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Boy-girl differences in pictorial verbal learning in students aged 8–12 years and the influence of parental education

Under review:

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ABSTRACT

This large-scale cross-sectional study of schoolchildren aged 8–12 years (N = 152) evaluates two factors which potentially determine individual differences in intentional learning: the child's sex and parental education. Intentional learning was assessed with a newly constructed Pictorial Verbal Learning Task (PVLТ). This task presents line drawings of concrete objects as to-be-remembered information instead of written or auditory presented words. The PVLТ has the advantage that performance is not confounded by individual differences in abilities related to verbal information processing. Results revealed clear sex differences in performance: Girls outperformed boys. Parental education also contributed to individual differences in performance since children of higher educated parents outperformed children of lower educated parents. The results therefore suggest that both sex and parental education could be potent contributors to individual differences in learning performance at school. The findings more specifically imply that children of less educated parents and boys need additional guidance and support in intentional learning when new information and procedures are presented for the first time.

INTRODUCTION

Intentional learning is of key importance for the acquisition of new information and for academic performance. The process of intentional learning can typically be described as having the purpose of learning information and committing it to one's memory (Hampshire et al., 2016; Lezak, Howieson, Bigler, & Tranel, 2012; Thomas & Rohwer, 1986). This is different from incidental learning, which is the accidental learning of information while actually concentrating on other information (Ahmed, 2017; Hampshire et al., 2016; Kontaxopoulou et al., 2017; Lezak et al., 2012; Thomas & Rohwer, 1986). The ability for intentional learning typically improves with experience and with age (Blachstein & Vakil, 2016; Meijer, de Groot, van Boxtel, van Gerven, & Jolles, 2006; Meijer, van Gerven, de Groot, van Boxtel, & Jolles, 2007; Meijs, Hurks, Rozendaal, & Jolles, 2013; Meijs, Hurks, Wassenberg, Feron, & Jolles, 2016). It appears that there are major individual differences in the pace at which intentional learning develops at the end of childhood and the beginning of adolescence (Jolles, 2016; Juraska & Willing, 2017; Meijer et al., 2007; Meijs et al., 2016).

Individual differences in intentional learning performance may contribute to individual variations in the ability to acquire and consolidate new information at school, as well as in learning motivation and school achievement. An example of intentional learning at school is when students have to learn lists of words that belong to a new language, and when they have to learn lists of conjugations of verbs. Another example of intentional learning at school is when new mathematical rules and multiplication tables have to be learned. Students with poor intentional learning ability may experience profound difficulties with learning lists of new words, conjugations of verbs as well as with learning new mathematical rules and lists of tables. This may negatively affect their language and mathematics performance as well as their learning motivation (Lawrence, Campbell & Skuse, 2015). Individual variations in intentional learning ability may, thus, contribute to substantial individual differences in school performance in various cognitive domains (e.g., language, mathematics). It is therefore of importance to find out whether students are characterized by individual differences in intentional learning performance, and whether there are external factors that contribute to these individual differences. Identification of external factors could allow early detection of those individuals who are at risk of poor intentional learning performance, and thus also for problems with learning at school. These factors could be regarded as risk factors. The existence of risk factors could enable the formulation of intervention programs that aim to stimulate the development of intentional learning ability (Dekker & Jolles, 2015). The present large-scale study aims to

evaluate the notion that there are at least two risk factors for inferior intentional learning performance in students aged 8–12 years, namely male sex and lower parental education.

