The Relationship between Giftedness, Visual-spatial Learning and School Results

Nelleke van der Giessen
Universiteit Utrecht

Masterthesis
Universiteit Utrecht
Masteropleiding Pedagogische Wetenschappen
Masterprogramma Orthopedagogiek

Studentnummer: 3660540
Thesis begeleider: J. H. van de Beek
Tweede beoordelaar: Asli Unlusay
Datum: 22-07-2015

Abstract

Objective: This research focusses on a possible correlation between giftedness and visual-spatial thinking: features of two groups of students with disappointing school achievements. **Method:** During this study 177 students from the 5th and 6th grades of 7 Dutch elementary schools were asked to fill out the My Thinking Style test (MTS) and several subtests of the NIO (*Nederlandse Intelligentietest voor Onderwijsniveau)*, a Dutch IQ test that consists of six subtests: three concerning language skills and three concerning spatial awareness and numeracy skills. Students were grouped in three thinking style categories: visual-spatial thinkers, auditory-sequential thinkers or no preference for either thinking style. NIO scores were used to group students into intelligence categories: low-ability, average-ability, high-ability and gifted students. Gifted students were classified based on a diagnosis for giftedness. Intelligence scores and school results were compared to measure the degree of underachievement. **Results:** Thinking style does not appear to predict giftedness; factors that predict a diagnosis for giftedness are intelligence, school results and age ($p < .001$). Intelligence and to an extent also thinking style influence school results ($p < .001$), but not underachievement ($p = .064$). Gifted students underachieve significantly more than non-gifted students ($p = .025$). No interaction between giftedness and thinking style preference was found ($p = .675$). **Conclusions:** Gifted students were shown to underachieve significantly more than non-gifted students, but this can not be attributed to thinking style: no correlation between thinking style preference and intelligence was found.

Keywords: giftedness, visual-spatial thinking, auditory-sequential thinking, school results, underachievement

Samenvatting

Doel: Dit onderzoek focust op een mogelijke samenhang tussen hoogbegaafdheid en beelddenken: kenmerken van twee groepen leerlingen met tegenvallende schoolresultaten. **Methode:** Hiertoe zijn 177 leerlingen uit de groepen 7 en 8 van 7 verschillende Nederlandse basisscholen onderzocht door middel van de Mijn Denkstijl-vragenlijst (MDS) en de Nederlandse Intelligentietest voor Onderwijsniveau (NIO), die bestaat uit zes deeltesten: drie betreffende taalvaardigheden en drie betreffende ruimtelijk inzicht en numerieke vaardigheden. Leerlingen zijn ingedeeld in drie denkstijlgroepen: beelddenkers, verbaal denkers en leerlingen zonder specifieke voorkeur voor een van beide denkstijlen. Ook op basis van de NIO werd een indeling gemaakt: laag-intelligente, gemiddeld intelligente, hoog intelligente-, en hoogbegaafde leerlingen. Leerlingen in de laatste groep werden opgenomen op basis van een diagnose voor hoogbegaafdheid. Schoolresultaten werden vergeleken met de IQ-score van de leerling om de mate van onderpresteren te meten. **Resultaten:** Denkstijl lijkt geen voorspeller te zijn voor de diagnose hoogbegaafdheid; voorspellers voor de diagnose hoogbegaafdheid zijn intelligentie, schoolresultaten en leeftijd ($p < .001$). Intelligentie en in mindere mate denkstijl zijn van invloed op schoolresultaten ($p < .001$), maar niet op onderpresteren ($p = .064$). Hoogbegaafde leerlingen laten echter een significant hogere mate van onderpresteren zien dan niet-hoogbegaafde leerlingen ($p = .025$). Interactie-effecten tussen hoogbegaafdheid en denkstijl werden niet gevonden ($p = .675$) **Conclusie:** Hoogbegaafde leerlingen bleken significant meer onder te presteren dan niet-hoogbegaafde leerlingen. Dit kan in dit onderzoek echter niet verklaard worden door denkstijl: een correlatie tussen denkstijl en intelligentie werd niet gevonden.

