

THE DYNAMICS OF GIFTEDNESS IN THE UPPER PRIMARY GRADES



JOYCE GUBBELS

Behavioural
Science
Institute

The dynamics of giftedness in the upper primary grades

Joyce Gubbels

The research presented in this dissertation was supported by a grant from the Netherlands Organization for Scientific Research (NWO; 411-12-621) awarded to Prof. Dr. P.C.J. Segers, Prof. dr. L.T.W. Verhoeven, Dr. A.J.M. Hoogeveen, Drs. D. Houkema, and Dr. J. Keuning and was carried out at the Behavioural Science Institute of the Radboud University, the Netherlands.

ISBN

978-94-028-0251-1

Cover

Aniek Smits

Design/lay-out

Promotie In Zicht, Arnhem

Print

Ipskamp Drukkers, Enschede

© Joyce Gubbels, 2016

All rights reserved. No parts of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, without written permission from the author.

The dynamics of giftedness in the upper primary grades

Proefschrift

ter verkrijging van de graad van doctor
aan de Radboud Universiteit Nijmegen
op gezag van de rector magnificus prof. dr. J.H.J.M. van Krieken,
volgens besluit van het college van decanen
in het openbaar te verdedigen op

donderdag 1 september 2016
om 10:30 uur precies

door

Joyce Catharina Gerarda Gubbels
geboren op 5 juli 1989
te Nijmegen

Promotor

Prof. dr. L.T.W. Verhoeven

Copromotor

Prof. dr. P.C.J. Segers

Manuscriptcommissie

Prof. dr. A.H.N. Cillessen

Prof. dr. C.A.M. van Boxtel (UvA)

Dr. E.H. Kroesbergen (UU)

Table of contents

Chapter 1	General introduction	7
Chapter 2	The Aurora Battery as an assessment of triarchic intellectual abilities in upper primary grades	21
Chapter 3	How children's intellectual profiles relate to their cognitive, social-emotional, and academic functioning	47
Chapter 4	Predicting the development of intellectual abilities in the upper primary grades	67
Chapter 5	Effects of an individualized ICT enrichment program on the development of intellectual abilities in gifted children	87
Chapter 6	Effects of a pull-out program on the development of intellectual abilities in gifted children	103
Chapter 7	General discussion	127
	Samenvatting	141
	Dankwoord	149
	Curriculum Vitae	155

1

General introduction

Ever since the introduction of a general intelligence factor by Spearman (1904), general intelligence has served as a major factor in identifying gifted children (Worrell & Erwin, 2011). When based on this general intelligence factor, giftedness is identified based on scores on standardized IQ tests such as the Wechsler Intelligence Scales (Worrell, 2009). With the 2.5% upper limit for defining giftedness, a child is typically labeled gifted when obtaining an IQ score of 130 or higher (McClain & Pfeiffer, 2012). Although the use of this narrow criterion is common practice in most schools (McClain & Pfeiffer, 2012), the concept of giftedness has undergone some major changes over the past few decades (Heller, 2004). Recent models of giftedness emphasize the dynamic nature of intelligence and giftedness (Dai, 2010). That is, intelligence is more and more considered to comprise a broad range of abilities rather than only analytical abilities reflected in standardized IQ scores (Ziegler & Heller, 2000). Moreover, ability levels are considered to develop in interaction with both personal and environmental characteristics (Subotnik, Olszewski-Kubilius, & Worrell, 2011). The present dissertation aimed to gain insight in these dynamic aspects of intelligence and giftedness. In longitudinal and intervention designs, it was examined what types of intellectual abilities can be discriminated in upper primary school children, how these abilities develop over time, and whether enrichment programs can enhance the development of abilities in gifted children.

Modeling intelligence

General intellectual abilities are at the foundation of all recent models of intelligence and giftedness (Dai, 2010), though conceptualization differs across models. Spearman (1904) suggested a general intelligence factor, the *g* factor. Thurstone (1938), however, identified a number of primary mental abilities (i.e., word fluency, inductive reasoning) rather than one general factor. Although it was first hypothesized that these abilities were independent constructs, recent studies showed that these abilities share some overlap (Mackintosh, 2011). Both theories were combined in a hierarchical intelligence model, in which the *g*-factor was suggested to overarch a visual spatial and verbal factor, that both included more specific abilities such as reading or arithmetic (Vernon, 1950). In 1963, Cattell distinguished fluid and crystallized intelligence. Whereas crystallized intelligence comprises acquired knowledge and skills, fluid intelligence involves abstract and flexible thinking. In following years, higher-order abilities as well as specific cognitive abilities were added to the Cattell model, which resulted in the comprehensive Cattell-Horn-Carroll (CHC) model of intelligence (McGrew, 1997). In this model, three strata are distinguished. The first stratum comprises more than 80 narrow abilities. These narrow abilities are aggregated in 16 broad abilities in stratum II. Stratum III represents an overall general ability or *g* (Flanagan & Dixon, 2013). The CHC-model is supported in an extensive body of evidence in research literature and is therefore often

considered the most comprehensive and empirically supported theory of the structure of intelligence (Flanagan & Dixon, 2013).

Next to such models that describe the structure of intelligence, several models address the role of intelligence in the identification of gifted children. All these models agree that giftedness is a dynamic construct for which general intelligence is necessary, yet not sufficient (Subotnik et al., 2011). Renzulli (1986), for example, argues that next to high levels of general intelligence, a second type of cognitive abilities is important for reaching gifted performances: creativity. Creativity is defined as the ability to generate original and effective ideas (Runco & Jaeger, 2012). The model of triarchic intelligence introduces a third type of abilities: practical abilities (Sternberg, 1985; 2011). According to this latter model, analytical abilities (i.e., general intelligence) are needed to analyze a situation, creative abilities are required to come up with multiple and original ideas, and practical abilities are essential to implement these ideas in the situation.

Of course, people differ with regard to their levels of analytical, creative, and practical abilities. The proposed mechanism to deal with the varying levels of abilities is to capitalize on strengths and compensate for weaknesses (Sternberg, 2009). The model of triarchic intelligence, however, hypothesizes that the chance of success is highest when children possess high levels of abilities in all three domains. Children with these high-balanced intellectual profiles are therefore considered successfully intelligent. In contrast to the various factors in the CHC model of intelligence, the three-factor structure as hypothesized in the model of triarchic intelligence is not yet evidenced in exploratory or confirmatory factor analyses. Although a differentiation between analytical, creative, and practical abilities is hypothesized, research has only limitedly addressed possibilities to differentiate between the three types of abilities.

A developmental perspective on intelligence

Next to the multidimensional aspect of intelligence, recent models emphasize intellectual abilities to develop over time (Dai, 2010). The model of triarchic intelligence, for example, assumes intellectual ability levels to be dynamic rather than static traits. Whereas analytical abilities are regularly found to increase over time (Flynn, 2007), the developmental path of creative and practical abilities is less clear. The development of practical abilities in the upper primary grades has not been studied, while studies on the development of creative abilities show inconsistent results. Claxton, Pannells, and Rhoads (2005) found a slight increase of creativity in the upper primary grades, whereas Memmert (2011) found creativity scores to stabilize in 10 to 13 year olds. According to the model of triarchic intelligence, both child characteristics and environmental conditions play a role in the development of analytical, creative, and practical abilities.

With regard to child characteristics, the various aspects of intelligence have been assumed to rely on a shared cognitive basis (Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014). The ability to hold relevant information in memory and combine it with existing knowledge is, for example, reported to be related to analytical ability levels (Ackerman, Beier, & Boyle, 2005). Memory capacity is also hypothesized to play an important role in creative processes (Paulus & Brown, 2007; Simonton, 2000). In addition, selective attention, the ability to attend to task-relevant cues and ignore distracters (Kolata, Light, Grossman, Hale, & Matzel, 2007), is suggested to relate to both analytical (Cowan, Fristoe, Elliott, Brunner, & Sauls, 2006) and creative abilities (M Emmert, 2011). The relation between either memory capacity or selective attention and practical ability levels has not been studied to date.

In addition to cognitive child characteristics, socio-emotional characteristics have also been reported to play a role in the development of the multiple types of abilities (Subotnik et al., 2011). Both motivational levels and self-concepts are for example repeatedly reported to be related to a child's intellectual performances (Duckworth, Lynam, Loeber, & Stoethamer-Loeber, 2011; Valentine, DuBois, & Cooper, 2004). In addition, intellectual abilities are also assumed to be influenced by feelings of subjective wellbeing (Baas, de Dreu & Nijstad, 2008; Wulff, Bergman, & Sverke, 2009).

Summarizing, the dynamics of giftedness are not only represented in the multi-dimensional structure of the concept, but also in the development of ability levels and the interaction with cognitive and socio-emotional child characteristics. Furthermore, the opportunity to develop gifted levels of abilities is determined by environmental conditions such as the availability of enrichment programs (Barnett & Durden, 1993; Ziegler, Vialle, & Wimmer, 2013).

Enrichment program effects

Enrichment programs generally broaden the scope of what is covered in the regular curriculum by confronting gifted children with challenging experiences (Gallagher, 2003; Renzulli & Reis, 2003). The aim of enrichment programs is to provide gifted children with the opportunity to optimally develop in the intellectual domain. Although more and more enrichment programs are developed, most enrichment programs are initiated improvisational or reactive (Mooij, Hoogeveen, Driessen, Van Hell & Verhoeven, 2007). Moreover, studies evaluating the effects of these programs have only small sample sizes and lack control groups (Mooij & Fettelaar, 2010) so that the number of methodologically sound evaluations of such programs is extremely small (Subotnik et al., 2011). Hoogeveen, van Hell, Mooij, and Verhoeven (2004) reviewed the effects of five types of enrichment programs: within class enrichment, pull-out programs, summer programs, gifted classes, and gifted schools. In general, programs had positive effects on children's intellectual development, whereas both positive and

negative effects on their socio-emotional development were found. Although all types of programs have their own benefits, pull-out programs were found to have the most positive effects on school performances and the least negative effect on children's self-concepts.

To enhance the development of analytical, creative, and practical abilities of gifted students in particular, triarchic enrichment programs have been developed. In these programs, teachers encourage children to analyze and evaluate a problem (Sternberg & Grigorenko, 2004). Creative abilities are induced by assignments that ask children to invent or create a solution. In addition, teachers relate to the practical needs of their students by supporting them to apply the solutions to the problem. Studies on the effects of triarchic enrichment programs showed students to score higher on analytical, creative, and practical assignments after having received triarchic instruction than after having received traditional instruction (Aljughaiman & Ayoub; Sternberg, Torff, & Grigorenko, 1998). Moreover, students participating in triarchic programs also gained higher scores on memorization assignments (Sternberg et al., 1998) and reading assignments (Grigorenko, Jarvin, & Sternberg, 2001).

In general, triarchic teaching thus seems to render positive effects on the development of intellectual abilities. Based on the assumption that children can learn to capitalize on their strengths to compensate for their weaknesses, Sternberg and colleagues (1999) studied the effects of triarchic teaching for children with varying intellectual profiles. Results showed that the enrichment program was most effective in enhancing students' overall intellectual development when the method of instruction was aligned to the students' best developed intellectual ability. Analytically-gifted students thus performed best with analytical instruction, creatively-gifted students with creative instruction, and practically-gifted students with practical instruction. The tools to differentiate instruction according to individual ability levels and needs of students in a heterogeneous classroom can be provided by online programs (Shaw & Giles, 2015; Thomson, 2010). Online programs have been shown to enhance analytical and creative thinking in upper elementary school children (Cavanaugh, Barbour, & Clark, 2009), yet research on the effects of these programs on the intellectual development of gifted children is lacking (Thomson, 2010).

The present research project

The present research project adopted a dynamic perspective to study intelligence and giftedness in upper primary school children in the Netherlands. That is, intelligence was assumed to comprise multiple types of intellectual abilities. Following the theory of successful intelligence (Sternberg, 1985), analytical, creative, and practical abilities were hypothesized to be distinguished. Moreover, these abilities were presumed to develop as a function of child characteristics as well as environmental factors.

International research has shown that in the Netherlands, in comparison with other countries, only small percentages of Dutch students scored well below or above average in their academic achievements (PIRLS, 2006; PISA, 2009). Dutch schools thus seem to do particularly well in supporting children with learning problems. However, results also imply that there is insufficient support for gifted children to excel, thereby possibly hindering the intellectual development of gifted children (Mooij et al., 2007). A substantial variability of enrichment programs is available (Mooij & Fettelaar, 2010) and 75% of Dutch schools report to adapt teaching to the needs of gifted students (Doolaard & Oudbier, 2010). The most commonly used adaptations are within-class differentiation, acceleration of the gifted student, and pull-out programs.

Whereas a dynamic approach to giftedness is advocated, a review of national and international literature showed that both in educational practice and in empirical studies assessment of giftedness is commonly identified solely on high IQ scores or high academic achievements (Doolaard & Oudbier, 2010; McClain & Pfeiffer, 2012). As a consequence, creatively-gifted and practically-gifted children are overlooked (Sternberg & Grigorenko, 2004) and participation in enrichment programs is limited to a small group of analytically-gifted children (McClain & Pfeiffer, 2012). Assessment batteries comprising all three types of abilities are needed to overcome this issue (McBee, Peters, & Waterman, 2014), yet research on the multidimensional assessment of intellectual abilities is rather limited. Moreover, assessment should not be constrained to only intellectual abilities since giftedness is also assumed to dynamically develop in interaction with both child and environmental characteristics. To gain more insight in the role of individual differences in the development of gifted children, psychological research should be integrated with educational research evaluating the effects of enrichment programs (Segers & Hoogeveen, 2012).

The aim of the present research project was to provide insight in the dynamics of giftedness in Dutch upper primary school children. In a first study, the possibilities of a multidimensional assessment of intellectual abilities were examined. Next, we investigated the role of child characteristics in the emergence and development of intellectual ability profiles. Thirdly, two types of enrichment programs were studied with respect to the effects on the development of intellectual abilities in gifted upper primary school children. In short, studies addressed three research questions:

1. What types of intellectual abilities can be distinguished in upper primary school children?
2. How are intellectual profiles and the development thereof related to cognitive and socio-emotional child characteristics?
3. Can the development of intellectual abilities in gifted children be enhanced with enrichment programs?

In order to examine what types of intellectual profiles can be distinguished, we explored the psychometric properties of the Aurora Assessment Battery. This battery was developed as a comprehensive assessment of analytical, creative, and practical intellectual abilities in upper primary school children (Chart, Grigorenko, & Sternberg, 2008). All seventeen Aurora subtests were translated into Dutch and completed by fourth-to-sixth graders. The dimensional structure of the battery was explored with correlation analyses and confirmatory factor analyses.

In order to answer the second research question, a sample of fifth-grade children was screened on their levels of intellectual abilities. In a first study addressing the relationship between intellectual ability levels and cognitive and socio-emotional child characteristics, we used these screening scores to identify groups of gifted and normally-achieving children. Next, differences in cognitive, socio-emotional, and academic functioning between gifted and normally-achieving children were evaluated. A second study addressed the longitudinal development of intellectual abilities over the final two grades of primary school. Moreover, an autoregressive cross-lagged structural equation model was used to examine the predictive role of cognitive and socio-emotional child characteristics in this development.

The third research question was also examined in two studies. In order to examine the effects of an individualized ICT program, the intellectual development of gifted children participating in an online enrichment program was compared to the development of gifted control group children following the standard curriculum. In a second study, the intellectual development of gifted upper primary school children participating in a pull-out program was assessed. Their development was compared to the development of a control group of gifted classmates.

Outline of the dissertation

The next five chapters each represent an empirical research paper accepted or submitted for publication. In Chapter 2 ('The Aurora Battery as an assessment of triarchic intellectual abilities in upper primary grades'), it is examined whether analytical, creative, and practical abilities can be discriminated using the Aurora Assessment Battery.

In Chapter 3 ('How children's intellectual profiles relate to their cognitive, social-emotional, and academic functioning'), we explored whether children with varying intellectual profiles differed with regard to their cognitive, socio-emotional, and academic functioning.

Chapter 4 ('Predicting the development of intellectual abilities in the upper primary grades') represents a longitudinal study in which the development of intellectual abilities over the final two grades of primary school was examined. Using a structural equation model, the predictive role of cognitive and socio-emotional child characteristics in the development of intellectual abilities is explored.

In Chapter 5 ('Effects of an individualized ICT enrichment program on the development of intellectual abilities in gifted children') an online enrichment program was provided to a group of gifted upper primary school children and the effects on the development of intellectual abilities are examined.

Chapter 6 ('Effects of a pull-out program on the development of intellectual abilities in gifted children') describes the effects of an enrichment program on the development of intellectual abilities in gifted children. The program was a pull-out program in which children spent one morning a week in the enrichment class.

Chapter 7 provides a summary of the results of the five studies, followed by theoretical implications. Ultimately, limitations, directions for future research, and educational implications are discussed.

References

- Ackerman, P. L., Beier, M. E., & Boyle, M. O. (2005). Working memory and intelligence: The same or different constructs? *Psychological Bulletin*, 131, 30-60. doi:10.1037/0033-2909.131.1.30
- Aljughaiman, A. M., & Ayoub, A. E. A. (2012). The effect of an enrichment program on developing analytical, creative, and practical abilities of elementary gifted students. *Journal for the Education of the Gifted*, 35, 153-174. doi:10.1177/0162353212440616
- Baas, M., De Dreu, C. K. W., & Nijstad, B. A. (2008). A meta-analysis of 25 years of mood-creativity research: Hedonic tone, activation, or regulatory focus? *Psychological Bulletin*, 134, 779-806. doi:10.1037/a0012815
- Barnett, L. B., & Durden, W. G. (1993). Education patterns of academically talented youth. *Gifted Child Quarterly*, 37, 161-168. doi:10.1177/001698629303700405
- Benedek, M., Jauk, E., Sommer, M., Arendasy, M., & Neubauer, A. C. (2014). Intelligence, creativity, and cognitive control: The common and differential involvement of executive functions in intelligence and creativity. *Intelligence*, 46, 73-83. doi:10.1016/j.intell.2014.05.007
- Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: a critical experiment. *Journal of Educational Psychology*, 54, 1-22. doi:10.1037/h0046743
- Cavanaugh, C., Barbour, M., & Clark, T. (2009). Research and practice in K-12 online learning: a review of open access literature. *The International Review of Research in Open and Distance Learning*, 10, 1-22.
- Chart, H., Grigorenko, E., & Sternberg, R. J. (2008). Identification: The Aurora Battery. In J. A. Plucker & C. M. Callahan (Eds.), *Critical issues and practices in gifted education* (pp. 281-301). Waco, TX: Prufrock Press.
- Cianciolo, A. T., Grigorenko, E. L., Jarvin, L., Gil, G., Drebot, M. E., & Sternberg, R. J. (2006). Practical intelligence and tacit knowledge: Advancements in the measurement of developing expertise. *Learning and Individual Differences*, 16, 235-253. doi:10.1016/j.lindif.2006.04.002
- Claxton, A. F., Pannells, T. C., & Rhoads, P. A. (2005). Developmental trends in the creativity of school-aged children. *Creativity Research Journal*, 17, 327-335. doi:10.1207/s15326934crj1704_4
- Cowan, N., Fristoe, N. M., Elliott, E. M., Brunner, R. P., & Saults, J. S. (2006). Scope of attention, control of attention, and intelligence in children and adults. *Memory and Cognition*, 34, 1754-1768.
- Dai, Y. D. (2010). *The nature and nurture of giftedness: A new framework for understanding gifted education*. New York, NY: Teachers College Press.
- Doolaard, S., & Oudbier, M. (2010). *Onderwijsaanbod aan (hoog)begaafde leerlingen in het basisonderwijs [Education for gifted pupils in primary education]*. Groningen, The Netherlands: GION.
- Duckworth, A. L., Quinn, P. D., Lynam, D. R., Loeber, R., & Stouthamer-Loeber, M. (2011). Role of test motivation in intelligence testing. *Proceedings of National Academy Sciences*, 108, 7716-7720. doi:10.1073/pnas.1018601108
- Flanagan, D. P., & Dixon, S. G. (2014). The Cattell-Horn-Carroll Theory of cognitive abilities. *Encyclopedia of Special Education*. New York, NY: Wiley & Sons. doi:10.1002/9781118660584.ese0431
- Flynn, J. R. (2007). *What is intelligence? Beyond the Flynn effect*. New York: Cambridge University Press.
- 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. 67-79). Amsterdam: Elsevier.
- Gallagher, J. J. (2003). Issues and challenges in the education of gifted students. In N. Colangelo & G. A. Davis (Eds.), *Handbook of gifted education* (3rd ed., pp. 11-23). Boston, MA: Allyn & Bacon.
- Grigorenko, E. L., Jarvin, L., & Sternberg, R. J. (2002). School-based tests of the triarchic theory of intelligence: Three settings, three samples, three syllabi. *Contemporary Educational Psychology*, 27, 167-208. doi:10.1006/ceps.2001.1087
- Heller, K. A. (2004). Identification of gifted and talented students. *Psychological Science*, 15, 302-323. doi:10.1080/15377903.2012.643757
- Hoogeveen, L., van Hell, J., Mooij, T., & Verhoeven, L. (2004). *Educational arrangements for gifted children: Meta-analysis and overview of international research*. Nijmegen, The Netherlands: ITS/CBO/Orthopedagogiek, Radboud University.

- Kolata, S., Light, K., Grossman, H. C., Hale, G., & Matzel, L. D. (2007). Selective attention is a primary determinant of the relationship between working memory and general learning ability in outbred mice. *Learning and Memory*, 14, 22-28. doi:10.1101/lm.408507
- Kornilov, S. A., Tan, M., Elliott, J. G., Sternberg, R. J., & Grigorenko, E. L. (2011). Gifted identification with the Aurora: Widening the spotlight. *Journal of Psychoeducational Assessment*, 30, 117-133. doi:10.1177/0734282911428199
- Lubart, T., Pacteau, C., Jacquet, A. -Y., & Caroff, X. (2010). Children's creative potential: An empirical study of measurement issues. *Learning and Individual Differences*, 20, 388-392. doi:10.1016/j.lindif.2010.02.006
- Mackintosh, N. J. (2011). *IQ and human intelligence* (2nd ed). Oxford, England: Oxford University Press.
- McBee, M. T., Peters, S. J., & Waterman, C. (2014). Combining scores in multiple-criteria assessment Systems: The impact of combination rule. *Gifted Child Quarterly*, 58, 69-89. doi:10.1177/0016986213513794
- McClain, M. C., & Pfeiffer, S. I. (2012). Education for the gifted in the United States today: A look at state definitions, policies, and practices. *Journal of Applied School Psychology*, 28, 59-88. doi:10.1080/15377903.2012.643757
- McGrew, K. S. (1997). Analysis of the major intelligence batteries according to a proposed Gf-Gc framework. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (pp. 151-179). New York, NY: Guilford Press.
- Memmert, D. (2011). Creativity, expertise, and attention: Exploring their development and their relationships. *Journal of Sports Science*, 29, 93-102. doi:10.1080/02640414.2010.528014
- Mönks, F. J. (1992). Development of gifted children: The issue of identification and Programming. In F. J. Mönks, & W. A. M. Peters (Eds.), *Talent for the Future*. Assen/Maastricht, The Netherlands: Van Gorcum.
- Mooij, T., Hoogeveen, L., Driessen, G., Van Hell, J., & Verhoeven, L. (2007). *Succescondities voor onderwijs aan hoogbegaafde leerlingen: Eindverslag van drie deelonderzoeken* [Success conditions for the education of gifted pupils: Final report of three studies]. Nijmegen, The Netherlands: Radboud University, ITS / CBO / Learning and Plasticity.
- Mooij, T., & Feltelaar, D. (2010). *Naar Excellente scholen, leraren, leerlingen en studenten. [To excellent schools, teachers, pupils, and students]*. Nijmegen, The Netherlands: Radboud University, ITS.
- PIRLS (2006). *PIRLS 2006 assessment framework and specifications* (2nd ed.). Chestnut Hill, MA: Boston College.
- Paulus, P. B., & Brown, V. R. (2007). Toward more creative and innovative group idea generation: A cognitive-social-motivational perspective of brainstorming. *Social and Personality Psychology Compass*, 1, 248-265. doi:10.1111/j.1751-9004.2007.00006.x
- PISA (2009). *PISA 2009 assessment framework. Key competencies in reading, mathematics and science*. Paris, France: OECD.
- Renzulli, J. S. (1986). The three ring conception of giftedness: A developmental model for creative productivity. In R. J. Sternberg & J. E. Davidson (Eds.), *Conceptions of giftedness* (pp. 246-279). New York, NY: Cambridge University Press.
- Renzulli, J. S., & Reis, S. M. (2003). Conception of giftedness and its relation to the development of social capital. In N. Colangelo & G. A. Davis (Eds.), *Handbook of gifted education* (pp. 75-87). Boston, MA: Allyn & Bacon.
- Runco, M. A., & Jaeger, G. J. (2012). The Standard Definition of Creativity. *Creativity Research Journal*, 24, 92-96. doi:10.1080/10400419.2012.650092
- Segers, E., & Hoogeveen, L. (2012). *Programmeringsstudie Excellentieonderzoek in primair, voortgezet en hoger onderwijs* [Programming study on Excellence research in primary, secondary, and higher education]. Nijmegen, the Netherlands: Behavioural Science Institute and Centre for the Study of Giftedness.
- Shaw, E. L., & Giles, R. M. (2015). Using technology to teach gifted students in a heterogeneous classroom. In L. Lennex & K. Fletcher Nettleton, *Cases on instructional technology in gifted and talented education* (pp. 31-53). Hershey, PA: IGI Global. doi:10.4018/978-1-4666-6489-0
- Simonton, D. K. (2000). Creativity: Cognitive, personal, developmental, and social aspects. *American Psychologist*, 55, 151-158. doi:10.1037//0003 066X.55.1.151

- Spearman, C. (1904). General intelligence, objectively determined and measured. *American Journal of Psychology*, 15, 201-293. doi:10.2307/1412107
- Sternberg, R. J. (1985). *Beyond IQ: a triarchic theory of human intelligence*. Cambridge: Cambridge University press.
- Sternberg, R. J. (2009). The theory of successful intelligence. In J. C. Kaufman & E. L. Grigorenko (Eds.), *The essential Sternberg: Essays on intelligence, psychology, and education*. New York, NW: Springer Publishing Company.
- Sternberg, R. J. (2011). The theory of successful intelligence. In R. J. Sternberg & S. B. Kaufman (Eds.), *The Cambridge handbook of intelligence*. New York, NY: Cambridge University Press.
- Sternberg, R. J., & Clinkenbeard, P. R. (1995). The triarchic model applied to identifying, teaching, and assessing gifted children. *Roeper Review*, 17, 255-260. doi:10.1080/02783199509553677
- Sternberg, R. J., & Grigorenko, E. L. (2004). Successful intelligence in the classroom. *Theory Into Practice*, 43, 274-280. doi:10.1207/s15430421tip4304_5
- Sternberg, R. J., Torff, B., & Grigorenko, E. L. (1998). Teaching triarchically improves school achievements. *Journal of Educational Psychology*, 90, 374-384.
- Sternberg, R. J., Grigorenko, E. L., Ferrari, M., & Clinkenbeard, P. (1999). A triarchic analysis of an aptitude-treatment interaction. *European Journal of Psychological Assessment*, 15, 3-13. doi:10.1027//1015-5759.15.1.3
- Subotnik, R. F., Olszewski-Kubilius, P., & Worrel, F. C. (2011). Rethinking giftedness and gifted education: A proposed direction forward based on psychological science. *Psychological Science in the Public Interest*, 12, 3-54. doi:10.1177/1529100611418056
- Thomson, D. L. (2010). Beyond the classroom walls: Teachers' and students' perspectives on how online learning can meet the needs of gifted students. *Journal of Advanced Academics*, 21, 662-712. doi:10.1177/1932202X1002100405
- Thurstone, L. L. (1938). *Primary mental abilities*. Chicago, IL: University of Chicago Press.
- Valentine, J. C., DuBois, D. L., & Cooper, H. (2004). The relation between self-beliefs and academic achievement: A meta-analytic review. *Educational Psychologist*, 39, 111-133. doi:10.1207/s15326985ep3902_3
- Vernon, P. E. (1950). *The structure of human abilities*. London, England: Methuen.
- Worrell, F. (2009). Myth 4: A single test score or indicator tells us all we need to know about giftedness. *Gifted Child Quarterly*, 53, 242-244. doi:10.1177/0016986209346828
- Worrell, F. C., & Erwin, J. O. (2011). Best practices in identifying students for gifted and talented education programs. *Journal of Applied School Psychology*, 27, 319-340. doi:10.1080/15377903.2011.615817
- Wulff, C., Bergman, L. R., & Sverke, M. (2009). General mental ability and satisfaction with school and work: A longitudinal study from ages 13 to 48. *Journal of Applied Developmental Psychology*, 30, 398-408. doi:10.1016/j.appdev.2008.12.015
- Ziegler, A., Vialle, W., & Wimmer, B. (2013). *The actiotope model of giftedness: A short introduction to some central theoretical assumptions*. In S. N. Phillipson, H. Stoeger, & A. Ziegler (Eds.), *Exceptionality in East Asia* (pp. 1-17). London, England: Routledge.
- Ziegler, A., & Heller, A. (2000). Conceptions of giftedness form a meta-theoretical perspective. In K. A. Heller, F. J. Mönks, R. J. Sternberg, & R. F. Subotnik (Eds.), *International handbook of giftedness and talent* (2nd ed., pp. 3-21). Oxford, UK: Pergamon Press.

2

The Aurora Battery as an assessment of triarchic intellectual abilities in upper primary grades

This chapter is based on: Gubbels, J., Segers, E., Keuning, J., & Verhoeven, L. (2016). The Aurora Battery as an assessment of triarchic intellectual abilities in upper primary grades. *Gifted Child Quarterly*, 60, 226-238. doi: 10.1177/0016986216645406

Abstract

The theory of triarchic intelligence posits that, in addition to widely acknowledged analytical reasoning abilities, creative and practical abilities should be included in assessments of intellectual capacities and identification of gifted students. To find support for such an approach, the present study examined the psychometric properties of the Aurora-a Assessment Battery of triarchic abilities in the upper primary grades. In order to assess the dimensional structure of the Aurora-a Assessment Battery, we analyzed subtest scores of 499 primary school children. Correlation and factor analyses showed a poor fit between Aurora-a subtest scores and the theory of triarchic intelligence, indicating deficiencies in either the theory or in the design of the Aurora-a Battery. Researchers should sustain their current efforts to evaluate the validity of various theories of intelligence and develop theory-based assessment instruments.

Introduction

The most frequently used tools to assess cognitive abilities of children are standardized achievement and IQ tests (McClain & Pfeiffer, 2012). However, the majority of states in the United States of America require the use of a multiple criteria model to assess cognitive abilities of children (NAGC, 2015). This requirement is in line with the triarchic theory of intelligence, that states that assessments of cognitive abilities should address analytical, creative, and practical abilities (Sternberg, 2011; Sternberg & Grigorenko, 2002). The *a*-part of the Aurora Assessment Battery attempts to assess triarchic intellectual abilities in upper primary school children (Chart, Grigorenko, & Sternberg, 2008). Although the Aurora-*a* Battery is used in various U.S. states, as well as in European and Middle East countries (Tan et al., 2009), the triarchic structure is assumed and not thoroughly examined in previous studies. To date, it is unclear whether Aurora-*a* subtests indeed reflect the three types of intellectual abilities. Therefore, the present study examined whether the Aurora-*a* Battery can discriminate analytical, creative, and practical abilities in Dutch upper elementary school children.

Modeling intelligence

Cognitive abilities are at the foundation of most theories of intelligence ever since the introduction of a general intelligence factor (i.e., *g*-factor) by Spearman (1904). Current theories of intelligence, however, assume intelligence to comprise a broad range of cognitive aspects (Ziegler & Heller, 2000). The Cattell-Horn-Carroll Model of Intelligence (CHC-model; McGrew, 1997), for example, incorporates Cattell's theory on fluid and crystallized intelligence and Carroll's Three-Stratum Theory. The CHC-model proposes a number of broad abilities that are on the one hand related to general intelligence and on the other hand to a great variety of narrow abilities. In contrast, Guilford (1959) made a distinction between two types of intelligence: convergent and divergent thinking. Sternberg's theory of triarchic intelligence (2011) also emphasized the role of divergent thinking abilities next to analytical abilities, although he referred to it as creativity. In contrast to other theories of intelligence, however, the triarchic theory of intelligence assumed a third type of ability to be of equal importance: practical abilities.

Practical ability can be defined as "the ability to adapt to, shape, and select environments" (Sternberg et al., 2000, p. 1) so that these better align with an individual's needs, abilities, and desires. In contrast to the formal and declarative academic knowledge that is represented as analytical abilities, practical abilities involve the use of tacit and procedural knowledge. More specifically, analytical and creative abilities are used to come up with solutions for real-life problems, yet practical abilities involve implementation of these solutions in the context via strategies that are

often acquired implicitly. That is, strategies are learned without explicit instruction, and are therefore also referred to as tacit knowledge (Cianciolo et al., 2006).

The assessment of this third type of abilities calls for tacit knowledge tests or practical ability inventories (Cianciolo et al., 2006; Sternberg, 2011). In these kinds of tests, participants have to find a solution for common problem situations either in real-life tests or via paper-and-pencil assignments. As indicator for practical intellectual abilities, participants have to make a situational judgement by specifying the usefulness of various responses to these situations.

Assessment of intelligence: The Aurora Assessment Battery

Although instruments for the assessment of analytical, creative, or practical abilities are available, practical and creative assessment instruments are only limitedly used. A national survey of state policies and practices in the United States of America showed that potential cognitive abilities were often identified by standardized IQ test and achievement test scores (McClain & Pfeiffer, 2012). As a consequence, children with abilities that are not recognized by these traditional assessments are underrepresented in gifted programs, as well as minority children and children from low SES backgrounds (Chart et al., 2008). Assessment of a broader range of cognitive abilities might especially benefit minority and economically disadvantaged students (Stemler, Grigorenko, Jarvin, & Sternberg, 2006). The Aurora Assessment Battery (Chart et al., 2008) is designed to recognize children with analytical, creative, or practical talents so that a more diverse population of children gains access to gifted programs. Especially for triarchic enrichment programs, in which teachers provide analytical, creative, and practical assignments (e.g., Aljughaiman & Ayoub, 2012), insight in children's intellectual profiles might help them to align their teaching to the individual ability levels of the children.

The Aurora battery consists of two parts which are both group-administered paper-and-pencil-tests. The Aurora *a*-part is grounded in the theory of triarchic intelligence and comprises analytical, creative, and practical subtests. Subtests are balanced across a verbal, figural, and numerical domain to allow students to demonstrate multiple and varied types of abilities. Whereas a supplemental Aurora *g*-part assesses conventional *g*-factor cognitive abilities (Chart et al., 2008), our study was only concerned with the assessment of triarchic abilities with the Aurora-*a* part.

Thus far, only four studies have been conducted with regard to the psychometric qualities of the Aurora-*a* subtests. Only one of these studies, however, examined whether the underlying structure of the Aurora-*a* battery matched the triarchic theory of intelligence. In a first study, Kornilov, Tan, Elliott, Sternberg, and Grigorenko (2011) found Aurora-*a* subtest scores to be substantially and positively related to conventional English achievement tests (i.e., median $r = .50$ for MidYIS and median $r = .43$ for Key Stage 1 and 2). However, only 10 to 20 percent of children classified as gifted based

on achievement test scores were also classified as gifted based on their Aurora scores. Similarly, Mandelman, Barbot, Tan, and Grigorenko (2013) found classification agreement rates of 38.5 percent for analytical abilities, 15.1 percent for creative abilities, and 61.5 percent for practical abilities between the TerraNova test for academic achievement and the Aurora-a Battery. A study conducted by Mandelman, Tan, Kornilov, Sternberg, and Grigorenko (2010) examined the association between children's self-reports of triarchic abilities and their scores on analytical, practical, and creative subtests as examined with the Aurora-a. Their results showed statistically significant, yet small correlations between the two types of assessment of triarchic intellectual abilities. However, analytical self-concept scores were also statistically significant related to practical ability scores, as were practical self-concept and analytical ability scores. All three studies assumed the three factor structure to be present in this test battery without analyzing this a priori on an item or subtest level. Although reliability statistics on subscale levels suggested high internal consistency between items within the three ability and three domain subscales (Mandelman et al., 2010), it was not examined whether item scores indeed coherently added up to subtest scores.

In a fourth study, Aljughaiman and Ayoub (2012) attempted to check whether the data of the Aurora-a Battery reflected the triarchic structure. To do so, they calculated analytical, creative, and practical subtest scores. Moderate Cronbach's alpha values were reported for analytical ($\alpha = .71$) and creative abilities ($\alpha = .67$), as well as for practical abilities ($\alpha = .68$). However, such alpha values can be found in both unifactorial and multifactorial test batteries (Drenth & Sijtsma, 2006) and thus cannot be used as indicator of the underlying structure of a test. Next, Aljughaiman and Ayoub (2012) split the ability scores in verbal, figural, and numerical scores so that nine ability-domain subscale scores (e.g., analytical-verbal, analytical-numerical) were calculated. These nine subscale scores were included as dependent variables in a confirmatory factor analysis (CFA). Results showed high factor loadings (.64 to .85) for all nine ability-domain subscales. Based on these results, the authors concluded that Aurora-a Battery scores adequately fitted the theory of triarchic intelligence. However, this latter study has the methodological drawback that the CFA was performed on a combined subtests level. Combining scores like this is a form of subtest parceling, which reduces uniqueness of constituent subtests and inflates fit statistics in CFA's and SEM models (Bandalos, 2002; Sass & Smith, 2006).