The notion that sex and level of parental education (LPE) may contribute to individual differences in intentional learning is, in part, based upon findings that boys and girls, and children of higher and lower LPE families differ in their school achievement. The average school achievement of girls is higher than that of boys in the age period between 8–12 years (see Organisation for Economic Cooperation and Development, i.e., OECD, 2015; Kontaxopoulou et al., 2017; Stoet & Geary, 2015; van der Elst, Dekker, Hurks, & Jolles, 2012; Voyer & Voyer, 2014; Williams, Meredith-Duliba, McWilliams, & Osipowicz, 2015). Likewise, there is a rapidly growing volume of literature indicating that the average school achievement of children of lower educated parents are significantly lower than those of their peers who have higher educated parents (e.g., Chiu et al., 2016; Davis-Kean, 2005; Rindermann & Baumeister, 2015; Inspection of Education the Netherlands, 2015). These findings with respect to sex and LPE differences are reported across many industrialized nations. They suggest that boys and girls, and children of higher and lower LPE families could differ in various cognitive abilities that are important for learning at school.

Previous studies have reported on sex differences and differences between children of higher and lower LPE families on various cognitive tasks. With respect to sex differences, there is ample scientific evidence that girls outperform boys in verbal fluency tasks and tasks that evaluate inhibitory control (e.g., Berlin & Bohlin, 2002; Dekker, Krabbendam, Aben, de Groot & Jolles, 2013; Hyde & Linn, 1988; Miller & Halpern, 2014). Other studies showed that boys outperform girls on spatial ability tasks (e.g., Hoyek, Collet, Fargier, & Guillot, 2011; Miller & Halpern, 2014; Voyer, Voyer, & Bryden, 1995). The notion that sex is a determinant of individual differences in performance of cognitive tasks is further substantiated by neuroimaging studies. These studies reported on sex differences in the maturation of brain areas and networks (Hampshire et al., 2016; Juraska & Willing, 2017; Lenroot & Giedd, 2011; Miller & Halpern, 2014). It appears that total cerebral volume and grey matter volume peak at a later age in boys (14.5 years) than in girls (10.5 years) (Giedd, 2008). With respect to differences between children of higher and lower LPE families on cognitive abilities, previous studies reported that children of higher educated parents tend to have superior verbal abilities, a larger vocabulary, and more rapid language development than children growing up in lower LPE families (Carr & Pike, 2012; Ganzach, 2000; Hoff, 2003; Kautz et al., 2014). Next to differences in verbal abilities, differences between children of higher and lower LPE families have been demonstrated in problem-solving behavior and attention (Hurks et al., 2006; Meijs et al., 2009). These LPE

differences have also been reported by teachers: They observed that planning and initiative taking behaviors were higher for children with higher LPE than for children with lower LPE at the ages of 8–12 years (van Tetering & Jolles, 2017). These findings are substantiated by those of neuroimaging studies showing associations between parental education and total brain surface area (Noble et al., 2015). These findings indicated that any increase in parental education – for example, an extra year of high school or at college – was associated with an increase in surface area over the course of childhood and adolescence (Noble et al., 2015). Taking the findings of all of these studies together, it is suggested that sex and LPE are relevant factors contributing to individual differences in cognitive development. Both factors may, therefore, also contribute to individual differences in intentional learning performance. It is of special interest to investigate whether sex and LPE are valuable determinants of individual differences in intentional learning performance because of the differences in school achievement between boys and girls and between children of higher and lower LPE families.

Sex differences and differences between children of higher and lower LPE families in intentional learning have been reported by previous studies using classical verbal learning tests, such as the Rey Auditory Verbal Learning Task (AVLT, Rey, 1964) and the California Verbal Learning Test (CVLT, Eric, 1987). Both typical intentional learning tasks consist of a learning phase. In this phase, the participants are presented with to-be-remembered information such as spoken or written words. Before this learning phase, participants are told to remember as many pieces of information as possible because they will be requested to recall the information afterwards (Ahmed, 2017). These kinds of tasks are analogous to various aspects of learning at school and in daily life, such as when learning a list of facts, rules, or words. Both the AVLT and the CVLT are frequently used for the evaluation of intentional learning in clinical settings (Lezak et al., 2012; Rey, 1964; Correia & Osorio, 2013; Emami, Nunez, Favela, Strauss, & Allen, 2017; Nunez, Emami, San, & Allen, 2017; van der Elst et al., 2005; Williams et al., 2015).