Kernwoorden: Hoogbegaafdheid, beelddenken, verbaal denken, schoolresultaten, onderpresteren

The Relationship between Giftedness, Visual-spatial Learning and School Results

Today's education system aims to prepare students for their careers in an ever-changing society. Nevertheless, in practice, some students appear to underachieve and dropout. Apparently the education system fails to engage all students in learning. Among other factors, this has been attributed to low socioeconomic status (SES) (Dunne & Gazeley, 2008), gender (Lindsey & Muijs, 2007) or lack of parental involvement (Harris & Goodall, 2008). There is one group of students that appears to underachieve more than might be expected, namely gifted students (Kim, 2008; Reis & McCoach, 2002). Another group that is reported to underachieve are the visual-spatial learners (Gohm, Humphreys, & Yao, 1998; Mann, 2005; Silverman, 2005). Yong and McIntyre (1992) suggest that gifted students may have a preference for visual learning. Their observation begs the question whether the underachievement of gifted students may be caused by this preference. This study aims to investigate a possible correlation between gifted students, visual-spatial learners and their learning achievements. First, the characteristics of gifted learners will be discussed, followed by visual-spatial learners.

The gifted learner

Many Americans believe giftedness to be an inborn high ability (Winner, 2000), while others believe it to be a product of goal-directed hard work (Ericsson, Krampe, & Tesch-Romer,1993). This research uses a definition of giftedness that is comprehensive to both assumptions:

> Giftedness is the manifestation of performance that is clearly at the upper end of the distribution in a talent domain even relative to other high-functioning individuals in that domain. Further, giftedness can be viewed as developmental in that in the beginning stages, potential is the key variable; in later stages, achievement is the measure of giftedness; and in fully developed talents, eminence is the basis on which this label is granted. (Subotnik, Olszewski-Kubilius, & Worrell, 2011, p. 3)

Leseman (2002) and Renzulli (2002) share this point of view. Renzulli (2002) proposed the three-ring conception model that, in contradiction to the long-held assumption that giftedness depends on IQ, accommodates other factors that partly overlap: above-average ability, creativity and task commitment. Whereas the three rings together define the giftedness of the child, both environmental and genetic factors will determine whether a child gets the chance to develop each ring individually. Although knowledge of giftedness has increased, some problems still appear in educational settings. These problems will be discussed based on the three-ring conception of giftedness, starting with above-average ability, followed by task commitment and creativity.

Above-average ability refers to the top 15% to 20% of performance in any area (Renzulli, 2002). In today's classroom there is generally more attention for students with learning difficulties than gifted students (Mooij, 2007). This is partly because teachers are rarely aware of the individual learning needs and may often think the gifted child does not need extra attention or possibilities (Pfeiffer & Stocking, 2008). Furthermore, primary teachers tend to have a perception of gifted learners as possessing strong reasoning skills, a general storehouse of knowledge, and facility with language, including a large vocabulary. Due to this perception, many gifted students remain unnoticed (Moon & Brighton, 2008), become used to education that does not focus on their strengths and skills, and do not learn to live up to their potential (Minne, Rensman, Vroomen, & Webbink, 2007; Mooij, 2007; Mooij, Hoogeveen, Driessen, Hell, & Verhoeven, 2007). In the exceptional situation that education is adjusted to their special needs, changes are not structurally embedded in the learning process and often implemented too late (Mooij et al., 2007). In other words: underachievement can be explained by a discrepancy between the needs of gifted students and the education offered.

Task commitment is named as the second characteristic of gifted students, so it is striking that underachievement is one of the most persistent problems among gifted students (Reis & McCoach, 2002). According to Renzulli (1986; 2002), task commitment represents perseverance, endurance, hard work, practice and the confidence in one's ability to engage in important work. Gottfried and Gottfried (2004) also name curiosity, enjoyment of learning and orientation toward mastery and challenge, which bear a significant relationship to a variety of academic achievements. In more recent studies, task commitment has been included in the term motivation (Gagné, 2000; Mönks & Mason, 2000). Motivation is affected by motivational practices used by teachers (Gottfried & Gottfried, 2004), and is the result of opportunities and encouragement that are provided within the context of stimulating and interest-related education (Renzulli, 2002; Sternberg, 2000). When students get the chance to influence their education and method of learning, their intrinsic motivation increases (Amnes, 1992). Still, one learning style is relatively neglected in gifted education: visual-spatial learning. Although visual-spatial ability is a multifaceted component of intelligence, verbal reasoning abilities are favoured in gifted programs (Andersen, 2014), which may cause students with visual-spatial abilities to be less motivated and underachieve.