Present study

To sum up, it is clear that even though the theory of triarchic intelligence is rich and full of potential for practical applications (Grigorenko, Jarvin, & Sternberg, 2002; Sternberg & Clinkenbeard, 1995), it needs more data to support the claims. To date, especially research on the assessment of triarchic abilities in primary school children

is rather limited. The Aurora-a Battery was developed to assess analytical, creative, and practical abilities in US elementary and middle school children (Chart et al., 2008). In three of the studies on the psychometric qualities of the Aurora-a Battery conducted so far, the underlying factor structure was assumed, but not examined. Moreover, no attempts have been made to examine whether item scores indeed coherently added up to subtest scores. In the only attempt to explore the underlying structure, Aljughaiman and Ayoub (2012) included combined subtest scores and not single subtest scores of children in Saudi Arabia. In the present study, we investigated the psychometric qualities of the Dutch version of the Aurora-a Battery. Because the Aurora was developed for American children, we started from item-level analysis to prevent biases due to differences in the cultural and linguistic environment of American and Dutch elementary school children. Next, we used correlational and factor analyses to examine the underlying triarchic structure of the Aurora-a Battery.

Method

Participants

In order to obtain a sample of 500 participants, we sent invitation letters to all primary schools located in three Dutch municipalities (i.e., Ede, Zeist, and Oss) in the central and south part of the Netherlands. Of these 86 schools, we invited the first six schools that agreed to participate in the present study. Subsequent schools were kindly informed that full participation had been accomplished and invited to participate in a follow-up study. Children attending the schools replying on our invitation mostly stemmed from high SES backgrounds. Because the number of children matched with our intentions, we did not approach the remaining schools.

Participants were 499 children from fourth (six classes, $n = 149$), fifth (six classes, $n = 195$), and sixth grade (six classes, $n = 155$). The average age of all participants was 11 years and one month and 48.1% were boys. Parents of all children provided consent for participation.

Materials

The Aurora-a Battery (Chart et al., 2008) comprises seventeen subtests divided over three domains (visual-spatial, verbal, and numerical) and three abilities (analytical, creative, and practical). Subtest names for all nine ability-domain combinations are presented in Table 1. The developers of the Aurora-a gave consent to translate the subtests into Dutch and provided us with all the necessary materials. For all subtests, the instructions were translated as strictly as possible. Except for the general instructions, the items of the visual and numerical subtests involved little or no language and were thus a one-to-one translation into Dutch. The translation of the verbal subtests was

more complex. Because the items concerned children's knowledge of certain linguistic or contextual characteristics, items had to be adapted to suit the level of knowledge of Dutch children. Any doubts with regard to the content and level of difficulty of the translated version were discussed with the developers, a consortium of international Aurora researchers, and Dutch primary school teachers. The verbal-practical subtest Headlines involved figurative language which is only incidentally used in Dutch. Because it was therefore problematic to maintain equivalencies with respect to meaning, psychometric construct, and item difficulty, the subtest was not translated into Dutch and not included in the present study.

Subtests' answering format were open-ended or multiple choice. The open-ended items required children to write down either an essay or a short-answer (i.e., one word or number). Coders polytomously rated 20% of the essays using the original Aurora-a Battery scoring manual. This manual provides extensive lists of examples of answers given by children together with their corresponding ratings. In order to get acquainted with the Aurora and its scoring manual, coders first rated data of a pilot study. Raters reviewed their ratings and discussed about ambiguities until the interrater correlations were .70 or higher. We again discussed any doubts with regard to the interpretation of criteria with the international consortium of Aurora researchers. Subsequently, multiple raters rated items for at least 90 children per subtest. Interrater correlations were high ($.72 \leq rs \leq .95$, $n \geq 30$, $ps = < .001$). The short open-ended answers were dichotomously scored ($0 = incorrect$; $1 = correct$), as were the multiple choice answers.

Table 1 The Subtests of the Aurora Divided Over the Three Intellectual Abilities and Domains

Domain	Ability		
	Analytical	Creative	Practical
Images	Boats (MC)	Book Covers(ES)	Toy Shadows (MC)
	Shapes (MC)	Multiple Uses (ES)	Paper Cutting (MC)
Words	Homophones (SA)	Conversations (ES)	Decisions (SA)
	Metaphors (ES)	Figuratives (MC)	Headlines (SA)*
Numbers	Letter Math (SA)	Cartoon Numbers (ES)	Money (SA)
	Algebra (SA)		Maps (SA)

Note. MC=Multiple Choice; SA= Short Answer; ES= Essay.

* = Subtest was not included in the present study.

The following six subtests from the Aurora-a Battery assessed children's analytical intellectual abilities:

1. *Boats*. This subtest presented 10 photographs displaying toy boats which were connected to each other with a cord. Boats could float around on the water, but stayed connected in the same way. Children had to choose out of four possible photographs which one displayed an impossible position of toy boats. Every correct answer rendered one point.
2. *Shapes*. This subtest assessed analytical abilities by presenting 10 figures of a broken shape with one piece missing. Children had to figure out which of four possible pieces would complete the broken shape, earning one point for every correct answer.
3. *Homophones*. This subtest consisted of two parts. In part A, children had to complete nine sentences by filling in two words sounding the same but having different meanings; for example, wear – where. In part B, children had to complete six sentences by filling in two words with reversed orders of strings; for example, desserts – stressed. Children earned one point for every correct pair of words. Because the words in this subtest had to be homophones, we could not include a translation of the English words, thus other words were included in the Dutch version.
4. *Metaphors*. In this subtest children had to finish nine metaphorical sentences by elaborating on the similarities between two objects. Raters coded the answers according to two criteria: (a) to what degree is the child able to think comparatively?, and (b) to what degree is the child able to identify common elements with clear, specific, and imaginative language? The mean percentage of agreement between raters was 72.5%.
5. *Letter Math*. This subtest presented five math problems, consisting of imaginative cards with a letter on one side and a number on the other. Children had to figure out which number should come on the back of the letter cards to correctly solve the math problem. A maximum of eleven points could be earned by replacing letters with the correct numbers.
6. *Algebra*. This subtest comprised five numerical story problems which had to be solved by careful reading and calculating. In some problems, more than one answer should be given, so that a total of eight points could be earned.

The following five subtests assessed creativity:

1. *Book Covers*. This subtest intended to measure creativity by presenting five images that had to be interpreted as book covers. Children had to write down, thereby expressing their creativity, what the imaginary books could be about. Raters coded their answers according to two criteria: (a) the degree to which the child conducted the task adequately, and (b) the degree to which the child created an original and substantial story accompanying the picture. The mean percentage of agreement between raters was 66.0%.

2. *Multiple Uses*. In this subtest children had to write down as many unusual uses of five common objects (e.g., chalkboard eraser and hammer) as they could make up. Coders rated (a) the degree to which the child expressed a clear list of multiple atypical uses, and (b) the degree to which answers were detailed and original. The mean percentage of agreement between raters was 77.4%.
3. *Conversations*. With this subtest, children had to write down conversations between two common objects (e.g., fork/knife and toothbrush/toothpaste). Coders rated (a) the degree to which the child expressed substantial dialogues, and (b) the degree to which a dialogue identified both characters in novel exchange. The mean percentage of agreement between raters was 74.8%.
4. *Figuratives*. This subtest comprised 12 sentences with a figurative element in it. Children had to choose out of four alternatives which would best fit within the story following the given sentence. Children earned one point for every correctly marked answer. In the Dutch version, we included Figuratives that we assumed upper primary school children to be familiar with.
5. *Cartoon Numbers*. In this subtest children had to write down a conversation between two numbers within seven given scenarios. Coders rated (a) the degree to which a social element was included, and (b) the degree to which responses incorporated both knowledge of numeric values and personification of numbers within a social situation. The mean percentage of agreement between raters was 72.5%.

The following five subtests assessed children's practical intellectual abilities:

1. *Toy Shadows*. This subtest presented eight photographs of a light shining on a toy placed in front of a screen. Children had to indicate which out of four photographs showed the exact shadow that would be projected on the screen. Every correct answer yielded one point.
2. *Paper Cutting*. Children saw 10 photographs of folded pieces of paper. In these photographs, an area was shaded to indicate which part should imaginatively be cut out. Children had to indicate which out of four photographs of cut-out, unfolded papers displayed the correct answer. Correct answers bore one point.
3. *Decisions*. This subtest presented three scenarios. Children had to designate whether statements were pro or con arguments for a decision within the scenario given. Irrelevant statements had to be left out. All correctly designated statements were worth one point so that a total of 17 points could be earned.
4. *Money*. This subtest consisted of five scenarios in which a number of persons had to divide a bill, thereby also taking into account debts from previous transactions. Children had to write down the expenses of 13 persons, bearing a maximum of 13 points.

5. *Maps*. In this subtest children had to draw a line showing the shortest route to the movie theatre for 10 items, thereby picking up a couple of friends from their homes along the route. Every fully correct route was worth two points, partly correct routes were worth one point.

Procedure

We group administered the Dutch version of the Aurora-a Battery to all children in the eighteen participating classrooms in multiple sessions. The order of subtests was randomly divided over either two or three test booklets. The 45 to 60 minutes sessions occurred in one or two days, dependent on the preferences of the teacher, always with a total of 120 minutes to complete the Aurora-a Battery.

Statistical analyses

We examined the structure of the Aurora-a Battery from two perspectives. First, we used test- and item analyses to evaluate the psychometric quality of the Aurora-a items and subtests. We computed the r_{it} -value for each item, and in addition, we estimated reliability statistics for each subtest. The r_{it} -value is the correlation between the item score and subtest score. Because r_{it} -values are inflated by item overlap, we corrected values by subtracting the item variance and replacing this with the best estimate of common variance (i.e., the squared multiple correlation). Negative r_{it} -values are indicative of poor item qualities and therefore problematic. Values between .00 and .19 indicate that the item does not discriminate well, values between .20 and .29 indicate sufficient discrimination, and values of .30 and above indicate good discrimination (Ebel & Frisbie, 1991). We estimated reliability in terms of the *greatest lower bound* (GLB) and Guttman's Lambda2 because these measures provide a weaker underestimation of the actual level of reliability than Cronbach's alpha (Sijtsma, 2009; Ten Berge & Sočan, 2004). Following guidelines suggested by Sijtsma, Lucassen, Meijer, and Evers, (2010), we considered reliability coefficients higher than .80 to be good and values below .70 to be insufficient.

Second, we calculated correlations between all Aurora-a subtests. In addition to the original correlations between subtests, we calculated disattenuated correlations (Osborne, 2003) in an attempt to be more realistic in our estimation of correlations. In the correction for attenuation, we used the GLB to get the most conservative estimation of the disattenuated correlation. Original correlations served as input for subsequent factor analyses.

We used a confirmatory factor analysis to examine whether the triarchic structure was present in the data regarding the sixteen Aurora-a subtests. Subtests were classified over three latent factors, corresponding with the three types of abilities as suggested by the theory of triarchic intelligence. We allowed factors to correlate because the theoretical model posits the three aspects of intelligence to be distinct,

but related abilities (Kornilov et al., 2011). We used guidelines by Hu and Bentler (1999) to evaluate the fit between the model and the data. Although these guidelines are not free from imperfections (e.g. Fan & Sivo, 2005), Bentler's comparative fit index (CFI) should exceed .95 in order for the model to accurately fit the data. The root mean square error of approximation (RMSEA) value should not exceed .06 as an indicator of discrepancies between observed and predicted covariances.

The test and item analyses were conducted using the R package 'psych' (Revelle, 2015) and LISREL version 9.1 (Jöreskog & Sörbom, 2012) was used to conduct the confirmatory factor analysis. Although the analyses are rather straightforward, missing data complicated the situation. The number of missing values ranged from one percent for Boats to 44 percent for Cartoon Numbers. The approach to handle the problem of missing data entailed the computation of Maximum Likelihood (ML) estimates of the mean vector and covariance matrix for the variables of interest (see, for example, Little & Rubin, 1987). The estimates were obtained using the Expectation-Maximization (EM) algorithm (Dempster, Laird, & Rubin, 1977). Application of the EM algorithm results in a mean vector and covariance matrix that is based on all collateral information available (Cudeck, 2000). The ML estimates of the means and covariances can directly be used in any multivariate analysis, but for practical reasons, we produced a single data set with imputed values based on the ML estimates. For each missing value, that is, the point estimate was filled in on the basis of the ML estimates of the means and covariances (see Truxillo, 2005). In order to use the EM algorithm, it was assumed that the data were multivariate normal and that the missingness was at random (MAR). Although simulations suggest the EM algorithm to be quite robust to violations of the multivariate normality assumption (e.g., Allison 2006; Enders, 2001; Graham & Schafer, 1999; Graham, Hofer, & MacKinnon, 1996), we checked the skewness and kurtosis of the score distributions. As can be seen from Table 2, almost all of the univariate distributions had a skew and kurtosis below +1.5 or above -1.5. This means that the distributions can be considered sufficiently close to normal (Tabachnick & Fidell, 2013; Kline, 2005; George & Mallery, 2010).

It is more difficult to check the MAR assumption. If there is no serious reason to assume non-randomness, erroneous assumption of MAR often has minor impact (Collins, Schafer, & Kam, 2001), but nevertheless we checked whether the subjects with missing values were different than the subjects without missing values. If we compare the means of the responders and non-responders on each subtest by conducting a series of *t*-tests and use the Bonferroni-Holm step-down procedure to adjust the *p*-values for multiple testing we see that in only a small 3 percent of the cases the two groups were significantly different from each other. This means that there is no reason to assume that the MAR assumption does not hold.

Results

Item analyses

Table 2 reports statistics with regard to the r_{it} -value, skewness, and kurtosis for all subtests. Because correlations have a skew distribution, the arithmetic mean of the item-total correlations of a subtest is not an appropriate reflection of the average correlation. Therefore, we first transformed r_{it} -values into Fisher's Z-values. Next, we calculated the mean of these transformed values and subsequently transformed these back to a mean r_{it} -value.

Table 2 Descriptive Statistics for the Item-Total Correlations

	r_{it}							Skewness	Kurtosis
	<i>M</i>	(SD)	Median	Min	Max	P10	P90	<i>M</i>	<i>M</i>
Boats	.57	(.12)	.58	.52	.61	.52	.61	-0.43	-0.76
Shapes	.39	(.07)	.41	.16	.55	.20	.51	-0.04	-0.45
Homophones	.45	(.09)	.44	.26	.61	.37	.54	0.70	0.22
Metaphors	.52	(.11)	.54	.35	.61	.41	.60	-0.58	0.39
Letter Math	.53	(.08)	.57	.33	.68	.33	.67	0.81	0.22
Algebra	.63	(.16)	.54	.37	.80	.43	.80	1.00	0.80
Book Covers	.74	(.26)	.72	.61	.82	.62	.81	0.10	-0.95
Multiple Uses	.56	(.12)	.55	.40	.70	.40	.69	0.17	-0.34
Conversations	.52	(.11)	.52	.36	.64	.39	.63	-1.07	1.79
Figuratives	.46	(.10)	.47	.30	.57	.35	.56	-0.93	0.15
Cartoon Numbers	.56	(.13)	.50	.31	.78	.39	.72	-0.03	-0.64
Toy Shadows	.49	(.09)	.50	.34	.57	.40	.55	-0.53	-0.39
Paper Cutting	.45	(.08)	.48	.11	.56	.32	.52	-0.40	-0.58
Decisions	.38	(.08)	.42	.06	.57	.14	.53	-1.50	3.20
Money	.54	(.12)	.49	.42	.71	.43	.70	0.20	-0.51
Maps	.40	(.07)	.41	.26	.46	.33	.46	-1.30	1.44

Note. P10 = 10th percentile score; P90 = 90th percentile score

Because the American Homophones and Figuratives subtests could not be used in Dutch children, new sentences had to be created in translating these subtests. One of the Dutch Homophones items was too complex for the 8-to-13 year old children participating in this study. This item involved the low-frequent word 'to stare' (in Dutch: *staren*) to be filled in the blanks, whereas the other Homophones items

involved high-frequent words (Dutch Word Frequency List, 2014). In addition, one Figuratives item showed low r_{it} -values. With 42 percent of children answering the item correctly, this item was not too difficult. However, the low r_{it} -value indicated that this item did not map into the same ability as the other items of this subtest. For both Paper Cutting and Toy Shadows, one item correlated very low with subtest total scores. For Paper Cutting, correctly answering that item required children to realize that the unfolded papers were held by a person. This was a crucial element, because the cut-out pieces of paper would fall down on the ground and would thus not be visible any longer. The discarded item of Toy Shadows did not differ with the other items in terms of content. However, one of the multiple choice alternatives resembled the correct answer too much so that a lot of children chose this incorrect alternative. Because of low item total correlations, we excluded five items of the subtest Decisions. Three of these items were irrelevant arguments that children should ignore when answering. Apparently, upper primary school children were not able to leave these irrelevant statements out. The other two excluded arguments were too ambiguous for the children to interpret. In total, we thus excluded nine items for further analyses.

Descriptive statistics and correlations

Table 3 shows reliability coefficients for all Aurora-a subtests. The reliability coefficient for the analytical subtest Shapes was low ($GLB = .39$; $\lambda_2 = .42$). This low reliability could be due to a high level of difficulty of some of the items. For four out of ten items, performances were below or at chance level. We excluded the subtest Shapes from further analyses. Reliability coefficients for the other Aurora-a subtests were acceptable to good.

Table 3 furthermore presents descriptive statistics for fourth, fifth, and sixth-grade children separately. The percentage of missings ranged from 44% (*Cartoon Numbers*) to 1% (*Boats*). The percentage of missings was highest in creative subtests. We expect this to be due to the unusual format of these subtests. Especially for Cartoon Numbers, the assignment involved the unusual situation of numbers involved in a social context. In the Netherlands, however, arithmetic is taught according to the idea that mathematics must be connected to reality, stay close to children's experience, and be relevant to society (Van den Heuvel, 2000). The Cartoon Numbers subtests might have differed too much from this format for children to answer the questions. Because a previous study showed ceiling effects in some of the Dutch subtests (Gubbels, Segers, & Verhoeven, 2014), we performed further frequency analyses. According to Terwee and colleagues (2007), a ceiling effect is present if more than 15% of all respondents achieved the highest possible score. Frequency analyses on the 15 Aurora subtests showed ceiling effects for the subtests *Decisions*, *Toy Shadows* and *Boats*, with respectively 29.7%, 27.0%, and 16.5% of all children achieving the highest possible score.

Table 3 Descriptive Statistics of the Aurora Subtests

	GLB	λ_2	Range	4			5			6		
				n	M	(SD)	n	M	(SD)	n	M	(SD)
Analytical Subtests												
Boats	.75	.70	0-10	148	5.77	(2.83)	194	6.85	(2.96)	153	7.05	(2.30)
Shapes*	.39	.41	0-10	147	3.87	(1.68)	194	4.15	(1.68)	153	4.41	(1.86)
Homophones	.81	.73	0-15	83	2.99	(2.05)	155	4.21	(2.47)	133	5.62	(2.84)
Metaphors	.80	.74	0-56	85	22.82	(7.95)	122	23.94	(8.36)	110	27.67	(6.82)
Letter Math	.91	.79	0-11	108	3.76	(2.28)	152	4.47	(2.44)	121	5.02	(2.75)
Algebra	.82	.76	0- 8	125	2.76	(1.63)	145	3.21	(1.78)	143	3.81	(2.04)
Creative Subtests												
Book Covers	.89	.86	0-30	144	16.94	(6.46)	165	17.47	(5.84)	139	17.47	(5.72)
Multiple Uses	.77	.74	0-30	132	13.66	(4.20)	164	14.66	(4.50)	142	15.63	(3.92)
Conversations	.88	.82	0-60	91	30.59	(9.28)	124	34.35	(8.38)	120	36.86	(7.54)
Figuratives	.68	.69	0-12	128	6.95	(3.15)	172	8.22	(2.71)	139	9.16	(2.54)
Cartoon Numbers	.86	.76	0-42	65	16.84	(6.77)	85	15.91	(6.00)	127	15.74	(6.45)
Practical Subtests												
Toy Shadows	.54	.54	0- 8	144	4.78	(1.70)	187	5.42	(1.84)	152	5.41	(1.78)
Paper Cutting	.58	.59	0-10	149	5.40	(2.13)	190	6.12	(1.88)	153	6.50	(1.96)
Decisions	.75	.61	0-17	87	11.38	(2.66)	127	12.09	(2.23)	122	12.90	(1.61)
Money	.90	.82	0-13	81	3.64	(2.68)	105	4.93	(2.79)	120	6.47	(3.11)
Maps	.75	.68	0-20	127	14.33	(3.82)	163	15.12	(4.14)	152	16.51	(2.80)

Note. λ_2 = Guttman's lambda2
* We excluded the analytical subtest Shapes from analyses due to the low GLB.

Table 4 presents Pearson's correlations and disattenuated correlations between Aurora-a subtests. Based on the theory of triarchic intelligence, we expected substantial correlations between subtests within the three ability-domains. Generally, correlations coefficients between Aurora-a subtests were however low, $\bar{r} = .23$, as were correlations between subtests designed to assess the same type of ability ($\bar{r} = .27$ for analytical abilities, $\bar{r} = .19$ for creative abilities, and $\bar{r} = .26$ for practical abilities). Similarly, disattenuated correlation coefficients between analytical ($\bar{r} = .28$), creative ($\bar{r} = .16$), and practical subtests ($\bar{r} = .26$) were also low to moderate. In addition, correlations between subtests within the same domain were also low: $\bar{r} = .22$ for subtests in the verbal, $\bar{r} = .27$ in the numerical domain, and $\bar{r} = .26$ in the spatial domain.

Factor analyses

A confirmatory factor analysis with three factors with LISREL (version 9.1) yielded an inadequate model fit (see Table 5). Figure 1 shows the standardized pattern coefficients for the 15 subtests. Standardized path coefficients ranged from .31 to .64 (mean = .54) for the analytical, .14 to .68 (mean = .38) for the creative, and .39 to .60 (mean = .51) for the practical subtests. Moreover, the figure shows that the correlation between the latent factors comprising analytical and practical subtests was 1.00. In addition, the creative factor also correlated substantially with the analytical ($r = .83$) and the practical factor ($r = .79$). Results of the CFA furthermore showed high levels of error variance for all subtests. Altogether, results of the CFA indicated that the model based on Aurora-a subtest scores deviated substantially from the suggested triarchic model.

In order to further explicate the underlying structure of the data, we next examined the fit for a two-factor model. In light of the high correlation between the analytical and practical factor in the three-factor model, we combined analytical and practical subtests into one factor. Again, the analytical and creative latent factor correlated substantially ($r = .81$). The fitted two-factor model showed standardized path coefficients ranging from .30 to .64 (mean = .52) for the analytical/practical factor. For the creative factor, standardized path coefficients ranged from .14 to .68 (mean = .38). Finally, we examined the fit for a single-factor model. Standardized path coefficients now ranged from .10 to .64 (mean = .46), with lowest standardized path coefficients found for the creative subtests. The goodness of fit statistics showed that both the two-factor model and the single-factor model did not adequately fit the data (see Table 5).

A chi-squared difference test in which the three- and two-factor models were compared to the single-factor model revealed a significant improvement in fit for both models (see Table 5). However, the goodness of fit statistics did not substantially differ for the three models. In addition, results for the three factor-model indicated very large overlap between the analytical and practical factor. Although a high

Table 4 Correlations^a and Disattenuated Correlations^b Between the Aurora Subtests

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 Boats		.302	.310	.290	.017	.132	.135	.133	.272	-.100	.399	.266	.187	.430	.426
2 Homophones	.343		.366	.359	.219	.188	.271	.173	.393	.062	.333	.167	.204	.311	.233
3 Algebra	.362	.363		.520	.159	.201	.216	.179	.346	.045	.328	.194	.316	.319	.378
4 Letter Math	.316	.326	.556		.180	.054	.146	.201	.326	-.041	.390	.256	.328	.349	.307
5 Metaphors	-.042	.135	.103	.116		.188	.316	.305	.279	.059	.140	.167	.202	.193	.018
6 Book Covers	.159	.227	.236	.054	.225		.215	.074	.177	.204	.202	-.033	.099	.212	.110
7 Multiple Uses	.141	.266	.215	.111	.342	.259		.277	.308	.028	.158	.093	.141	.083	.121
8 Conversations	.113	.069	.126	.139	.273	.079	.277		.157	.035	.127	.151	.235	.062	.174
9 Figuratives	.335	.410	.383	.328	.266	.230	.359	.079		.114	.354	.143	.371	.305	.313
10 Cartoon Numbers	-.110	.124	.082	-.021	.109	.237	.058	.075	.196		.070	.005	.164	.173	.042
11 Paper Cutting	.584	.424	.430	.495	.132	.281	.189	.106	.510	.123		.309	.140	.340	.288
12 Toy Shadows	.385	.153	.228	.306	.173	-.056	.085	.142	.143	.032	.510		.184	.277	.198
13 Decisions	.199	.119	.325	.317	.147	.117	.108	.188	.420	.252	.136	.209		.223	.186
14 Money	.501	.276	.315	.329	.143	.239	.037	-.023	.310	.230	.430	.345	.188		.426
15 Maps	.548	.223	.441	.325	-.060	.132	.111	.150	.378	.075	.400	.263	.179	.485	

Note. $rs \leq -.09$ and $rs \geq .09$ are significant.
^a Pearson correlations are presented above the diagonal; ^b Disattenuated correlations are presented below the diagonal.

Table 5 Goodness of Fit Statistics for the CFA Models

	χ^2	df	p	CFI	RMSEA	90% CI for RMSEA	Model comparisons ^a		
							$\Delta\chi^2$	Δdf	p
Single-factor model	453.82	90	< .001	.88	.09	[.08, .10]			
Two-factor model	436.67	89	< .001	.88	.09	[.08, .10]	17.15	1	< .001
Three-factor model	436.07	87	< .001	.88	.09	[.08, .10]	17.75	3	< .001
Adapted two-factor model	325.81	85	< .001	.92	.08	[.07, .08]	128.01	5	< .001

Note. CFI = Comparative fit index; RMSEA = Root mean square error of approximation.

^a Models are compared to the single factor model.

correlation between the analytical/practical factor and creative factor was found in the two-factor model as well, the low factor loadings for the creative subtests in the single-factor model seem to indicate that there might be a second factor involved. Therefore, we inspected modification indices of the two-factor model's factor loadings and changed the parameters if they resulted in a considerable improvement in fit. The model fit of the adapted two-factor model presented in Figure 2 improved, although still not adequately fitted the data (see Table 5). The correlation between the analytical/practical and creative factor was .42. With regard to subtests' factor loadings, the originally analytical subtest Metaphors was found to load more strongly on the creative factor. In addition, the subtests Homophones, Decisions, Book Covers, and Figuratives loaded both on the creative and the analytical factor.

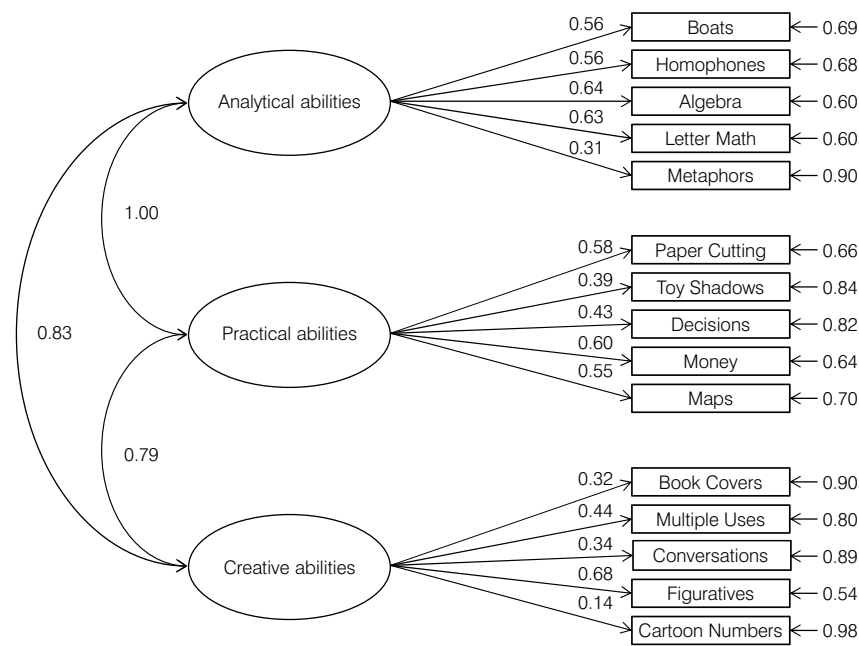


Figure 1 Standardized path coefficients for the 15 Aurora-a subtests in the three-factor triarchic model

Discussion

The aim of the present study was to investigate whether triarchic intellectual abilities can be discriminated in upper primary school children using the paper-and-pencil test of the Aurora-a Battery. Low correlations between subtests indicated that the categorization of subtests did not correspond with the original classification of analytical, creative, and practical abilities. In addition, correlations between subtests within the verbal, numerical, and spatial domains were also low. The only earlier study that addressed the structure of the Aurora-a with a CFA found an excellent fit between Aurora-a data and the model of triarchic intelligence (Aljughaiman & Ayoub, 2012). In addition, they found high factor loadings for all combined ability-domain subscales. In contrast, we performed the CFA on a subtest level and did not find support for a triarchic factor structure in the Dutch version of the Aurora-a. An adapted model with an analytical/practical and creative factor fitted the data best. An explanation for these results might be found in either the underlying theory of triarchic intelligence, or the design and adaptation of the subtests.

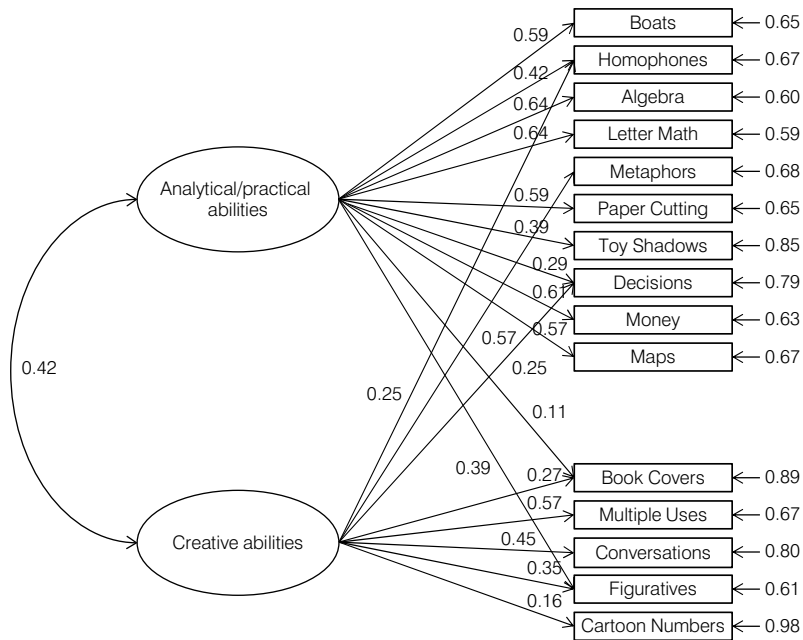


Figure 2 Standardized path coefficients for the 15 Aurora-a subtests in the adapted two-factor model

First, results of the three factor model indicated a very high correlation between the analytical and practical factor. In addition, creativity factor scores also correlated substantially with analytical and practical factor scores in both the three- as the two-factor model. The high correlations between factors might be due to our sampling procedure. Our research sample mainly comprised children from high SES backgrounds. Previous research has, however, shown that especially minority and economically disadvantaged students profit from assessment batteries addressing a broad range of cognitive skills (Stemler, Grigorenko, Jarvin, & Sternberg, 2006). In a study sample with children from more diverse backgrounds, the Aurora-a might thus be found to differentiate the three types of abilities more strongly than in the current sample. However, the extremely high correlation between the three latent factors might also indicate that the theory of triarchic intelligence is flawed. Although triarchic theory considers practical abilities as essential as analytical and creative abilities, we did not find any evidence for the first type of abilities.

After some adaptations were made based on modification indices, the model fit of a two-factor model was better than that of the three-factor model, yet still inaccurate.

The substantial factor loadings found for analytical and creative subtests were supportive of Guilford's (1959) distinction between convergent and divergent thinking. This distinction is also acknowledged in many of the more recent models of intelligence and giftedness. In the CHC-model of intelligence (McGrew, 1997), for example, some of the narrow abilities in the long-term storage and retrieval component are related to divergent thinking abilities. Similarly, the Differentiated Model of Giftedness and Talent by Gagné (2004) considers creativity and intellectual abilities as two types of natural abilities or gifts. The models by Renzulli (1986) and Mönks and Van Boxtel (1985), on the other hand, include creativity and intellectual abilities as distinct, yet associated determinants in reaching gifted levels of performance. Although the terminology and exact role of both types of abilities varies over theories, most theories acknowledge both analytical and creative abilities to play a role in the intellectual development of children. The role of practical abilities is, however, less evidenced and not supported in the present study.

With regard to the design of the subtests, the type of assessment might diverge from the targeted ability. Researchers often use tasks in which children have to find as many responses as possible in a limited time as an assessment of children's creative abilities (Lubart, Pacteau, Jacquet, & Caroff, 2010). In our results, substantial correlations were found between Aurora-a subtests that resembled these divergent thinking tasks. With the *Multiple Uses* subtests, children had to write down as many applications of common objects as they could think of. Similarly, the subtests *Metaphors* and *Conversations* required children to find as many similarities and conversational expressions respectively. Although *Metaphors* originally belonged to the analytical domain, these subtest strongly resembled the Unusual Uses subtest from the Torrance Test of Creative Thinking which was designed to assess creative abilities (Sternberg, 1998). Practical abilities, on the other hand, can be assessed with either tacit-knowledge tests or practical ability inventories. In previous studies using these inventories, both Heng (2000) and Cianciolo and colleagues (2006) found an overlap between general academic abilities and practical abilities. Of the practical subtests, *Toy Shadows* and *Decisions* were the only subtests that partly matched the tacit-knowledge format of judgement of real-life situations. With regard to *Paper Cutting*, a similar subtest is included in the well-established Stanford-Binet Intelligence Scales (Terman & Merrill, 1960) as an assessment of abstract visual reasoning. The design of the practical subtests might thus have resembled general intelligence test formats too much to discriminate between the two types of abilities.

As a final point for discussion, it should be noted that there was little room to improve for some children. High subtests scores were found earlier in a Dutch sample of gifted upper primary school children (Gubbels et al., 2014, see Chapter 6). The present study amplifies these findings, showing maximum scores in number of children in a more heterogeneous sample including 10-to-12 year old children of all

intelligence levels. None of the earlier studies evaluating the Aurora-a Battery reported descriptive statistics, so that it is unclear how children in other countries scored on the seventeen Aurora-a subtests. Further research is needed to examine the presence of ceiling effects in other than Dutch children and the role of cultural differences herein.

Limitations

The present study has some limitations. First, the current study addressed scores of a Dutch translation of the Aurora-a. Although we tried to translate subtests as strictly as possible, we cannot be sure that the Dutch version was similar to the original version or the Arabic version used by Aljughaiman and Ayoub (2012) with respect to meaning and psychometric qualities. In addition, cultural differences between Dutch and Arabic children might limit the comparability of both studies. Secondly, we did not take into account individual variation in ability profiles. A study by Kornilov and colleagues (2011) demonstrated that some individuals show rather flat intelligence patterns with no apparent strengths or weaknesses, whereas others clearly excel in one of the abilities. In addition, Lohman, Gambrell, and Lakin (2008) showed that high-ability children show extreme discrepancies in abilities more often than average ability children. Thirdly, we did not include any school achievement tests, so that the association between intellectual abilities and academic performance cannot be elucidated. Moreover, data were cross-sectional so that conclusions on the development of intellectual abilities over ages could not be drawn. The development of these abilities and its relation to school achievements could be addressed in future research using a longitudinal design.

Conclusion

To conclude, results from the present study showed that the Dutch version of the Aurora-a Battery did not accurately represent the underlying theory of triarchic intelligence, yet did differentiate analytical/practical and creative ability scores. These findings might either indicate deficiencies in the triarchic theory or in the design of the Aurora-a Battery. Researchers should sustain their current efforts to evaluate the validity of various theories of intelligence and develop theory-based assessment instruments.