Sex differences and differences between children of higher and lower LPE families in performance on classical intentional learning tasks, however, give no clear answer to the question whether there are sex and LPE differences in intentional learning performance. A problem with these tasks is that they offer to-be-learned information in written or spoken words (e.g., AVLT and the CVLT; Correia & Osorio, 2013; Rey, 1964; van der Elst et al., 2005; Lezak et al., 2012). Performance on these tasks therefore relies heavily on reading and hearing ability, and on other abilities related to verbal information processing. This is an important notion when studying intentional learning performance in children, as it has repeatedly been shown that girls have superior verbal abilities compared to boys (e.g., Hoff, 2003; Hoff-

Ginsberg, 1991; Hyde & Linn, 1988; Miller & Halpern, 2014). Superior performance of girls in classical verbal learning tasks may, therefore, represent their superior verbal abilities rather than superior performance in intentional learning. Likewise, accumulating evidence shows that children who grow up in higher LPE families have superior verbal abilities compared to children growing up in lower LPE families (e.g., Hoff, 2003; Hoff, Laursen, Tardif & Bornstein, 2002; Hoff-Ginsberg, 1991). Previous studies showed that children from lower LPE families lag behind in their language development because they have gained less experiences with reading books, and the language and verbal communication practiced in their family is less complex than in higher LPE families (Hoff, 2003; Hoff et al., 2002; Hoff-Ginsberg, 1991). Moreover, classical verbal learning tasks cannot be used by children that have hearing and reading difficulties. In order to investigate sex differences and the importance of LPE to intentional learning without major confounding by pre-existing differences in the processing of verbal information (e.g., reading, hearing), the present study introduces a newly developed task; the Pictorial Verbal Learning Task (PVLT).

The uniqueness of the PVLT comes from the modality in which to-be-learned information is offered, which is pictorially. The PVLT, therefore, has the advantage compared to classical verbal learning tasks of being less sensitive to pre-existing individual differences in verbal information processing, which can influence learning performance. Another advantage of the PVLT is that it assesses intentional learning as important for learning at school and in daily life where information is often presented pictorially. Performance on the PVLT is analogous to that on the AVLT and the CVLT, and reflects intentional learning since the subject gets the explicit instruction to remember as many pictures as possible. After each trial, they are asked to recall as many pictures as they have remembered. An important note with regard to the use of pictures as stimuli is that it has repeatedly been shown that visuospatial abilities of boys are superior to those of girls (e.g., Hoyeck et al., 2012; Miller & Halpern, 2014; Voyer et al., 1995). A pictorial task could, therefore, be to the advantage of boys because visual perception and recognition are more important in such a pictorial task than word recognition. If girls outperform boys on the PVLT, it would thus give even stronger support to our hypothesis that there are sex differences in intentional learning.

In order to investigate sex and LPE differences on the PVLT, a large-scale cross-sectional study was conducted with children aged 8–12 years. Specifically, this study investigated (1a) whether there are sex differences in intentional learning over this age period, and (1b) whether sex differences differed in pre-teens (aged 8–10 years) versus young teens (aged 10–12 years). A second research question was whether (2a) there are differences between children of higher

versus lower LPE families in intentional learning over the total age period, and (2b) whether LPE differences differed in pre-teens (aged 8–10 years) versus young teens (aged 10–12 years).