Creativity is named as the third characteristic of gifted students. The term creativity refers to someone who is recognized for creative accomplishments or has a facility for generating many interesting and feasible ideas (Renzulli, 2002). Despite extensive research on the relationship between creativity and intelligence, there is surprisingly little empirical convergence (Plucker, Esping, Kaufman, & Avitia, 2015). Kershner and Ledger (1985) claim that children with a high IQ are more creative in verbal originality. Preckel, Holling, and Wiese (2006) similarly conclude that verbal creativity correlates strongest with intelligence. Still, Silvia and Beaty (2012) found a relationship between creativity and intelligence that was based on non-verbal tasks, indicating a correlation between visual-spatial creativity and intelligence. Neither verbal nor visual-spatial creativity are required for most school environments, which focus on logical, sequential, linear thinking and verbal information (Kershner & Ledger, 1985). By emphasising these forms of conventional thinking, old-fashioned school environments impede innovative and creative thinking (Chamorro-Premuzic, 2006). This indicates that highly creative students, thus gifted students also, will underachieve more than less creative children. Visual-spatially creative children may experience an even bigger disadvantage because this form is only required in scientific subjects (Kozhevnikov, Kozhevnikov, Yu, & Blazhenkova, 2013).

The visual-spatial learner

Recently, researchers have focussed on students that have these previously mentioned visual-spatial abilities in order to prevent negative school experiences and underachievement (Silverman, 2000). The question is: what exactly is visual-spatial learning and might this learning preference be another aspect that causes gifted learners to underachieve? Learners can be divided into two groups based on their learning preference: auditory-sequential and visual-spatial learners (Shea, Lubinski, & Benbow, 2001; Silverman, 2000). Auditory-sequential learners have well-developed auditory and reading skills and are able to express themselves fluently. This generally leads to a strong sense of self-efficacy in our highly verbal society (Silverman, 2000).

Learners with strong visual-spatial abilities, on the other hand, have been connected to several learning problems, such as dyslexia (Károlyi, Winner, Gray, & Sherman, 2002), inability to communicate well, and reduced vocabulary (Steen, 2007). Visual-spatial learners think in pictures, learn better visually than auditory and do not learn from repetition and drill. They are whole-part learners (Mann, 2005; Silverman, 2000; Silverman, 2005) and do not learn in a step-by-step manner. These learners have difficulty with easy tasks but show amazing ability with difficult, complex tasks. Just as gifted students, visual-spatial learners often score high on technological, mathematical or creative subjects (Silverman, 2000; Silverman, 2005).

Visual-spatial thinking has been connected to giftedness by several researchers (Yong & McIntyre, 1992; Hindal, 2014). Van Garderen and Montague (2003) found a significant relation between mathematical problem-solving performance and visual-spatial representations, especially for gifted students. Silverman (2000) showed that most exceptionally gifted individuals appear to have remarkable spatial abilities and prefer visual-spatial processing. Based on these findings, one would expect a large number of visual-spatial learners amongst gifted students. However, there is a competing view that auditory-sequential learners are more often recognised as gifted by their environment (Gohm, Humphreys, & Yao, 1998; Mann, 2005).

Not only is there an indication for gifted students to have a preference for visual-spatial processing, visual-spatial learners also show the same pattern of underachievement as gifted students (Andersen, 2014). One possible explanation is the focus of today's education system (Silverman, 2000; Webb, Gore, Amend, & Vries, 2007) on following directions, memorizing facts, showing steps of work and accurate spelling (Silverman, 2005). Such aspects create trouble for both visual-spatially oriented and gifted learners due to their preference for visual and holistic representation of facts and a creative approach to problems.

Research questions

The main aim of this research is to investigate a possible correlation between gifted students, visual-spatial learners and their underachievement. This results in the following research questions:

- Are auditory-sequential learners overrepresented amongst gifted students?
- Which factors predict whether a student will be recognised as gifted?
- Is thinking style a predictor for school results and underachievement?
- Is there a correlation between underachievement of gifted students and a visual-spatial preference for learning?

It is hypothesised that auditory-sequential learners are overrepresented amongst gifted learners, and that school results, intelligence and a preference for auditory-sequential thinking are predictors for being recognised as gifted. Subsequently, it is expected that more visual-spatial than auditory-sequential learners underachieve, and that the percentage of underachievers among gifted students is significantly higher than among non-gifted students.

Method

Participants

This study involved 177 Dutch fifth- and sixth-grade students of ages 10 through 12 (*M* = 11.28, *SD* = 0.69). See Table 1 for descriptive statistics.

Table 1

Descriptive statistics (age, sample size, percentage within complete sample) of participants, grouped by Giftedness (diagnosis) and Gender.