References

- Aljughaiman, A. M., & Ayoub, A. E. A. (2012). The effect of an enrichment program on developing analytical, creative, and practical abilities of elementary gifted students. *Journal for the Education of the Gifted*, 35, 153-174. doi:10.1177/0162353212440616
- Allison, P. D. (2006). Multiple imputation of categorical variables under the multivariate normal model. Paper presented at the annual meeting of the American Sociological Association, Montreal Convention Center, Montreal, Canada, August 11, 2006.
- Bandalos, D. L. (2002). The effects of item parceling on goodness-of-fit and parameter estimates bias in structural equation modeling. *Structural Equation Modeling*, 9, 78-102. doi:10.1207/S15328007SEM0901_5
- Chart, H., Grigorenko, E., & Sternberg, R. J. (2008). Identification: The Aurora Battery. In J. A. Plucker & C. M. Callahan (Eds.), *Critical issues and practices in gifted education* (pp. 281-301). Waco, TX: Prufrock Press.
- Cianciolo, A. T., Grigorenko, E. L., Jarvin, L., Gil, G., Drebot, M. E., & Sternberg, R. J. (2006). Practical intelligence and tacit knowledge: Advancements in the measurement of developing expertise. *Learning and Individual Differences*, 16, 235-253. doi:10.1016/j.lindif.2006.04.002
- Collins, L. M., Schafer, J. L., & Kam, C. A. (2001). Comparison of inclusive and restrictive strategies in modern missing data procedures. *Psychological Methods*, 6, 330-351. doi:10.1037/1082-989X.6.4.330
- Cudeck, R. (2000). Exploratory factor analysis. In H. E. A. Tinsley & S. D. Brown (Eds.), *Handbook of applied multivariate statistics and mathematical modeling* (pp. 265-296). San Diego, CA: Academic Press.
- Dempster, A. P., Laird, N. M., & Rubin, D. B. (1977). Maximum likelihood from incomplete data via the EM algorithm. *Journal of the Royal Statistical Society, Series B*, 39, 1-38. doi:10.2307/2984875
- Drenth, P. J. D., & Sijsma, K. (2006). *Testtheorie: Inleidng in the theorie* [Test theory: introduction to the theory]. Houten, The Netherlands: Bohm, Stafleu, van Loghum.
- Dutch Word Frequency List (2014, October). Wortschatz – University of Leipzig. Retrieved October 28 2014, from <http://wortschatz.uni-leipzig.de/Papers/top10000nl.txt>.
- Ebel, R. L., & Frisbie, D. A. (1991). *Essentials of educational measurement* (5th ed.). Englewood Cliffs, NY: Prentice Hall.
- Enders, C. K. (2001). A primer on maximum likelihood algorithms available for use with missing data. *Structural Equation Modeling*, 8, 128-14. doi:10.1207/S15328007SEM0801_7
- Fan, X., & Sivo, S. A. (2005). Sensitivity of fit indexes to misspecified structural or measurement model components: Rationale of two-index strategy revisited. *Structural Equation Modeling: A Multidisciplinary Journal*, 12, 343-367. doi:10.1207/s15328007sem1203_1
- Gagné, F. (2004). Transforming gifts into talents: The DMGT as a developmental theory. *High Ability Studies*, 15, 119-147. doi:10.1080/1359813042000314682
- George, D. & Mallery, M. (2010). *Using SPSS for Windows step by step: A simple guide and reference*. Boston, MA: Allyn & Bacon.
- Graham, J. W., Hofer, S. M., & MacKinnon, D. P. (1996). Maximizing the usefulness of data obtained with planned missing value patterns: An application of maximum likelihood procedures. *Multivariate Behavioral Research*, 31, 197-218. doi:10.1207/s15327906mbr3102_3
- Graham, J. W., & Schafer, J. L. (1999). On the performance of multiple imputation for multivariate data with small sample size. In R. Hoyle (Ed.), *Statistical strategies for small sample research* (pp. 1 – 29). Thousand Oaks, CA: Sage.
- Grigorenko, E. L., Jarvin, L., & Sternberg, R. J. (2002). School-based tests of the triarchic theory of intelligence: Three settings, three samples, three syllabi. *Contemporary Educational Psychology*, 27, 167-208. doi:10.1006/ceps.2001.1087
- Gubbels, J., Segers, E., & Verhoeven, L. (2014). Cognitive, socio-emotional and attitudinal effects of a triarchic enrichment program for gifted children. *Journal for the Education of the Gifted*, 37, 378-397. doi:10.1177/0162353214552565
- Guilford, J. P. (1959). Three faces of intelligent. *American Psychologist*, 14, 469-479. doi:10.1037/h0046827
- Heller, K. A., Perleth, C., & Lim, T. K. (2005). The Munich Model of Giftedness designed to identify and promote gifted students. In R. J. Sternberg & J. E. Davidson (Eds.), *Conceptions of giftedness* (2nd ed., pp. 147-170). New York, NY: Cambridge University Press.

- Heng, M. A. (2000). Scrutinizing common sense: The role of practical intelligence in intellectual giftedness. *Gifted Child Quarterly*, 44, 171-181. doi:10.1177/001698620004400303
- Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6, 1-55. doi:10.1080/10705519909540118
- Jöreskog, K. G., & Sörbom, D. (2012). *LISREL 9.10 for Windows [Computer software]*. Skokie, IL: Scientific Software International, Inc.
- Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd Ed.). New York, NY: The Guilford Press.
- Kornilov, S. A., Tan, M., Elliott, J. G., Sternberg, R. J., & Grigorenko, E. L. (2011). Gifted identification with the Aurora: Widening the spotlight. *Journal of Psychoeducational Assessment*, 30, 117-133. doi:10.1177/0734282911428199
- Little, R. J. A., & Rubin, D. B. (1987). *Statistical analysis with missing data*. New York, NY: John Wiley & Sons.
- Lohman, D. F., Gambrell, J., & Lakin, J. (2008). The commonality of extreme discrepancies in the ability profiles of academically gifted students. *Psychology Science Quarterly*, 50, 269-282.
- Lubart, T., Pachteau, C., Jacquet, A. Y., & Caroff, X. (2010). Children's creative potential: An empirical study of measurement issues. *Learning and Individual Differences*, 20, 388-392. doi:10.1016/j.lindif.2010.02.006
- Mandelman, S. D., Barbot, B., Tan, M., & Grigorenko, E. L. (2013). Addressing the 'quiet crisis': Gifted identification with Aurora. *Educational & Child Psychology*, 30, 101-109.
- Mandelman, S. D., Tan, M., Kornilov, S. A., Sternberg, R. J., & Grigorenko, E. L. (2010). The metacognitive component of academic self-concept: The development of a triarchic self-scale. *Journal of Cognitive Education and Psychology*, 9, 73-86. doi:10.1891/1945-8959.9.1.73
- McClain, M. C., & Pfeiffer, S. I. (2012). Education for the gifted in the United States today: A look at state definitions, policies, and practices. *Journal of Applied School Psychology*, 28, 59-88. doi:10.1080/15377903.2012.643757
- McGrew, K. S. (1997). Analysis of the major intelligence batteries according to a proposed comprehensive Gf-Gc framework. In D. P. Flanagan, J. L. Genshaft, & P. L. Harrison (Eds.), *Contemporary intellectual assessment* (pp. 151-179). New York, NY: Guilford Press.
- Mönks, F. J., & van Boxtel, H. W. (1985). Gifted adolescents: A developmental perspective. In Freeman, J. (ed.), *The psychology of gifted children*. New York, NY: John Wiley & Sons Ltd.
- National Association for Gifted Children & Council of State Directors of Programs for the Gifted (2015). 2014-2015 State of the states in gifted education: Policy and practice data. Washington, DC: NACG.
- Osborne, J. W. (2003). Effect sizes and the disattenuation of correlation and regression coefficients: Lessons from educational psychology. *Practical Assessment, Research and Evaluation*, 8. Retrieved October 30, 2014 from <http://PAREonline.net/getvn.asp?v=8&n=11>
- Renzulli, J. S. (1986). The three ring conception of giftedness: A developmental model for creative productivity. In R. J. Sternberg & J. E. Davidson (Eds.), *Conceptions of giftedness* (pp. 246-279). New York, NY: Cambridge University Press.
- Revelle, W. (2015) psych: Procedures for Personality and Psychological Research, Northwestern University, Evanston, Illinois, USA, <http://CRAN.R-project.org/package=psych> Version = 1.5.1.
- Sas, D. A., & Smith, P. L. (2006). The effects of parceling unidimensional scales on structural parameter estimates in structural equation modeling. *Structural Equation Modeling*, 13, 566-586. doi: 10.1207/s15328007sem1304_4
- Sijsma, K. (2009). On the use, the misuse, and the very limited usefulness of Cronbach's alpha. *Psychometrika*. doi:10.1007/s11336-008-9101-0
- Sijsma, K., Lucassen, W., Meijer, R. R., & Evers, A. V. A. M. (2010). The Dutch review process for evaluating the quality of psychological tests: History, procedure and results. *International Journal of Testing*, 10, 295-317. doi:10.1080/15305058.2010.518325
- Spearman, C. (1904). General intelligence, objectively determined and measured. *American Journal of Psychology*, 15, 201-293. doi:10.2307/1412107
- Stemler, S. E., Grigorenko, E. L., Jarvin, L., & Sternberg, R. J. (2006). Using the theory of successful intelligence as a basis for augmenting AP exams in psychology and statistics. *Contemporary Educational Psychology*, 31, 344-376. doi:10.1016/j.cedpsych.2005.11.001

- Sternberg, R. J. (1998). Principles of teaching for successful intelligence. *Educational Psychologist*, 33, 65-72. doi:10.1080-00461520.1998.9653291
- Sternberg, R. J. (2011). The theory of successful intelligence. In R. J. Sternberg & S. B. Kaufman (Eds.), *The Cambridge handbook of intelligence*. New York, NY: Cambridge University Press.
- Sternberg, R. J., & Clinkenbeard, P. R. (1995). The triarchic model applied to identifying, teaching, and assessing gifted children. *Roeper Review*, 17, 255-260. doi:10.1080/02783199509553677
- Sternberg, R. J., Forsythe, G. B., Hedlund, J., Horvath, J. A., Wagner, R. K., Williams, W. M., Snook, S. A., & Grigorenko, E. L. (2000). *Practical intelligence in everyday life*. New York, NY: Cambridge University Press.
- Sternberg, R. J. & Grigorenko, E. L. (2002). The theory of successful intelligence as a basis for gifted education. *Gifted Child Quarterly*, 46, 265-277. doi:10.1177/001698620204600403
- Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Boston, MA: Pearson.
- Tan, M., Aljughaiman, A. M., Elliott, J. G., Kornilov, S. A., Ferrando-Prieto, M., Bolden, D. S., ... Grigorenko, E. L. (2009). Considering language, culture, and cognitive abilities: The international translation and adaptation of the Aurora Assessment Battery. In E. L. Grigorenko (Ed.), *Multicultural psychoeducational assessment* (pp. 443–468). New York, NY: Springer.
- Ten Berge, J. M. F., & So an, G. (2004). The greatest lower bound to the reliability of a test and the hypothesis of unidimensionality. *Psychometrika*, 69, 613-625. doi:10.1007/bf02289858
- Terman, L. M., & Merrill, M. A. (1960). *Stanford-Binet intelligence scale: Manual for the third revision*. Oxford, England: Houghton Mifflin.
- Terwee, C. B., Bot, S. D. M., de Boer, M. R., van der Windt, D. A. W. M., Knol, D. L., Dekker, J., . . . de Vet, H. C. W. (2007). Quality criteria were proposed for measurement properties of health status questionnaires. *Journal of Clinical Epidemiology*, 60, 34-42. doi:10.1016/j.jclinepi.2006.03.012
- Truxillo, C. (2005). Maximum Likelihood parameter estimation with incomplete data. *Proceedings of the thirtieth annual SAS users group international conference*, 30, 111-30.
- Van den Heuvel, M. (2000). Mathematics education in the Netherlands: A guided tour. *Freudenthal Institute Cd-rom for ICME9*. Utrecht, The Netherlands: Utrecht University.
- Ziegler, A., & Heller, K. A. (2000). Conceptions of giftedness from a meta-theoretical perspective. In K. A. Heller, F. J. Mönks, R. J. Sternberg, & R. F. Subotnik (Eds.), *International handbook of giftedness and talent* (2nd ed., pp. 3-21). Oxford, England: Pergamon.

3

How children's intellectual profiles relate to their cognitive, social-emotional, and academic functioning

This chapter is based on: Gubbels, J., Segers, E., & Verhoeven, L. (resubmitted). How children's intellectual profiles relate to their cognitive, socio-emotional, and academic functioning.

Abstract

Intellectual abilities are consistently found to be associated to child functioning. To date, however, it is unclear how varying intellectual profiles relate to differential aspects of child functioning. We screened 513 fifth-grade children on their intellectual abilities and distinguished a subsample of four groups: normally-achieving ($n = 152$), analytically-gifted ($n = 14$), creatively-gifted ($n = 18$), and analytically-creatively gifted ($n = 13$). We examined how these four groups differed in cognitive, socio-emotional, and academic aspects of child functioning. Results showed cognitive, socio-emotional, and academic benefits for the analytically-creatively gifted children when compared to the normally-achieving children. In addition, analytically-gifted and creatively-gifted children showed equal levels of cognitive, socio-emotional, and academic functioning as the normally-achieving children. A combination of high analytical and creative abilities thus seemed to lead to enhanced functioning in all three domains.

Introduction

Ever since the introduction of a general intelligence factor (i.e., *g*-factor) by Spearman (1904), IQ is at the foundation of most theories of giftedness. As a consequence, children's levels of intellectual abilities are still most commonly assessed with IQ-tests (McClain & Pfeiffer, 2012). Next to the largely analytical abilities assessed in IQ-tests, most theories agree that creative abilities are an important additional aspect of intelligence (Ziegler, & Heller, 2000). Moreover, the theory of triarchic intelligence adds practical abilities as a third aspect in perspective of successful child functioning. Previous research has shown that a great variation in intellectual profiles exists (Kornilov, Tan, Elliott, Sternberg, & Grigorenko, 2011; Sternberg, Grigorenko, Ferrari, & Clinkenbeard, 1999). It is, however, unclear how differences in intellectual profiles relate to differential aspects of child functioning in school settings. The present study examined differences in cognitive, socio-emotional, and academic child functioning in upper primary school children with varying types of intellectual profiles.

Intelligence as a multidimensional construct

Although the multidimensionality of the construct of intelligence is increasingly emphasized in theoretical models (Dai, 2010), researchers still commonly use standardized IQ-tests to assess children's general level of intelligence (McClain & Pfeiffer, 2012; Sternberg & Clinkenbeard, 1995). These general, mostly convergent intellectual abilities are assumed to be related to children's cognitive (Cohen & Sandberg, 1977; Miller & Vernon, 1993) and academic development (Laidra, Pullmann, & Allik, 2007). In addition, children with high levels of IQ are also often found to differ from normally-achieving children with regard to their socio-emotional functioning (Subotnik, Olszewski-Kubilius, & Worrel, 2011). Already in 1959, however, Guilford proposed a second type of intellectual abilities to be of equal importance to successful child functioning in the cognitive, socio-emotional, and academic domain: divergent thinking abilities.

Nowadays, divergent thinking is often referred to as creativity. Although creativity is included in most models of giftedness (Ziegler, & Heller, 2000), its assumed role and impact varies. In the Three Ring Model of intelligence (Renzulli, 1984), for example, above average intellectual abilities and creativity are both considered essential for gifted achievements, together with task commitment. Mönks (1985) further broadened the model of giftedness by including environmental factors, yet still emphasized both types of intellectual abilities in their relationship to child functioning. In the more recent Cattell-Horn-Carroll Model of Intelligence (McGrew, 1997), creative abilities are also included within one of the components of intelligence. Although most theories thus emphasize the impact of both analytical and creative abilities on child functioning, only few studies have examined whether a combination of high ability

levels in both types of abilities is beneficial for child functioning in the cognitive, socio-emotional, or academic domain.

How intellectual profiles relate to child functioning

With regard to gifted and normally-achieving children's cognitive functioning, research consistently shows levels of analytical abilities to be associated with short-term memory (STM) capacity (Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014). According to Kolligian and Sternberg (1987), the encoding of information, holding it in STM, and consequently performing mental operations with it is an important cognitive process in analytical tasks. In addition, a similar role for STM is suggested for creative processes because the generation of new ideas puts a high demand on retrieval from memory (Paulus & Brown, 2007). Greater STM capacity might thus be related to high levels of both analytical and creative abilities.

Next to differences in cognitive functioning, children with diverse patterns of intellectual abilities might also differ in their socio-emotional functioning. A first important indicator of socio-emotional child functioning is motivation. The expectancy-value theory posits that motivation arises when a task is worth doing in combination with the expectation that the task is doable (Eccles et al., 1983). In line with this hypothesis, longitudinal research has shown that analytically-gifted children have higher levels of academic intrinsic motivation than a comparison group of normally-achieving children at the ages 9 to 13 years (Gottfried & Gottfried, 1996). Moreover, according to the intrinsic motivation hypothesis of creativity (Amabile, 1996), motivation also enhances aspects of creativity, such as curiosity, cognitive flexibility, and risk taking behavior.

A second indicator of socio-emotional functioning is self-concept. Self-concept has consistently been found to be related to the academic development of both gifted and normally-achieving children (Hoogeveen, Van Hell, & Verhoeven, 2009; Verschueren & Gadeyne, 2007). Self-concept is often defined as "an organized informational summary of perceived facts about oneself, including such things as one's traits, values, social roles, interests, physical characteristics, and personal history" (Bergner & Holmes, 2000, p.36). Whereas research on differences in self-concept between gifted and normally-achieving children showed mixed results (Neihart, 1999), an early review study showed a small positive effect in favor of the gifted children (Hoge & Renzulli, 1993).

The evidence regarding wellbeing as a third socio-emotional indicator is less unequivocal. Some studies suggested that giftedness enlarges vulnerability to adjustment difficulties, whereas in other studies it was suggested that giftedness protects children from maladjustment (Neihart, 1999). According to Neihart (1999), it can only be concluded that the level of psychological wellbeing of gifted children is related to other factors than solely intellectual abilities, including educational fit and life circumstances.

Concerning academic functioning, the influence of analytical abilities is most extensively studied and acknowledged (Subotnik et al., 2011). Analytically-gifted children are generally found to outperform normally-developing children (e.g., Caraisco-Alloggiamento, 2008). Even in the top 1% of young adolescents, individual differences in general intellectual ability levels were related to differences in educational outcomes (Robertson, Smeets, Lubinski, & Benbow, 2010). A positive relationship between creativity and academic achievements was first reported in 1962 (Getzels & Jackson) and has consistently been supported in more recent studies (e.g., Mandelman, Barbot, Tan, & Grigorenko, 2013). With regard to differences between children with varying intellectual profiles, a study by Palaniappan (2007) showed that analytically-creatively gifted children attained higher academic achievements than children with low levels of abilities in both domains. No differences were, however, found between analytically-creatively gifted children and children gifted in either one of these domains. In contrast, Cleanthous, Pitta-Pantazi, Christou, Kontoyianni, and Kattou (2010) found children with both high analytical and high creativity scores to attain higher arithmetic scores than children with gifted levels of either analytical or creative abilities.

Altogether, previous research has shown that levels of analytical and creative abilities are positively related to children's cognitive, socio-emotional, and academic functioning. However, only few studies examined whether the combination of high levels of analytical and creative abilities adds a benefit over a high level of ability in only one of the intellectual domains. According to the theory of triarchic intelligence (Sternberg, 1985, 2011) a third type of ability is of equal importance as analytical and creative abilities to reach success in life: practical abilities. Practical abilities are required to adapt to, shape, and select environments so that the change of success is further enhanced. In contrast to the well-documented effects of analytical and creative abilities in relation to child-functioning, however, the role of practical abilities has only been examined with regard to academic functioning. Moreover, the few studies that did incorporate practical abilities, showed inconsistent results. Whereas some studies showed a positive effect on academic achievements (Heng, 2000; Koke & Vernon, 2003; Mandelman et al., 2013) others did not find a significant relationship (Ekinci, 2014), or found the relationship to be negative (Sternberg et al., 2001). Nevertheless, Kornilov and colleagues (2011) showed analytical, creative, and practical intelligence scores together to predict 20% to 56% of the variance in achievement test scores, suggesting that it might be valuable to also take practical abilities into account.

Present study

Summarizing, previous studies suggest that a variety of intellectual profiles can be identified and that variation in these intellectual profiles is related to child functioning.

However, most studies, base their selection of gifted children on analytical IQ and performance tests (McClain & Pfeiffer, 2012) while focusing on child functioning in either the cognitive, socio-emotional, or academic domain. It is still by no means clear how varying profiles of intellectual abilities relate to differential aspects of child functioning. To the best of our knowledge, no previous study explored differences between the three areas of child functioning in children with varying intellectual profiles within one design.

The present study first explored what intellectual profiles can be distinguished in upper primary school children. Based on the study with the Dutch version of the Aurora Assessment Battery described in Chapter 2, we expected a newly composed battery to discriminate analytical and creative abilities. In an attempt to additionally assess practical ability levels, we also included practical subtests in our newly composed assessment battery. Secondly, we examined how intellectual profiles of a group of upper primary school children relate to their cognitive, socio-emotional, and academic functioning. Because memory abilities are considered to be associated with general intellectual abilities and creativity, we expected highest STM capacity for children gifted in both domains. Moreover, we expected analytically-gifted children to have higher levels of motivation (Gottfried & Gottfried, 1996) and self-concept (Hoge & Renzulli, 1993) than normally-achieving children, because their abilities are more likely to be acknowledged. Based on the intrinsic motivation hypothesis of creativity, we also hypothesized creatively-gifted children to rate their level of motivation higher than normally-achieving children. For wellbeing, mixed results have been found (Neihart, 1999) so that no concrete hypothesis was formulated. Ultimately, in the face of the expected positive effect of analytical abilities on academic achievements and the analytical focus of academic achievement tests, higher vocabulary and arithmetic scores were hypothesized for analytically-gifted children. Because research on the functioning of practically gifted children is sparse and inconsistent, no hypotheses were formulated with regard to the role of practical abilities.

Method

Participants

As part of a longitudinal study into the development of triarchic intellectual abilities, 513 fifth-grade children from 15 primary schools in the Netherlands participated in a screening of their intellectual abilities. Based on the scores on the intellectual ability subtests of the remaining 483 children, gifted and normally-achieving children were identified (see results section). One school withdrew from the study, so that 30 children were excluded from all analyses.

For the present study, a subsample of 225 children was invited to complete the cognitive, socio-emotional, and academic functioning subtests. Twenty-eight children were absent at one of the measurement occasions. Therefore, their scores were excluded from analyses. Results thus represent child functioning scores of 197 children (101 boys; 96 girls). The mean age of these children was 10 years and 4 months.

Materials

Intellectual abilities. We composed a test battery to assess analytical, creative, and practical abilities using standardized tests where possible. Although the Aurora Assessment Battery (Chart, Grigorenko, & Sternberg, 2008) was developed to assess these abilities in upper primary school children, results in Chapter 2 showed an inadequate fit between the Dutch version of the Aurora and the triarchic model of intelligence. Moreover, a number of subtests showed ceiling effects in 10-to-12 year old children. To minimize chances of ceiling effects, especially concerning the gifted sample, we included subtests with a higher expected degree of difficulty in the newly composed test battery. That is, tests were originally developed for secondary school students.

Three subtests from the Dutch Intelligence Test for Education Level (Van Dijk & Tellegen, 2004) assessed analytical abilities: *Analogies*, *Numbers*, and *Figures*. All subtests consisted of multiple choice items with five alternatives. With *Analogies*, children had to mark which of five words would follow a series of three words most properly. Therefore, they should analyze the relationship between the first two words and apply this to the third word. In the subtest *Numbers*, children were provided with a series of numbers for which they had to indicate which of five alternatives would be the correct successive number in the series. Both *Analogies* and *Numbers* comprised 25 items. The subtest *Figures* consisted of eight items. Children had to indicate which out of five paper models could be folded into a three dimensional figure. Every correctly marked alternative was worth one point, whereas every wrongly marked alternative reduced the score with one point. Reliability statistics were good to excellent for *Analogies* ($\alpha = .64$), *Numbers* ($\alpha = .85$), and *Figures* ($\alpha = .69$).

We included the subtest *Toy Shadows* of the Aurora and the *Practical Intellect* subtest of the Dutch version of the Differential Aptitude Test (DAT; Fokkema & Dirkzwager, 1968) to assess practical abilities. *Toy Shadows* presented children with eight photographs of a light shining on a toy. Children had to indicate which of four photographs showed the exact shadow of the toy. *Practical Intellect* consisted of 50 images in which a practical problem was presented. Answering the accompanying 50 multiple choice questions asked for insight into the operation of mechanical equipment or simple physical principles. Cronbach's alpha reliability coefficients were .53 for *Toy Shadows* and .79 for *Practical Intellect*.

The Aurora subtests *Book Covers*, *Multiple Uses*, and *Metaphors* assessed creative abilities. *Book Covers* ($\alpha = .89$) comprised five images that should be interpreted as book covers. Children had to write down, thereby expressing their creativity, what the books could be about. *Multiple Uses* ($\alpha = .76$) asked children to write down as many unusual uses as possible for five common objects. With *Metaphors* ($\alpha = .75$), children had to elaborate on the similarities between two common objects. Although this subtest was included as an analytical subtest in the original Aurora Battery, the study in Chapter 2 showed that *Metaphors* correlated more strongly with creative subtests. All open ended answers were polytomously coded on accuracy and creativity by three trained coders. The percentage of agreement between raters was 72.2% for *Book Covers*, 80.2% for *Multiple Uses*, and 73.8% for *Metaphors*.

Cognitive functioning. The subtest *Remembering Images* of the Dutch Differentiatie Testserie (Van Hoorn, Van der Kamp, & Den Brinker, 2004) assessed visual short-term memory (STM) abilities. After observing two times 10 images for a minute, pupils had to write down as many images as they remembered. This procedure was then repeated with 20 new images.

The subtest *Word Couples* of the Dutch Differentiatie Testserie assessed verbal STM abilities. The test assistant read aloud a list of 10 word couples. Subsequently, pupils had to complete as many couples as possible by writing down words belonging to the stimulus words. Immediately afterwards, this procedure was repeated with the same list of 10 word couples.

Socio-emotional functioning. Children rated 80 statements from the Dutch School Attitude Questionnaire (Vorst, Smits, Oort, Stouthard, & David, 2008) addressing their motivation for schoolwork, their self-concept regarding school and social achievements, and their wellbeing in school. All items were rated on a three points Likert scale (1= *do not agree*; 2= *no opinion*; 3= *agree*) so that scores for *Motivation*, *Self-concept*, and *Wellbeing* could be computed. Reliability statistics were excellent: $\alpha = .89$ for *Motivation*, $\alpha = .88$ for *Self-concept* and $\alpha = .86$ for *Wellbeing*.

Academic functioning. Vocabulary and arithmetic skills were assessed with items from the Dutch national Monitoring and Evaluation System (see Vlug, 1997). The mean degree of difficulty of items stemming from this monitoring and evaluation system is .70. Again, we selected more difficult items to reduce the chance of ceiling effects and increase differentiation within the gifted group. For *Vocabulary*, 40 multiple choice items addressed children's knowledge of word meanings, synonyms, and antonyms. The *Arithmetic* test comprised 23 open-ended items and one multiple choice item. These items tapped into basic arithmetic skills such as counting, subtracting, dividing, multiplying, and calculating with fractions and percentages. The mean degree of difficulty was .48 for the vocabulary ($\alpha = .78$) and .51 for the arithmetic test ($\alpha = .87$).

Procedure

A research assistant visited the classrooms twice. During the first visit, children completed the intellectual screening battery in a classroom setting in two one-hour sessions. After scoring and analyzing these data, a subsample of children was invited to take part in the longitudinal study. Again, the assistant visited the classroom and explained the procedure to the children. Children then filled out all cognitive, socio-emotional, and academic subtests in two one-hour classroom sessions.

Statistical Analyses

First, we performed correlation and exploratory factor analyses (EFA) to examine the underlying structure of the intellectual abilities battery. Since the types of abilities are hypothesized to be distinct but correlated (Kornilov et al., 2011), we used an oblique rotation method for the EFA. To gain insight into the profiles of intellectual abilities of gifted children, children with performances representative of the top 10% in either one or multiple intellectual domains were selected as gifted.

Next, we calculated descriptive statistics of children's level of intellectual abilities, as well as their cognitive, socio-emotional, and academic functioning and the correlations between all measures. A MANOVA was performed to examine differences between groups. Since n varied largely and we were interested in all pairwise comparisons between groups, we used Tukey's Honestly Significance Difference (HSD) with Kramer modification in post-hoc tests (Day & Quinn, 1989).

Results

Intellectual profiles

Table 1 presents correlations between the eight intellectual ability subtests. Results showed substantial positive correlations between the three analytical subtests as well as between the three creative subtests. Although correlations between the two practical subtests were also significant, the two practical subtests correlated more strongly with the three analytical subtests than with each other.

An exploratory factor analysis examining the factor structure of the newly composed battery supported these correlational results. Based on the scree plot and the Kaiser Criterion that factors with an *eigenvalue* greater than 1 should be considered significant (Kaiser, 1960), two factors were extracted. Table 2 shows uniqueness statistics and oblique rotated factor loadings for all subtests. Both the analytical and the practical subtests were found to load substantially to the first factor, whereas the three creative subtests were all found to load substantially to the second factor. Weighted regression factor scores for analytical and creative abilities were computed.

Table 1 Correlations Between Intellectual Ability Subtests

	1	2	3	4	5	6	7	8
1 Analogies	-							
2 Numbers	.409**	-						
3 Figures	.334**	.339**	-					
4 Toy Shadows	.176**	.213**	.340**	-				
5 Practical Intellect	.404**	.396**	.307**	.173**	-			
6 Book Covers	.113*	.093*	.086	.056	-.003	-		
7 Multiple Uses	.205**	.146**	.227**	.095	.173**	.205**	-	
8 Metaphors	.138**	.152**	.115*	.121*	.127**	.181**	.262**	-

Note. * $p \leq .05$; ** $p \leq .01$.

Table 2 Oblique Rotated Factor Loadings

	Uniqueness	Loadings	
		Factor 1	Factor 2
Analogies	.634	.599	.015
Numbers	.655	.584	.006
Figures	.678	.540	.060
Toy Shadows	.864	.346	.048
Practical Intellect	.638	.634	-.093
Book Covers	.783	-.085	.493
Multiple Uses	.730	.130	.453
Metaphors	.769	.068	.448

Note. Rotated factor loadings > .40 are in boldface.

Table 3 presents correlations between intellectual, cognitive, socio-emotional, and academic measures. Analytical and creative ability scores were found to be highly correlated. In addition, the significant correlations between both types of intellectual abilities and the cognitive, socio-emotional, and academic measures indicated that higher levels of intellectual abilities were associated with better functioning in all three domains.

Table 3 Correlations Between Intellectual, Cognitive, Socio-Emotional, and Academic Measures

	1	2	3	4	5	6	7	8	9
1 Analytical abilities	-								
2 Creative abilities	.563**	-							
3 Visual STM	.407**	.353**	-						
4 Verbal STM	.313**	.265**	.329**	-					
5 Motivation	.148*	.308**	.187**	.057	-				
6 Self-concept	.304**	.314**	.151*	.120	.442**	-			
7 Wellbeing	.103	.224**	.129	.151*	.501**	.347**	-		
8 Vocabulary	.495**	.450**	.285**	.303**	.206**	.195**	.297**	-	
9 Arithmetic	.621**	.425**	.251**	.358**	.249**	.235**	.383**	.560**	-

Note. STM = Short-term memory.

* $p \leq .05$; ** $p \leq .01$.

Identification of gifted and normally-achieving students

Following Kornilov and colleagues (2011), we identified 45 gifted children with top 10% scores in either one or both of the intelligence domains as gifted. Gifted children were classified over three groups: 14 children were analytically-gifted (i.e., A+), 18 children were creatively- gifted (i.e., C+), and 13 children were analytically-creatively gifted children (i.e., AC+).

Gifted and normally-achieving children did not differ with regard to age, $t(195) = 0.91$, $p = .362$, $d = 0.16$, or gender, $\chi^2(1, N = 197) < .01$, $p = .981$, Cramér's $V < .01$. No differences between the three groups of gifted children were present in age either, $F(2,42) = .32$, $p = .726$, $\eta^2 = .02$. The proportion of boys and girls did, however, differ between the three groups with varying gifted intelligence profiles, $\chi^2(2, N = 45) = 9.82$, $p = .007$, Cramér's $V = .47$. More boys than girls were included in the A+ group, whereas a larger proportion of girls than boys were included in the C+ group. In the combined AC+ group, the number of boys and girls was equal.

Table 4 presents means and standard deviations for the intellectual measures for the four groups. An one-way MANOVA with post hoc Tukey HSDs confirmed that the four groups differed in their level of analytical and creative abilities. As expected in face of the classification, children in the A+ and AC+ groups outperformed normally-achieving ($ps < .001$) and C+ children ($ps < .001$) on the analytical subtests, whereas no difference was found between the A+ and AC+ group ($p = .893$). The group of C+ children, however, also showed significantly higher analytical scores

Table 4 Descriptive Statistics for Analytical and Creative Abilities for the Groups with Varying Intelligence Profiles

	<i>n</i>	Analytical abilities		Creative abilities	
		<i>M</i>	(SD)	<i>M</i>	(SD)
NA	152	-0.05	(0.74)	-0.07	(0.55)
A+	14	1.51	(0.33)	0.40	(0.45)
C+	18	0.50	(0.48)	1.19	(0.19)
AC+	13	1.70	(0.44)	1.40	(0.17)

Note. NA= normally-achieving; A+ = Analytically-gifted; C+ = Creatively-gifted;
AC+ = Analytically-Creatively gifted

than normally-achieving children ($p = .008$), indicating that their level of analytical ability fell in between that of the normally-achieving and analytically-gifted groups. A similar pattern was found for creative abilities. Children in the C+ and AC+ did not differ in creativity level ($p = .679$), therewith both outperforming normally-achieving ($ps < .001$) and A+ children ($ps < .001$), whereas creativity scores of the A+ group of children were higher than those of the normally-achieving ($p = .005$) and lower than those of the creatively-gifted groups (i.e., C+ and AC+; $ps < .001$).

Variation in cognitive, socio-emotional, and academic measures

A MANOVA was performed to assess differences between normally-achieving children and the three groups of gifted children in their cognitive, socio-emotional, and academic functioning. With regard to the cognitive measures, results showed significant differences between the four groups of children for both visual and verbal STM, $F(3, 193) = 4.74$, $p = .003$, $\eta^2 = .07$ and $F(3, 193) = 3.56$, $p = .015$, $\eta^2 = .05$ respectively. Tukey's HSD post hoc tests showed higher levels of both visual ($p = .008$) and verbal STM ($p = 0.047$) for AC+ than normally-achieving children, whereas A+ and C+ children did not differ from their normally-achieving peers. In addition, the three groups of gifted children also did not differ in STM (see Figure 1).

Concerning the socio-emotional development, motivation and self-concept ratings, differed significantly between groups, respectively $F(3, 193) = 3.08$, $p = .029$, $\eta^2 = .05$ and $F(3, 193) = 4.59$, $p = .004$, $\eta^2 = .07$. Post-hoc tests again indicated higher ratings for both motivation ($p = .044$) and self-concept ($p = .010$) for AC+ children than normally-achieving children (see Figure 2). Again, children gifted in either one of the intellectual domains (i.e., A+ or C+ children) did not differ from normally-achieving children or analytically-creatively gifted children. Wellbeing ratings were similar for all four groups, $F(3, 193) = 0.91$, $p = .437$, $\eta^2 = .01$.

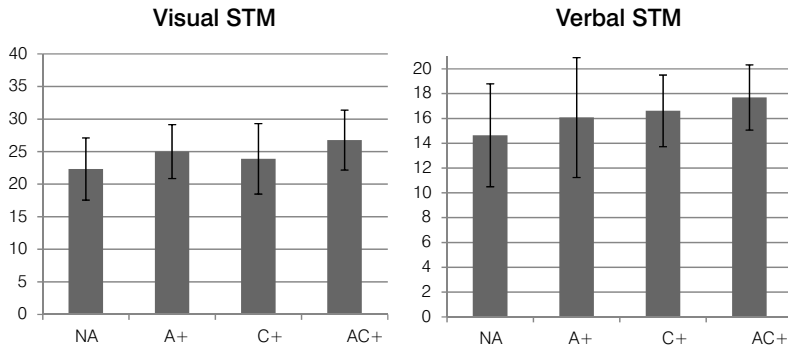


Figure 1 Levels of visual and verbal short-term memory (STM) of normally-achieving (NA), analytically-gifted (A+), creatively-gifted (C+), and analytically-creatively gifted (AC+) children. Error bars represent standard deviations

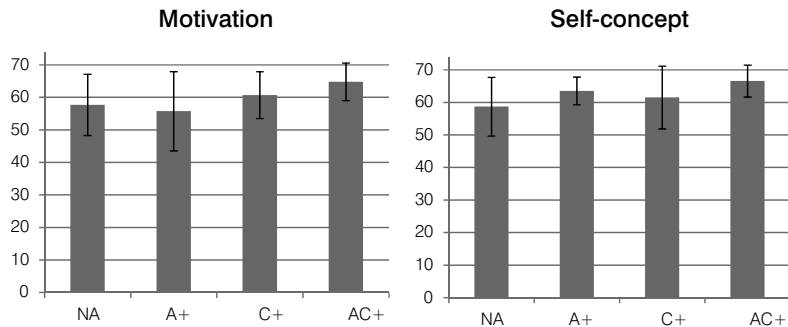


Figure 2 Ratings for motivation and self-concept of normally-achieving (NA), analytically-gifted (A+), creatively-gifted (C+), and analytically-creatively gifted (AC+) children. Error bars represent standard deviations

Thirdly, MANOVA results illustrated significant differences in both vocabulary, $F(3, 193) = 15.97, p < .001, \eta^2 = .25$, and arithmetic scores, $F(3, 193) = 13.15, p < .001, \eta^2 = .17$. Normally-achieving children gained lower vocabulary scores than both groups of creatively-gifted children ($ps \leq .001$; see Figure 3). For arithmetic, all three groups of gifted children were found to outperform the normally-achieving children ($ps \leq .046$). All comparisons between the three groups of gifted children were again non-significant.