Sex differences and differences between children of higher and lower LPE families in intentional learning were investigated in two age groups. This was needed because an increasing number of studies has repeatedly shown that the magnitude of sex differences on various cognitive abilities is influenced by age. For instance, results of the large-scale longitudinal study of Camarata and Woodcock (2006) showed that the effect on information processing speed was relatively small in young children (aged nine years and younger), larger in early adolescence (aged 10–13 years), and the largest in middle adolescence (aged 14–18 years). Also, Cross, Copping, and Campbell (2011) reported that sex differences in impulse control were more pronounced in adolescence than in adulthood. In addition to sex, it is considerable that the magnitude of LPE differences also fluctuates with age. For instance, studies reported rapid brain maturation in childhood and early adolescence, followed by a more gradual rate, ultimately plateauing in early adulthood (e.g., Raznahan et al., 2011; Schnack et al., 2014). It is therefore considerable that LPE especially influences brain maturation at early ages. Results of previous studies, thus, stress the need to examine the issue of sex and LPE differences in cognitive abilities during adolescence in narrow age classes. The present study, therefore, investigates sex and LPE differences in intentional learning in two age groups with narrow age classes.

This study contributes to a better understanding of differences and similarities in the neuropsychological development of boys and girls and between children growing up in lower and higher LPE families. These are insights which – from the perspective of applied neuropsychology – can have important consequences for educational innovations and improvement of learning performance at school (see Camarata & Woodcock, 2006). They allow the adjustment of learning materials and procedures to each students' needs in order to optimize learning outcomes.

METHOD

Procedure & Participants

The data used in this study were derived from a large-scale cross-sectional study into the determinants of learning performance in students aged 8-12 years. All data were collected in April 2014 (Tetering & Jolles, 2017). Participants were recruited from four regular mainstream primary schools in a rural area near the greater Amsterdam region (the Netherlands). All

schools belonged to one school organization with the same board involving 22 schools. The choice for the four schools was based on the presence of participants with a broad range of socioeconomic statuses (SES) ranging from low to high. The SES of the participants was evaluated according to the mean income and educational levels of the individuals living in the schools' neighborhood (CBS., 2016a; CBS., 2016b). By including a roughly equivalent number of participants from low, moderate and high SES families we controlled for SES differences between participants to interfere with our main outcomes. Participation in the study was voluntary. All caregivers were informed that no personal information would be obtained and all data were assembled and analyzed at group level. The parents or caregivers (referred to as caregivers in the rest of this paper) gave written permission for their child to participate. The consent obtained from all caregivers of the non-adult participants was thus both informed and written. The Ethics Committee of the Faculty of Behavioral and Movement Sciences of the Vrije Universiteit Amsterdam approved the study protocol.

After permission of the caregivers for their child to participate, caregivers received an e-mail with login details for a short questionnaire which was presented via the internet. They were asked to indicate the highest level of education of both the father and the mother of the child on a 9-point scale (0 = not finished any education to 9 = finished post university education). This classification is based on the International Standard Classification of Education (Singh., 2010).

Well-trained research assistants of the research center tested all children individually. Children were tested at their own school. A fixed battery with 8 neuropsychological tests was administered. Administration of the total battery took approximately 60 minutes. The second test within this battery was a measure of intentional learning.

Inclusion and exclusion of participants

In total, $N = 310$ subjects participated in the study. Data of participants were excluded from analysis when they accelerated or delayed a class ($n = 81$). This was done in order to have a relatively homogeneous sample with typically developing participants in each grade. Accordingly, the October-norm was used to create sharp age-boards between grades. The exclusion of participants was therefore based on their date of birth. An example in third grade: All participants born before 1 October 2004 or after 1 October 2005 were excluded (Rijksoverheid, 2017). Participants were additionally excluded if data was unreliable due to technical problems ($n = 3$), or if data was missing on the LPE ($n = 38$). In addition, equal sex ratios between grades were created to control for sex effects within grades (note: This prevents

that mean performance of a grade was affected by the unequal distribution of boys and girls within the grade, given the expectation that girls outperform boys). Boys and girls were randomly paired per school based on their age. This resulted in the exclusion of $n = 30$ boys and $n = 6$ girls (i.e., $n = 7$ boys in grade 3, $n = 3$ boys and $n = 1$ girl in grade 4, $n = 12$ boys and $n = 2$ girls in grade 5 and $n = 8$ boys and $n = 3$ girls in grade 6).