	Boys	Girls	Age (years)	
IQ group	*n*	*n*	*M*	*SD*
Gifted	15 (8.5%)	6 (3.4 %)	10.67	.58
Non-gifted	70 (39.5%)	86 (48.6%)	11.36	.66
Total	85 (48%)	92 (52%)	11.28	.69

Procedure

Seven Dutch primary schools were approached to participate in this research. Parents of the target participants were informed about the research and received a parental consent form. Teachers filled out a survey concerning CITO-scores (reading comprehension and mathematics), age, gender and diagnoses for giftedness.

The My Thinking Style test (MTS) (Mann, 2005) and four subtests of the Dutch IQ test NIO (*Nederlandse Intelligentietest voor Onderwijsniveau),*were filled out in a classroom setting. Due to organisational issues, this was at different times at each school. Participants started with the NIO subtests. Each subtest was explained, after which participants had the opportunity to ask questions. In line with NIO regulations, participants had ten minutes to finish numbers and plans, and five minutes to finish synonyms and categories. Subsequently, the participants filled out the MTS. The tests took 45 minutes in total.

Measures

Learning style. To investigate learning style, the MTS (α = .59, K = 98%) was used. This 14-item survey was developed to identify students with spatial strengths at elementary school level. Results are scored on a five-point scale, one point associated with answers matching auditory-sequential preferences, three points with answers that did not represent a preference for either thinking style, and five points with answers matching a visual-spatial preference. For example:

I remember best:

a. What other people say. (1 point)
b. What other people look like. (5 points)

Participants score between 14 and 70 points, on the basis of which they were classified in preferred thinking style categories.Those with scores below the 33rd percentile were classified as auditory-sequential thinkers, those in-between the 33rd and 66th percentile as 'no preference', and those above the 66th percentile as visual-spatial.

IQ. IQ was measured using four subtests of the IQ test NIO: two concerning language-skills and two concerning spatial awareness and numeracy skills. The subtests used are categories (*categorieën),* plans *(uitslagen),* synonyms *(synoniemen)* and numbers (*getallen). All subtests* were assessed as valid and reliable by COTAN (2010). Participants were divided into four groups using NIO scores: participants with a diagnosis for giftedness score within the category gifted learners, participants that score one *SD* above average on the NIO (with the exception of gifted learners) are high-capacity learners, participants that score one *SD* below average are low-ability learners. Remaining participants are the average learners.

School achievements. School achievements were measured using results on the CITO test mathematics *(rekenen-wiskunde)* and reading comprehension *(begrijpend lezen)* of the CITO student tracking system (*CITO-leerlingvolgsysteem)*; these two scores were averaged. CITO-test mathematics has a reliability of $.93 < \alpha > .96$ (Janssen, Verhelst, Engelen, & Scheltens, 2010). Reliability scores for reading comprehension are unknown. Both tests were assessed as valid and reliable by COTAN (2013).

Data Analysis and design

Several correlations were examined through cross-sectional data of the NIO, MTS and CITO scores. To answer the first research question, whether auditory-sequential learners are overrepresented among gifted students, a chi-squared test of contingencies was used for IQ and learning style. The independent variable, learning style as measured by the MTS, consists of three levels: visual-spatial learners, auditory-sequential learners and the group with no preference. Assumptions for this test were met.

The second research question aims to investigate the factors that predict the chance that a student is diagnosed as gifted. To answer this question and to further investigate the outcome of the chi-square test, a logistic regression was used for IQ, school achievements and learning preference. The dependent variable has two levels: gifted or non-gifted. Assumptions for the logistic regression were met.

Two multiple regression analyses were used to answer the third and fourth research question on whether or not thinking style preference and intelligence are predictors for school results and underachievement. Underachievement is conceptualised as the difference between school results that would be expected based on intelligence score, and actual school results compared to intelligence score. To define the degree of underachievement, unstandardized residuals of a linear regression for IQ and school results were used. Assumptions for the multiple regression analysis were checked. There were no extreme outliers in this analysis, and the normality, homoscedasticity and linearity criteria were met. The Mahalanobis distance (13.58) and Cook's distance (.08) did not exceed the critical boundaries, meaning there were no multivariate outliers.

An analysis of variance (ANOVA) was performed to answer the last research question, whether there is a correlation between underachievement of gifted students and a visual-spatial preference for learning, Underachievement levels in the different thinking style groups among gifted learners were compared. Shapiro-Wilk and Levene's test were used to evaluate the assumptions of normality and homogeneity of variance. Neither assumption was violated.