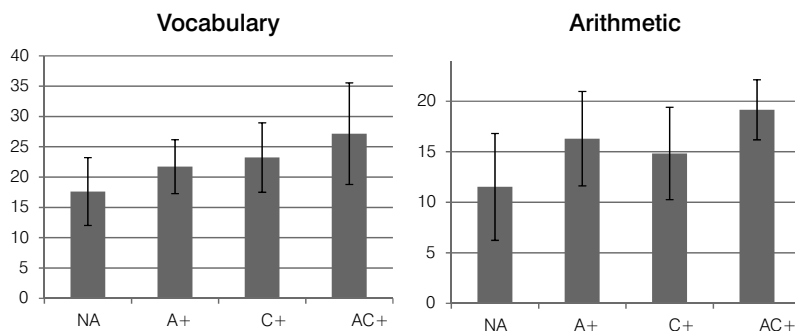


Figure 3 Vocabulary and arithmetic achievements of normally-achieving (NA), analytically-gifted (A+), creatively-gifted (C+), and analytically-creatively gifted (AC+) children. Error bars represent standard deviations

Discussion

Current theories of intelligence and giftedness emphasize the role of multiple types of abilities in reaching success (Ziegler & Heller, 2000). The present study aimed to examine differences in cognitive, socio-emotional, and academic functioning of upper primary school children with varying intellectual ability profiles. More specifically, we examined whether children with both high analytical and high creative abilities perform better than children with high levels of abilities in either one of the domains and normally-achieving children. Despite our attempts to design a triarchic assessment battery based on established analytical, creative, and practical subtests, we could not explicate the role of practical abilities. Whereas both the Toy Shadows (Tan et al., 2012) and the Practical Intellect subtest (Fokkema & Dirkzwager, 1968) had been shown to reflect practical abilities, in our study scores seemed to coincide with analytical subtest scores. This high overlap was also found in a study by Mandelman, Tan, Kornilov, Sternberg, and Grigorenko (2010). Although analytical and creative ability levels were also related, we were able to distinguish a group of analytically-gifted, creatively-gifted, analytically-creatively gifted, and a group of normally-achieving children.

Our results with regard to differences between children with varying types of intellectual profiles showed that analytical-creatively gifted children had greater STM capacities than normally-achieving children. These results support earlier findings by Benedek and colleagues (2014) that levels of both analytical and creative abilities are related to short-term memory ability. The high levels of abilities in both domains might beneficially affect short-term memory abilities of the analytically-creatively

gifted children. The effect might, however, also be reciprocal, with higher levels of short-term memory ability enhancing the children's ability to store and compare analytical information (Kolligian & Sternberg, 1987) or use the information together with preexisting knowledge to come up with creative ideas (Paulus & Brown, 2007).

With regard to socio-emotional functioning, analytically-creatively gifted again surpassed normally-achieving children in motivation. Accordingly, results were supportive of both the expectancy-value theory and the intrinsic motivation hypothesis of creativity (Amabile, 1996; Eccles, 1983), yet only in a group of children with high levels of both analytical and creative abilities. Levels of self-concept also differed between normally-achieving and analytically-creatively gifted children. The small difference in self-concept that was found in a review by Hoge and Renzulli (1993) in comparison to normally-achieving children was thus only replicated for the double-gifted children. With regard to wellbeing, we found gifted children to have equal levels of wellbeing as their normally-achieving peers. Although previous research showed mixed results, our results regarding children's wellbeing matched with results by Neihart (1999) in showing that intellectual abilities have only limited influence on the experience of wellbeing.

Concerning differences in academic achievement, results showed that children with gifted levels in both the analytical and creative domain gained higher scores on vocabulary and arithmetic tests than normally-achieving students. These results are in line with Palaniappan's findings (2007) that children with high IQ and high creativity attain higher academic achievement than children with low IQ and low creativity. Whereas Cleanthous and colleagues (2010) found children with both high analytical and high creativity scores to also attain higher arithmetic scores than children gifted in either one of these domains, no significant differences between the three groups of gifted children were found in the present study or in Palaniappan's (2007) study. These results are supportive of the threshold theory regarding creativity and intelligence (Barron, 1963; Jauk, Benedek, Dunst, & Neubauer, 2013). Scores of children with high levels of both analytical and creative abilities were only found to be enhanced when compared to normally-achieving children. No additional benefits were however found when compared to children with gifted levels of either analytical or creative abilities.

An explanation for the finding that especially creatively-gifted children outperformed the normally-achieving children on vocabulary might be found in the type of creativity tests used. The first creativity subtest, Book Covers, reflects storytelling abilities. The other two creativity subtests, Metaphors and Multiple Uses were constrained production tasks (Lubart, Pacteau, Jacquet, & Caroff, 2010) asking children to write down as many similarities or uses as they could think of. Although subtests thus comprise the two most frequently used types creativity assessments (Lubart et al., 2010), all three subtests depend strongly on verbal abilities with more elaborate and original answers

bearing higher creativity scores. As a result, the vocabulary scores of the creatively-gifted children might be inflated due to this focus on a verbal expression of creativity.

Limitations

Of course, some limitations apply to the present study. First, the number of participants in the gifted groups was fairly small, considering that only the top 10% of our participants was selected as gifted. Secondly, we did not examine reciprocity of relationships between the cognitive, socio-emotional, and academic measures. Academic achievements might for example be influenced by higher levels of STM (Bull, Espy, & Wiebe, 2008), motivation (Steinmayr & Spinath, 2009), or self-concepts (Marsh & Craven, 2006). Adversely, self-concept and motivation might also be enhanced by high academic functioning (Hoge & Renzulli, 1993; Ireson & Hallam, 2009; Verschueren & Gadeyne, 2007). Future research might adopt a longitudinal design to explore causal relations in developmental patterns of cognitive, socio-emotional, and academic functioning of children with varying ability profiles over time.

Conclusion

In sum, the results of the present study showed that analytically-creatively gifted children outperformed normally-achieving children with regard to short term memory abilities, motivation, and self-concept, suggesting that their combined giftedness does provide them with additional benefits. Furthermore, all groups of gifted children scored higher than their normally-achieving peers on the arithmetic tests, whereas only creatively and analytically-creatively gifted children outperformed normally-achieving children in vocabulary. Although our study showed that all groups of gifted children had equal levels of cognitive, socio-emotional, and academic functioning, Mandelman and colleagues (2013) found that creatively-gifted children are less likely to be identified as being gifted with regularly used achievement tests. To allow a greater range of children to be encouraged to further develop their potential, other types of abilities should be addressed in both screening and evaluation instruments. Moreover, education and enrichment programs might enhance levels of analytical and creative abilities in both gifted (Sternberg, Ferrari, Clinkenbeard, & Grigorenko, 1996) and normally-achieving children, especially when teaching is aligned to children's individual patterns of strengths and weaknesses (Sternberg et al., 1999).

References

- Amabile, T. M. (1996). *Creativity in context*. Boulder, CO: Westview Press.
- Barron, F. (1963). *Creativity and psychological health*. Princeton, NY: Van Nostrand.
- Benedek, M., Jauk, E., Sommer, M., Arendasy, M., & Neubauer, A. C. (2014). Intelligence, creativity, and cognitive control: The common and differential involvement of executive functions in intelligence and creativity. *Intelligence*, 46, 73-83. doi:10.1016/j.intell.2014.05.007
- Bergner, R. M., & Holmes, J. R. (2000). Self-concepts and self-concept change: A status dynamic approach. *Psychotherapy: Theory, Research, Practice, Training*, 37, 36-44. doi:10.1037/h0087737
- Bull, R., Espy, K. A., & Wiebe, S. A. (2008). Short-term memory, working memory, and executive functioning in preschoolers: Longitudinal predictors of mathematical achievement at age 7 years. *Developmental Neuropsychology*, 33, 205-228. doi:10.1080/87565640801982312
- Caraisco-Alloggiamento, J. (2008). *A comparison of the mathematics achievement, attributes, and attitudes of fourth-, sixth-, and eighth-grade students*. Unpublished doctoral dissertation, St. John's University, School of Education and Human Services, New York.
- Chart, H. E. L., Grigorenko, E. L., & Sternberg, R. J. (2008). Identification: The Aurora Battery. In J. A. Plucker & C. M. Callahan (Eds.), *Critical issues and practices in gifted education* (pp. 281-301). Waco, TX: Prufrock Press.
- Cleanthous, E., Pitta-Pantazi, D., Christou, C., Kontoyianni, K., & Kattou, M. (2010). What are the differences between high IQ/low creativity students and low IQ/high creativity students in mathematics? *Proceedings of the 6th International Conference on Creativity in Mathematics Education and the Education of Gifted students* (pp. 52 – 55). Retrieved may 18th 2015 from <http://www.mathgifted.org/publications/D3.1.pdf> . Riga, Latvia: International Group for Mathematical Creativity and Giftedness (MCG).
- Dai, Y. D. (2010). *The nature and nurture of giftedness: A new framework for understanding gifted education*. New York, NY: Teachers College Press.
- Day, R. W., & Quinn, G. P. (1989). Comparisons of treatments after an analysis of variance in ecology. *Ecological Monographs*, 59, 433-463. doi:10.2307/1943075
- Eccles, J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J., & Midgley, C. (1983). Expectancies, values and academic behaviors. In Spence, J. T. (ed.), *Achievement and Achievement Motives*. San Francisco, CA: W. H. Freeman.
- Ekinci, B. (2014). The relationships among Sternberg's triarchic abilities, Gardner's multiple intelligences, and academic achievement. *Social Behavior and Personality*, 42, 625-634. doi:10.2224/sbp.2014.42.4.625
- Fokkema, S. D., & Dirkzwager, A. (1968). *Handleiding voor de Differentiële Aanleg Test [Manual for the Differential Aptitude Test]*. Lisse: Swets & Zeitlinger.
- Getzels, J. W., & Jackson, P. W. (1962). *Creativity and intelligence*. New York, NY: John Wiley & Sons, Inc.
- Gottfried, A. E., & Gottfried, A. W. (1996). A longitudinal study of academic intrinsic motivation in intellectually gifted children: Childhood through early adolescence. *Gifted Child Quarterly*, 40, 179-183. doi:10.1177/001698629604000402
- Heng, M. A. (2000). Scrutinizing common sense: the role of practical intelligence in intellectual giftedness. *Gifted Child Quarterly*, 44, 171-181. doi:10.1177/001698620004400303
- Hoge, R. D., & Renzulli, J. S. (1993). Exploring the link between giftedness and self-concept. *Review of Educational Research*, 63, 449-462. doi:10.3102/00346543063004449
- Hoogeveen, L., Van Hell, J. G., & Verhoeven, L. (2009). Self-concept and social status of accelerated and nonaccelerated students in the first 2 years of secondary school in the Netherlands. *Gifted Child Quarterly*, 53, 50-67. doi:10.1177/0016986208326556
- Ireson J., & Hallam, S. (2009). Academic self-concepts in adolescence: Relations with achievement and ability grouping in schools. *Learning and Instruction*, 19, 201-213. doi:10.1016/j.learninstruc.2008.04.001
- Jauk, E., Benedek, M., Dunst, B., & Neubauer, A. C. (2013). The relationship between intelligence and creativity: New support for the threshold hypothesis by means of empirical breakpoint detection. *Intelligence*, 41, 212-221. doi:10.1016/j.intell.2013.03.003
- Kaiser, H. F. (1960). The application of electronic computer to factor analysis. *Educational and Psychological Measurement*, 20, 141-151. doi:10.1177/001316446002000116

- Koke, L. C., & Vernon, P. A. (2003). The Sternberg Triarchic Abilities Test (STAT) as a measure of academic achievement and general intelligence. *Personality and Individual Differences*, 35, 1803-1807. doi:10.1016/S0191-8869(03)00005-9
- Kolligian, J., & Sternberg, R. J. (1987). Intelligence, information processing, and specific learning disabilities: a triarchic synthesis. *Journal of Learning Disabilities*, 20, 8-17. doi:10.1177/002221948702000103
- Kornilov, S. A., Tan, M., Elliott, J. G., Sternberg, R. J., & Grigorenko, E. L. (2011). Gifted identification with the Aurora: Widening the spotlight. *Journal of Psychoeducational Assessment*, 30, 117-133. doi:10.1177/0734282911428199
- Laidra, K., Pullmann, H., & Allik, J. (2007). Personality and intelligence as predictors of academic achievement: A cross-sectional study from elementary to secondary school. *Personality and Individual Differences*, 42, 441-451. doi:10.1016/j.paid.2006.08.001
- Lubart, T., Pachteau, C., Jacquet, A., -Y., Caroff, X. (2010). Children's creative potential: An empirical study of measurement issues. *Learning and Individual Differences*, 20, 388-392. doi:10.1016/j.lindif.2010.02.006
- Mandelman, S. D., Barbot, B., Tan, M., & Grigorenko, E. L. (2013). Addressing the 'quiet crisis': Gifted identification with Aurora. *Educational & Child Psychology*, 30, 101-109.
- Mandelman, S. D., Tan, M., Kornilov, S. A., Sternberg, R. J., & Grigorenko, E. L. (2010). The metacognitive component of academic self-concept: a development of a triarchic self-scale. *Journal of Cognitive Education and Psychology*, 9, 73-86. doi:10.1891/1945-8959.9.1.73
- Marsh, H. W., & Craven, R. G. (2006). Reciprocal effects of self-concept and performance from a multi-dimensional perspective: Beyond seductive pleasure and unidimensional perspectives. *Perspectives on Psychological Science*, 1, 133-163. doi:10.1111/j.1745-6916.2006.00010.x
- McClain, M. C., & Pfeiffer, S. I. (2012). Education for the gifted in the United States today: A look at state definitions, policies, and practices. *Journal of Applied School Psychology*, 28, 59-88. doi:10.1080/15377903.2012.643757
- McGrew, K. S. (1997). Analysis of the major intelligence batteries according to a proposed comprehensive Gf-Gc framework. In D. P. Flanagan, J. L. Genshaft, & P. L. Harrison (Eds.), *Contemporary intellectual assessment* (pp. 151-179). New York, NY: Guilford Press.
- Miller, L. T., & Vernon, P. A. (1992). The general factor in short-term memory, intelligence, and reaction time. *Intelligence*, 16, 5-29. doi:10.1016/0160-2896(92)90023-K
- Mönks, F. J. (1985). In F. J. Mönks & P. Span (Eds.), *Hoogbegaafden in de samenleving, Congresbundel [Gifted people in society, Conference bundle]*. Assen, The Netherlands: Dekker & Van de Vegt.
- Neihart, M. (1999). The impact of giftedness on psychological well-being: What does the empirical literature say? *Roeper Review*, 22, 10-17.
- Palaniappan, A. K. (2007). Academic achievement of groups formed based on creativity and intelligence. Paper presented at the The 13th International Conference on Thinking Norrköping. Retrieved may 18th 2015 from <http://www.ep.liu.se/ecp/021/vol1/020/index.html>
- Paulus, P. B., & Brown, V. R. (2007). Toward more creative and innovative group idea generation: A cognitive-social-motivational perspective of brainstorming. *Social and Personality Psychology Compass*, 1, 248-265. doi:10.1111/j.1751-9004.2007.00006.x
- Renzulli, J. S. (1984). The triad/revolving door system: A research based approach to identification and programming for the gifted and talented. *Gifted Child Quarterly*, 28, 163-171. doi:10.1177/001698628402800405
- Robertson, K. F., Smeets, S., Lubinski, D., & Benbow, C. P. (2010). Beyond the threshold hypothesis: Even among the gifted and top math/science graduate students, cognitive abilities, vocational interests, and lifestyle preferences matter for career choice, performance, and persistence. *Current Directions in Psychological Science*, 19, 346-351. doi:10.1177/0963721410391442
- Spearman, C. (1904). General intelligence, objectively determined and measured. *The American Journal of Psychology*, 15, 201-292. doi:10.2307/1412107
- Steinmayr, R., & Spinath, B. (2009). The importance of motivation as a predictor of school achievement. *Learning and Individual Differences*, 19, 80-90. doi:10.1016/j.lindif.2008.05.004
- Sternberg, R. J. (1985). *Beyond IQ: a triarchic theory of human intelligence*. Cambridge, England: Cambridge University press.

- Sternberg, R. J. (2011). The theory of successful intelligence. In R.J. Sternberg & S.B. Kaufman (Eds.), *The Cambridge Handbook of Intelligence*. New York, NY: Cambridge University Press.
- Sternberg, R. J., & Clinkenbeard, P. R. (1995). The triarchic model applied to identifying, teaching, and assessing gifted children. *Roeper Review*, 17, 255-260. doi:10.1080/02783199509553677
- Sternberg, R. J., Ferrari, M., Clinkenbeard, P., & Grigorenko, E. L., (1996). Identification, instruction, and assessment of gifted children: A construct validation of a triarchic model. *Gifted Child Quarterly*, 40, 129-137. doi:10.1177/001698629604000303
- Sternberg, R. J., Grigorenko, E. L., Ferrari, M., & Clinkenbeard, P. (1999). A triarchic analysis of an aptitude-treatment interaction. *European Journal of Psychological Assessment*, 15, 3-13. doi:10.1027//1015-5759.15.1.3
- Sternberg, R. J., Nokes, C., Geissler, P. W., Prince, R. Okatcha, F., Bundy, D. A., & Grigorenko, E. L. (2001). The relationship between academic and practical intelligence: A case study in Kenya. *Intelligence*, 29, 401-418. doi:10.1016/S0160-2896(01)00065-4.
- Subotnik, R. F., Olszewski-Kubilius, P., & Worrel, F. C. (2011). Rethinking giftedness and gifted education: A proposed direction forward based on psychological science. *Psychological Science in the Public Interest*, 12, 3-54. doi:10.1177/1529100611418056
- Tan, M., Mourgues, C., Aljughaiman, A., Ayoub, A., Mandelman, S. D., Zbainos, D., & Grigorenko, E. L. (2012). What the shadow knows: assessing aspects of practical intelligence with Aurora's *Toy Shadows*. In H. Stoeger, A. Aljughaiman, & B. Harder (Eds.), *Talent Development and Excellence* (pp. 211-240). Münster, Germany: Lit.
- Van Dijk, H., & Tellegen, P. J. (2004). *Nederlandse Intelligentietest voor Onderwijsniveau: Handleiding [Dutch Intelligence Test for Educational Level: Manual]*. Amsterdam, The Netherlands: Boomtest uitgevers.
- Van Hoorn, W., Van der Kamp, L., & Den Brinker, W. (2004). *Handleiding Nederlandse Differentiatie Testserie (NDT) [Manual Dutch Differentiation Testseries]*. Lisse, The Netherlands: Harcourt Test Publishers.
- Verschueren, K., & Gadeyne, E. (2007). *Zelfconcept [Selfconcept]*. In Verschueren, K. & Koomen, H., *Handboek diagnostiek in de leerlingenbegeleiding [Diagnostic manual for student counseling]* (pp. 151-167). Antwerp, Belgium: Garant.
- Vlug, K. F. M. (1997). Because every pupil counts: the success of the pupil monitoring system in The Netherlands. *Educational and Information Technologies*, 2, 287-306. doi:10.1023/A:1018629701040
- Vorst, H. C. M., Smits, J. A. E., Oort, F. J., Stouthard, M. E. A., & David, S. A. (2008). *Schoolvragenlijst voor basisonderwijs en voortgezet onderwijs: handleiding en verantwoording [School questionnaire for primary and secondary education: SVL user manual]*. Amsterdam, The Netherlands: Pearson.
- Ziegler, A., & Heller, A. (2000). Conceptions of giftedness form a meta-theoretical perspective. In K. A. Heller, F. J. Mönks, R. J. Sternberg & R. F. Subotnik (Eds.), *International Handbook of Giftedness and Talent (2nd ed., pp.3-21)*. Oxford, England: Pergamon.

4

Predicting the development of intellectual abilities in the upper primary grades

This chapter is based on: Gubbels, J., Segers, E., & Verhoeven, L. (submitted). Predicting the development of analytical and creative abilities in upper elementary grades.

Abstract

Intelligence has been described as a multidimensional construct comprising both analytical and creative abilities and is considered to be dynamic rather than static. Using structural equation modeling, we examined the predictive role of cognitive (visual short-term memory, verbal short-term memory, selective attention) and socio-emotional (motivation, self-concept, wellbeing) child characteristics in the development of analytical and creative abilities in 116 Dutch children over the course of fifth and sixth grade. Results showed increasing levels of both analytical and creative abilities over the grades with the two types of abilities developing more or less independently. The development of analytical abilities was predicted by visual and verbal short-term memory and self-concept, the development of creative abilities by visual short-term memory and wellbeing. These results show that analytical and creative abilities have highly independent developmental trajectories, each with specific cognitive and socio-emotional predictors.

Introduction

In models of giftedness and intelligence, a distinction is made between various types of intellectual abilities, including analytical and creative abilities (Ziegler & Heller, 2000). Given the fact that intelligence is also considered to be a dynamic construct, it is important to study the development of intellectual abilities over time (Worrell, 2009). Cognitive and socio-emotional child characteristics have been found to predict the development of the two types of abilities (Simonton, 2000; Subotnik et al., 2011). However, no attempt has been made to examine the role of both cognitive and socio-emotional predictors in the development of analytical and creative abilities in one and the same design. Therefore in the present study, we adopted a talent-development approach and examined the predictive role of cognitive and socio-emotional child characteristics in the development of analytical and creative abilities in upper primary school children.

Intelligence: a multidimensional and developing expertise

Traditional methods of assessing human ability have been closely related to the concept of IQ in which intellectual ability is seen as a clearly constrained and static entity of a person (Dai, 2010). In line with these traditional conceptions, high ability is still often identified based on high IQ scores and excellent academic performances (McClain & Pfeiffer, 2012). Because of the analytical nature of most subtests assessing IQ or academic performances, intellectual ability scores mainly reflect children's analytical abilities. Intelligence is, however, considered to be a multidimensional and dynamic construct. That is, intelligence is often assumed to include not only analytical IQ scores, but also creativity (Ziegler & Heller, 2000). Creativity is the ability to generate ideas that are novel, high in quality, and task appropriate (Sternberg, 2003). Ideas should thus be original as well as effective (Runco & Jaeger, 2012). Although creativity has consistently been found to be related to analytical intellectual abilities as assessed with standardized ability tests (Batey & Furnham, 2006), the two are assumed to be relatively independent aspects of intelligence (Carroll, 1993; Kornilov, Tan, Elliott, Sternberg, & Grigorenko, 2011).

In addition to the multidimensionality of the construct of intelligence, intelligence is also often assumed to be a developing expertise (Foley Nicpon & Pfeiffer, 2011). Both levels of analytical and creative abilities are thus considered dynamic rather than static characteristics. Whereas analytical abilities seem to increase over time, the developmental path of creative abilities is not consistent over studies (Kim, 2011). Some studies found a fourth-grade slump in creativity (Torrance, 1968) followed by slight increases in creativity scores in subsequent grades (Claxton, Pannells, & Rhoads, 2005; Cropley, 2003). Others, however, found creativity scores to stabilize in 10 to 13 year olds (Memmert, 2011) or decrease from sixth grade (Kim, 2011).

The predictive role of cognitive child characteristics

Both cognitive and socio-emotional child characteristics are assumed to play a role in the development of analytical and creative abilities (Simonton, 2000; Subotnik et al., 2011). Regarding cognitive characteristics, memory and selective attention have been often referred to in relation to both types of abilities. Benedek, Jauk, Sommer, Arendasy, and Neubauer (2014) suggested that both analytical and creative abilities rely on a shared cognitive basis such as the storage of information in short-term memory (STM) or attention capacity. According to the model by Baddely and Hitch (2007), separate systems are responsible for the storage of either visuo-spatial or verbal information, resulting in a differentiation between visual and verbal STM. Kolligian and Sternberg (1987) considered the encoding of information, holding it in STM, and consequently performing mental operations with it important cognitive processes needed for analytical tasks. Meta-analyses by Mukunda and Hall (1992) and Ackerman, Beier, and Boyle (2005) showed a weighted average correlation of .20 to .30 between STM and analytical intellectual abilities. Although the predictive role of STM capacity in the development of creative abilities is not studied to date, a similar role for STM has been suggested for creative processes. In order to come up with novel ideas, knowledge from memory should be combined with existing knowledge (Paulus & Brown, 2007).

A second cognitive characteristic that might be related to the development of both analytical and creative abilities is selective attention. Selective attention involves the ability to attend to task-relevant cues and ignore distracters (Kolata, Light, Grossman, Hale, & Matzel, 2007). Earlier studies found significant correlations between scope of attention and intelligence scores in adults as well as children (Cowan, Fristoe, Elliott, Brunner, & Sauls, 2006). Moreover, Martindale (1999) showed attention to be associated with creativity as well. In primary school children, Memmert (2011) found this effect to be strongest in 7-year olds, whereas the role of attention declined at the ages of 10 and 13 years.

The predictive role of socio-emotional child characteristics

Regarding socio-emotional child characteristics three predictors are most prominent in the literature: motivation, self-concept, and wellbeing. Motivation refers to a child's drive to achieve (Subotnik et al., 2011) and has been found to be positively related to IQ scores (Duckworth, Quinn, Lynam, Loeber, & Stouthamer-Loeber, 2011). In Self-Determination Theory, two types of motivation are distinguished: intrinsic and extrinsic motivation (Deci & Ryan, 1985). Intrinsic motivation refers to inherently interesting actions, whereas extrinsic motivation refers to actions that lead to a favorable outcome. According to the intrinsic motivation hypothesis of creativity, intrinsic motivation is conducive to creativity (Amabile, 1983). Extrinsic motivation, on the other hand, is considered detrimental for creativity.

A second socio-emotional predictor of intellectual development is children's level of self-concept. According to Shavelson, Hubner and Stanton (1976), a person's self-concept is formed through experience with and interpretations of one's environment. With regard to the relationship with actual performances, Marsh and Craven (2006) proposed that people who consider themselves more effective and able, will gain higher achievements than people with less positive self-concepts. This relationship has, however, consistently been found to be reciprocal: higher achievements also lead to more positive self-concepts (Valentine, DuBois, & Cooper, 2004). A central element in children's self-concepts is their knowledge and perception about their academic abilities: their academic self-concepts (Shavelson et al., 1976). Academic self-concepts have been found to be domain specific (Marsh & Seaton, 2013). That is, self-concepts in a domain are more strongly related to achievements within that specific domain than to achievements in other domains.

Thirdly, children's subjective wellbeing is suggested to be related to both analytical and creative achievements. According to Diener, Oishi, and Lucas (2003), subjective wellbeing involves people's emotional reactions to events and their moods and judgments about their life satisfaction and fulfillment. Already in 1925, Terman reported a positive correlation between subjective wellbeing and intelligence, yet later studies showed these correlations to be only weak (Wulff, Bergman, & Sverke, 2009). Baas, de Dreu, and Nijstad (2008) concluded from a meta-analysis that creativity is induced by moods via a flexibility route. That is, positive moods promote cognitive flexibility, whereas negative moods induce creative thinking by triggering persistence. Isen (1999) indeed found wellbeing to be related to cognitive flexibility. In addition, Dolan and Metcalfe (2012) found adults with high wellbeing report themselves to be more original and imaginative than others. Amabile, Barsade, Mueller, and Staw (2005) used time-lagged analyses to show that positive affect is an antecedent of creativity in employees. In adults, wellbeing thus seems to be related to both analytical and creative abilities. Whether wellbeing also predicts analytical and creative ability levels in children has been less thoroughly studied.

Present study

Given the fact that intelligence can be considered a dynamic construct, it is important to study the development of intellectual abilities over time. Both cognitive and socio-emotional child characteristics have been found to predict the development of intellectual abilities. However, no attempt has been made to examine the role of both cognitive and socio-emotional predictors in the development of analytical and creative abilities in one and the same design. Therefore, the aim of the present study was to examine the development of analytical and creative abilities and the predictive role of socio-emotional and cognitive child characteristics herein. We expected analytical and creative abilities to be distinct, yet correlated constructs that both

increase over the final two years of primary school. In addition, we expected higher levels of motivation, self-concept, and wellbeing to augment the development of both analytical and creative abilities. Similarly, positive effects of visual and verbal STM and selective attention as cognitive child characteristics were hypothesized.

Method

Participants

Participants were 150 fifth-grade children from 8 primary schools across the Netherlands. Due to the length and frequency of all measurements, not all children were able to complete the full test battery at all three moments in time. In addition, a number of children repeated a class or changed schools over the course of the study. Results regard data from a subsample of 116 children (56 boys, 60 girls) who completed all pre-, post- and follow-up measurements. At the start of the study, the average age of these children was 10 years and 4 months.

Materials

A test battery consisting of several subtests was included to assess analytical and creative abilities. A factor analysis that showed that eight subtests successfully discriminate analytical and creative abilities is described in Chapter 3.

Analytical abilities. We included the subtests *Analogies*, *Numbers*, and *Figures* from the Dutch Intelligence Test for Education Level (Van Dijk & Tellegen, 2004) to assess Analytical ability levels. *Analogies* consisted of 25 series of three words, for which children had to find the most appropriate fourth word following this series. The subtest *Numbers* comprised 25 series of numbers for which the correct successive number should be found. *Figures* consisted of eight three-dimensional figures. For all figures, children had to indicate which out of five paper models could be used to construct the figure. Reliability was good to excellent for *Analogies* ($\alpha = .64$), *Numbers* ($\alpha = .85$), and *Figures* ($\alpha = .69$). Answering formats of the three subtests were multiple choice. Children gained one point for every correct answer. For the *Figures* subtests, wrong answers reduced the score with one point.

In addition to these three subtests, the subtests *Practical Intellect* (Dutch Differential Aptitude Test; Fokkema & Dirkzwager, 1968) and *Toy Shadows* (Aurora battery; Chart et al., 2008) were also included as indicative of Analytical abilities. *Practical Intellect* ($\alpha = .79$) consisted of 50 multiple choice items tapping into children's knowledge of and insight in simple physical operations. With *Toy Shadows*, children had to indicate which of four images displayed the true shadow of a toy. The reliability coefficient was acceptable ($\alpha = .53$).

Creative abilities. The subtests *Book Covers*, *Multiple Uses*, and *Metaphors* were included to assess Creative abilities. These three open-ended subtests originate from the Aurora battery (Chart et al., 2008). *Book Covers* involved children writing down for five images, what an imaginative book with this image as cover would be about. With *Multiple Uses*, children were asked to list as many possible uses for common objects. Likewise, *Metaphors* asked to list as many similarities between two common objects as possible. Answers were coded by two undergraduates and the first author on accuracy (0 = no answer; 1 = partly complete answer; 2 = complete answer) and ability-creativity (0 = no answer; 1 = short or non-creative answer; 2 = answer including original interpretation; 3 = answer including two or more original interpretations; 4 = completely original interpretation). The percentage of agreement between raters was acceptable for a randomly selected sample of 20% of all answers: 72.2% for *Book Covers*, 80.2% for *Multiple Uses*, and 73.8% for *Metaphors*. Cronbach's alpha reliability coefficients were .89 for *Book Covers*, .76 for *Multiple Uses*, and .75 for *Metaphors*.

Socio-emotional functioning. The School Attitude Questionnaire (Vorst, Smits, Oort, Stouthard, & David, 2008) is a standardized assessment of primary school children's socio-emotional functioning. The questionnaire comprised 80 statements for which children had to indicate on a three point scale whether it described their experiences and feelings in school (1 = do not agree; 2 = no opinion; 3 = agree). Statements were classified over three subscales. Children's level of *Motivation* was assessed with statements addressing their task orientation, concentration, and attitude towards homework. Children's ratings of their expressional and social skills, and self-esteem with tests indicated their levels of academic *Self-concepts*. Statements regarding children's feelings of satisfaction, social acceptance, and their relationship with the teacher were indicative of their *Wellbeing* in school. Reliability statistics were excellent: $\alpha = .89$ for *Motivation*, $\alpha = .88$ for *Self-concept*, and $\alpha = .86$ for *Wellbeing*.

Cognitive functioning. Children's level of visual and verbal Short-Term Memory (STM) abilities and selective attention were used as indicators of cognitive functioning. Scores on the subtest *Remembering Images* and *Word Couples* of the Dutch Differentiatie Testserie (Van Hoorn, Van der Kamp, & Den Brinker, 2004) were indicative of children's Visual and Verbal STM abilities respectively. For Visual STM, children observed two sets of 10 images for a minute, and subsequently wrote down as many images as they remembered. Subsequently, this procedure was repeated with two new sets of 10 images. For Verbal STM, the research assistant read aloud a list of 10 word couples. Subsequently, pupils had to complete as many word couples as possible by writing down words belonging to the stimulus words. Immediately afterwards, this procedure was repeated with the same list of 10 word couples.

The *Digit Crossing Test* (Dekker, Dekker, & Mulder, 2007) examined children's levels of Selective Attention. Pupils had three minutes to mark all 4s and cross out all 3s and 7s in a list of 800 digits. Selective Attention scores were calculated by subtracting the number of errors and missings of the total number of edited digits.

Procedure

Analytical and creative ability subtests were administered at three occasions: at the beginning of fifth grade (B5), at the end of fifth grade (E5), and at the end of sixth grade (E6). The testing procedure was equal for the three moments in time and was supervised by educational science students as research assistants. The research assistant visited the classroom and children completed all subtests in a two-hour session. Pretest scores of social-emotional and cognitive functioning subtests were also gathered in a group-setting.

Statistical analyses

First, we calculated descriptive statistics and analyzed the development of analytical and creative abilities with a repeated measures MANOVA. Next, we calculated correlations between intellectual ability levels and socio-emotional as well as cognitive predictors. Thirdly, we examined the stability of individual differences in analytical and creative abilities over time in an autoregressive cross-lagged structural equation model (Selig & Little, 2012). In addition, we examined the predictive role of socio-emotional and cognitive child characteristics on the development of both types of intellectual abilities. We considered the model to adequately fit to the data when the χ^2 -value was non-significant, the Root Mean Square Error Approximation (RMSEA) did not exceed .06, and the Goodness of Fit Index adjusted for the number of parameters (AGFI) exceeded .85 (Hu & Bentler, 1999).

Results

Descriptive statistics

Table 1 presents descriptive statistics on the levels of analytical and creative abilities. A repeated measures MANOVA showed significant increases between the beginning of Grade 5 and end of Grade 6 in both analytical, $F(1, 115) = 319.25, p \leq .001, \eta_p^2 = .74$, and creative abilities, $F(1, 115) = 20.62, p \leq .001, \eta_p^2 = .15$. Table 2 shows descriptive statistics on the levels of socio-emotional and cognitive child characteristics at the beginning of Grade 5.

Table 1 Means (M) and Standard Deviations (SD) of Analytical and Creative Ability Levels

	B5		E5		E6	
	<i>M</i>	(SD)	<i>M</i>	(SD)	<i>M</i>	(SD)
Intellectual abilities						
Analytical abilities	48.82	(13.17)	62.25	(14.88)	73.66	(16.68)
Creative abilities	57.09	(10.24)	59.39	(10.48)	63.74	(12.45)

Note. B5 = Begin Grade 5; E5= End Grade 5; E6= End Grade 6; STM = Short-term memory.

Table 2 Means (M) and Standard Deviations (SD) of Cognitive and Socio-Emotional Child Characteristics

	B5	
	<i>M</i>	(SD)
Cognitive functioning		
Visual STM	22.59	(4.84)
Verbal STM	14.54	(4.27)
Selective attention	294.45	(56.45)
Socio-emotional functioning		
Motivation	58.97	(9.03)
Self-concept	59.04	(8.97)
Wellbeing	65.78	(6.38)

Note. B5 = Begin Grade 5; STM = Short-term memory.

Correlations

Table 3 presents correlations between analytical and creative ability levels at the three measurement occasions, as well as with socio-emotional predictors, and cognitive predictors. Coefficients show that the three assessments of analytical ability levels were highly correlated ($r_s > .71$). Similarly, the scores for creativity correlated moderately ($r_s > .48$). Creative ability scores at the beginning of fifth grade were marginally significantly correlated with analytical abilities at that time point. Similarly, creative and analytical abilities at the end of fifth and sixth grade correlated significantly.

With regard to cognitive functioning, it can be seen in Table 3 that visual and verbal STM were significantly correlated with each other and with levels of both analytical and creative abilities. Selective attention was, however, neither related to

Table 3 Correlations Between Intellectual, Cognitive, and Socio-Emotional Measures

	1	2	3	4	5	6	7	8	9	10	11	12
1 Analytical abilities B5	-											
2 Analytical abilities E5	.748**	-										
3 Analytical abilities E6	.719**	.806**	-									
4 Creative abilities B5	.158	.131	.140	-								
5 Creative abilities E5	.194*	.249**	.241**	.459**	-							
6 Creative abilities E6	.217*	.234*	.214*	.481**	.518**	-						
7 Visual STM	.382**	.433**	.347**	.324**	.272**	.129	-					
8 Verbal STM	.221*	.261**	.378**	.191*	.207*	.254**	.246**	-				
9 Selective Attention	.179	.229*	.168	.012	.133	-.019	.246**	.138	-			
10 Motivation	.132	.128	.108	.238*	.268**	.237*	.173	-.043	.005	-		
11 Self-concept	.243**	.237*	.230*	.243**	.188*	.116	.109	.077	-.034	.437**	-	
12 Wellbeing	.090	.075	.118	.321**	.245**	.367**	.149	.067	-.024	.571**	.307**	-

Note. * $p \leq .05$; ** $p \leq .01$.

levels of STM or intellectual ability levels. Significant correlations were also found between the three indicators of socio-emotional functioning ($r_s > .43$). Whereas ratings of motivation, self-concept, and wellbeing were all related to creative ability levels, a significant correlation with analytical ability levels was only found for ratings of self-concepts. In addition, none of the socio-emotional child characteristics was related to indicators of cognitive child functioning.

