demotivation. The fact that deficits in fine motor skills lead to a loss of motivation, low persistence and attention problems is also stated by Stoeger and Ziegler (2013). With reference to several other research papers (Christensen, 2004; Graham, 1990; Scardamalia et al., 1982), they argue that „Gifted children who demonstrate fine motor skills deficits must permanently switch their attention back and forth between their hand movements and the task they are working on. As a result, they lack the full attention that they need to resolve the task at. These shortfalls in attention are, in effect, induced by their deficits in fine motor skills." (Stoeger and Ziegler, 2013, p. 29). Only the automation of basic fine motor functions opens up capacity resources that can then be utilized for higher order cognitive activities. This is also impressively demonstrated in the present study: subtest *7 Coding* asks testees to code symbols on a speed condition. Afterwards – without having been instructed beforehand – they should reproduce those symbols they could remember. The resulting score in subtest *7 Association* is in a statistically significant low range in both highly gifted samples. As a result, we conclude that the highly gifted children devote their attention to basal visual-motor activity, so that the higher cognitive memory performance is impaired. It appears that not the visual working memory is per se deficient, but capacity resources are blocked because of the visual-motor task.

In both highly gifted samples, beside fine motor skills, visual-spatial perception proved to be comparatively low. We will now discuss this intra-individual weakness in the context of tactile-kinaesthetic perception und gross motor development. Gifted children often display sensitivities to their environment that vary from those of the general population (Roedell, 1984; Bachtold, 1980; Gere et al., 2009). Findings support the hypothesis that gifted children are more sensitive to their physical environment. Thus, minimal stimuli may generate non-traditional reactions or behaviors. The controlling and regulating of the sensory input and the sequencing of responses for all organs of the body take place in the central nervous system (Reeves, 2001). By processes of neural modulation, a normal internal balance and adaptive responses to stimuli are established. Thus, sensory modulation is the process of the brain´s self-regulation (Ayres, 1979). Children, who are hypersensitive to their world, show difficulties with sensory modulation and integration. Consequently, deficits in gross und fine motor skills can appear. Sensomotoric and gross motor activities in the first two years are, in turn, essential to the development and comprehension of visual-spatial relations and the experience of three-dimensionality. (Senso-)Motoric activities therefore have a significant impact on the development of visual-spatial perception (see e.g. Schenk-Danzinger, 1993; Fischer, 1995). Ayres (1979) concludes that difficulties with tactile-kinaesthetic, proprioceptive and/or vestibular sensory modulation and integration may thus not only cause atypical responses and behaviors but also deficits in visual/spatial perception. Therefore, we deduce that the intra-individual weakness in spatial-visual perception in the intelligence profiles could be an indicator of hypersensitivity and basal deficits of sensory modulation and integration.

In our clinical, but not in our non-clinical, highly gifted sample subtest 4, a measurement of social comprehension, proved to be comparatively low as well. Collectively, research findings have not concluded that highly gifted children face more social problems. However, characteristics associated with giftedness like sensitivity, intensity, as well as psychomotor, intellectual, sensual, emotional, and imaginational overexciteabilities are considered risk factors (Peterson, 2009; Grobman, 2006). Depending on the degree of characteristics associated with giftedness, it could be more or less difficult to anticipate social and emotional concerns. In addition, even Peterson (2009) points out that giftedness may also co-occur with one or more learning disabilities, contributing to frustration, behavior problems, and general discomfort in the classroom which in turn entails social and emotional difficulties. If intra-individual weaknesses in the AID 3 intelligence profiles indicate deficits in fine motor skills and psychomotor as well as sensual hypersensitivity, it becomes apparent that highly gifted children in our clinical sample have a high degree of risk factors that influence social and emotional development. Social integration in the group of less able and less intellectual interested peers may fail, with social and emotional discomfort increasing and social learning experience decreasing.

In the clinical, but not in our non-clinical, highly gifted sample subtest 5, a measurement of auditory working memory, additionally proved to be comparatively low. Similar results are discussed in literature about twice-exceptionals suffering from dyslexia. We identified this risk factor in our clinical-highly gifted sample, although dyslexia is (not yet) current.

From neuropsychological perspective, the co-occurrence of cognitive strength and weakness are explicable with the concept of atypical brain development (Kalbfleisch, 2004; Gilger & Hynd, 2008). Learning disabilities, motor deficits, inattention, and/or gifts are seen as "expressing symptoms of a diffusely atypical brain affecting multiple areas of behaviour simultaneously" (Gilger & Hynd, 2008, p. 218). By the concept of atypical brain development, a focus limited on a specific learning or behavior-related deficit while neglecting the entire profile of neurocognitive strengths and weaknesses can be avoided. Although we think that this neuropsychological concept could be a helpful approach to better understand and accommodate twice-exceptional children, we will finally discuss a few psychological factors that may influence the aetiology of the observed phenomenon.

An interest – an essential motivational basis for the development of new competences and skills – of highly gifted children often appears to be limited to individually very specific contents (Travers, 1978). It seems that the intense hunger for knowledge acquisition and stimulus gratification of highly gifted children represses the universal interest in many age-appropriate activities, like common fine and gross motor activities. Furthermore, our experiences with highly gifted children show that learning conditions for practicing fine and gross motor skills are often inappropriate for the cognitive and creative aspiration level as well as to the hypersensitivity of gifted children. Common activities and curricula in preschool, for example, very often appear to be inappropriate. Moreover, we could observe that parental attitudes and the learning environment at home are often limited to stimulating cognitive but not fine and gross motor development. The parent's main interest often appears to be as limited to cognitive contents as their children's.

Limitations and future research

We propose that our study provides a number of ideas upon which future research can be based. It is unclear if the current samples are truly representative since our investigation included a rather small non-clinical, highly gifted sample size. Thus, it would be interesting if findings could be replicated in larger and balanced clinical and non-clinical, highly gifted samples. Furthermore, empirical research using standardized measurements would be interesting in order to prove the coherence between hypersensitivity, deficits in sensory modulation and visual-spatial perception for highly gifted children. Further research contributing to the explanation of the co-occurrence of strengths and weaknesses is additionally required. To further explore the influence of parental attitudes and home as well as preschool learning environments and compare it to (neuro)developmental influences, longitudinal designs as well as more experimental approaches to isolate the influencing factors are needed.

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