Results

Nine children failed to answer all questions on the MTS and were excluded from the Pearson's chi-square test (n = 168, α = .05). The chi-square test for intelligence and thinking style was not statistically significant, X^2 (6, N = 168) = 2.89, p = .832 (see Table 2). When dividing students into IQ-categories, it was noticed that some gifted students would not count as gifted based on their score on the NIO. The chi-square test was therefore repeated with the IQ categories solely based on NIO scores, classifying those one *SD* above average as high-ability, and two *SD* above average as gifted students. This test was also not statistically significant, X^2 (4, N = 168) = 1.18, p = .882. Further analyses were therefore based on the diagnosis of giftedness.

Table 2

Prevalence of Learning styles amongst Low-, Average-, High-ability and Gifted students.

Learning style	IQ category				Total
	Low-ability	Average-ability	High-ability	Gifted	
Auditory-sequential	6	33	10	7	56
No preference	6	32	9	9	56
Visual-spatial	7	38	6	5	56
Total	19	103	25	21	168

A logistic regression analysis was conducted to predict giftedness, using intelligence, school achievements and learning preference as independent variables. CITO-scores that were used to operationalize school results were available for 114 participants (n = 114). The predictors as a set reliably distinguished between gifted and non-gifted students (X^2 = 8.759, p = .033, with df = 3). Nagelkerke's R^2 of 0.120 indicated a weak relationship between prediction and grouping. Prediction success overall was 80.7% (4.8% for gifted and 97.8% for non-gifted). The Wald criterion demonstrated that only intelligence and school results made a significant contribution to prediction (p = .009, p = .042). Thinking style was not a significant predictor. EXP(B) value indicates that when intelligence is raised by one unit (IQ point) the odds to be recognised as gifted decrease from one to 0.94. EXP(B) value indicates that when school results is raised by one unit the odds to be recognised as gifted increase from one to 1.04 and therefore participants are more likely to be diagnosed as gifted.

However, the *casewise list* revealed that six gifted students did not fit the model well. The logistic regression was therefore repeated, adding possible explanatory variables, namely gender and age. Thinking style was removed because it was not significant. In this test only two outliers were found. The predictors as a set reliably distinguished between gifted and non-gifted students (X^2 = 38.838, p < .001, with df = 4). Nagelkerke's R^2 of 0.465 indicated a moderately strong relationship between prediction and grouping. Prediction success overall was 85.3% (38.1% for diagnosis and 95.8% for no diagnosis). The Wald criterion demonstrated that of the added variables, only age made a significant contribution to prediction (p < .001). Gender was not a significant predictor. EXP(B) value indicates that when age is raised by one year the odds ratio increases from one to 12.40 and therefore participants are 12 times more likely to be diagnosed as gifted.

A multiple regression analysis (n = 114) indicates that a significant 30.3% of variance in school results is caused by intelligence R^2 = .303, adjusted R^2 = .296, F(1, 112) = 48.6, p < .001. School results can therefore partially be predicted by intelligence. Adding thinking style in a hierarchical multiple regression explained an additional significant 3.2% of variance R^2 = .335, adjusted R^2 = .323, F(2, 111) = 27.94, p < .001.

Variance in underachievement is caused by intelligence for a non-significant 0.2%, R^2 = .002, adjusted R^2 = -.007, F(1, 112) = .264, p = .608. Adding thinking style as an independent variable in a hierarchical multiple regression explained an additional non-significant 4% of variance R^2 = .048, adjusted R^2 = .031, F(2, 111) = 2.819, p = .064.

Finally, a factorial between groups analysis of variance (ANOVA) was used to compare underachievement of six groups using Giftedness x Thinking style (n = 114). The main effect of thinking style on underachievement was not statistically significant, $F(2, 108) = 2.074$, $p = .131$. Partial eta-squared *(η^2)* for this effect was .037. The main effect of giftedness was statistically significant, $F(1, 108) = 5.187$, $p = .025$, with gifted participants underachieving significantly more ($M = -6.271$, $SD = 14.323$) than those who are not gifted ($M = .924$, $SD = 15.260$). Partial eta-squared *(η^2)* for this effect was .046. There was no interaction between thinking style and giftedness, $F(2, 108) = .395$, $p = .675$, partial $\eta^2 = .007$.

Discussion

In a predominantly verbal education system, visual-spatial learners are at risk of underachieving. Due to a similar pattern of underachievement among gifted learners, the question is begged whether a preference for visual-spatial thinking may cause gifted learners to underachieve. The aim of this research was to investigate to what extent giftedness and aptitude for visual-spatial thinking correlate with underachievement in school. The present data cannot confirm any correlation just yet.