The development of analytical and creative abilities

Next, we examined the development of analytical and creative abilities and the predictive role of socio-emotional and cognitive child characteristics in an integrative approach in a two-step structural equation modeling procedure. In step 1, we examined the development and interaction of analytical and creative abilities in an autoregressive cross-lagged model. Figure 1 shows the path diagram for this model. Results indicated significant coefficients for the autoregressive paths, whereas the cross-lagged paths were non-significant. That is, initial analytical scores strongly predicted later analytical ability levels, yet did not predict later creative ability levels. Similarly, creative ability levels at the beginning of Grade 5 significantly predicted later creative but not analytical ability scores. The autoregressive model adequately fitted the data ($X^2 = 0.58$, $df = 4$, $p = .966$, $RMSEA < 0.01$, $AGFI = 0.99$).

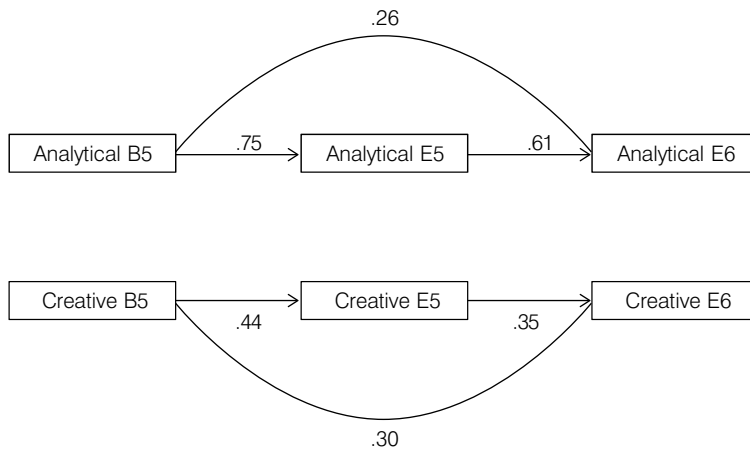


Figure 1 Path diagram for the autoregressive and cross-lagged development of analytical and creative abilities. Only significant paths and their standardized estimates are displayed. B5= Begin Grade 5; E5= End Grade 5; E6= End Grade 6

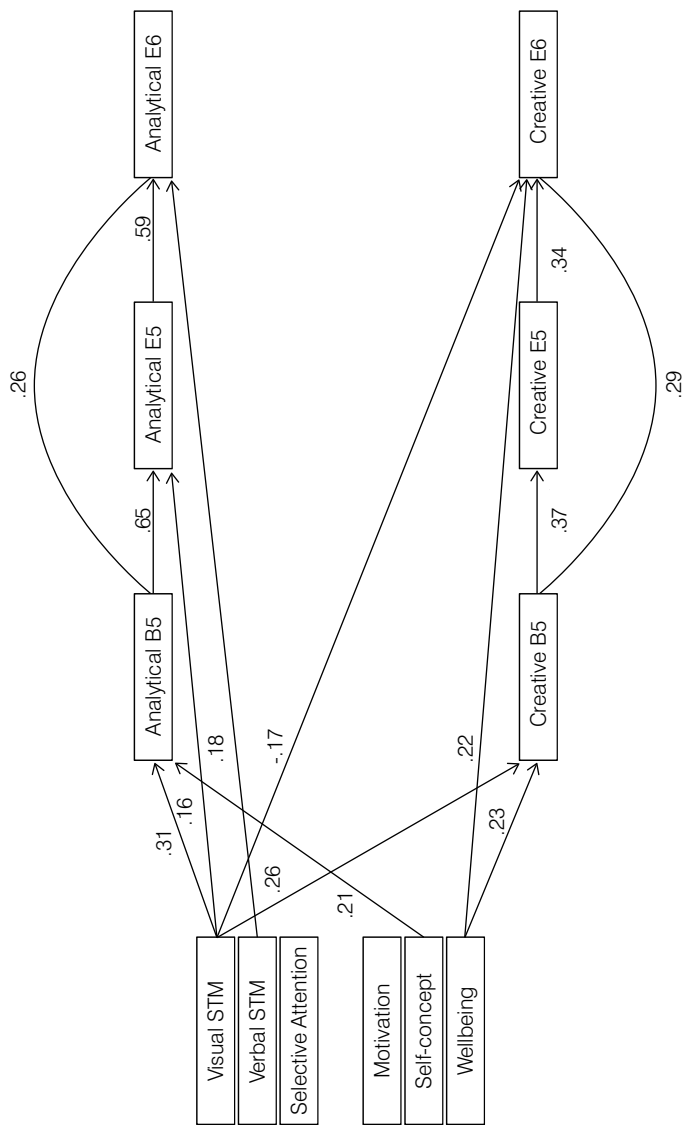


Figure 2 Path diagram for the predictive role of socio-emotional and cognitive child characteristics in the development of analytical and creative abilities. Only significant paths and their standardized estimates are displayed.
B5= Begin Grade 5; E5= End Grade 5; E6= End Grade 6

The predictive role of cognitive and socio-emotional child characteristics

In step 2, we included both cognitive and socio-emotional child functioning levels as predictors of the development of analytical and creative abilities. Figure 2 shows the path diagram for this full model, which yielded an adequate fit with the data ($\chi^2 = 2.84$, $df = 18$, $p = .999$, $RMSEA < 0.01$, $AGFI = 0.98$). Again, autoregressive paths were significant whereas cross-lagged paths were non-significant.

With regard to cognitive measures, visual STM was predictive of analytical ability levels both at the beginning and end of fifth grade. In addition, visual STM also positively predicted creative ability levels at the beginning of Grade 5. Conversely, a negative effect was found for visual STM on creative abilities at the end of sixth grade (Maassen & Bakker, 2001). Verbal STM was predictive of analytical ability levels at the end sixth grade only, whereas selective attention predicted neither analytical nor creative ability levels.

Results furthermore revealed that motivational levels were not predictive of either analytical or creative abilities. However, a significant predictive role of self-concept was found for initial levels of analytical, yet not creative abilities. In addition, wellbeing was predictive of initial and later creative ability levels.

Discussion

In the present study, we examined the development of analytical and creative abilities in the final grades of primary school. Secondly, we examined how the development of analytical and creative abilities can be explained from cognitive and socio-emotional predictors. We found significant increases in both analytical and creative ability scores over the final two years of primary school. In addition, results showed levels of analytical and creative abilities to be correlated, yet the developmental patterns of analytical and creative abilities were found to be relatively independent. The development of analytical ability levels was predicted by both visual and verbal short-term memory capacity, whereas only visual STM was predictive of the development of creative abilities. With regard to socio-emotional predictors, we found self-concept to predict the development of analytical abilities, and wellbeing to predict the development of creative abilities.

Analytical and creative ability levels were found to be correlated at all points in time. Although analytical and creative ability levels both increased over time, the longitudinal model showed that the developmental patterns of both types of abilities are rather independent. Analytical ability scores at the beginning of fifth grade were highly predictive of later analytical ability scores, yet did not predict later creative ability scores. Similarly, we also found a predictive value for initial creative ability

levels on later creative ability levels, yet not for later analytical ability levels. The significant autoregressive coefficients were indicative of the stability of both analytical and creative abilities as a developing expertise. However, the autoregressive coefficients were higher for analytical than for creative abilities. This might be due to the analytical focus in teaching and assessment in primary schools. Although creative abilities are considered important in more and more models of intelligence (Ziegler & Heller, 2000), creativity is only limitedly included in educational assessments (McClain & Pfeiffer, 2012).

The predictive role of cognitive child characteristics

Secondly, we aimed to study how the development of both types of abilities could be explained from cognitive and socio-emotional predictors. Concerning cognitive predictors, visual STM was found to be a significant predictor of both analytical and creative ability levels. At the end of sixth grade, however, the effect of visual STM on creative abilities was suppressed (Maassen & Bakker, 2001). That is, the path coefficients became negative because visual STM correlated with creative abilities at the beginning and end of fifth grade, yet did not correlate with creative abilities at the end of sixth grade any more. In contrast, verbal STM was only predictive of later, yet not initial analytical ability levels. This might be due to the increasing verbal nature of academic assignments over the final grades of primary school. Once students have mastered basis skills, assignments become more complex and abstract. Moreover, assignments are more and more embedded in a complex verbal description of a real-life context. Research has shown that even for mathematical problem solving, the use of schematic representation as opposed to visual representations led to more successful solutions in sixth graders (Hegarty & Kozhevnikov, 1999). Results of our study support these findings by showing that visual STM abilities become less important over the final grades of primary school, whereas verbal STM abilities become increasingly important.

Selective attention did not play a predictive role for either the development of analytical or creative abilities. That we did not find the significant correlations reported by Cowan and colleagues (2006) might be due to the inclusion of different types of cognitive functions in our predictive model. Friedman, Miyake, Corley, Young, DeFries, and Hewitt (2006) showed that cognitive functions are differentially related to intelligence. Specifically, they found that the STM ability to add and delete information in memory was most closely to intellectual abilities in young adults. Results of the present study support these findings by showing that selective attention abilities do not add to the prediction of analytical ability levels when the ability to encode information, hold it in memory, and consequently perform mental operations with it is also taken into account. In addition, selective attention did also not predict creative ability levels. Whereas Martindale (1999) and Memmert (2011) found an

association between attention and creativity, Memmert also showed that the strength of the effect declines at the ages 10 and 13. Results of our study expand these findings in showing that attention does not affect the development of creative abilities in upper primary school children.

The predictive role of socio-emotional child characteristics

Regarding the role of socio-emotional child characteristics, motivation did not play a role in the development of either analytical or creative abilities. Although previous studies showed an effect of motivation on IQ scores (Duckworth et al., 2011), we did not find such an effect for scores on analytical ability subtests. Instead of using a measure of test motivation specifically related to our intellectual ability subtests, we used a general measure of intrinsic motivation for school and homework. This measure might have been too broad to capture any predictive effect of motivation on the development of analytical abilities. Motivation did correlate with creative ability levels at the three points in time. Levels of motivation, however, also correlated strongly with levels of self-concept and wellbeing, so that the relationship with creativity was no longer visible in the comprehensive developmental model.

In line with findings by Valentine and colleagues (2004), self-concepts predicted the initial level of analytical abilities. Self-concepts were, however, not predictive of creative ability levels. This result might be due to our predominantly academic measure of self-concept. Previous research showed that both children and adults not only have conceptions of their academic abilities, but also of their creative abilities (Mandelman, Tan, Kornilov, Sternberg, & Grigorenko, 2010). Both Mandelman and colleagues (2010) and Tierney and Farmer (2002) found these beliefs with regard to creativity to be related to creative achievements. The development of creative abilities might thus be better explained by creative than by academic self-concept levels.

Results with regard to wellbeing showed a positive effect on initial and later creative ability levels. In contrast to the weak correlations found by Wulff and colleagues (2009), however, we did not find a relationship between wellbeing and analytical ability levels. The lack of a predictive effect on the development of analytical abilities might be due to a restriction of range in wellbeing scores. Descriptive statistics showed that children in general reported high levels of wellbeing with only little variance between children. For the development of creative abilities, however, we did find a positive predictive role of wellbeing. This finding suggests that positive moods endorse cognitive flexibility, thereby supporting the flexibility route hypothesis (Baas et al., 2008). Previous research in adults has shown that people experiencing positive feelings indeed consider a wider range of relevant factors in a task (Aspinwall, 1998). Our results suggest that in children, positive wellbeing also plays a role in the development of creativity.

Limitations

A number of limitations apply to the present study. First, we included socio-emotional and cognitive child characteristics only as predictors. According to a meta-analysis by Valentine and colleagues (2004), self-beliefs did not only have an effect on students' achievements, but also vice versa. The relationship between intellectual, socio-emotional, and cognitive child characteristics might thus be reciprocal. Secondly, the time period of this study was limited to the two final years of primary school. Assessments starting at the primary middle grades would provide more insight in the longitudinal development of analytical and creative abilities. Moreover, assessments in the first grades of secondary education might show whether the slight increases in creativity continue into a peak in early adulthood (Cropley, 2003).

Conclusion

Summarizing, both analytical and creative ability scores increased over the upper primary grades. Moreover, results showed that although analytical and creative abilities were correlated, both types of abilities develop independently via separated paths. Schools mainly address the development of analytical abilities, yet creative assignments and lessons could further support the development of creative abilities. Results moreover show that intellectual abilities are dynamic characteristics that develop in complex interplay with socio-emotional and cognitive child characteristics. When teachers also take socio-emotional and cognitive child characteristics into account in a comprehensive teaching approach, the development of analytical and creative abilities might be enhanced even further.

References

- Ackerman, P. L., Beier, M. E., & Boyle, M. O. (2005). Working memory and intelligence: The same or different constructs? *Psychological Bulletin*, 131, 30-60. doi:10.1037/0033-2909.131.1.30
- Amabile, T. M. (1983). Social psychology of creativity: A componential conceptualization. *Journal of Personality and Social Psychology*, 45, 997-1013. doi:10.1037/0022-3514.45.2.357
- Amabile, T. M. (1996). *Creativity in context*. Boulder, CO: Westview Press.
- Amabile, T. M., Barsade, S. G., Mueller, J. S., & Staw, B. M. (2005). Affect and creativity at work. *Administrative Science Quarterly*, 50, 367-403. doi:10.2189/asqu.2005.50.3.367
- Aspinwall, L. G. (1998). Rethinking the role of positive affect in self-regulation. *Motivation and Emotion*, 22, 1-32. doi:10.1023/A:1023080224401
- Baas, M., De Dreu, C. K. W., & Nijstad, B. A. (2008). A meta-analysis of 25 years of mood-creativity research: Hedonic tone, activation, or regulatory focus? *Psychological Bulletin*, 134, 779-806. doi:10.1037/a0012815
- Baddeley, A. D., & Hitch, G. J. (2007). Working memory: Past, present, and future? In N. Osaka, R. H. Logie, & M. D'Esposito (Eds.), *The cognitive neuroscience of working memory*. Oxford, England: Oxford University Press.
- Batey, M., & Furnham, A. (2006). Creativity, intelligence, and personality: A critical review of the scattered literature. *Genetic, Social, and General Psychology Monographs*, 132, 355-429. doi:10.3200/MONO.132.4.355-430
- Benedek, M., Jauk, E., Sommer, M., Arendasy, M., & Neubauer, A. C. (2014). Intelligence, creativity, and cognitive control: the common and differential involvement of executive functions in intelligence and creativity. *Intelligence*, 46, 73-83. doi:10.1016/j.intell.2014.05.007
- Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytical studies*. New York, NY: Cambridge University Press.
- Chart, H., Grigorenko, E., & Sternberg, R. J. (2008). Identification: The Aurora Battery. In J. A. Plucker & C. M. Callahan (Eds.), *Critical issues and practices in gifted education* (pp. 281-301). Waco, TX: Prufrock Press.
- Claxton, A. F., Pannells, T. C., & Rhoads, P. A. (2005). Developmental trends in the creativity of school-aged children. *Creativity Research Journal*, 17, 327-335. doi:10.1207/s15326934crj1704_4
- Cowan, N., Fristoe, N. M., Elliott, E. M., Brunner, R. P., & Sauls, J. S. (2006). Scope of attention, control of attention, and intelligence in children and adults. *Memory and Cognition*, 34, 1754-1768.
- Cropley, A. J. (2003). *Creativity in education and learning: A guide for teachers and educators*. London, England: Kogan Page.
- Dai, Y. D. (2010). *The nature and nurture of giftedness: A new framework for understanding gifted education*. New York, NY: Teachers College Press.
- Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum.
- Dekker, R., Dekker, P. H., & Mulder, J. L. (2007). De ontwikkeling van vijf nieuwe Nederlandstalige tests [*The development of five new Dutch tests*]. Leiden, The Netherlands: PITS.
- Diener, E., Oishi, S., & Lucas, R. E. (2003). Personality, culture, and subjective well-being: Emotional and cognitive evaluation of life. *Annual Review of Psychology*, 54, 503-525. doi:10.1146/annurev.psych.54.101601.145056
- Dolan, P., & Metcalfe, R. (2012). The relationship between innovation and subjective wellbeing. *Research Policy*, 41, 1489-1498. doi:10.1016/j.respol.2012.04.001
- Duckworth, A. L., Quinn, P. D., Lynam, D. R., Loeber, R., & Stouthamer-Loeber, M. (2011). Role of test motivation in intelligence testing. *Proceedings of National Academy Sciences*, 108, 7716-7720. doi:10.1073/pnas.1018601108
- Fokkema, S. D., & Dirkzwager, A. (1968). *Handleiding voor de Differentiële Aanleg Test [Manual for the Differential Aptitude Test]*. Lisse, The Netherlands: Swets & Zeitlinger.
- Foley Nicpon, M., & Pfeiffer, S. I. (2011). High-ability students: New ways to conceptualize giftedness and provide psychological services in schools. *Journal of Applied School Psychology*, 27, 293-305. doi:10.1080/15377903.2011.616579
- Friedman, N. P., Miyake, A., Corley, R. P., Young, S. E., DeFries, J. C., & Hewitt, J. K. (2006). Not all executive functions are related to intelligence. *Psychological Science*, 17, 172-179. doi:10.1111/j.1467-9280.2006.01681.x

- Gubbels, J., Segers, E., & Verhoeven, L. (2016). *How children's intellectual profiles relate to their cognitive, social-emotional, and academic functioning*. Manuscript resubmitted for publication.
- Hegarty, M., & Kozhevnikov, M. (1999). Types of visual-spatial representations and mathematical problem solving. *Journal of Educational Psychology*, 91, 684-689. doi:10.1037/0022-0663.91.4.684
- Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6, 1-55. doi:10.1080/10705519909540118
- Isen, A. M. (1999). On the relationship between affect and creative problem solving. In S. W. Russ (Ed.), *Affect, creative experience and psychological adjustment* (pp. 3-17). Philadelphia, PA: Brunner/Mazel.
- Kim, K. H. (2011). The creativity crisis: The decrease in creative thinking scores on the Torrance tests of creative thinking. *Creativity Research Journal*, 23, 285-295. doi:10.1080/10400419.2011.627805
- Kolata, S., Light, K., Grossman, H. C., Hale, G., & Matzel, L. D. (2007). Selective attention is a primary determinant of the relationship between working memory and general learning ability in outbred mice. *Learning and Memory*, 14, 22-28. doi:10.1101/lm.408507
- Kolligian, J., & Sternberg, R. J. (1987). Intelligence, information processing and specific learning disabilities: A triarchic synthesis. *Journal of Learning Disabilities*, 20, 8-17. doi:10.1177/002221948702000103
- Kornilov, S. A., Tan, M., Elliott, J. G., Sternberg, R. J., & Grigorenko, E. L. (2011). Gifted identification with the Aurora: Widening the spotlight. *Journal of Psychoeducational Assessment*, 30, 117-133. doi:10.1177/0734282911428199
- Maassen, G. H., & Bakker, A. B. (2001). Suppressor variables in path models: Definitions and interpretations. *Sociological Methods & Research*, 30, 241-270. doi:10.1177/0049124101030002004
- Mandelman, S. D., Tan, M., Kornilov, S. A., Sternberg, R. J., & Grigorenko, E. L. (2010). The metacognitive component of academic self-concept: The development of a triarchic self-scale. *Journal of Cognitive Education and Psychology*, 9, 73-86. doi:10.1891/1945-8959.9.1.73
- Marsh, H. W., & Craven, R. G. (2006). Reciprocal effects of self-concept and performance from a multi-dimensional perspective: Beyond seductive pleasure and unidimensional perspectives. *Perspectives on Psychological Science*, 1, 133-163. doi:10.1111/j.1745-6916.2006.00010.x
- Marsh, H. W., & Seaton, M. (2013). Academic self-concept. In J. Hattie & E. Anderman (Eds.), *International guide to student achievement* (pp. 62-63). New York, NY: Routledge.
- Martindale, C. (1999). Biological bases of creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 137-152). New York, NY: Cambridge University Press.
- McClain, M. C., & Pfeiffer, S. I. (2012). Education for the gifted in the United States today: A look at state definitions, policies, and practices. *Journal of Applied School Psychology*, 28, 59-88. doi:10.1080/15377903.2012.643757
- Memmert, D. (2011). Creativity, expertise, and attention: Exploring their development and their relationships. *Journal of Sports Science*, 29, 93-102. doi:10.1080/02640414.2010.528014
- Mukunda, K. V., & Hall, V. C. (1992). Does performance on memory for order correlate with performance on standardized measures of ability? A meta-analysis. *Intelligence*, 16, 81-91. doi:10.1016/0160-2896(92)90026-N
- Paulus, P. B., & Brown, V. R. (2007). Toward more creative and innovative group idea generation: A cognitive-social-motivational perspective of brainstorming. *Social and Personality Psychology Compass*, 1, 148-162. doi:10.1111/j.1751-9004.2007.00006.x
- Pfeiffer, S. I. (2003). Challenges and opportunities for students who are gifted: What the experts say. *Gifted Child Quarterly*, 47, 161-169. doi:10.1177/001698620304700207
- Runco, M. A., & Jaeger, G. J. (2012). The Standard Definition of Creativity. *Creativity Research Journal*, 24, 92-96. doi:10.1080/10400419.2012.650092
- Selig, J. P., & Little, T. D. (2012). Autoregressive and cross-lagged panel analysis for longitudinal data. In B. Laursen, T. D. Little, & N. A. Card (Eds.), *Handbook of developmental research methods* (pp. 265-278). New York, NY: Guilford.
- Shavelson, R. J., Hubner, J. J., & Stanton, J. C. (1976). Self-concept: Validation of construct interpretations. *Review of Educational Research*, 46, 407-441. doi:10.3102/00346543046003407
- Simonton, D. K. (2000). Creativity: Cognitive, personal, developmental, and social aspects. *American Psychologist*, 55, 151-158. doi:10.1037/0003 066X.55.1.151

- Sternberg, R. J. (1998). Abilities are forms of developing expertise. *Educational Researcher*, 27, 11-20. doi:10.3102/0013189X027003011
- Sternberg, R. J. (2003). WICS: A model of leadership in organizations. *Academy of Management Learning and Education*, 2, 386-401. doi:10.5465/AMLE.2003.11902088
- Subotnik, R. F., Olszewski-Kubilius, P., & Worrell, F. C. (2011). Rethinking giftedness and gifted education: A proposed direction forward based on psychological science. *Psychological Science*, 12, 3-54. doi:10.1177/1529100611418056
- Terman, L. M. (1925). *Genetic studies of genius: Volume I. Mental and physical traits of a thousand gifted children*. Palo Alto, CA: Stanford University Press
- Tierney, P., & Farmer, S. M. (2002). Creative self-efficacy: Its potential antecedents and relationship to creative performance. *The Academy of Management Journal*, 45, 1137-1148. doi:10.2307/3069429
- Torrance, E. P. (1968). A longitudinal examination of the fourth grade slump in creativity. *Gifted Child Quarterly*, 12, 195-199. doi:10.1177/001698626801200401
- Torrance, E. P. (1984). The role of creativity in identification of the gifted and talented. *Gifted Child Quarterly*, 28, 153-156. doi:10.1177/001698628402800403
- Valentine, J. C., DuBois, D. L., & Cooper, H. (2004). The relation between self-beliefs and academic achievement: A meta-analytic review. *Educational Psychologist*, 39, 111-133. doi:10.1207/s15326985ep3902_3
- Van Dijk, H., & Tellegen, P. J. (2004). *Nederlandse intelligentietest voor onderwijsniveau: Handleiding [Dutch intelligence test for educational level: Manual]*. Amsterdam, The Netherlands: Boomtest uitgevers.
- Van Hoorn, W., Van der Kamp, L., & Den Brinker, W. (2004). *Handleiding Nederlandse Differentiatie Testserie (NDT) [Manual Dutch Differentiation Testseries]*. Lisse, The Netherlands: Harcourt Test Publishers.
- Vorst, H. C. M., Smits, J. A. E., Oort, F. J., Stouthard, M. E. A., & David, S. A. (2008). *Schoolvragenlijst voor basisonderwijs en voortgezet onderwijs: Handleiding en verantwoording [School questionnaire for primary and secondary education: SVL user manual]*. Amsterdam, The Netherlands: Pearson.
- Worrell, F. (2009). Myth 4: A single test score or indicator tells us all we need to know about giftedness. *Gifted Child Quarterly*, 53, 242-244. doi:10.1177/0016986209346828
- Wulff, C., Bergman, L. R., & Sverke, M. (2009). General mental ability and satisfaction with school and work: A longitudinal study from ages 13 to 48. *Journal of Applied Developmental Psychology*, 30, 398-408. doi:10.1016/j.appdev.2008.12.015
- Ziegler, A., & Heller, A. (2000). Conceptions of giftedness form a meta-theoretical perspective. In K. A. Heller, F. J. Mönks, R. J. Sternberg & R. F. Subotnik (Eds.), *International handbook of giftedness and talent (2nd ed., pp.3-21)*. Oxford, England: Pergamon.

5

Effects of an individualized ICT enrichment program on the development of intellectual abilities in gifted children

This chapter is based on: Gubbels, J., Segers, E., & Verhoeven, L., (submitted).
Effects of an individualized ICT enrichment program on the development of analytical
and creative abilities in gifted children.

Abstract

Enrichment programs offer gifted students experiences beyond what is covered in the regular curriculum. Current technologies allow programs to be adapted to children's intellectual ability levels. We examined the effects of an individualized ICT enrichment program on the development of analytical and creative abilities of 26 gifted experimental group children and compared this to a control group of 20 equally gifted children. Results showed stable levels of creative abilities and increasing levels of analytical abilities in both groups. In addition, regression analyses showed a positive effect of the ICT enrichment program on the development of analytical abilities in children with relatively weak starting levels of analytical abilities. Therewith, results imply that rather than analytically-gifted children, children with talents in other domains benefit most from participation in an individualized ICT enrichment program.

Introduction

Enrichment programs are needed to prevent gifted children from underachieving (Matthews & McBee, 2007) or dropping out of school (Renzulli & Park, 2000). Integration of computers and related technologies into the learning environment of gifted students could facilitate the design of enrichment activities for gifted children in heterogeneous classrooms (Shaw & Giles, 2005; Sprague & Shaklee, 2015). Enrichment programs using these technologies have the benefit that learning can be individualized (Thomson, 2010) because materials can be provided via a broad range of multimedia tools (Dykman & Davis, 2008). Although ICT enrichment programs are used more and more, empirical studies on the effects of these programs on the development of intellectual abilities in gifted children are lacking (Thomson, 2010). In the present study, we examined the possibilities of an individualized ICT enrichment program to enhance the development of analytical and creative abilities in gifted elementary school children.

In education, giftedness is still mostly identified based on high IQ scores or excellent academic performances (McClain & Pfeiffer, 2012). This narrow approach to identification has a number of limitations (Pfeiffer, 2003). First and foremost, only children who perform well on standardized tests are considered gifted, whereas children with gifted levels of abilities in other domains are overlooked (Chart, Grigorenko, & Sternberg, 2008). As a consequence, children with talents that are not recognized by traditional assessment measures are underrepresented in gifted programs (Chart et al., 2008). One type of ability domain that is often recommended to be included in the identification process is creativity (McClain & Pfeiffer, 2012): the ability to generate original, yet effective ideas (Runco & Jaeger, 2012). Assessment of both analytical and creative intellectual abilities allows children with a greater range of intellectual profiles to be identified as gifted (Kornilov, Tan, Elliott, Sternberg, & Grigorenko, 2011) and therewith to gain access to gifted programs.

A second limitation is that standardized tests often assume intelligence to be static so that the development of ability levels over time is not taken into account. Foley Nicpon and Pfeiffer (2011), however, describe intelligence as a developing expertise. In elementary school children, pedagogical practices are considered to play an important role in the development of intellectual abilities (Besançon & Lubart, 2008; Pfeiffer & Thomson, 2013). According to Fairweather and Cramond (2010), both analytical and creative abilities can and should be explicitly taught. Analytical abilities can be emphasized by instructing children to analyze, evaluate, compare, and explain parts of a problem (Sternberg & Grigorenko, 2002). Creative abilities, on the other hand, can be enhanced by modeling the ability to create, design, and imagine. Rather than separate analytical and creative instruction, Sternberg and Grigorenko (2002) advocate to integrate both types of instruction. Moreover, for gifted

children to develop both types of abilities to their full potential, they need challenging educational opportunities (VanTassel-Baska, 2007). These opportunities can be provided with enrichment programs.

Enrichment program effects

Enrichment programs offer gifted students educational experiences that are not covered in the conventional curriculum (Renzulli & Reis, 2003). In general, enrichment programs have been found to have positive effects on gifted student's intellectual and academic development (see for a review Hoogeveen, van Hell, Mooij, & Verhoeven, 2004). A study on the effects of enrichment programs that integrated analytical and creative instruction showed positive effects on both intellectual and memorization assessments when compared to enrichment programs with standard memory-based instruction (Sternberg, Torff, & Grigorenko, 1998). Moreover, the first type of enrichment program also resulted in higher reading scores than the program with standard instruction (Grigorenko, Jarvin, & Sternberg, 2001). In their study on an enrichment program for gifted elementary school children, Aljughaiman and Ayoub (2012) also found a positive effect on both types of abilities. These results suggest that a focus on both analytical and creative abilities does not only enhance the development of both types of intellectual abilities, but also results in a transfer to academic achievements. Other studies, however, did not find effects on analytical or creative abilities in gifted elementary school children for a pull-out program (Gubbels, Segers, & Verhoeven, 2014) or extracurricular activities (Liu, He, & Li, 2015).

Individualized enrichment programs

In general, enrichment programs with both analytical and creative instruction thus tend to result in higher levels of intellectual abilities and academic achievements. An important benefit of this multidimensional instruction is that it provides opportunities to align instruction to the intellectual profiles of the children (Sternberg et al., 1998). Previous studies have shown a wide range of intellectual profiles in both adolescents (Sternberg, Grigorenko, Ferrari, & Clinkenbeard, 1999) and elementary school children (Gubbels, Segers, & Verhoeven, 2016; Kornilov et al., 2011). Whereas some children were found to excel in only the analytical or creative domain, others showed high levels of abilities in both the domains. A study on aptitude-treatment interaction showed analytically-gifted students to perform best after analytical instruction, whereas creatively-gifted students profited most from creative instruction (Sternberg et al., 1999). Overall, effects of the enrichment programs were thus greatest when method of instruction was adapted to students' intellectual profiles.

To adapt the curricular program to individual levels of ability and needs of gifted students in a heterogeneous classroom, teachers can use ICT (Shaw & Giles, 2015). According to both students and teachers, ICT programs provide more opportunities

to individualize and differentiate learning in within-class enrichment (Thomson, 2010). A review by Periathiruvadi and Rinn (2012) showed that gifted students had positive attitudes towards the use of technology for their learning. Specifically, children mentioned the flexibility as an advantage of ICT programs (Blair, 2010). Another benefit of ICT programs is that it provides opportunities for new modes of learning (Thomson, 2010) because materials can be provided by a wide range of multimedia tools (Dykman & Davis, 2008). ICT programs thus allow students to choose the tool that best matches their individual preferences (Moore, 2007). In a review, Cavanaugh, Barbour, and Clark (2009) showed that students in online courses in general improved more in both critical thinking and creative thinking than students in traditional classrooms. Empirical research evaluating the effects of ICT programs for gifted children on both types of abilities, however, is lacking (Thomson, 2010).

Present study

In the present study, we examined the effects of an individualized ICT enrichment program on the development of analytical and creative abilities in gifted children. The program – Acadin - is an example of an individualized enrichment program, because it provides teachers the opportunity to match assignments to children's initial levels of intellectual abilities. The individualized program was provided to a group of Dutch gifted upper elementary school children, whose intellectual development was compared to a group of gifted control group children following the regular education program. Next to these group effects, we also examined differential effects of the individualized ICT enrichment program on the development of analytical and creative abilities in gifted children. We hypothesized Acadin to differentially enhance the intellectual development for children with varying initial levels of analytical and creative abilities.

Method

Participants

In line with Kornilov et al (2011), children were considered gifted when belonging to the 10% best performing children of a longitudinal study sample ($N = 513$) in either or both of the intellectual domains. Following this criterion, we selected 34 children from the seven schools in the experimental group and 21 children from the eight schools in the control group as being gifted. One school in the experimental group withdrew from the study and some gifted children were absent at a day of measurement so that 9 gifted children had missing values. These children were excluded from analyses. We thus compared the intellectual development of 26 gifted children (15 boys, mean age = 10 years and 3 months) in the experimental group with the development of 20 gifted children of the control group (8 boys, mean age = 10 years and 4 months).

Gifted children from the control and experimental group did not differ from each other in gender, $\chi^2(1, N = 46) = 1.42, p = .234$, Cramér's $V = .18$, or age, $t(44) = .347, p = .731$.

Materials

Analytical abilities. The subtests Analogies, Numbers, and Figures from the Dutch Intelligence Test for Education Level (Van Dijk & Tellegen, 2004) assessed analytical abilities. With Analogies ($\alpha = .64$) children had to find the most appropriate word following a series of three words. The subtest Numbers ($\alpha = .85$) asked children to indicate the correct number following a series of seven numbers. Both Analogies and Numbers comprised 25 multiple choice items. The subtest Figures ($\alpha = .69$) comprised eight items representing a three-dimensional figure. Children had to indicate which out of five paper models could be used to construct the figure. For each item, multiple answers were correct. Each correct answer was granted one point, whereas every wrong answer reduced the score with one point.

In addition, the subtests Practical Intellect (Dutch Differential Aptitude Test; Fokkema & Dirkzwager, 1968) and Toy Shadows (Aurora battery; Chart et al., 2008) were also indicative of analytical abilities (Gubbels et al., 2016). Practical Intellect ($\alpha = .79$) tapped into children's insight in physical operations with 50 multiple choice items. Toy Shadows ($\alpha = .53$) asked for eight items which of four images represented the true shadow of a toy.

Creative abilities. We included the Aurora Battery subtests Book Covers, Multiple Uses, and Metaphors to assess creative abilities (Chart et al., 2008). All three subtests have open-ended answering formats. With Book Covers ($\alpha = .89$), children had to write down what a book with the presented imaginative book cover could be about. Multiple Uses ($\alpha = .76$) required children to write down as many uses for common objects as possible. Both Book Covers and Multiple Uses comprised five items. Metaphors ($\alpha = .75$) comprised nine items for which children had to list as many similarities between two common objects as possible.

Answers on all three subtests were coded by two undergraduates and the first author on accuracy ($0 = no\ answer$; $1 = partly\ complete\ answer$; $2 = complete\ answer$) and ability-creativity ($0 = no\ answer$; $1 = short\ or\ non-creative\ answer$; $2 = answer\ including\ original\ interpretation$; $3 = answer\ including\ two\ or\ more\ original\ interpretations$; $4 = completely\ original\ interpretation$). The percentage of agreement between raters was high for a randomly selected sample of 20% of all answers: 72.2% for Book Covers, 80.2% for Multiple Uses, and 73.8% for Metaphors.

Procedure

A research assistant visited the classrooms at the beginning of fifth grade and at the end of fifth grade. After receiving instruction, children completed the intellectual abilities battery in a group setting.

In order to offer teachers the tools and knowledge needed to optimally support children in gaining the most from the Acadin enrichment program, professionals in the field of gifted education provided a training of three afternoon sessions. In the first session, teachers were informed on current theories of giftedness and intelligence in which giftedness is described as a multidimensional construct. Moreover, the developmental nature of intelligence and giftedness and the importance of a challenging learning environment herein were explained. Next, teachers discussed in small groups what student characteristics are important for children to profit from the use of Acadin. Afterwards, teachers were challenged to discuss the role of the teacher for successful use of Acadin.

In the second afternoon, the trainers aimed to provide teachers with the practical knowledge and skills to start working with Acadin. Teachers were first presented with tools to gain more insight in the intellectual profiles of their students. Next, they were taught how to search for and select activities that matched these individual profiles. In addition, the possibilities for monitoring students' progress and providing feedback online were shown. After the second day of training, all teachers were able to start with Acadin in their schools.

The third session was aimed at providing help and support with issues that teachers had already encountered in working with Acadin. Teachers were encouraged to share their experiences and discuss any problems that they encountered thus far. In this final training session, the trainers instructed teachers to let the gifted children work on Acadin assignments for at least one hour per week for 25 weeks. In choosing assignments, children were allowed to follow their own interests, yet boundary conditions were that the learning activities were of an appropriate intellectual level and focused on analytical and creative abilities.

Research assistants had monthly interviews with the teachers to provide help with organizational and technical problems and to monitor the implementation. Teachers in the control group did not receive any training and their students followed the regular educational program.

Individualized ICT enrichment program: Acadin

The individualized enrichment program was provided in Acadin, a sheltered ICT environment funded by the Dutch government to stimulate excellence. Acadin comprises a database of challenging assignments developed and provided in an evidence-informed way. All assignments were open ended tasks for which children need more than just academic knowledge and skills. That is, assignments targeted 21st century skills as collaborative learning, problem solving, and creativity. Therewith, assignments were especially suitable for challenging gifted children to expand their abilities.