First, the relationship between thinking style and giftedness was examined, focussing on a possible overrepresentation of auditory-sequential learners among gifted students. No overrepresentation was found. Factors that predict giftedness are age, school results and IQ. The lack of overrepresentation may be due to children’s familiarity with certain learning styles: children tend to choose from a repertoire that is known to them (Chan, 2001). Perhaps tests for differences in working memory could provide future researchers with a more accurate measuring tool of thinking style, because according to Silverman (2000), auditory-sequential learners have a well-developed auditory working memory compared to visual-spatial learners. School results and intelligence were expected to be predictors for giftedness. It is difficult to explain why age is a predictor for giftedness, because research often compares gifted students with non-gifted students in the same age group (Steiner & Carr, 2003). However, Chan (2001) concludes that younger learners prefer structured learning activities more than older learners. This could mean that with age, gifted learners will differ more from their peers, thus increasing their chance to be recognised as gifted.

Concerning the relationship between thinking style and underachievement, it was hypothesised that visual-spatial learners underachieve more often than auditory-sequential learners (Silverman, 2005). Results show that thinking style does not affect underachievement, and only partially affects school results. This may be because both learning styles are based on cognitive reasoning. Tactile and auditory aspects of learning style do appear to have a significant influence on underachievement (Rayneri, Gerber, & Wiley, 2003; Rayneri, Gerber, & Wiley, 2006). Another reason that no effect of thinking style on underachievement was found may be the use of the MTS. A better tool to measure thinking style preference may provide future researchers with different results.

Finally, it was expected that gifted students would show a higher level of underachievement than non-gifted students, which was confirmed by the results. This finding is striking, because gifted students that participated in this research receive special education for several hours a week. This education is meant to reduce the discrepancy between their learning style and the education. Future research could focus on gifted students in regular primary education to retest the hypothesis. Still, there are other explanations for underachievement amongst gifted learners: students' attitude towards school (Clemons, 2008), low self-motivation, low self-regulation, low self-efficacy (Reis & McCoach, 2002; Rayneri, Gerber, & Wiley, 2003) or more serious physical, cognitive or emotional issues (Reis & McCoach, 2002).

There are several limitations of this study. One is the small sample size (n = 177), especially concerning the group gifted children (n = 21). Also, the NIO only implements norms for grades six through nine. In this study, the norms for sixth-grade students were applied to results of fifth-grade students, which may have influenced their IQ score. Furthermore, the main instrument MTS appears less reliable than expected. As previously mentioned, this problem can be avoided in the future by using a test for working memory.

Still, there was another interesting finding: not all students that have a diagnosis for giftedness would be considered gifted students based on their scores on the NIO. This might be due to the fact that: 1) they are diagnosed as gifted, but underachieved on the NIO, or 2) they are not gifted but have somehow been diagnosed as gifted. Future research might take the effect of wrongful diagnoses into account.

References

Amnes, C. (1992). Classrooms: Goals, Structures, and Student Motivation. *Journal of Educational Psychology, 84*(3), 261-271.

Andersen, L. (2014). Visual-Spatial Ability: Important in STEM, Ignored in Gifted Education. *Roeper Review, 36*, 114- 112. doi:10.1080/02783193.2014.884198

Cotan, 2010. Nederlandse intelligentietest voor Onderwijsniveau, NIO, 2004. Retrieved from: http://www.cotandocumentatie.nl.proxy.library.uu.nl/test_details.php?id=73

Cotan, 2013. Begrijpend lezen groep 7 en 8 (papieren versie, 2011). Retrieved from: http://www.cotandocumentatie.nl.proxy.library.uu.nl/test_details.php?id=796

Chamorro-Premuzic, T. (2006). Creativity versus conscientiousness: Which is a better predictor of student performance? *Applied Cognitive Psychology, 20*, 521-531. doi:10.1002/acp.1196

Chan, D. W. (2001). Learning styles of gifted and nongifted secondary students in Hong Kong. *Gifted Child Quarterly, 45*(1), 35-44. doi:10.1177/001698620104500106

Clemons, T. L. (2008). Underachieving Gifted Students: A Social Cognitive Model. *National Research Center on the Gifted and Talented*. Retrieved from: http://files.eric.ed.gov/fulltext/ED505382.pdf

Dunne, M. & Gazeley, L. (2008). Teachers, social class and underachievement. *British Journal of Sociology of Education. 29*(5), 451-463. doi:10.1080/01425690802263627

Ericsson, K. A., Krampe, R., & Tesch-Romer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, *100*, 363-406. doi:10.1037/0033-295X.100.3.363