To gain access to the assignments, teachers had to request a school domain in which they could add individual students as users. Each student was connected to at

least one teacher. Teachers could select and plan assignments for their students. The individualized nature of the program allowed teachers to match characteristics of assignments to child characteristics. Moreover, teachers had access to an overview of all activities that their students performed so that they could easily monitor their progress, provide feedback, and evaluate assignments.

Students had access to a personalized learning environment with assignments that were planned by the teacher. In addition, students could also search for activities in the database. After approval by their teacher, students had access to all documents and websites needed to complete the assignment. Students could work on the assignments online, save their work in between sessions, and submit it once completed. Moreover, the environment provided opportunities for gifted children to interact with each other and the teacher online.

Results

Implementation

In monthly interviews with the six teachers of in the experimental group, four teachers said they strived for 1 hour of Acadin time each week and two teachers indicated that the students worked with Acadin for 2 hours a week. Whereas two of the teachers indicated that this time was scheduled at fixed time points each week, the other teachers indicated that pupils were only allowed to do Acadin assignments after completing their regular academic achievements. Some teachers indicated that there was a problem with the availability of desktops. As a consequence, teachers reported that pupils regularly completed the Acadin assignments on paper rather than on a computer or laptop. Descriptive statistics of online behaviors support these findings. The median number of assignments that was formally approved by the teachers was only 5. The total learning time of these assignments was estimated on 13 hours. Although Acadin has the possibility to provide pupils with feedback online, this feature was not used by any of the teachers in the current study. In the interviews, however, four out of six teachers told that they did provide feedback, either group wise, individually, or both. The other three teachers declared not to have the time and possibilities to provide pupils with feedback on their Acadin assignments.

All six teachers indicated that children were allowed to choose the assignments themselves, yet they had to be approved by the teachers. Whereas Acadin provides the opportunity to match the type of intellectual ability addressed in an assignment to children's individual intellectual profiles, correlations revealed that the initial level of ability was not related to the number of assignments in either the analytical, $r = .21$, $p = .400$, or creative domain, $r = -.33$, $p = .176$.

Group effects

Table 1 presents descriptive statistics on the development of analytical and creative abilities in gifted children in the control and experimental group. To examine the overall effect of the Acadin program, we performed a 2 (Ability) by 3 (Time) repeated measures MANOVA with Group (Acadin, Control) as between subjects factor.

Table 1 Means (M) and Standard Deviations (SD) of Intellectual Ability Levels in Gifted Children of the Control and Experimental Group

	B5		E5	
	M	(SD)	M	(SD)
Control Group				
Analytical abilities	63.00	(14.11)	75.15	(18.95)
Creative abilities	67.60	(8.02)	66.26	(11.01)
Experimental group				
Analytical abilities	69.62	(6.97)	81.80	(8.70)
Creative abilities	67.62	(8.92)	64.90	(9.52)

Note. B5 = Begin Grade 5; E5= End Grade 5.

For creative abilities, the repeated measures MANOVA showed no main effect of Time, $F(1,38) = 2.01$, $p = .165$, $\eta_p^2 = .05$, no main effect of Group, $F(1,38) = 0.25$, $p = .623$, $\eta_p^2 = .06$, as well as no interaction of Time*Group, $F(1,38) = 0.00$, $p = .953$, $\eta_p^2 < .01$. Therewith, results indicated that creative abilities levels were stable in gifted children of both the Acadin and the control group.

For analytical abilities, a significant main effect of Time, $F(1,38) = 104.19$, $p < .001$, $\eta_p^2 = .99$, indicated that in general, gifted children's analytical abilities increased over the final two years of elementary school. Both the main effect of Group, $F(1,38) = 2.96$, $p = .093$, $\eta_p^2 = .07$, and the interaction between Time and Group was not significant, indicating that the growth in analytical abilities was equal for children in the two groups, $F(1,38) = 0.04$, $p = .834$, $\eta_p^2 < .01$.

Differential effects

To further investigate the effects of the Acadin program on the development of analytical and creative abilities in gifted children, we examined whether the intellectual development differed as a function of children's initial ability levels in the analytical and creative domains. Therefore, we performed a hierarchical linear regression analysis with analytical and creative abilities at the end of fifth grade as dependent variables. In step 1, the pretest level of the intellectual ability was included to control

for initial ability levels. In step 2, we included group as a dummy (control, experimental). In step 3, the interaction terms of initial intellectual ability level by group was included to examine whether the effect of initial ability levels was different for children in the two groups. Table 2 presents the results.

Table 2 Predictors of Analytical and Creative abilities at the End of Fifth Grade (E5)

	Analytical abilities			Creative abilities	
	<i>B</i>	<i>sig.</i>		<i>B</i>	<i>sig.</i>
Step1			Step1		
Analytical abilities B5	0.81	.000	Creative abilities B5	0.48	.002
Step 2			Step 2		
Analytical abilities B5	0.82	.000	Creative abilities B5	0.48	.002
Group	0.01	.891	Group	0.03	.816
Step 3			Step 3		
Analytical abilities B5	0.46	.016	Creative abilities B5	0.31	.094
Group	-0.03	.725	Group	0.03	.840
Analytical abilities B5*Group	0.40	.030	Creative abilities B5*Group	0.28	.121

Note. Significant *p*-values are boldfaced.

Results showed a significant predictive role of initial analytical ability levels on later levels of analytical abilities, yet the main effect of group was non-significant. A significant interaction between group and ability showed differential developmental patterns for children in the experimental and control group as a function of their initial analytical ability level. More specifically, post hoc correlation analyses indicated that in the experimental group, children with *lower* initial analytical ability levels had largest growth of analytical abilities by the end of fifth grade. This was not the case in the control group in which initial ability level was uncorrelated to growth of analytical abilities.

For creative ability level, again the main effect of initial ability level was significant: children with higher levels of creative abilities at the beginning of grade 5 also showed higher levels of creative abilities at the end of grade 5. Furthermore, results in Table 2 show a non-significant main effect of group, as well as a non-significant interaction effect of initial ability levels by group. Therewith, results indicate that Acadin did not differentially affect the development of gifted children's creative abilities.

Discussion

The aim of the present study was to examine the differential effects of an individualized ICT enrichment program on the development of analytical and creative abilities in gifted upper elementary school children. Results showed stable levels of creative abilities in gifted children in both the experimental and the control group. In contrast, analytical ability levels increased in both groups of gifted children. Hierarchical regression analyses showed a positive effect of the individualized ICT program specifically for the development of analytical abilities in children with relatively low starting levels of analytical abilities.

Whereas ICT enrichment programs are assumed to have great potential to enhance learning of gifted students (Cavanaugh, 2007; Dykman & Davis, 2008; Moore, 2007), results of the present study showed only a small sample of gifted children to benefit from participation in the enrichment program. In contrast to earlier studies (Gubbels et al., 2014; Liu et al., 2015), we did find increases in analytical abilities in gifted children in both the experimental and control group. Whereas previous studies either used teacher nominations (e.g., Gubbels et al., 2014) or standardized examinations (e.g., Liu et al., 2015) to identify gifted children, we used multidimensional assessment to identify gifted children. Results of the present study are in line with the hypothesis of intellectual abilities as developing expertise (Foley Nicpon & Pfeiffer, 2012) and show that with broad identification, gifted children do show development of analytical abilities over the upper elementary grades.

Further analyses of the data showed that the effect of the individualized program was related to child characteristics. For children in the experimental group, we found that gains in analytical abilities were negatively correlated to initial ability levels. That is, children in the Acadin group with relatively weak levels of analytical abilities at the start of the program showed larger gains in analytical ability levels than children with high levels of analytical abilities. In the control group, children all showed equal growth in analytical abilities irrespective of their initial ability levels. Altogether, results seem to imply that if at all, children with other than analytical talents might profit from the Acadin program. In the present studies, these children were the creatively-gifted children. For analytically-gifted children, the use of the program in the current intervention seemed to put a hold on their development. In practice, however, children are most commonly identified or nominated for gifted services based on high scores on analytical IQ scores within the top 3 to 5% range (McClain & Pfeiffer, 2012). As a consequence, enrichment programs are mostly provided to analytically-gifted children whereas children with other talents are overlooked. To allow a greater range of children to be identified for enrichment programs, assessment should be multi-dimensional including tests for analytical ability but also for other types of abilities (Chart et al., 2008). Expanding the cut-off criteria might also lead to a more diverse

sample of gifted children to be identified. McBee, Peters, and Waterman (2014) showed that a disjunctive model is most appropriate for identifying a wide range of abilities. With this model, children are selected for gifted services when they have at least one score above the cutoff criterion in a series of multiple assessments. In contrast to the conjunctive model in which children have to meet the cutoff criterion on all measures, the disjunctive model leads to a more heterogeneous gifted sample.

With regard to the development of creative abilities, scores were found to remain stable in gifted upper elementary school children from both the experimental and the control group. In addition, the online ICT enrichment program was not found to differentially enhance the development of creative abilities in children with varying initial levels of creative abilities. Similar to results by previous studies (Gubbels et al., 2014; Liu et al., 2015), results of the present study indicated that enrichment activities do not contribute to the development of creative abilities. In contrast, Aljughaiman and Ayoub (2012) did find an effect of an enrichment program on gifted children's development of creative abilities. Whereas children spend eight hours a week for six weeks in the gifted program studied by Aljughaiman and Ayoub (2012), online data with regard to the implementation of Acadin showed that children on average spend only 13 hours online during a full year of school. Moreover, Beghetto and Kaufman (2014) showed that the learning environment and teacher behaviors are of great influence in nurturing creativity. Whereas the Acadin program has benefits regarding adaptability, the online nature of the program reduces face-to-face interaction between students and teachers which might have resulted in the lack of effects on the creative development of gifted children.

Implementation

With regard to the implementation of Acadin, data of online behaviors suggested that Acadin was used for only a total of 13 hours, while we aimed for 25. However, teachers indicated that part of the assignments were completed offline. Online data might thus underestimate the amount of hours that pupils spent on Acadin assignments. A review by Durlak and DuPre (2008) showed that there are numerous contextual factors that influence the level of implementation, yet one important factor is the amount and content of training (Henderson, MacKay, & Peterson-Badali, 2006). Whereas the Acadin program can be implemented after a one-hour online teacher training, we provided the teachers participating in the present study with a three day teacher program in which we provided them with information about giftedness and prepared them for their new tasks. However, the infrastructure of the schools is also of major importance (Fagan & Mihalic, 2003). Teachers in the current study experienced difficulties in integrating the Acadin program into the regular curriculum, because they did not want a loss of instruction time for academic subjects. For successful implementation, it thus seems important that the organizational structure of the school is adapted to the content and requirements of the program.

Limitations

Some limitations apply to the present study. First, because of the criterion of top 10% scores, the two groups of gifted children were fairly small. Second, although we tried to monitor the online activities of the children and teachers, a lot of information is still lacking. Despite the fact that the teacher training explicitly addressed that the program has a lot of potential for teachers and children to communicate online, the present study showed that these features were rarely used. We did not monitor offline child and teacher behaviors, so that we are unsure about the frequency of communication in person. To create a creativity-supportive environment (Davies, Jindal-Snape, Collier, Digby, Hay, & Howe, 2012), teachers should model creativity in their everyday teaching. Moreover, by encouraging creative behaviors, teachers can further foster the creative development of their students (Beghetto & Kaufman, 2014). Future studies might explore the exact behaviors of the children more closely using video or in class observations.

Conclusion

To summarize, gifted children in both the control group and experimental group showed gains in analytical abilities, whereas creative ability levels were stable in both groups. With results showing differential effects as a function of initial ability levels, the individualized ICT enrichment program seems to enhance the development of analytical abilities in only a subsample of gifted children with relatively weak starting levels of analytical abilities. Educators and psychologists should carefully consider the consequences of the various identification models before the start of the identification process. It can thus be concluded that multidimensional assessment is essential to identify not only analytically-gifted children but also children with other talents who seem to benefit most from participation in an individualized ICT enrichment program.

References

- Aljughaiman, A. M., & Ayoub, A. E. A. (2012). The effect of an enrichment program on developing analytical, creative, and practical abilities of elementary gifted students. *Journal for the Education of the Gifted*, 35, 153-174. doi:10.1177/0162353212440616
- Beghetto, R. A., & Kaufman, J. C. (2014). Classroom contexts for creativity. *High Ability Studies*, 25, 53-69. doi:10.1080/13598139.2014.905247
- Besançon, M., & Lubart, T. (2008). Differences in the development of creative competencies in children schooled in diverse learning environments. *Learning and Individual Differences*, 18, 381-389. doi:10.1016/j.lindif.2007.11.009
- Blair, R. (2010). Online learning for gifted students from the parents' perspectives. *Gifted Child Today*, 30, 28-30.
- Cavanaugh, C. (2007). Effectiveness of K-12 online learning. In M. Moore (Ed.), *Handbook of distance education* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum.
- Cavanaugh, C., Barbour, M., & Clark, T. (2009). Research and practice in K-12 online learning: a review of open access literature. *The International Review of Research in Open and Distance Learning*, 10, 1-22.
- Chart, H., Grigorenko, E., & Sternberg, R. J. (2008). Identification: The Aurora Battery. In J. A. Plucker & C. M. Callahan (Eds.), *Critical issues and practices in gifted education* (pp. 281-301). Waco, TX: Prufrock Press.
- Davies, D., Jindal-Snape, D., Collier, C., Digby, R., Hay, P., & Howe, A. (2012). Creative learning environments in education: A systematic literature review. *Thinking Skills and Creativity*, 8, 80-91.
- Durlak, J. A., & DuPre, E. P. (2008). Implementation matters: A review of research on the influence of implementation on program outcomes and the factors affecting implementation. *American Journal of Community Psychology*, 41, 327-350. doi:10.1007/s10464-008-9165-0
- Dykman, C. A., & Davis, C. K. (2008). Online education forum: Part two- Teaching online versus teaching conventionally. *Journal of Information Systems Education*, 19, 156-163.
- Fagan, A. A., & Mihalic, S. (2003). Strategies for enhancing the adoption of school-based prevention programs: Lessons learned from the blueprints for violence prevention replications of the life skills training program. *Journal of Community Psychology*, 31, 235-253. doi:10.1002/jcop.10045
- Fairweather, E., & Cramond, B. (2010). Infusing creative and critical thinking into the curriculum together. In R. A. Beghetto & J. C. Kaufman (eds.) *Nurturing creativity in the classroom* (pp. 113-141). Cambridge, England: Cambridge University Press.
- Foley Nicpon, M., & Pfeiffer, S. I. (2011). High-ability students: New ways to conceptualize giftedness and provide psychological services in schools. *Journal of Applied School Psychology*, 27, 293-305. doi:10.1080/15377903.2011.616579
- Grigorenko, E. L., Jarvin, L., & Sternberg, R. J. (2001). School-based tests of the triarchic theory of intelligence: Three settings, three samples, three syllabi. *Contemporary Educational Psychology*, 27, 167-208. doi:10.1006/ceps.2001.1087
- Gubbels, J., Segers, E., & Verhoeven, L. (2014). Cognitive, socio-emotional and attitudinal effects of a triarchic enrichment program for gifted children. *Journal for the Education of the Gifted*, 37, 378-397. doi:10.1177/0162353214552565
- Gubbels, J., Segers, E., & Verhoeven, L. (2016). *How children's intellectual profiles relate to their cognitive, social-emotional, and academic functioning*. Manuscript resubmitted for publication.
- Henderson, J. L., MacKay, S., & Peterson-Badali, M. (2006). Closing the research-practice gap: Factors affecting adoption and implementation of a children's mental health program. *Journal of Clinical Child and Adolescent Psychology*, 35, 2-12. doi:10.1207/s15374424jccp3501_1
- Hoogeveen, L., van Hell, J., Mooij, T., & Verhoeven, L. (2004). *Educational arrangements for gifted children: Meta-analysis and overview of international research*. Nijmegen, The Netherlands: ITS/CBO/Orthopedagogiek, Radboud University.
- Kornilov, S. A., Tan, M., Elliott, J. G., Sternberg, R. J., & Grigorenko, E. L. (2011). Gifted identification with the Aurora: Widening the spotlight. *Journal of Psychoeducational Assessment*, 30, 117-133. doi:10.1177/0734282911428199

- Liu, Z. K., He, J., & Li, B. (2015). Critical and creative thinking as learning processes at top-ranking Chinese middle-schools: possibilities and required improvements. *High Ability Studies*, 26, 139-152. doi:10.1080/13598139.2015.1015501
- Matthews, M. S., & McBee, M. T. (2007). School factors and the underachievement of gifted students in a talent search summer program. *Gifted Child Quarterly*, 51, 167-181. doi:10.1177/0016986207299473
- McBee, M. T., Peters, S. J., & Waterman, C. (2014). Combining scores in multiple-criteria assessment Systems: The impact of combination rule. *Gifted Child Quarterly*, 58, 69-89. doi:10.1177/0016986213513794
- McClain, M. C., & Pfeiffer, S. I. (2012). Education for the gifted in the United States today: A look at state definitions, policies, and practices. *Journal of Applied School Psychology*, 28, 59-88. doi:10.1080/15377903.2012.643757
- Moore, M. G. (2007). Learners come in different types. *The American Journal of Distance Education*, 21, 1-2. doi:10.1080/08923640701298571
- Periathiruvadi, S., & Rinn, N. (2012). Technology in gifted education: A review of best practices and empirical research. *Journal of Research and Technology in Education*, 45, 153-169. doi:10.1080/15391523.2012.10782601
- Pfeiffer, S. I., & Thompson, T. L. (2013). Creativity from a talent development perspective: How it can be cultivated in the schools. In K. H. Kim, J. C. Kaufman, J. Baer, & B. Sriraman (Eds.), *Creatively gifted students are not like other gifted students: Research, theory, and practice* (pp. 231-256). Rotterdam, The Netherlands: Sense Publishers.
- Renzulli, J. S., & Park, S. (2000). Gifted dropouts: The who and the why. *Gifted Child Quarterly*, 44, 261-271. doi:10.1177/001698620004400407
- Renzulli, J. S., & Reis, S. M. (2003). Conception of giftedness and its relation to the development of social capital. In N. Colangelo & G. A. Davis (Eds.), *Handbook of gifted education* (3th ed., pp. 75-87). Boston, MA: Allyn & Bacon.
- Shaw, E. L., & Giles, R. M. (2015). Using technology to teach gifted students in a heterogeneous classroom. In L. Lennex & K. Fletcher Nettleton, *Cases on instructional technology in gifted and talented education* (pp. 31-53). Hershey, PA: IGI Global. doi:10.4018/978-1-4666-6489-0
- Sprague, D. R., & Shaklee, B. (2015). Differentiating through technology for gifted students. In L. Lennex, & K. Nettleton (Eds.) *Cases on Instructional Technology in Gifted and Talented Education* (pp. 269-286). Hershey, PA: Information Science Reference. doi:10.4018/978-1-4666-6489-0.ch013
- Sternberg, R. J., & Grigorenko, E. L. (2002). The theory of successful intelligence as a basis for gifted education. *Gifted Child Quarterly*, 46, 265-277. doi:10.1177/001698620204600403
- Sternberg, R. J., Grigorenko, E. L., Ferrari, M., & Clinkenbeard, P. (1999). A triarchic analysis of an aptitude-treatment interaction. *European Journal of Psychological Assessment*, 15, 3-13. doi:10.1027//1015-5759.15.1.3
- Sternberg, R. J., Torff, B., & Grigorenko, E. L. (1998). Teaching triarchically improves school achievements. *Journal of Educational Psychology*, 90, 374-384. doi:10.1037/0022-0663.90.3.374
- Thomson, D. L. (2010). Beyond the classroom walls: Teachers' and students' perspectives on how online learning can meet the needs of gifted students. *Journal of Advanced Academics*, 21, 662-712. doi:10.1177/1932202X1002100405
- VanTassel-Baska, J., & Brown, E. F. (2007). Toward best practice: An analysis of the efficacy of curriculum models in gifted education. *Gifted Child Quarterly*, 51, 342-358. doi:10.1177/0016986207306323

6

Effects of a pull-out program on the development of intellectual abilities in gifted children

This chapter is based on: Gubbels, J., Segers, E. & Verhoeven, L. (2014). Cognitive, socio-emotional and attitudinal effects of a triarchic enrichment program for gifted children. *Journal for the Education of the Gifted*, 37, 378-397. doi:10.1177/0162353214552565

Abstract

In most industrialized societies, the regular educational system does not meet the educational needs of gifted pupils, causing a lag in their school achievement. One way in which more challenge can be provided to gifted children is with an enrichment program. In the present study, intellectual, socio-emotional, and attitudinal effects of a triarchic enrichment program were examined in a pretest–posttest control group design. Participants were 66 upper primary school children. With positive effects on practical intelligence, motivation, self-concept, and enjoyment of science being found, the results of this study indicated that the pull-out program is a valuable experience in the intellectual and socio-emotional development of gifted children.

Introduction

In the past few decades, numerous interventions have been developed for children who lag behind in their educational achievements to provide the opportunity for them to catch up. However, policymakers have only recently suggested that educational programs need to be adjusted to suit the needs of gifted children (Subotnik, Olszewski-Kubilius, & Worrell, 2011). The standard curriculum generally offers insufficient challenge for these children (Heller, Mönks, Sternberg, & Subotnik, 2000), thereby risking a decrease in motivation and the development of negative attitudes toward school (McCoach & Siegle, 2003), which could eventually lead to underachievement. The problem of underachievement is most profound in the areas of science and technology (Gonzales et al., 2008; Programme for International Student Assessment [PISA], 2009). Although gifted children typically have the skills needed for a successful career in science, the lack of achievement and involvement in science and technology is visible in most industrialized societies (Bøe, Henriksen, Lyons, & Schreiner, 2011; Organisation for Economic Co-Operation and Development [OECD], 2008). A science-based enrichment program may help enhance the science and technology skills and attitudes of gifted pupils in primary grades. Although various educational programs for gifted children have been developed (Hoogeveen, van Hell, Mooij, & Verhoeven, 2004), the number of methodologically sound evaluations of such programs is extremely small (Subotnik et al., 2011). The present study aimed to fill this gap by evaluating the effects of a triarchic, science-based enrichment program for upper primary gifted children using a pretest–posttest control group design.

Definition of giftedness: Theory of triarchic intelligence

In traditional definitions of giftedness, general intelligence has long served as a major factor in identifying gifted children (Worrell & Erwin, 2011). Today, however, most theories of intelligence also consider personal and environmental factors (Sternberg & Grigorenko, 2000; Ziegler & Heller, 2000). Gagné (1995), for example, proposed the Differentiated Model of Giftedness and Talent, which states that a basic set of gifts evolves into talents through the interaction with persons, events, environment, and chance factors. In his multiple intelligences model, Gardner (1993) proposed that human abilities comprise seven talents, ranging from linguistic to bodily kinesthetic abilities. The multiple intelligences theory has often been used to structure school and gifted programs, showing mixed effects (Callahan, Tomlinson, & Plucker, 1997). Another influential theory that has been used in school and enrichment programs is the theory of triarchic intelligence developed by Sternberg (1985). This theory defines intelligence as the collective and balanced ability to adapt, shape, and select the environments to accomplish one's goals as well as the goals of society. According to this theory, three types of abilities, analytical, creative, and practical, are

needed to be successful in education and life. Analytical abilities involve analyzing, evaluating, comparing, and contrasting. Creative abilities comprise inventing, discovering, imagining, and supposing. Practical abilities involve implementing, using, applying, and seeking relevance. Importantly, these three types of abilities are not static or determined characteristics of a person but rather dynamic factors that can be influenced by personal and environmental factors. So far, it has been demonstrated that gifted abilities are better identified in childhood by means of triarchic teaching (Kornilov, Tan, Elliott, Sternberg, & Grigorenko, 2012) and that it is possible to enhance the three types of abilities in students through education (Grigorenko, Jarvin, & Sternberg, 2002).

Enrichment program effects

Enrichment programs offer additional educational experiences aimed at providing more challenge (Gallagher, 2003). In a review, Hooegeveen and colleagues (2004) compared the effects of various types of interventions for gifted students: enrichment within the class, pull-out programs, summer programs, acceleration, separate classes or schools, and enrichment plus teacher training. They concluded that, in general, the programs have positive effects on students' intellectual and scholastic skills, with pull-out programs showing the best effects. A meta-analysis on pull-out programs found small to medium positive effects on academic achievement as well as on critical and creative abilities (Vaughn, Feldhusen, & Asher, 1991). Pull-out programs are often used because their implementation is easy and only a few teachers are needed to provide instructions. Moreover, they enable gifted children to stay in the regular classroom most of the time while still permitting interaction with gifted peers. This can, however, also be seen as a drawback of pull-out programs. These types of programs allow children to be challenged only for a limited time during a week, whereas greater positive effects of enrichment programs have been found with more extensive programs (Rogers, 2007).

With respect to the evaluation of enrichment programs, it is important to consider factors in not only the intellectual domain but also the socio-emotional domain (Hooegeveen et al., 2004). In a recent overview on giftedness and gifted education, Subotnik and colleagues (2011) stated that a large number of socio-emotional factors are associated with outstanding achievement. To begin with, motivation comprises gifted children's drive to achieve (Subotnik et al., 2011). It is important for gifted children to experience challenging educational experiences and to be exposed to opportunities to mix with others with similar abilities and interests to maintain or retrieve their motivation to achieve (Lens & Rand, 2000; Philips & Lindsay, 2006). Furthermore, it has been found that educational placement in a pull-out program may have great influences on gifted children's wellbeing (Neihart, 2007), with children in pull-out programs showing higher levels of wellbeing compared with those in gifted

classes or gifted schools (Morgan, 2007; Zeidner & Schleyer, 1999). Based on the frame of reference theory (Marsh, 1987, 1990), grouping gifted children with other gifted children may also decrease their self-concept due to a contrast effect, the so-called big-fish-little-pond effect (BFLPE). Indeed, Preckel, Götz, and Frenzel (2010) found a decrease in self-concept after grouping gifted children based on their abilities.

Generally, science-based enrichment programs have been particularly effective in increasing science knowledge of mainstream children (Burkam, Lee, & Smerdon, 1997; Freedman, 1997), as well as gifted children (Bui, Craig, & Imberman, 2011; Pyryt, Masharov, & Feng, 1993). A positive attitude toward science has, however, been a more powerful and long-range predictor of success and interest in science than science knowledge (Weinburgh, 1995). Attitude toward science is also positively related to the selection of science courses (Miller, Lietz, & Kotte, 2002; Simpson & Oliver, 1990). Several studies have shown that attitudes toward science can be improved by means of a science-based program (Caleon & Subramaniam, 2007; Moore, 2001). However, most studies on attitudes toward science involved mainstream children, and studies dealing with the attitudes of intellectually gifted children remain scarce (Caleon & Subramaniam, 2008).

Present study

According to PISA (2009), children in European countries and the United States lag behind in scientific and mathematic achievement compared with Asian countries. Moreover, a declining trend is visible in the scientific achievements of these children, and relatively lower degrees of achievement are reached with increasing potential (Onderwijsraad, 2007; PISA, 2009; Van der Steeg, Vermeer, & Lanser, 2011). It thus seems that the children with the highest potential to excel in scientific fields are generally left behind in educational opportunities. Although an increasing number of educational institutes are developing educational programs for gifted children, evaluations of these programs are scarce and have a number of limitations. First, they used small numbers of participants (Vaughn et al., 1991), and second, they lacked control or comparison groups (Subotnik et al., 2011; VanTassel-Baska & Brown, 2007). Another limitation of the research on enrichment programs is that most evaluative studies focus on either intellectual effects (e.g., Balogh, David, Nagy, & Tóth, 2001; Barnett & Durden, 1993) or socio-emotional and attitudinal effects (e.g., Cornell, Delcourt, Goldberg, & Oram, 1994).

The aim of the present study was to examine the intellectual, socio-emotional, and attitudinal effects of a triarchic pull-out program for gifted children in the Netherlands. By examining the effects of the enrichment program in all three domains, this study may reveal whether the program can affect gifted children across different domains. The triarchic program was provided to two groups of upper primary

children. A control group of classmates with similar intelligence levels was included to enable group comparisons. The ultimate research question addressed in this study was “How does the triarchic enrichment program for gifted children affect their intellectual, socio-emotional, and attitudinal development?” Given the triarchic setup of the program, an increase in all three abilities was expected (cf. Sternberg, Torff, & Grigorenko, 1998). An increase in motivation to achieve and in wellbeing as well as a decrease in self-concept was also expected (cf. Lens & Rand, 2000; Philips & Lindsay, 2006; Preckel et al., 2010). Finally, it was expected that due to the special focus of the enrichment program on science and technology, the attitudes of the participating gifted children toward science would improve (cf. Caleon & Subramaniam, 2007; Moore, 2001).

Method

Participants

A letter was sent to all primary schools in the municipality of The Hague (the Netherlands) to recruit participants. This letter explained the design of the pull-out program and asked schools to nominate fifth- or sixth-grade gifted children to participate. Criteria for nomination were above-average intelligence as indicated by the national pupil monitoring system, motivation to participate in extracurricular activities, and absence of clinical diagnoses of behavioral or emotional problems. Fourteen schools responded by nominating a number of children for the program. For organizational reasons, only 40 of 57 nominated children could be involved in the program. Three children were excluded based on information gathered in conversation with parents and teachers. Of the other 54 nominated children, 40 children were selected by lot to participate in the enrichment program.

The program had two components, the implementation and the intervention. During the first half of the year, which was the implementation period, the teachers set up the program while children were already placed in the new learning environment in which the teacher acknowledged their abilities. After a couple of weeks, some children left the enrichment program and new children entered the program. During this implementation period, teachers were still adapting their methods of teaching to the needs of the children. In February, two stable groups of 20 children were formed, and teachers adapted their teaching to these groups prior to the start of the intervention.

Also prior to the start of the intervention period, primary schoolteachers of the participating children were asked to nominate nonselected classmates with similar general intelligence levels to take part in the study as a control group. In addition, the 14 pupils who were nominated but excluded from participation were included in the

Table 1 Descriptive Statistics of Age, General Intelligence, and SES

	Group					
	Experimental			Control		
	Range	<i>M</i>	(SD)	Range	<i>M</i>	(SD)
Age	9 – 12	11.32	(0.77)	10 – 12	11.71	(0.51)
General intelligence scores	35 – 119	74.69	(18.67)	44 – 98	72.26	(12.82)
SES	2.5 – 3.0	2.94	(0.17)	2.0 – 3.0	2.89	(0.28)

Note. SES = socioeconomic status.

control group. Because control group children were recruited from the same schools, teacher characteristics and type of education were constant across groups.

In total, 37 fifth- and sixth-grade children agreed to participate in the control group. During the school year, two children withdrew from participation in the pull-out program before all data were collected due to personal circumstances. In addition, six experimental group and three control group children were not present on one measurement occasion. These children were not included in the analyses; hence, the participants comprised 32 children (20 boys) in the experimental and 34 children (17 boys) in the control group.

Descriptive statistics for the control variables (i.e., intelligence level, socioeconomic status [SES], and age) are presented in Table 1. Pearson's chi-square tests and independent-sample *t* tests revealed that participants in the two groups did not differ in intelligence level, as measured with the Dutch Intelligence Structure Test (IST; Liepmann, Beauducel, Brocke, & Amthauer, 2010), $t(64) = 0.62$, $p = .539$, $d = .15$, or SES, $\chi^2(2, n = 66) = 2.07$, $p = .355$, Cramér's $V = .18$. The two groups were also equal in terms of gender, $\chi^2(1, n = 66) = 1.05$, $p = .307$, Cramér's $V = .13$ and grade level, $\chi^2(1, n = 66) = 1.99$, $p = .655$, Cramér's $V = .06$. However, the analyses revealed that the two groups did differ in age. Children in the control group were on average 5 months older compared with children in the experimental group, $t(52.97) = 2.39$, $p = .020$, $d = .61$. In the subsequent analyses designed to compare the experimental and control group data, age was therefore included as covariate.

Procedure

At the start of the implementation period, a researcher visited the classroom to administer the first tests (M0). Tests were administered over 2 weeks. Children were first given instructions on how to complete the test. They were assured that all answers would be treated confidentially and scores would remain anonymous.

The second round of measurements (M1) was administered in February at the start of the intervention period, and the final measurement (M2) was administered in

June at the end of the intervention period. These measurement occasions followed the procedure similar to the one used in the first measurement occasion.

To get an insight into the effects of the triarchic enrichment program, children in the control group completed all questionnaires at the start (M1) and at the end of the intervention period (M2). These children received the same instructions on how to complete the test as well as the same information on confidentiality and anonymity. All control group measurements were completed in one morning. To get an insight into intelligence levels, children in both groups completed the Intellectual Structure Test (IST) in April.

Intervention

Children spent all of their time in the regular classroom, except for the morning of the week during which they participated in the pull-out program provided by a secondary school. The program comprised three successive 1-hr classes each week: robotics, mathematics, and research and design. Three qualified secondary schoolteachers with experience in teaching gifted children taught the successive classes.

In the research and design classes during the implementation period, children completed adapted versions of lessons developed for the Thinker-Tinker-Lab of the Center for the Study of Giftedness in Nijmegen (Schrover, 2010). The lessons were tested extensively with 8- to 12-year-olds. They aimed to provide children with a better insight into their thought processes. The assignments asked children to construct multiple solutions to a problem and adapt them repeatedly to obtain the best result. An example of such an assignment is "Build a boat out of aluminum foil that can hold as many marbles as possible." All lessons were based on Sternberg's (1985) theory of triarchic intelligence. This means that assignments were designed to enhance analytical, creative, and practical abilities. Moreover, teachers adapted their teaching to the triarchic principles. To support the analytical abilities, children were encouraged to think critically and judge and evaluate the solution to a problem (Sternberg & Grigorenko, 2004). For creative thinking, they role-modeled creativity in their own behavior and supported and encouraged creativity when displayed by pupils. In addition, all teaching addressed the practical needs of the children.

During the intervention period, the attention of the research and design classes shifted from stimulating triarchic abilities to stimulating higher order skills, such as reasoning and synthesizing knowledge. Longitudinal projects, like making a mind map or designing a city, were used as assignments that supported children's analytical, creative, and practical abilities only implicitly.

In the robotic classes, children had to build and program robots using LEGO MINDSTORMS NXT Software. With this software, children could build a robot by themselves or by following a description provided with the software. During the implementation period, children were challenged to build and program their own

model in a group, without the help from a manual. In these lessons, the teacher again supported triarchic abilities. During the intervention period, children built robots following standard lessons and detailed instructional models.

The mathematics lessons comprised three areas of mathematics: geometry, algebra, and arithmetic. The lessons were derived from first-grade secondary school mathematics, and they provided only a brief introduction into the important aspects of the three mathematical areas. Lessons and assignments were not predefined but were adapted to the questions and interests of the pupils. In addition, mathematic and logic puzzles were provided. Both the implementation and intervention period addressed metacognitive skills, such as logical reasoning and integration of knowledge.

Materials

SES. Mean educational level of both parents was used as an indicator of SES. Children indicated the highest level of their parents' education (low = *primary education or lower secondary education*; intermediate = *upper secondary education or vocational training*; high = *college or university*).

Intelligence. The Dutch Intellectual Structure Test (IST; Liepmann et al., 2010) was used to measure verbal, numerical, and figural intelligence levels. Each area of intelligence was assessed using three subtests comprising 20 multiple-choice items. With the first verbal intelligence subtest, *Sentence Completion*, children had to indicate which of five options could complete a sentence best. Second, in *Verbal Analogies*, three words were presented, and children needed to identify the correct fourth word out of five alternatives. With *Similarities*, participants were asked to select two words belonging to the same category out of a list of six words. The second set of subtests included *Numerical Calculations*, *Number Series*, and *Numerical Signs*. *Numerical Calculations* involved mathematical problems with realistic numbers. With *Number Series*, pupils were provided with a series of numbers and were asked to choose from five alternatives the correct number following this series. In the *Numerical Signs* items, an equation using rational numbers is presented from which the mathematical operators have been omitted. Pupils had to choose from the four basic mathematical operators (add, subtract, divide, multiply) which was correct. For figural intelligence, the first subtest, *Figure Selection*, involved pupils indicating which 5 out of 10 whole shapes could be produced by fitting together presented geometrical pieces of shapes. Cubes presented children with three out of six possible patterns of cubes. Answering entailed designating the cube corresponding to the initial cube out of five answering possibilities. Finally, *Matrices* provided figures arranged according to a particular rule for which children had to point out the one figure that conformed to this rule. The reliability measures for all subtests ranged from .63 to .90 in our sample of participants. Together, scores on these nine subtests were combined to

form a general intelligence score ($\alpha = .95$). Raw scores may be converted into standardized scores with a mean of 100 and a standard deviation of 15, yet norm scores are only available for children aged 12 and older. Therefore, the present study used raw scores.

Triarchic abilities. A Dutch translation of the original American Aurora Assessment Battery (Tan et al., 2009) was used to measure triarchic abilities. This battery is based on the theory of triarchic intelligence (Sternberg, 1985) and is being further developed in multiple countries around the world (e.g., Saudi Arabia, Greece, Portugal). The paper-and-pencil test of the Aurora Assessment Battery comprises 18 subtests measuring analytical, creative, and practical abilities. In the Netherlands, only a few subtests were properly translated with equivalencies with respect to meaning, psychometric properties, and item difficulty. Therefore, only one subtest was used per type of ability. Based on a pilot study, the *Boats* subtest assessed analytical abilities, *Book Covers* assessed creative abilities, and *Money* assessed practical abilities. In the present study, internal consistency was found to be acceptable to good for all scales, with $\alpha = .82$ for analytical, $\alpha = .89$ for creative abilities, and $\alpha = .76$ for practical.

On the analytical subtest, children saw 10 items comprising a photograph of toy boats that were connected to each other with a cord. The children were told that the boats could float around on the water, but would stay connected in the same way. Subsequently, four photographs portrayed the toy boats after floating. Only three of these were correct. For all 10 items, the children had to indicate which of the four was false. Every right answer was worth one point, allowing participants to earn 10 points overall.

The *Book Covers* subtest measured creative abilities and consisted of five colored drawings of possible book covers. The children were asked about the possible content of the book. In the instructions, they were told that they should use their imagination and that all answers were correct. Answers were coded according to two criteria: accuracy and ability-creativity. For accuracy, a score from 0 to 2 could be obtained, dependent on the degree to which the child carried out the given task appropriately. With the variable ability-creativity, it was coded whether the child created an original substantial story to accompany the picture. The scores for ability-creativity ranged from 0, representing nonsense, to 4 when two or more interpretive or elaborating elements were described in a sequence to create a novel story. An independent rater coded 19% of the answers so that reliability measures could be calculated. Creativity codings of the two raters correlated .85 ($n = 31, p \leq .001$).

Practical abilities were assessed using the *Money* subtest. Children responded to five items asking about a situation involving money. A sample item included, "Oliver's aunt is taking him to the zoo. A ticket for Oliver costs 5 euro; a ticket for his aunt costs 8.75 euro. Oliver will pay half of his ticket; his aunt will pay the other half.

How much should every one of them pay?" All items include payment of debts between the persons involved and payment to a third person. In total, children had to write down the expenses of 13 persons, so that a total of 13 points could be earned.

Socio-emotional factors. The Dutch School Attitude Questionnaire (Vorst, Smits, Oort, Stouthard, & David, 2008) measured *Motivation* for schoolwork, *Self-concept*, and *Wellbeing*. For 80 items, children had to indicate on a 3-point scale the degree to which they agreed with the statement (1 = *do not agree*; 2 = *no opinion*; 3 = *agree*).

Attitude toward science. Attitude toward science was measured using a scale developed by Denessen and colleagues (2011). The test comprised 20 items equally divided over four subscales: *Importance of science to society*, *Difficulty of learning science*, *Enjoyment of learning science*, and *Aspirations to pursue a future career in science*. Children had to indicate on a 4-point scale the extent to which they agreed with statements provided (1 = *strongly disagree*; 4 = *strongly agree*).

Data Analysis

Children in the experimental group completed all questionnaires and tests on three measurement occasions (M0, M1, and M2), whereas children in the control group only completed the measures in the intervention period (M1 and M2). Because the number of measurements differed for both groups, the data of children in the experimental group were first analyzed separately from the data of children in the control group. Second, the effects of the intervention were examined by including data for both groups in a repeated-measures MANOVA. Due to the large number of tests, alpha was set to .01.

Results

Descriptive statistics

Descriptive statistics on the intellectual, socio-emotional, and attitudinal variables were computed first. Table 2 presents pretest (M0), posttest (M1), and retention test (M2) outcomes for the intellectual measures of analytical, creative, and practical abilities; the socio-emotional measures of motivation, wellbeing, and self-concept; and the attitudinal measures of importance, difficulty, enjoyment, and aspirations regarding science education for the experimental group and the control group.

Enrichment program effects

To examine the progress of children in the experimental and control group over the course of the schoolyear, repeated measures MANOVAs were performed for the intellectual, socio-emotional, and attitudinal task domains. Results are presented in

Table 2 Descriptive Statistics on the Intellectual, Socio-Emotional, and Attitudinal Measures

	Experimental						Control					
	M0			M1			M2			M1		
	Range	M	(SD)	Range	M	(SD)	Range	M	(SD)	Range	M	(SD)
Intellectual measures												
Analytical abilities	4–10	8.78	(1.52)	4–10	9.09	(1.40)	4–10	9.28	(1.42)	5–10	8.56	(1.46)
Creative abilities	8–29	18.72	(6.32)	10–29	19.75	(5.62)	8–30	18.28	(5.79)	11–30	21.65	(5.26)
Practical abilities	2–13	9.28	(2.80)	2–13	10.44	(2.61)	6–13	11.72	(2.88)	4–13	10.24	(2.52)
Socio-emotional measures												
Motivation	43–72	62.44	(7.53)	41–72	62.53	(7.29)	45–71	61.03	(7.87)	33–72	60.29	(9.03)
Wellbeing	49–72	64.53	(6.74)	48–72	66.53	(6.46)	56–72	67.00	(4.27)	38–72	67.00	(6.47)
Self-concept	47–72	63.84	(6.87)	48–72	64.78	(5.77)	49–72	66.19	(5.42)	38–72	62.65	(7.80)
Attitude toward science												
Importance	9–20	16.00	(2.10)	11–20	16.25	(2.48)	13–20	16.91	(2.23)	13–20	16.47	(2.02)
Difficulty	6–14	10.22	(2.04)	5–13	9.56	(1.83)	5–13	9.33	(2.12)	7–16	11.06	(2.26)
Enjoyment	11–20	17.19	(2.60)	10–20	16.08	(2.80)	10–20	16.28	(2.70)	5–20	14.97	(3.46)
Aspirations	5–20	12.84	(3.87)	5–20	12.41	(4.81)	5–20	13.03	(4.84)	5–20	11.41	(3.87)

Table 3 and demonstrated that children in the control group did not develop in any of the triarchic abilities. For analytical and creative abilities, no effects over time were found for the experimental group either. However, practical scores were found to change in both the implementation, $F(1, 31) = 6.56, p = .016$, and the intervention period, $F(1, 31) = 6.90, p = .013$, resulting in an overall increase in practical abilities in children in the experimental group from the start to the end of the schoolyear (see Table 3).

Table 3 Repeated Measures MANOVA Results for Developmental Measures (M0-M2) for Experimental and (M1-M2) Control Group

Variable	Experimental group		Control group	
	F	η_p^2	F	η_p^2
Intellectual				
Analytical abilities	2.00	.06	1.08	.03
Creative abilities	0.86	.03	0.81	.02
Practical abilities	11.70**	.28	0.39	.12
Socio-emotional				
Motivation	0.91	.03	11.98*	.27
Wellbeing	3.00	.09	0.52	.02
Self-concept	4.28 [†]	.12	0.18	.01
Attitude toward science				
Importance	3.12	.09	1.90	.05
Difficulty	3.19 [†]	.09	0.01	.00
Enjoyment	3.59 [†]	.10	12.25**	.27
Aspirations	0.75	.02	0.77	.02

Note. Significant F -values are boldfaced.

[†] $p \leq .05$; * $p \leq .01$; ** $p \leq .001$.

Concerning socio-emotional factors, results in Table 3 showed that motivation in the control group *decreased* during the intervention period, whereas motivation of children in the intervention group remained stable over the course of the schoolyear. For wellbeing, changes were not observed in either of the groups. Children participating in the enrichment program experienced increased self-concepts over the entire course of the program. Repeated-measures MANOVAs for the intervention and implementation period separately showed that this increase in self-concept was driven by changes in the intervention, $F(1, 31) = 4.14, p = .050$, rather than the

implementation period, $F(1, 31) = 1.14, p = .293$. In control group children, no changes were found in self-concept.

The results with regard to attitudinal factors showed a marginally significant effect for difficulty of science scores. A decrease in these difficulty scores was found in experimental group children in the implementation period, $F(1, 31) = 6.89, p = .047$, whereas during the intervention period, scores did not change, $F(1, 31) = 0.39, p = .537$. Children in the control group did not show any changes in their experience of difficulty of science. Furthermore, a *decrease* in enjoyment scores was found in control group children in the intervention period. For the experimental group, only a marginally significant change was found when comparing enjoyment scores at the beginning and end of the enrichment program. The enjoyment variable did not change during the intervention period, $F(1, 31) = 0.52, p = .477$, and it decreased marginally significantly during the implementation period, $F(1, 31) = 4.79, p = .036$. For importance and aspirations scores, no changes were found in both groups.

To test the effects of the enrichment program over the intervention period, a repeated-measures MANOVA with intellectual, socio-emotional, and attitudinal factors (M1 and M2) as within-subjects factors and Group (experimental, control) as between-subjects factor was performed. Table 4 summarizes the Time \times Group interaction effects.

It can be seen that children in both groups did not develop differentially with regard to their triarchic abilities in the intervention period. For the socio-emotional variables, the data revealed that only self-concept developed differentially in children in both groups. Children in the experimental group reported an increase in self-concept, whereas self-concept in children in the control group remained stable. With regard to the attitudinal data, it was evidenced that gifted children in the experimental group thought science to be more important at the end of the intervention period whereas gifted children in the control group reported no changes. Furthermore, the enjoyment of science decreased in the control group and remained stable in experimental group children.

Table 4 Repeated-Measures MANOVA Results with Developmental Measures (M1-M2) as Within-Subjects and Group (Experimental, Control) as Between Subjects Factor

Variables	Time X Group interaction	
	F	η^2
Intellectual		
Analytical abilities	0.09	.00
Practical abilities	0.50	.01
Creative abilities	0.10	.00
Socio-emotional		
Motivation	0.63	.01
Wellbeing	0.90	.01
Self-concept	5.38 [†]	.08
Attitude toward science		
Importance	4.07 [†]	.06
Difficulty	0.00	.00
Enjoyment	11.60**	.16
Aspirations	3.09	.05

Note. Significant *F*-values are boldfaced.

[†] $p \leq .05$; * $p \leq .01$; ** $p \leq .001$.

Discussion

The present study aimed to evaluate the intellectual, socio-emotional, and attitudinal effects of a triarchic enrichment program on upper primary gifted children. Earlier research on the effectiveness of enrichment programs is scarce and the existing research often included small numbers of participants and no comparison groups. The current study examined differences in intellectual, socio-emotional, and attitudinal development of children participating in a triarchic enrichment program and a control group of children. Interestingly, effects were found for all three domains.

With respect to intellectual effects, the results indicated an increase in practical ability levels among children in the experimental group and no changes in control group children. Triarchic teaching was found to have a direct and prolonged effect on practical abilities. These results expand the previous research, showing that triarchic teaching can not only improve different intelligence domains of students (Grigorenko et al., 2002) but also of gifted primary school children. This is an important finding, as

the earlier children learn to use different abilities corresponding with three types of abilities, the more they can profit from these skills. Analytical abilities, however, were found to be stable over time. This can probably be ascribed to a ceiling effect. For the present study, teachers were asked to nominate children they considered gifted. In most schools, analytical abilities are regularly supported and assessed, favoring analytically strong children and overlooking practical and creative talents (Sternberg & Grigorenko, 2004). The high pretest scores on analytical rather than practical or creative ability tests are in line with this reasoning, suggesting that mostly children with high analytical abilities were being considered gifted and selected for the enrichment program.

With regard to socio-emotional measures, differential effects were found. Motivation was found to decrease in control group children and to remain stable in experimental group children. Participation in the enrichment program for one morning a week thus prevented children from losing motivation in primary school. These findings are in accordance with the hypothesis that challenging educational experiences and an opportunity to mix with others of similar abilities and interests are very important in maintaining motivation in gifted children (Lens & Rand, 2000; Philips & Lindsay, 2006).

In contrast with our hypothesis, no effects on wellbeing were found. It was expected that better fit between the intellectual level of the child and the academic level of the offered education in the enrichment program would lead to higher wellbeing in these children (Robinson, 2004). An explanation could be that a large number of children in the experimental and control group already participated in some kind of enrichment program in their primary schools. Enrichment facilities ranged from autonomously going through assignments to participating in a special gifted class for an hour a week. It could be speculated that these children already received education at an appropriate level, so that the expected effect on wellbeing was less present. A second explanation could be found in the nomination and selection criteria used to identify students to participate in the program. Teachers were asked to nominate children who were intellectually talented. Children with emotional or behavioral problems were excluded from participation because the pull-out program teachers would not be able to deal with these additional issues. In combination with the fact that most students already were provided with enrichment activities in their primary schools, these issues may have accounted for the absence of wellbeing effects.

Concerning self-concept, the results indicated an increase in scores for children participating in the enrichment program while no changes were observed in control group children. Although small changes were already visible in the implementation phase, self-concept of experimental group pupils significantly enhanced only in the intervention phase. This may be due to the limited time that they spend in the pull-out

program compared with the regular education program. Enhancing pupils' self-concept is a long-lasting process that can only occur with successive positive experiences (Shavelson, Hubner, & Stanton, 1976). The reversed BFLPE found in this study contrasts the earlier findings by Marsh and colleagues (2008), which supported the effect across diverse educational populations, settings, and cultures. One possible explanation for our findings may lie in the fact that children interacted with other gifted children for only one morning a week. For the remaining time, they followed lessons in their regular school; hence, they could still compare themselves to their nongifted classmates. A second explanation may concern the pull-out program itself. In the enrichment program, the gifted children had to work in cooperative groups to solve problems and complete assignments. Although cooperative learning may elicit negative effects in heterogeneous groups (Neber, Finsterwald, & Urban, 2001), cooperative learning in homogeneous groups with other gifted children is beneficial for gifted children's academic self-esteem (Johnson, Johnson, & Taylor, 1993). Moreover, cooperative learners have higher academic self-esteem compared with individual learners (Neber et al., 2001). The cooperative nature of the teaching and assignments in the current enrichment program may have caused the increase in self-concept.

Finally, in addition to intellectual and socio-emotional factors, children's attitudes toward science were examined. The enjoyment of science declined in the control group children, yet remained stable in children participating in the enrichment program. Moreover, experimental group children seemed to find science less difficult and appeared to value the importance of science more after the program. The lack of encouraging and challenging scientific experiences in the regular primary schools may have caused the disinterest in science of gifted children in the control group (Batterham, 2000). These results are expanding earlier results showing that a science-based enrichment program can enhance attitudes toward science in gifted primary school children.

Limitations

Of course, the present study has several limitations. To begin with, environmental factors in the school or family have not been considered. School and family characteristics can, however, exert great influence on the performance of gifted children (Freeman, 2000; Minne, Rensman, Vroomen, & Webbink, 2007). Further research examining the role of child characteristics and of environmental factors is needed. With bigger understanding of the complex interaction between the arrays of factors involved, programs may be adapted to gifted children's need to optimize their development. Another weakness of the present study was that children were not randomly selected or screened before participation; instead, they were selected based on the recommendations of their primary schoolteachers, thereby possibly

causing a selection bias. Although children for both the experimental and control group were recruited in the same grades, children from the control group were found to be nearly half a year older than experimental group children. Teachers may have considered younger children brighter than older children and thus nominated them for enrichment activities more often. In addition, descriptive statistics showed that only children with high-SES parents were included in the study (in both groups). This is not surprising, as children of different ethnicity or low-SES parents are less likely to be identified as gifted (Callahan, 2005), resulting in an underrepresentation of programs for gifted children (Ford, Grantham, & Whiting, 2008). Sternberg and Grigorenko (2004) observed that students from minority ethnic and low socioeconomic backgrounds often scored high on creative and practical abilities, which were overlooked by regular achievement tests. Triarchic assessment may thus not only be helpful in improving intellectual abilities of gifted children but also help identify gifted minority children better.

Conclusion

The current findings have several implications for educational practice. First, the present study showed that triarchic instruction allows students to capitalize on practical abilities, allowing children who do not presently excel to excel (Sternberg, 2003). Second, positive effects on motivation and self-concept were found. Motivation plays a crucial role in the process through which one reaches excellence, and a positive self-concept is reciprocally related to high achievements (Guay, Marsh, & Boivin, 2003). An enrichment program may thus effectively improve the intellectual as well as socio-emotional characteristics of gifted children. For future research, it would be interesting to implement triarchic teaching in regular school classes to examine the effects on not only gifted but all students. Moreover, adapting teaching to individual pupils' intellectual profiles might optimize the effects of triarchic teaching (Sternberg et al., 1998). Finally, it is interesting to note that the enrichment program in our study has shown to be effective in promoting positive science attitudes, an important predictor of science enrollment later in life (Farenga & Joyce, 1998). In most Western countries, the number of students, especially gifted students (PISA, 2009), entering an education in Science, Technology, Engineering, and Math (STEM) fields has declined rapidly (OECD, 2008), creating a shortage of native-born scientists and engineers (Gallagher, 2003). The positive enhancement of science-related attitudes in gifted children might be a first step in increasing the number of students interested in a career in science.

To conclude, the enrichment program increased practical abilities in gifted primary school children. Moreover, self-concept was enhanced while motivation as well as difficulty and enjoyment of science were maintained by participating in the enrichment program. Together, the results are promising, showing that a triarchic and

scientific enrichment program can improve the intellectual, socio-emotional, and attitudinal development of gifted primary school children.

References

- Balogh, L., David, I., Nagy, K., & Tóth, L. (2001). Learning techniques and self-knowledge with talented schoolchildren. In L. Balogh & L. Tóth (Eds.), *Gifted development at schools: Research and practice* (pp. 159–167). Debrecen, Hungary: Department of Educational Psychology, University of Debrecen.
- Barnett, L. B., & Durden, W. G. (1993). Education patterns of academically talented youth. *Gifted Child Quarterly*, 37, 161–168. doi:10.1177/001698629303700405
- Batterham, R. (2000). *The chance to change*. Canberra: Commonwealth of Australia.
- Bøe, M. V., Henriksen, E. K., Lyons, T., & Schreiner, C. (2011). Participation in science and technology: Young people's achievement-related choices in late modern societies. *Studies in Science Education*, 47, 37–72. doi:10.1080/03057267.2011.549621
- Bui, S. A., Craigh, S. G., & Imberman, S. A. (2011, May). *Is gifted education a bright idea? Assessing the impact of gifted and talented programs on achievement* (NBER Working Paper 17089). Retrieved from <http://www.nber.org/papers/w17089>
- Burkam, D. T., Lee, V. E., & Smerdon, B. A. (1997). Gender and science learning early in high school: Subject matter and laboratory experiences. *American Educational Research Journal*, 34, 297–331. doi:10.3102/00028312034002297
- Caleon, I. S., & Subramaniam, R. (2007). Augmenting learning in an out-of-school context: The cognitive and affective impact of two cryogenics-based enrichment programmes on upper primary students. *Research in Science Education*, 37, 333–351. doi:10.1007/s11165-9032-7
- Caleon, I. S., & Subramaniam, R. (2008). Attitudes towards science of intellectually gifted and mainstream upper primary students in Singapore. *Journal of Research in Science Teaching*, 45, 940–954. doi:10.1002/tea.20250
- Callahan, C. M. (2005). Identifying gifted students from underrepresented populations. *Theory Into Practice*, 44, 98–104. doi:10.1207/s15430421tip4402_4
- Callahan, C. M., Tomlinson, C. A., & Plucker, J. (1997). *Project START: Using a multiple intelligences model in identifying and promoting talent in high-risk students* (Research Monograph No. 95136). Storrs, CT: National Research Center on the Gifted and Talented, University of Connecticut.
- Cornell, D. G., Delcourt, M. A., Goldberg, M. D., & Oram, G. (1994). Low incidence of behavior problems among elementary school students in gifted programs. *Journal for the Education of the Gifted*, 18, 4–19. doi:10.1177/016235329401800102
- Denessen, E., Vos, N., Damen, T., Koch, S., Louws, M., & Wigboldus, D. (2011). Explicit and implicit measures of teacher attitudes toward science and technology. In M. de Vries, H. van Keulen, S. Peters, & J. Walma van der Molen (Eds.), *Professional development for primary teachers in science and technology* (pp. 107–120). Rotterdam, The Netherlands: Sense.
- Farenga, S. J., & Joyce, B. A. (1998). Science-related attitudes on science course selection: A study of high ability boys and girls. *Roeper Review*, 20, 247–251.
- Ford, D. Y., Grantham, T. C., & Whiting, G. W. (2008). Culturally and linguistically diverse students in gifted education: Recruitment and retention issues. *Exceptional Children*, 74, 289–309. doi:10.1080/02783199809553901
- Freedman, M. P. (1997). Relationship among laboratory instruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science Teaching*, 34, 343–357. doi:10.1002/(SICI)1098-2736(199704)34:4<343::AID-TEA5>3.0.CO;2-R
- Freeman, J. (2000). Families, the essential context for gifts and talents. In K. A. Heller, F. J. Mönks, R. J. Sternberg, & R. F. Subotnik (Eds.), *International handbook of giftedness and talent* (2nd ed., pp. 573–585). Amsterdam, The Netherlands: Elsevier.
- Gagné, F. (1995). From giftedness to talent: A developmental model and its impact on the language of the field. *Roeper Review*, 18, 103–111. doi:10.1080/02783199509553709
- Gallagher, J. J. (2003). Issues and challenges in the education of gifted students. In N. Colangelo & G. A. Davis (Eds.), *Handbook of gifted education* (3rd ed., pp. 11–23). Boston, MA: Allyn & Bacon.
- Gardner, H. (1993). *Multiple intelligences: The theory into practice*. New York, NY: Basic Books.

- Gonzales, P., Williams, T., Jocelyn, L., Roey, S., Kastberg, D., & Brenwald, S. (2008). *Highlights from TIMSS 2007: Mathematics and science achievement of U.S. fourth and eighth-grade students in an international context* (NCES 2009-001). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.
- Grigorenko, E. L., Jarvin, L., & Sternberg, R. J. (2002). School-based tests of the triarchic theory of intelligence: Three settings, three samples, three syllabi. *Contemporary Educational Psychology*, 27, 167–208. doi:10.1006/ceps.2001.1087
- Guay, F., Marsh, H. W., & Boivin, M. (2003). Academic self-concept and academic achievement: Developmental perspective on their causal ordering. *Journal of Educational Psychology*, 95, 124–136. doi:10.1037/0022-0663.95.1.124
- Heller, K. A., Mönks, F. J., Sternberg, R. J., & Subotnik, R. F. (2000). *International handbook of giftedness and talent* (2nd ed.). Oxford, UK: Pergamon Press.
- Hoogeveen, L., van Hell, J., Mooij, T., & Verhoeven, L. (2004). *Educational arrangements for gifted children: Meta-analysis and overview of international research*. Nijmegen, The Netherlands: ITS/CBO/Orthopedagogiek, Radboud University.
- Johnson, D. W., Johnson, R. T., & Taylor, B. (1993). Impact of cooperative and individualistic learning on high-ability students' achievement, self-esteem, and social acceptance. *The Journal of Social Psychology*, 133, 839–844. doi:10.1080/00224545.1993.9713946
- Kornilov, S. A., Tan, M., Elliott, J. G., Sternberg, R. J., & Grigorenko, E. L. (2012). Gifted identification with Aurora: Widening the spotlight. *Journal of Psychoeducational Assessment*, 30, 117–133. doi:10.1177/0734282911428199
- Lens, W., & Rand, P. (2000). Motivation and cognition: Their role in the development of giftedness. In K. A. Heller, F. J. Mönks, R. J. Sternberg, & R. F. Subotnik (Eds.), *International handbook of giftedness and talent* (2nd ed., pp. 193–202). Oxford, UK: Pergamon Press.
- Liepmann, D., Beauducel, A., Brocke, B., & Amthauer, R. (2010). *IST Intelligentie Structuur Test: Handleiding met normen voor studenten* [IST Intelligence Structure Test: Manual with student norms]. Amsterdam, The Netherlands: Hogrefe.
- Marsh, H. W. (1987). The big-fish-little-pond effect on academic self-concept. *Journal of Educational Psychology*, 79, 280–295. doi:10.1037/0022-0663.79.3.280
- Marsh, H. W. (1990). The influences of internal and external frames of reference on the formation of math and English self-concepts. *Journal of Educational Psychology*, 82, 107–116. doi:10.1037/0022-0663.82.1.107
- Marsh, H. W., Seaton, M., Trautwein, U., Lüdtke, O., Hau, K. T., O'Mara, A. J., & Craven, R. G. (2008). The big-fish-little-pond-effect stands up to critical scrutiny: Implications for theory, methodology, and future research. *Educational Psychology Review*, 20, 319–350. doi:10.1007/s10648-008-9075-6
- McCoach, D. B., & Siegle, D. (2003). Factors that differentiate underachieving gifted students from high-achieving gifted students. *Gifted Child Quarterly*, 47, 144–154. doi:10.1177/001698620304700205
- Miller, J., Lietz, P., & Kotte, D. (2002). On decreasing gender differences and attitudinal changes: Factors influencing Australian and English pupils' choice of a career in science. *Sexualities, Evolution & Gender*, 4, 69–92. doi:10.1080/1461666021000013670
- Minne, B., Rensman, M., Vroomen, B., & Webbink, D. (2007). *Excellence for productivity?* The Hague, The Netherlands: CPB Netherlands Bureau for Economic Policy Analysis.
- Moore, J. M. (2001). *The effects of inquiry-based summer enrichment activities on raising eight graders' knowledge of science processes, attitude toward science and perception of scientists* (Doctoral dissertation). Available from ProQuest Digital Dissertations. (AAT 3011938)
- Morgan, A. (2007). Experiences of a gifted and talented enrichment cluster for pupils aged five to seven. *British Journal of Special Education*, 34, 144–153. doi:10.1111/j.1467-8578.2007.00470.x
- Neber, H., Finsterwald, M., & Urban, N. (2001). Cooperative learning with gifted and high-achieving students: A review and meta-analysis of 12 studies. *High Ability Studies*, 12, 199–214. doi:10.1080/13598130120084339
- Neihart, M. (2007). The socioaffective impact of acceleration and ability grouping: Recommendations for best practice. *Gifted Child Quarterly*, 51, 330–341. doi:10.1177/0016986207306319

- Onderwijsraad. (2007). *Presteren naar vermogen, alle talenten benutten in het funderend onderwijs* [Achieving according to ability, making use of all talents in primary and secondary education]. The Hague, The Netherlands: Onderwijsraad.
- Organisation for Economic Co-Operation and Development. (2008). *Encouraging student interest in science and technology studies*. Paris, France: Global Science Forum.
- Philips, N., & Lindsay, G. (2006). Motivation in gifted students. *High Ability Studies*, 17, 57–73.
- Preckel, F., Götz, T., & Frenzel, A. (2010). Ability grouping of gifted students: Effects on academic self-concept and boredom. *British Journal of Educational Psychology*, 80, 451–472. doi:10.1348/000709909X480716
- Programme for International Student Assessment (2009). *PISA 2009 assessment framework—Key competencies in reading, mathematics and science*. Paris, France: Organisation for Economic Co-Operation and Development.
- Pyryt, M. C., Masharov, Y. P., & Feng, C. (1993). Programs and strategies for nurturing talents/gifts in science and technology. In K. A. Heller, F. J. Mönks, & A. H. Passow (Eds.), *International handbook of research and development of giftedness and talent* (pp. 453–471). New York, NY: Pergamon Press.
- Robinson, N. M. (2004). Effects of academic acceleration on the social-emotional status of gifted students. In N. Colangelo, S. G. Assouline, & M. U. M. Gross (Eds.), *A nation deceived: How schools hold back America's brightest students* (Vol. 2., pp. 59–68). Iowa City, IA: The Connie Belin & Jacqueline N. Blank International Center for Gifted Education and Talent Development, The University of Iowa.
- Rogers, K. B. (2007). Lessons learned about educating the gifted and talented: A synthesis of the research on educational practice. *Gifted Child Quarterly*, 51, 382–396. doi:10.1177/0016986207306324
- Schrover, E. (2010). *Het grote vooruitwerklaboek* [The Thinker-Tinker-Lab book]. Nijmegen, The Netherlands: Stichting Ontwikkeling Leermethoden.
- Shavelson, R. J., Hubner, J. J., & Stanton, G. C. (1976). Self-concept: Validation of construct interpretations. *Review of Educational Research*, 46, 407–441.
- Simpson, R. D., & Oliver, J. S. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. *Science Education*, 74, 1–18. doi:10.1002/sce.3730740102
- Sternberg, R. J. (1985). *Beyond IQ: A triarchic theory of human intelligence*. New York, NY: Cambridge University Press.
- Sternberg, R. J. (2003). Implications of the theory of successful intelligence for career choice and development. *Journal of Career Assessment*, 11, 136–152. doi:10.1177/1069072703011002002
- Sternberg, R. J., & Grigorenko, E. L. (2000). *Teaching for successful intelligence*. Arlington Heights, IL: Skylight.
- Sternberg, R. J., & Grigorenko, E. L. (2004). Successful intelligence in the classroom. *Theory Into Practice*, 43, 274–280. doi:10.1207/s15430421tip4304_5
- Sternberg, R. J., Torff, B., & Grigorenko, E. L. (1998). Teaching triarchically improves school achievement. *Journal of Educational Psychology*, 90, 374–384. doi:10.1037/0022-0663.90.3.374
- Subotnik, R. F., Olszewski-Kubilius, P., & Worrell, F. C. (2011). Rethinking giftedness and gifted education: A proposed direction forward based on psychological science. *Psychological Science*, 12, 3–54. doi:10.1177/1529100611418056
- Tan, M., Aljughaiman, A. M., Elliott, J. G., Kornilov, S. A., Ferrando-Prieto, M., Bolden, D. S., . . . Grigorenko, E. L. (2009). Considering language, culture, and cognitive abilities: The international translation and adaptation of the Aurora Assessment Battery. In E. L. Grigorenko (Ed.), *Multicultural psychoeducational assessment* (pp. 443–468). New York, NY: Springer.
- Van der Steeg, M., Vermeer, N., & Lanser, D. (2011). *Nederlandse onderwijsprestaties in perspectief* [Dutch educational achievements in perspective]. The Hague, The Netherlands: CPB Netherlands Bureau for Economic Policy Analysis.
- VanTassel-Baska, J., & Brown, E. F. (2007). Toward best practice: An analysis of the efficacy of curriculum models in gifted education. *Gifted Child Quarterly*, 51, 342–358. doi:10.1177/0016986207306323
- Vaughn, V. L., Feldhusen, J. F., & Asher, J. W. (1991). Meta-analysis and review of research on pull-out programs in gifted education. *Gifted Child Quarterly*, 35, 92–98. doi:10.1177/001698629103500208
- Vorst, H. C. M., Smits, J. A. E., Oort, F. J., Stouthard, M. E. A., & David, S. A. (2008). *Schoolvragenlijst voor basisonderwijs en voortgezet onderwijs: handleiding en verantwoording* [School questionnaire for primary and secondary education: SVL user manual]. Amsterdam, The Netherlands: Pearson.

- Weinburgh, M. (1995). Gender differences in student attitudes toward science: A meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching*, 32, 387–398. doi:10.1002/tea.3660320407
- Worrell, F. C., & Erwin, J. O. (2011). Best practices in identifying students for gifted and talented education programs. *Journal of Applied School Psychology*, 27, 319–340. doi:10.1080/15377903.2011.615817
- Zeidner, M., & Schleyer, E. (1999). The effect of educational context on individual difference variables, self-perceptions of giftedness, and school attitudes in gifted adolescents. *Journal of Youth and Adolescence*, 28, 687–702. doi:10.1023/A:1021687500828
- Ziegler, A., & Heller, A. (2000). Conceptions of giftedness form a meta-theoretical perspective. In K. A. Heller, F. J. Mönks, R. J. Sternberg, & R. F. Subotnik (Eds.), *International handbook of giftedness and talent* (2nd ed., pp. 3–21). Oxford, UK: Pergamon Press.

7

General discussion

According to the theory of triarchic intelligence (Sternberg, 1985; 2011), intelligence comprises three types of abilities: analytical, creative, and practical. Moreover, these three types of abilities are hypothesized to develop in close interaction with both personal and environmental characteristics. The aim of the present dissertation was to gain insight in the multidimensional and developmental aspects of intelligence and giftedness. Three research questions were examined. First, it was studied whether intellectual abilities can be distinguished in upper primary school children. The second research questions addressed the relationship between children's levels of cognitive and socio-emotional functioning and their levels and development of intellectual abilities. Thirdly, the effects of enrichment programs on the development of intellectual abilities in gifted upper primary school children were examined.

On the basis of results of the studies described in the present dissertation, this final chapter will discuss the dynamic aspects of giftedness. An overview of the main results is given, followed by limitations, directions for future research, and educational implications.

Multidimensional assessment of intelligence

To answer the first research question, it was examined what types of intellectual abilities can be distinguished in upper primary school children. The theory of triarchic intelligence differentiates between analytical, creative, and practical abilities. These three types of abilities are assumed to be independent, yet related, constructs. To gain insight in the intellectual profiles of primary school children, assessment batteries should include ability tests in all three domains (Kornilov, Tan, Elliott, Sternberg, & Grigorenko, 2011). Chart, Grigorenko, and Sternberg (2008) developed the Aurora Assessment Battery to assess analytical, creative, and practical abilities with one comprehensive series of subtests. Although the Aurora Battery had been used in earlier studies (e.g., Aljughaiman & Ayoub, 2012; Kornilov et al., 2011; Mandelman, Barbot, Tan, & Grigorenko, 2013; Mandelman, Tan, Kornilov, Sternberg, & Grigorenko 2010), a three factor structure was not yet evidenced. Chapter 2 described the results of a study examining the psychometric properties and the dimensional structure of a Dutch translation of the Aurora Assessment Battery.

The Aurora Battery is a group-administered assessment that comprises seventeen subtests balanced over the three intellectual domains. Because the study in Chapter 2 was the first to address the Dutch version of the Aurora Battery, the psychometric quality of the subtests was first examined on item-level. Some items were found to be too difficult for Dutch upper primary school children and therefore excluded from analyses. In general, however, descriptive statistics showed high scores for both analytical and practical subtests, with some subtests even showing ceiling effects.

With regard to the multidimensional structure of the Aurora Battery, results from both correlation and factor analyses indicated very high overlap between analytical and practical abilities. Whereas both types of abilities also correlated substantially with creative abilities, factor loadings and model diagnostics of a confirmatory factor analysis were most supportive of a two-factor model. Previous studies assumed subtests to represent a three-factor model, yet results in Chapter 2 indicated that the Dutch version of the Aurora only discriminates analytical/practical from creative abilities in upper primary school children. Therefore, an adapted assessment battery was composed to screen children participating in a longitudinal follow-up study.

The newly composed assessment battery included standardized Dutch intelligence tests to evaluate analytical and practical abilities as well as Aurora subtests to assess creative abilities. Because of the ceiling effects found in Chapter 2 and our aims to use the assessment battery as an instrument to identify gifted children, we included subtests that were originally developed for secondary school children when possible. Chapter 3 described an exploratory factor analysis that again showed a two-factor structure with a distinction between analytical/practical and creative subtests. Once more, practical intellectual abilities were difficult to discriminate from analytical abilities in upper primary school children using group-administered paper-and-pencil tests.

The results of the first two studies in the present dissertation thus both seem to indicate a clear division between analytical and creative abilities in upper primary school children. This division is widely acknowledged ever since Guilford's theory on the structure of intellect (1959) and described in all recent models of intelligence (Ziegler & Heller, 2000). According to the theory of triarchic intelligence, however, practical abilities form a third, separated type of intellectual abilities. Results of the present dissertation did not support this claim of a triarchic structure of intelligence. This finding might be due to the design of the practical subtests, narrow sampling of participants, or flaws in the theory of triarchic intelligence.

Practical ability subtests are often designed as tacit-knowledge tests or practical ability inventories, which both require children to make a judgment about real-life situations. Although some of the practical subtests used in the present dissertation (i.e., *Toy Shadows*) resembled this format, other subtests (i.e., *Maps*) were very similar to regular arithmetic reasoning assignments often practiced at schools. Possibly as a consequence of this, we did not find a clear discrimination from analytical ability subtests. It might be that practical abilities are not measurable with a paper-and-pencil test due to the implicit nature of these abilities.

A second explanation for the high overlap between analytical and practical subtests scores might be found in the composition of the research sample in our studies. The sample in both Chapter 2 and 3, as in the other chapters, mainly consisted of children from high SES backgrounds. Multidimensional assessment

batteries, however, are assumed to be most profitable for ethnic minority and economically disadvantaged children (Stemler, Grigorenko, Jarvin, & Sternberg, 2006). On the other hand, results might also be an indication that the two types of abilities share too much overlap in upper primary school children. Practical abilities represent implicitly learned abilities needed to adapt to the environment to reach successful outcomes. For upper primary school children, practical abilities are needed to adapt to the school environment so that they perform well academically. Because instruction and assessment in primary schools most often involves analytical tasks (Chart et al., 2008), adaptation to the environment does not only involve practical but also analytical ability levels. Hence, for upper primary school children with high SES backgrounds, the two types of abilities might represent the same underlying construct.

Thirdly, results might indicate a flaw in the theory of triarchic intelligence. The distinction between analytical and creative abilities is widely acknowledged in empirical literature regarding intelligence and giftedness. The theory of triarchic intelligence is unique in stating that practical abilities are as essential to reach success. In the present dissertation, we did not manage to discriminate practical and analytical abilities, and therefore it is also plausible that the third type of abilities simply does not exist.