Gagné, F. (2000) Understanding the complex choreography of talent development through DMGT-based analysis, in: K. A. Heller, F. J. Mönks, R. J. Sternberg & R. F. Subotnik (Eds.), *International handbook of giftedness and talent* (pp. 67-80). doi:10.1016/B978-008043796-5/50005-X

Van Garderen, D., & Montague, M. (2003). Visual-spatial representation, mathematical problem solving, and students of varying abilities. *Learning Disabilities Research & Practice, 18*(4), 246-254. doi:10.1111/1540-5826.00079

Gohm, C. L., Humphreys, L. G., & Yao, G. (1998). Underachievement among spatially gifted students. *American Educational Research Journal, 35*, 515-531. doi:10.3102/00028312035003515

Gottfried, A. E., & Gottfried, A. W. (2004). Toward the development of a conceptualization of gifted motivation. *Gifted Child Quarterly*, *48*(2), 121-132. doi:10.1177/001698620404800205

Harris, A. & Goodall, J. (2008). Do parents know they matter? Engaging all parents in learning. *Educational Research, 50*(3), 277-289. doi:10.1080/00131880802309424

Hindal, H. S. (2014). Visual-Spatial Learning: A Characteristic of Gifted Students. *European Scientific Journal*, *10*(13), 557-574. Retrieved from: http://eujournal.org/index.php/esj/article/view/3378

Janssen, J., Verhelst, N., Engelen, R., & Scheltens, F. (2010). *Wetenschappelijke verantwoording van de toetsen LOVS Rekenen-Wiskunde voor groep 3 tot en met 8.* Arnhem: Cito.

Károlyi, C. Von, Winner, E., Gray, W., & Sherman, G. F. (2003). Dyslexia linked to talent: Global visual-spatial ability. *Brain and language*, *85*(3), 427-431. doi:10.1016/S0093-934X(03)00052-X

Kershner, J. R., & Ledger, G. (1985). Effect of sex, intelligence, and style of thinking on creativity: A comparison of gifted and average IQ children. *Journal of personality and social psychology*, *48*(4), 1033-1040. doi:10.1037/0022-3514.48.4.1033

Kim, K.H. (2008). Underachievement and creativity: Are gifted underachievers highly creative? *Creative Research Journal*, *20*, 234-242. doi:10.1080/10400410802060232

Kozhevnikov, M., Kozhevnikov, M., Yu, C. J., & Blazhenkova, O. (2013). Creativity, visualization abilities, and visual cognitive style. *British journal of educational psychology*, *83*(2), 196-209. doi:10.1111/bjep.12013

Leseman, P. P. M. (2002). *Onderzoek in de voor- en vroegschoolse periode. Trends en nieuwe vragen.* Den Haag: NWO/PROO.

Lindsey, G. & Muijs, D. (2006). Challenging underachievement in boys. *Educational Research*, *48*(3), 313-332. doi:10.1080/00131880600992389

Mann, R. L. (2005). *The identification of gifted students with spatial strengths: An exploratory study*. (Doctoral dissertation). Retrieved from: http://www.gifted.uconn.edu/Siegle/Dissertations/Rebecca%20Mann.pdf (UMI No. 3180228)

Minne, B., Rensman, M., Vroomen, B., & Webbink, D. (2007). *Excellence for productivity.* Den Haag: CPB. Retrieved from: http://download.springer.com.proxy.library.uu.nl/static/pdf/659/art%253A10.1007%252FBF03061036.pdf?auth66=1426156793_51b96b94e770297db680158ff370651a&ext=.pdf

Mönks, F. J. & Mason, E. J. (2000) Developmental psychology and giftedness: theories and research, in: K. A. Heller, F. J. Mönks, R. J. Sternberg & R. F. Subotnik (Eds.), *International handbook of giftedness and talent* (pp. 587-594). Oxford: Elsevier Science.

Mooij, T. (2007). Ontwikkeling van hoogbegaafde leerlingen en schoolse kenmerken. *Kind en adolescent*, *28*(4), 167-172. doi:10.1007/BF03061036

Mooij, T., Hoogeveen, L., Driessen, L., Hell, J. van, & Verhoeven, L. (2007). *Succescondities* *voor onderwijs aan hoogbegaafde leerlingen. Intern rapport.* Nijmegen: Centrum voor Begaafdheidsonderzoek. Retrieved from: https://www.deltascholen.org/delta_C03/UploadData/images/5/1787/4542/Artikel_Succescondities_voor_onderwijs_aan_hoogbegaafde_leerlingen.pdf