The role of child characteristics

The second aim of this dissertation was to examine how intellectual profiles and the development thereof were related to cognitive and socio-emotional child characteristics. To answer this question, children with varying intellectual profiles were identified and compared with regard to their cognitive, socio-emotional, and academic functioning in Chapter 3. In Chapter 4, the predictive role of cognitive and socio-emotional child characteristics in the development of analytical and creative abilities was examined in a longitudinal design.

In Chapter 3, four groups of intellectual profiles were identified based on scores of a screening of children's analytical and creative abilities: (1) children with gifted levels of both analytical and creative abilities, (2) children with gifted levels of analytical abilities only, (3) children with gifted levels of creative abilities only, and (4) normally-achieving children that did not reach gifted levels in either the analytical or creative domain. These four groups of children were compared with regard to their cognitive, socio-emotional, and academic development.

In line with the hypothesis of successful intelligence, results showed that children with gifted levels of both analytical and creative abilities outperformed normally-achieving children in the cognitive, socio-emotional, and academic domains. Whereas children that were gifted in either the analytical or creative domain also showed higher levels of academic functioning than normally-achieving children, they did not differ from this latter group with regard to cognitive and socio-emotional

functioning. Therewith, results showed that a combination of high analytical and creative abilities is positively related to child functioning in other domains.

Results in Chapter 4 expand this finding in showing that the development of both types of abilities is also closely related to both cognitive and socio-emotional child characteristics. A positive predictive role of visual short term memory was found for the development of both analytical and creative abilities. Verbal short term memory abilities, however, were only predictive of analytical ability levels. Socio-emotional child characteristics were also found to differentially predict the development of analytical and creative abilities. Whereas self-concepts predicted the development of analytical abilities, the development of creative abilities was predicted by ratings of wellbeing.

In Chapter 3, children's level of intellectual abilities was included as independent variable and their functioning in other domains as dependent variable. In Chapter 4, on the other hand, we showed that children's level of functioning in the cognitive and socio-emotional domain as independent variable was predictive of their intellectual development (as dependent variable). Together, results imply that the level and development of intellectual abilities is interrelated with children's development in other domains. That is, children with high levels of analytical and creative abilities gain higher academic achievements and might therefore report higher levels of self-concepts (Valentine, DuBois, & Cooper, 2004) and motivation (Wigfield & Eccles, 2000), which in turn might lead to even higher achievements (Marsh & Craven, 2006). Although we did not examine mutual effects in either of the studies, we hypothesize reciprocal effects between children's functioning in the various domains.

Furthermore, results in Chapter 3 seem to imply that high levels of creative abilities add to the benefits of high levels of analytical abilities. With the analytical assessment batteries regularly used to identify giftedness (McClain & Pfeiffer, 2012), these creative abilities are overlooked. Sternberg and Grigorenko (2004) showed that especially students from ethnic minorities or low SES backgrounds gain high creative and practical ability scores, yet are less likely to be identified as gifted with standardized intelligence tests (Callahan, 2005). Multidimensional assessment and broad identification criteria, rather than the use of standardized IQ tests, provide opportunities to identify these creatively-gifted children and allow them to participate in enrichment programs.

Enrichment program effects

Although enrichment programs are more and more provided to gifted children (Doolaard & Oudbier, 2010), the effects of these programs have only been studied limitedly (Subotnik, Olszewski-Kubilius, & Worrel, 2011). The few studies that did examine enrichment program effects used small numbers of participants, based conclusions on descriptive or qualitative research, and lacked control or comparison

groups (Subotnik et al., 2011; VanTassel-Baska & Brown, 2007; Vaughn, Feldhusen, & Asher, 1991). Moreover, most studies focused on intellectual effects, whereas especially enrichment programs in which children substantially increase contacts with gifted peers might affect the socio-emotional development of gifted children as well (Hoogeveen et al., 2004).

Enrichment programs can be provided either group-based or individualized. Of the group-based programs, pull-out programs have been found to render greatest effects on the intellectual and academic development of gifted children (Hoogeveen et al., 2004). An advantage of individualized programs, however, is that the method of instruction can be adapted to the needs and intellectual ability levels of every child (Shaw & Giles, 2015). The third research question evaluated the effects of both types of programs in two studies. The study in Chapter 5 evaluated the effects of an individualized ICT enrichment program on the intellectual development of gifted children in the final two grades of primary school. A second intervention study (Chapter 6) examined the effects of a pull-out program on the intellectual and socio-emotional development of gifted children.

For the individualized ICT program, children were screened on their levels of analytical and creative abilities rather than nominated by their teachers. Children with either high levels in one of the two domains or in both domains were allowed to participate in the ICT program that consisted of challenging online learning activities. The intellectual development of these children was compared to a control group of equally gifted children. Results showed equal growth in analytical abilities in gifted children in the experimental and control group. Further analyses indicated that whereas children in the control group did not differ with regard to their growth in analytical abilities, growth rates in children in the experimental group did vary. Children with lower initial levels of analytical abilities showed larger growth rates, whereas children with higher initial level of analytical abilities showed smaller growth rates. The individualized ICT program was thus found to enhance the development of analytical abilities, yet only in gifted children with relatively low starting levels of analytical abilities. On the other hand, the program seemed to put a hold on the analytical development of children with high initial levels of analytical abilities. For the development of creative abilities in gifted children, no effects were found in either the control or experimental group.

The pull-out program in Chapter 6 provided gifted upper primary school children with enrichment activities for one morning a week during a full year of school. During this morning, qualified secondary school teachers with ample experience teaching gifted children, taught robotics, mathematics, and research and design classes. Primary school teachers nominated gifted children for participation in the enrichment program and 40 children were selected to participate. Their intellectual and socio-emotional development was again compared to the development of a control

group of equally gifted classmates. With regard to gifted children's socio-emotional development, the pull-out program was found to prevent gifted children from a loss in motivation. Moreover, results showed positive effects on the development of practical abilities as measured with the Aurora subtest Money. No effects were however found for the development of analytical abilities and creative abilities.

Whereas the study on the effects of the pull-out program (Chapter 6) reported positive effects for training practical abilities, the study in Chapter 2 indicated that the Money subtest might better be interpreted as an indicator of analytical rather than practical abilities. Results of the pull-out program (Chapter 6) then indicate that positive effects for analytical abilities can be found when children do not reach ceiling levels at the beginning of the program. In addition, positive effects for gifted children's socio-emotional development were also found. Whereas motivation in gifted children in a control group decreased over the course of the school year, motivation in gifted children participating in a gifted program remained stable. Moreover, participating children showed increases in their self-concepts, whereas control group children did not show changes in self-concept.

Altogether, it thus seems possible to enhance the development of gifted children with enrichment programs especially in the analytical domain. The development of creative abilities, on the other hand, was not enhanced by either the pull-out program or the individualized ICT program. Moreover, the pull-out program also enhanced gifted children's socio-emotional development. More than in the individualized ICT program, the pull-out program allowed children to interact with gifted peers. This contact might be important for not only their intellectual, but also socio-emotional development.

The theory of triarchic intelligence revisited

To summarize, the present dissertation showed that two types of abilities can be distinguished in upper elementary school children: analytical and creative abilities. Although results did not support the claim of practical abilities as a third type of abilities, the discrimination between analytical and creative abilities calls for multidimensional assessment of ability levels. Moreover, both types of abilities were found to develop over time and in close interaction with both child and environmental characteristics, advocating for a dynamic rather than static approach to the assessment of intellectual abilities. Whereas static tests give information about the past learning level, dynamic testing provides insight in the level of development or modifiability of intellectual abilities (Fabio, 2005). Previous studies have shown that individuals with high levels of modifiability also reached higher levels of cognitive and academic performances (Fabio, 2005). That is, when exposed to the same educational experiences, children with more plastic brains develop higher levels of intellectual abilities (Garlick, 2002). Consequently, the label 'gifted' might better apply to the

children with both high static levels of analytical and creative abilities and high modifiability levels. With their high susceptibility for environmental factors, these children might also profit most from additional educational experiences such as enrichment programs.

Limitations and directions for future research

The studies in the present dissertation have some limitations. In the studies in Chapter 3 and 4, the focus was on the relationship between child characteristics and intellectual ability levels. In Chapter 3, differences in child functioning as a function of differences in intellectual profiles were examined. In Chapter 4, our aim was to investigate the predictive role of child characteristics, cognitive and socio-emotional measures in their intellectual development. The development of intellectual abilities might, however, also affect the cognitive and socio-emotional development. Although the studies in the present dissertation evidenced a close interrelatedness of cognitive, socio-emotional, and intellectual abilities, future research is needed to gain more insight in the reciprocal relationships between the development in the three domains.

A second limitation is that studies in this dissertation did not take into account the home environment of the children. Because families select and create experiences for children, the family background of children might exert great influence on their development (Perleth, Schatz, & Mönks, 2000). In addition, the attitude towards learning from parents has also been found to play an important role in the development of children (Peters, Grager-Loidl, & Supplee, 2000). In the present dissertation, the only indicator of family background was a rating on the socio-economic status (SES). Whereas multidimensional assessment has been shown to improve identification of gifted children from minority and low SES backgrounds (Sternberg & Grigorenko, 2004), our studies mainly included children with high SES backgrounds. Further research is needed to examine the possibilities of the Aurora Assessment Battery to discriminate analytical, creative, and practical abilities in children from low SES backgrounds. Moreover, future research might also explicate the role of socio-cultural background for the identification of gifted children.

Educational implications

Based on the results of the present dissertation, it can be concluded that it is worthwhile to adopt a comprehensive approach that includes multiple assessment criteria. The use of only a standardized IQ test score for the identification of gifted students puts on some serious limitations. First, standardized IQ tests assume intelligence to be fixed rather than dynamic and can therefore not be administered regularly. Studies in the present dissertation, however, showed that analytical and creative ability levels increase over the upper primary grades of primary education. When assessment of intelligence is limited to a single measurement, this development

of intellectual abilities cannot be monitored. Second, only analytically gifted children are identified, whereas results of the present study showed that children gifted in both the analytical and creative domain are the ones outperforming normally-achieving students in their cognitive and academic performances. Rather than the typically identified analytically-gifted children, these double gifted children thus should be challenged with enrichment programs. Moreover, previous studies suggest that the traditional IQ tests are not sufficiently suitable to identify talents in children from minority or low SES backgrounds. As a consequence, these groups of children are underrepresented in gifted programs (Chart et al., 2008). Broadening the approach to the assessment of ability levels allows not only children with high levels of abilities in the analytical domain, but also children with high levels of creative abilities to be identified for enrichment programs.

Enrichment programs provide gifted children with activities beyond what is typically covered in the regular curriculum. In the present dissertation, we examined the effects of both an individualized enrichment program and a pull-out program. The individualized ICT program was not found to enhance the development of intellectual abilities in gifted children. The pull-out program, on the other hand, did show positive effects on gifted children's intellectual development. Moreover, the pull-out program was also found to be effective in maintaining gifted children's levels of motivation, whereas gifted children that were not allowed to participate in the pull-out program showed a loss of motivation. Educators should therefore be aware of the consequences of their criteria on which students were and were not identified for pull-out programs. Furthermore, it is important to not only monitor the development of gifted children participating in the pull-out program, but also the development of children excluded from participation. Whereas in pull-out programs the activities and progress of students is monitored by the teacher of the program, this is less self-evident with within-class ICT enrichment programs. For within-class ICT enrichment programs to have a positive effect on the development of gifted children, careful implementation and monitoring of the students is important. Altogether, results advocate a multi-dimensional and developmental perspective to gain more insight in the dynamics of giftedness in the upper primary grades.

References

- Aljughaiman, A. M., & Ayoub, A. E. A. (2012). The effect of an enrichment program on developing analytical, creative, and practical abilities of elementary gifted students. *Journal for the Education of the Gifted*, 35, 153-174. doi:10.1177/0162353212440616
- Callahan, C. M. (2005). Identifying gifted students from underrepresented populations. *Theory Into Practice*, 44, 98-104. doi:10.1207/s15430421tip4402_4
- Chart, H., Grigorenko, E., & Sternberg, R. J. (2008). Identification: The Aurora Battery. In J. A. Plucker & C. M. Callahan (Eds.), *Critical issues and practices in gifted education* (pp. 281-301). Waco, TX: Prufrock Press.
- Doolaard, S., & Oudbier, M. (2010). *Onderwijsaanbod aan (hoog)begaafde leerlingen in het basisonderwijs [Education for gifted pupils in primary education]*. Groningen, The Netherlands: GION.
- Fabio, R. A. (2005). Dynamic assessment of intelligence is a better replay to adaptive behavior and cognitive plasticity. *The Journal of General Psychology*, 132, 41-66. doi:10.3200/GENP132.1.41-66
- Ford, D. Y., Grantham, T. C., & Whiting, G. W. (2008). Culturally and linguistically diverse students in gifted education: Recruitment and retention issues. *Exceptional Children*, 74, 289-309. doi:10.1080/02783199809553901
- Garlick, D. (2002). Understanding the nature of the general factor of intelligence: The role of individual differences in neural plasticity as an explanatory mechanism. *Psychological Review*, 1, 116-136. doi:10.1037//0033-295X.109.1.116
- Guilford, J. P. (1959). Three faces of intelligent. *American Psychologist*, 14, 469-479. doi:10.1037/h0046827
- Hoogeveen, L., van Hell, J., Mooij, T., & Verhoeven, L. (2004). *Educational arrangements for gifted children: Meta-analysis and overview of international research*. Nijmegen, The Netherlands: ITS/CBO/Orthopedagogiek, Radboud University.
- Kornilov, S. A., Tan, M., Elliott, J. G., Sternberg, R. J., & Grigorenko, E. L. (2012). Gifted identification with Aurora: Widening the spotlight. *Journal of Psychoeducational Assessment*, 30, 117-133. doi:10.1177/0734282911428199
- Mandelman, S. D., Barbot, B., Tan, M., & Grigorenko, E. L. (2013). Addressing the 'quiet crisis': Gifted identification with Aurora. *Educational & Child Psychology*, 30, 101-109.
- Mandelman, S. D., Tan, M., Kornilov, S. A., Sternberg, R. J., & Grigorenko, E. L. (2010). The metacognitive component of academic self-concept: The development of a triarchic self-scale. *Journal of Cognitive Education and Psychology*, 9, 73-86. doi:10.1891/1945-8959.9.1.73
- Marsh, H. W., & Craven, R. G. (2006). Reciprocal effects of self-concept and performance from a multidimensional perspective: Beyond seductive pleasure and unidimensional perspectives. *Perspectives on Psychological Science*, 1, 133-163. doi:10.1111/j.1745-6916.2006.00010.x
- Peters, W. A. M., Grager-Loidt, H., & Supplee, P. (2000). Underachievement in gifted children and adolescents: Theory and practice. In K. A. Heller, F. J. Mönks, & A. H. Passow (Eds.), *International handbook of research and development of giftedness and talent* (pp. 609-619). Oxford, England: Pergamon.
- Perleth, C., Schatz, T., & Mönks, F. J. (2000). Early identification of high ability. In K. A. Heller, F. J. Mönks, & A. H. Passow (Eds.), *International handbook of research and development of giftedness and talent* (pp. 297-315). Oxford, England: Pergamon.
- Shaw, E. L., & Giles, R. M. (2015). Using technology to teach gifted students in a heterogeneous classroom. In L. Lennex & K. Fletcher Nettleton, *Cases on instructional technology in gifted and talented education* (pp. 31-53). Hershey, PA: IGI Global. doi:10.4018/978-1-4666-6489-0
- Stemler, S. E., Grigorenko, E. L., Jarvin, L., & Sternberg, R. J. (2006). Using the theory of successful intelligence as a basis for augmenting AP exams in psychology and statistics. *Contemporary Educational Psychology*, 31, 344-376. doi:10.1016/j.cedpsych.2005.11.001
- Sternberg, R. J. (1985). *Beyond IQ: a triarchic theory of human intelligence*. Cambridge: Cambridge University press.
- Sternberg, R. J. (2011). The theory of successful intelligence. In R. J. Sternberg & S. B. Kaufman (Eds.), *The Cambridge handbook of intelligence*. New York, NY: Cambridge University Press.
- Sternberg, R. J., & Grigorenko, E. L. (2004). Successful intelligence in the classroom. *Theory Into Practice*, 43, 274-280. doi:10.1207/s15430421tip4304_5

- Subotnik, R. F., Olszewski-Kubilius, P., & Worrel, F. C. (2011). Rethinking giftedness and gifted education: A proposed direction forward based on psychological science. *Psychological Science in the Public Interest*, 12, 3-54. doi:10.1177/1529100611418056
- Thorndike, E. L. (1918). The nature, purposes, and general methods of measurements of educational products. In G. M. Whipple (Ed.), *The seventeenth yearbook of the National Society for Study of Education. Part II: The measurement of educational products*. Bloomington, IL: Public School Publishing.
- Valentine, J. C., DuBois, D. L., & Cooper, H. (2004). The relation between self-beliefs and academic achievement: A meta-analytic review. *Educational Psychologist*, 39, 111-133. doi:10.1207/s15326985ep3902_3
- VanTassel-Baska, J., & Brown, E. F. (2007). Toward best practice: An analysis of the efficacy of curriculum models in gifted education. *Gifted Child Quarterly*, 51, 342-358. doi:10.1177/0016986207306323
- Vaughn, V. L., Feldhusen, J. F., & Asher, J. W. (1991). Meta-analysis and review of research on pull-out programs in gifted education. *Gifted Child Quarterly*, 35, 92-98. doi:10.1177/001698629103500208
- Wigfield, A., & Eccles, J. S. (2000). Expectancy-Value Theory of achievement motivation. *Contemporary Educational Psychology*, 25, 68-81. doi:10.1006/ceps.199.1015
- Ziegler, A., & Heller, A. (2000). Conceptions of giftedness from a meta-theoretical perspective. In K. A. Heller, F. J. Mönks, R. J. Sternberg, & R. F. Subotnik (Eds.), *International handbook of giftedness and talent* (2nd ed., pp. 3-21). Oxford, UK: Pergamon Press.

Samenvatting

Hoogbegaafdheid wordt vaak vastgesteld op basis van een hoge score op een IQ-test. Deze score geeft vooral een beeld van de analytische vaardigheden van een leerling. Volgens de theorie van succesvolle intelligentie heeft een leerling naast analytische vaardigheden echter ook creatieve en praktische vaardigheden nodig om succesvol te worden. Bovendien stelt de theorie dat het mogelijk is analytische, creatieve en praktische vaardigheden te ontwikkelen, bijvoorbeeld door er aandacht aan te besteden in het onderwijs. De studies in dit proefschrift bieden meer inzicht in de ontwikkeling van de verschillende vaardigheden van leerlingen in de bovenbouw van het basisonderwijs. De volgende drie onderzoeksvragen stonden centraal:

- 1) Welke vaardigheden kunnen worden onderscheiden bij basisschoolleerlingen in de bovenbouw?
- 2) Hoe hangen intelligentieprofielen en de ontwikkeling daarvan samen met cognitieve en sociaal-emotionele leerlingkenmerken?
- 3) Kan de ontwikkeling van de verschillende typen vaardigheden van hoogbegaafde leerlingen worden gestimuleerd met verrijgingsprogramma's?

De drie vaardigheden: analytisch, creatief, praktisch

Met de studie in hoofdstuk 2 is onderzocht of het mogelijk is analytische, creatieve en praktische vaardigheden te toetsen van leerlingen in de bovenbouw van het basisonderwijs. Daarbij is gebruik gemaakt van de Aurora-test, een klassikale test die ontwikkeld is om de drie vaardigheden in kaart te brengen en begaafde leerlingen te identificeren op basis van hun scores. De test bestaat uit zes analytische, vijf creatieve en vijf praktische onderdelen. Deze onderdelen zijn afgenomen bij leerlingen van groep 6, 7 en 8. De resultaten van het onderzoek lieten zien dat de scores op de praktische onderdelen grote overlap hebben met de scores op de analytische onderdelen. Door deze overlap is het niet mogelijk een aparte score voor praktische vaardigheden te berekenen. De Aurora-test geeft dus alleen een beeld van de analytische en creatieve vaardigheden van bovenbouwleerlingen.

In een tweede poging om ook praktische vaardigheden in kaart te brengen hebben we een nieuwe test samengesteld met onderdelen uit bestaande intelligentietesten. Deze nieuwe test hebben we opnieuw afgenomen bij bovenbouwleerlingen en de resultaten van dit onderzoek zijn beschreven in hoofdstuk 3. Opnieuw vonden we hoge overlap tussen de analytische en praktische onderdelen. Op basis van beide studies kan daarom geconcludeerd worden dat er een duidelijk onderscheid kan worden gemaakt tussen analytische en creatieve vaardigheden, maar dat het moeilijk is praktische vaardigheden in kaart te brengen.

De rol van cognitieve en sociaal-emotionele leerlingkenmerken

Op basis van de scores van de nieuwe test konden begaafde leerlingen geïdentificeerd worden. In dit proefschrift werden leerlingen die scoorden binnen de top 10% van de onderzoeksgroep geselecteerd als begaafde leerlingen. Omdat de test een score voor zowel analytische als creatieve vaardigheden opleverde, konden er drie groepen begaafde leerlingen onderscheiden worden. Er was een groep leerlingen die een top 10% score behaalde op alleen de analytische onderdelen: de analytisch begaafden. Ook was er een groep leerlingen die alleen op de creatieve onderdelen tot de top 10% behoorden: de creatief begaafden. Daarnaast was er een groep leerlingen die zowel analytisch als creatief begaafd waren: de analytisch-creatief begaafden. Uiteraard was er ook een groep normaal-ontwikkellende leerlingen die noch op de analytische noch op de creatieve onderdelen tot de top 10% behoorde. In hoofdstuk 3 werd onderzocht of leerlingen met deze verschillende profielen ook verschillen op andere gebieden. Resultaten lieten zien dat de groep analytisch-creatief begaafde leerlingen een beter korte-termijn geheugen (verbaal en visueel) had dan de groep normaal ontwikkelende leerlingen. De analytisch-creatief begaafde leerlingen gaven bovendien aan dat ze meer gemotiveerd waren en een positiever zelfbeeld hadden dan de groep normaal ontwikkelende leerlingen. Op basis van deze resultaten kan er geconcludeerd worden dat analytisch-creatief begaafde leerlingen ook in andere gebieden de hoogste scores behalen. Wat betreft schoolprestaties lieten de resultaten zien dat op toetsen voor woordenschat en rekenen niet alleen de analytisch-creatief begaafde leerlingen beter scoorden dan de groep normaal ontwikkelende leerlingen, maar ook leerlingen die begaafd waren in een van de twee gebieden.

In hoofdstuk 4 is onderzocht welke rol het geheugen, motivatie, welbevinden en zelfbeeld hadden in de ontwikkeling van analytische en creatieve vaardigheden in groep 7 en 8. Resultaten lieten zien dat het visueel korte termijn geheugen een belangrijke voorspeller was voor de ontwikkeling van zowel analytische als creatieve vaardigheden. Het verbaal korte termijn geheugen speelde echter alleen een rol in de ontwikkeling van analytische vaardigheden. Ook voor de sociaal-emotionele kenmerken van leerlingen werden verschillende effecten gevonden: zelfbeeld voorspelde de ontwikkeling van analytische vaardigheden terwijl welbevinden een rol speelde in de ontwikkeling van creatieve vaardigheden. Samenvattend kan worden gesteld dat de ontwikkeling van analytische en creatieve vaardigheden nauw samenhangt met zowel cognitieve als sociaal-emotionele leerlingkenmerken.

De rol van verrijgingsprogramma's

Hoofdstuk 5 en 6 beschrijven de effecten van twee verrijgingsprogramma's. Verrijgingsprogramma's bieden begaafde leerlingen extra uitdaging door lesstof aan te bieden die in de reguliere les niet aan bod komt. In hoofdstuk 5 werden de effecten

van een online verrijkingsprogramma onderzocht. Een voordeel van een online verrijkingsprogramma is dat leerlingen zelf hun opdrachten kunnen kiezen en het programma dus aangepast kan worden aan het niveau en de interesses van de leerling. In het onderzoek hebben we de ontwikkeling van analytische en creatieve vaardigheden van begaafde leerlingen die deelnamen aan een online programma vergeleken met de ontwikkeling van begaafde leerlingen die het reguliere lesprogramma volgden. Er werden geen effecten gevonden wat betreft de ontwikkeling van creatieve vaardigheden: de scores op creativiteit bleven stabiel in beide groepen begaafde leerlingen. Analytische vaardigheden namen daarentegen toe in beide groepen. Analyses lieten verder zien dat leerlingen die het online programma volgden en aan het begin van het programma relatief zwak scoorden op analytische vaardigheden de meeste vooruitgang boekten in analytische vaardigheden. Het programma lijkt hiermee vooral gunstig voor analytisch zwakke leerlingen.

In hoofdstuk 6 werden de effecten van een plusklas onderzocht. Begaafde basisschoolleerlingen die door hun leerkracht waren aangemeld mochten één ochtend in de week lessen volgen op een middelbare school. In deze ochtend kregen ze Robotica, Onderzoeken & Ontwerpen en Wiskunde van ervaren docenten. De ontwikkeling van deze groep begaafde leerlingen werd vergeleken met begaafde klasgenoten die niet deelnamen aan deze plusklas. Begaafde leerlingen die deelnamen aan een plusklas scoorden na afloop beter op verhaalsommen, terwijl deze scores stabiel bleven bij hun begaafde klasgenoten. De plusklas bleek ook een positief effect te hebben op de motivatie van begaafde leerlingen. Terwijl de motivatie van begaafde leerlingen die niet deelnamen aan de plusklas achteruit ging, bleef de motivatie van plusklasleerlingen stabiel. Uit deze resultaten kan worden opgemaakt dat de plusklas niet alleen een positief effect had op de ontwikkeling van schoolse vaardigheden, maar ook verlies van motivatie voor school zou kunnen voorkomen.

Conclusies en implicaties

De onderzoeken in dit proefschrift hebben laten zien dat het moeilijk is praktische vaardigheden van leerlingen in kaart te brengen. Met de gebruikte testen kregen we echter wel een beeld van de analytische en creatieve vaardigheden van bovenbouwleerlingen. Op scholen en bij intelligentie-onderzoeken wordt echter vooral aandacht besteed aan analytische vaardigheden. Daardoor worden voornamelijk analytisch-begaafde leerlingen herkend. Een bredere aanpak is nodig om ook de leerlingen met creatieve talenten te herkennen. Resultaten in dit proefschrift lieten zien dat leerlingen die zowel analytisch als creatief begaafd zijn ook in andere gebieden het beste presteren. Wellicht zijn het dus niet de analytisch-begaafde leerlingen, maar deze dubbel-begaafde leerlingen die de meeste behoefte hebben aan extra uitdaging, bijvoorbeeld in de vorm van een verrijkingsprogramma.

Uit de studies in dit proefschrift blijkt dat verrijgingsprogramma's een positieve bijdrage kunnen leveren aan de ontwikkeling van denkvaardigheden van begaafde leerlingen. Een online verrijgingsprogramma bleek de ontwikkeling van analytische vaardigheden van analytisch zwakke leerlingen te stimuleren, terwijl de ontwikkeling van analytisch sterke leerlingen stagneerde. Juist deze analytisch-sterke leerlingen worden echter het vaakst geselecteerd worden voor deelname aan verrijgingsprogramma's. Leerkrachten zouden goed na moeten denken over de selectiecriteria voor deelname aan verrijgingsprogramma's. Met brede toetsing kunnen creatieve talenten niet alleen herkend worden, maar kan ook aan creatief begaafde leerlingen de kans worden geboden deel te nemen aan een verrijgingsprogramma. Ook een plusklas bleek een positieve bijdrage te leveren aan de ontwikkeling van denkvaardigheden van begaafde leerlingen. De plusklas zorgde er bovendien voor dat begaafde leerlingen gemotiveerd bleven voor schoolwerk. Begaafde leerlingen die niet mochten deelnemen aan de plusklas verloren daarentegen hun motivatie voor school. Het is daarom belangrijk om niet alleen de ontwikkeling van plusklasleerlingen, maar ook de ontwikkeling van hun begaafde klasgenoten te volgen.

Dankwoord

Een aantal mensen heeft me geholpen bij het schrijven van dit proefschrift. Op deze plek wil ik al deze mensen bedanken voor hun betrokkenheid en inzet.

Ten eerste Ludo en Eliane. Al tijdens mijn research master onderzoek stimuleerden jullie me verder te gaan met een promotieproject. Ik was zelf minder overtuigd en bleef volhouden dat ik eerst ervaring op wilde doen in de praktijk. Ik ben blij dat jullie me die mogelijkheid gaven, maar ook dat jullie me toch hebben weten over te halen verder te gaan in het onderzoek. Vanaf de start van mijn promotieproject heb ik geen moment spijt gehad. Ludo, jij hielp me de grote lijnen te zien en had voor elk probleem een oplossing. Eliane, jij kwam regelmatig even binnen om te checken hoe het ervoor stond en wist daardoor altijd precies hoe het liep. Bedankt voor jullie vertrouwen en alle kansen die jullie me hebben gegeven. Fijn dat we ook na mijn promotie nog blijven samenwerken!

Lianne, toen ik me tijdens mijn bachelor wilde verdiepen in hoogbegaafdheid gaf jij me die mogelijkheid met een onderzoeksstage bij het CBO. Samen met Els startten we een pilot om de Aurora-test te vertalen en af te nemen. Dit was mijn eerste ervaring met onderzoek en ik heb veel van deze pilot geleerd. Els, jouw enthousiasme werkte aanstekelijk en heeft mij doen besluiten het onderzoek naar intelligentie en hoogbegaafdheid voort te zetten. Door je ziekte kon je er zelf helaas niet betrokken bij blijven, maar je interesse bleef. Lianne, bedankt voor je hulp bij het vinden van deelnemers en bij de Acadintraining. Ik ben ook erg dankbaar voor alle mogelijkheden die je me hebt geboden om mijn resultaten te delen met leerkrachten, orthopedagogen en andere onderzoekers.

Odilia en Wim, bedankt dat ik vanaf het begin van de Class for the Gifted bij jullie aan mocht sluiten. Ik heb de reis naar Den Haag altijd met veel plezier gemaakt. Ik kreeg veel vrijheid en dankzij jullie hulp heb ik in korte tijd een studie kunnen opzetten en uitvoeren. Jullie maakten dat ik me welkom voelde en het meedraaien in de klas gaf voor mij de perfecte afwisseling tussen onderzoek doen en werken in de praktijk.

Desirée, bedankt voor je hulp bij de Acadintraining en bij het verzamelen van alle data die opgeslagen was door Acadin. Jos, bedankt voor alle tijd die je in de analyses hebt gestoken. Het was soms ingewikkeld, maar met jouw grondige analyses zijn we uiteindelijk tot een onverwachte maar interessante conclusie gekomen. Natuurlijk wil ik ook de leerkrachten en kinderen bedanken die hebben deelgenomen aan mijn onderzoek. Bedankt voor alle tijd die jullie vrij hebben gemaakt.

Ik had mijn onderzoek nooit uit kunnen voeren zonder de hulp van alle student-assistenten. Anna, Nadia, Anne, Carolien, Rosalie, Annelien, Nicky en Marleen, bedankt

dat jullie zo'n groot deel van de dataverzameling op jullie hebben genomen. Anne, jij hebt naast alle schoolbezoeken ook veel tijd gestoken in het beoordelen van de antwoorden van de leerlingen. Het was erg fijn dat je altijd zo flexibel was en dat je zelfs in drukke periodes tijd vrij maakte om mij uit de brand te helpen. Carolien, ook jij hebt me enorm geholpen. Naast alle hulp met de dataverzameling en het scoren, was jij ook betrokken bij de opzet van het onderzoek en de interpretatie van resultaten. Bedankt voor alle momenten waarop we hebben zitten sparren onder het genot van een kop thee. Ik ben blij dat we inmiddels collega's zijn en ik hoop dat we nog vaak samen thee kunnen drinken.

Ook mijn andere OLO-collega's kan ik niet vergeten. Gitta, toen ik als student stage liep op de afdeling kwam jij al regelmatig binnenlopen en toen we collega's werden was jij de eerste die me feliciteerde. Bedankt voor alle tijd die we zeker aan het begin van ons onderzoek samen in het DE-café hebben doorgebracht. Moniek en Sanne, het was fijn om te weten dat ik altijd bij jullie binnen kon lopen met vragen of gewoon om even te kletsen. Arjan en Nicole, ik ben blij dat er collega's zijn die mijn flauwe humor delen. Bedankt voor alle humor en moppen aan de lunchtafel. Sabine en Liza, jullie hebben me als kamergenoten niet alleen enorm geholpen met mijn onderzoek, maar ook voor de nodige gezelligheid gezorgd. Natuurlijk wil ik ook alle andere collega's bedanken. Zonder jullie was mijn promotietijd een stuk minder gezellig geweest.

Als volgende wil ik mijn teamgenoten van de laatste jaren bedanken. Ik heb samen met jullie veel plezier gehad bij de trainingen en wedstrijden, maar vooral ook bij andere activiteiten. Als ik terugdenk aan alle borrels, toernooien en teamavonden krijg ik vanzelf een lach op mijn gezicht. Ook de teamweekenden, vooral ons weekend in Bergen op Zoom, zal ik niet snel vergeten. Annet en Tiele, bedankt voor onze vele koffiepauzes waarin jullie ook tijdens het werk voor de nodige afleiding zorgden. Milou, binnen het volleybalveld, maar zeker ook daarbuiten heb ik ontzettend veel lol met jou gehad. Zonder een woord te zeggen kunnen wij samen al de slappe lach krijgen en met één blik weten we vaak al van elkaar wat de ander denkt. Ik ben dan ook heel blij dat jij mijn paranimf wil zijn.

Franka, Mieke, Suzan, Pieternel, ook al zien we elkaar niet meer vaak, als we elkaar zien is het altijd weer gezellig. Marike, Mireille, Laura, Lieke, Marian, Hilde, Iris, Milou, na de research master hebben we allemaal een andere weg gekozen, maar gelukkig hebben we nog steeds contact. Het is fijn dat we nog steeds onze ervaringen kunnen delen, maar ik geniet vooral van alle gezelligheid bij onze lunchafspraken, spelletjesmiddagen en natuurlijk het jaarlijkse weekendje weg.

Mike, Janske en Tom, ook jullie wil ik bedanken voor de steun de afgelopen jaren. Tom, jij was altijd geïnteresseerd in mijn onderzoek en vroeg regelmatig hoe het ervoor stond. Mike, bedankt voor de vele taxiritjes vanaf het station. Fijn dat ik elke keer weer op je kon rekenen. Janske, jouw adviezen als leerkracht waren vaak waardevol voor mijn onderzoek en de regelmatige zussendagjes zorgden voor een leuke afleiding. Maar ik wil jullie vooral bedanken voor alle momenten dat we gewoon samen waren en lol hadden. Niet iedereen begrijpt onze humor, maar ik ben blij dat we het in ieder geval met elkaar delen.

Tot slot wil ik pap en mam bedanken. Jullie hebben me altijd gestimuleerd te kiezen voor iets wat ik leuk vond en alle kansen te grijpen. Ook al was het spannend dat ik alleen op reis ging voor een conferentie, jullie moedigden me wel aan om te gaan. Ook mijn nuchtere houding heb ik van jullie en dat heeft er zeker aan bijgedragen dat ik mijn promotietijd als zo relaxed heb ervaren. Pap en mam, het was fijn dat ik na een week met werk, volleybal, muziek en vriendinnen weer bij kon komen in rusthuis Gubbels. Bedankt voor het vertrouwen dat jullie altijd in me hebben gehad!

Curriculum Vitae

Joyce Gubbels is geboren op 5 juli 1989 te Nijmegen en opgegroeid in het Noord-Limburgse dorp Melderslo. Na het behalen van haar gymnasiumdiploma aan het Dendron College in Horst startte ze in 2007 met de opleiding Pedagogische Wetenschappen en Onderwijskunde aan de Radboud Universiteit. Tijdens deze bachelor werd haar interesse voor hoogbegaafdheid en onderzoek gewekt door haar werkzaamheden als onderzoeksassistent bij het Centrum voor Begaafdheidsonderzoek (CBO). Na het afronden van haar bacheloropleiding (cum laude) besloot ze haar opleiding te vervolgen met de Research Master Behavioural Science, eveneens aan de Radboud Universiteit. Tijdens haar onderzoeksstage aan de afdeling Orthopedagogiek werkte ze opnieuw samen met het CBO in een onderzoek naar de effecten van een verrijkkingsklas voor begaafde leerlingen.

Na afronding van de onderzoeksstage heeft Joyce met een klinische stage bij het Over Betuwe College te Bommel de NVO basisaantekening diagnostiek behaald. Direct daaropvolgend is ze bij het Behavioural Science Institute begonnen met een promotieonderzoek. In samenwerking met het CBO, het Nationaal Expertisecentrum Talentontwikkeling en CITO deed zij onderzoek naar de ontwikkeling van verschillende typen intelligenties in basisschoolleerlingen. De resultaten van dit onderzoek heeft ze gepresenteerd aan onderzoekers, beleidsmakers en onderwijsprofessionals op nationale en internationale conferenties. Ook gaf Joyce zowel klinisch als wetenschappelijk onderwijs aan Orthopedagogiek en ALPO studenten, waarmee ze de Basiskwalificatie Onderwijs (BKO) behaalde.

Na haar promotie vervolgt Joyce haar carrière als postdoctoraal onderzoeker bij zowel de Radboud Universiteit als de Academische Werkplaats Onderwijs van de Universiteit Maastricht.

Behavioural
Science
Institute

Radboud University