Moon, T. R., & Brighton, C. M. (2008). Primary Teachers' Conceptions of Giftedness. *Journal for the Education of the Gifted, 31*(4), 447-480. Retrieved from: http://files.eric.ed.gov/fulltext/EJ799762.pdf

Pfeiffer, S. I., & Stocking, V. B. (2008). Vulnerabilities of academically gifted students. *Special Services in the Schools, 16,* 83-93. doi:10.1300/J008v16n01_06

Plucker, J. A., Esping, A., Kaufman, J. C., & Avitia, M. J. (2015). Creativity and Intelligence. In S. Goldstein et al. (Eds.), *Handbook of Intelligence: Evolutionary Theory, Historical Perspective, and Current Concepts* (pp. 283-291). doi: 10.1007/978-1-4939-1562-0_19

Preckel, F., Holling, H., & Wiese, M. (2006). Relationship of intelligence and creativity in gifted and non-gifted students: An investigation of threshold theory.*Personality and individual differences*, *40*(1), 159-170. doi:10.1016/j.paid.2005.06.022

Rayneri, L. J., Gerber, B. L., & Wiley, L. P. (2003). Gifted achievers and gifted underachievers: The impact of learning style preferences in the classroom. *Prufrock Journal*, *14*(4), 197-204. doi: 10.4219/jsge-2003-434

Rayneri, L. J., Gerber, B. L., & Wiley, L. P. (2006). The relationship between classroom environment and the learning style preferences of gifted middle school students and the impact on levels of performance. *Gifted child quarterly,50*(2), 104-118. doi: 10.1177/001698620605000203

Reis, S. M., & McCoach, D. B. (2002). Underachievement in gifted and talented students with special needs. *Exceptionality, 10*(2), 113-125. doi: 10.1207/S15327035EX1002_5

Renzulli, J. S. (1986). The three ring conception of giftedness: a developmental model of creative productivity, in: R. J. Sternberg & J. E. Davidson (Eds.), *Conceptions of giftedness* (pp. 53–92). doi:10.1207/S15327035EX1002_2

Renzulli, J. S. (2002). Emerging conceptions of giftedness: Building a bridge to the new century. *Exceptionality*, *10*(2), 67-75. doi:10.1207/S15327035EX1002_2

Shea, D.L., Lubinski, D. & Benbow, C.P. (2001). Importance of assessing spatial ability in intellectually talented young adolescents: A 20-year longitudinal study. *Journal of Educational Psychology, 93*(3), 604-614. doi:10.1037/0022-0663.93.3.604

Silverman, L. K. (2000). Identifying visual-spatial and auditory-sequential learners: A validation study. Talent development V: Proceedings from the. Retrieved from: http://www.visualspatial.org/files/idvsls.pdf

Silverman, L. K. (2005). Upside-down brilliance: The visual-spatial learner. Retrieved from: http://www.visualspatial.org/files/idvsls.pdf

Silvia, P. J., & Beaty, R. E. (2012). Making creative metaphors: The importance of fluid intelligence for creative thought. *Intelligence*, *40*(4), 343-351. doi:10.1016/j.intell.2012.02.005

Steen, van der, J. (2007). Vormen van geheugen. *Denkbeeld*, *19*(1), 7-9. doi:10.1007/BF03059358

Steiner, H. H., & Carr, M. (2003). Cognitive development in gifted children: Toward a more precise understanding of emerging differences in intelligence. *Educational Psychology Review*, *15*(3), 215-246. doi: 1040-726X/03/0900-0215/0

Sternberg, R. J. (2000) Giftedness as developing expertise, in: K. A. Heller, F. J. Mönks, R. J. Sternberg & R. F. Subotnik (Eds.), *International handbook of giftedness and talent* (pp. 55–66). doi:10.1016/B978-008043796-5/50004-8

Subotnik, R. F., Olszewski-Kubilius, P., & Worrell, F. C. (2011). Rethinking Giftedness and Gifted Education: A Proposed Direction Forward Based on Psychological Science. *Association for Psychological Science. 12*(1), 3-54. doi:10.1177/1529100611418056

Webb, J. T., Gore, J. L., Amend, E. R., & de Vries, A. R. (2007). *A parent's guide to gifted children.* Scottsdale: Great Potential Pr Inc.

Winner, E. (2000). The origins and ends of giftedness. *American Psychologist, 55*(1), 159-169. doi:10.1037/0003-066X.55.1.159

Yong, F. L., & McIntyre, J. D. (1992). A comparative study of the learning style preferences of students with learning disabilities and students who are gifted. *Journal of Learning Disabilities*, *25*(2), 124-132. doi:10.1177/002221949202500206