Table 1. Participants characteristics per age-group.

	<i>Age Groups</i>	
	1	2
<i>Group demographics</i>		
N	80	72
Age (mean (SD))	9.6 (0.6)	11.5 (0.5)
Age-range (min-max)	8.6-10.7	10.7-12.7
Sex distribution (boys/girls)	40/40	36/36
LPE (low-moderate/high)	36/44	31/41
Mean (SD) LPE ¹	6.4 (1.4)	6.5 (1.3)

*Note:*¹LPE was measured on a 9-point scale, ranging from 0 = no finished education to 9 = post university education.

Data of $n = 152$ children were analyzed. These participants were divided in two age-groups (i.e., age-group 1 includes children from grades 3 and 4, aged 8.6-10.7 years, and age-group 2 includes children from grades 5 and 6, aged 10.7-12.7 years). These age-groups were chosen on the basis of earlier literature reporting that the period of early adolescents starts from the age of 11 and lasts until the age of 14 (e.g., Steinberg & Silverberg, 1986). Next to creating two age-groups, also LPE was dichotomized into two levels: low-to-moderate LPE (i.e. vocational training or lower, $N = 67$) and high LPE (higher than vocational training, $N = 85$). Dichotomization was based on the frequency distribution of LPE, so that two groups were created with comparable sample sizes. Table 1 shows the demographic data for both age-groups. All children were Dutch speakers.

Instrument: the Pictorial Verbal Learning Task

The multi-trial Pictorial Verbal Learning Task (PVLTL) was used to measure intentional learning. Verbal learning tests are among the most often-used neuropsychological tests in applied settings and memory research, and the test-retest reliability has been reported to be high (Brand & Jolles, 1985; Lezak et al., 2012; van der Elst et al., 2005). The PVLTL consisted of three trials: Each trial consisted of the presentation of the same 15 pictures of familiar objects in the

same order. The words that the pictures referred to were controlled for frequency of use in the Dutch language (Linschoten, 1963) and the number of syllables and imageability (van Loon-Vervoorn, 1989). The pictures refer to concrete objects such as hammer, vesta, beard and crane (see Figure 1). Various possible categories of words (e.g., animals, body parts, parts of the house, furniture) were evenly distributed over the list in order to control for potential semantic and acoustic associations. Care was taken to avoid pictures with possible emotional connotations. The pictures were presented in the same order in each trial (Meijs et al., 2009; Meijs et al., 2013; Meijs et al., 2016).

Fifteen pictures were presented on the screen of a tablet (13.60 x 21.80cm). The presentation duration was one second and there was an inter-stimulus interval of one second. The pictures (9.4 x 10.4 cm) consisted of line drawings and they were presented in black against a white background in the center of the screen. The distance between the participant and the tablet was approximately 30 centimeters. After each complete presentation, the participant had to verbally recall as many pictures as possible, regardless of the order that they were presented in. This procedure was repeated three times (trial 1-3). After a period of approximately 15 to 20 minutes, in which several information processing tests were administered that did not interfere with memory, a delayed recall trial was executed. The participant had to recall as many pictures as possible from the list without prompting (Meijs et al., 2009; Meijs et al., 2013; Meijs et al., 2016).

PVLT Outcome Measures

The following measures were analyzed: (1) immediate recall after trial 1: The number of correctly recalled pictures after the first learning trial, (2) total recall trials 1-3: The total number of correctly recalled pictures over three learning trials, and (3) delayed recall: The number of correctly recalled pictures after a 20-minutes delay in which the subjects engaged in simple information processing tasks. The immediate recall on trial 1 score is taken as an indication of a subject's ability to deal with unfamiliar procedures and to learn newly presented information. The total number of pictures recalled, summed over the three learning trials reflects learning ability after repeated presentation of the same information. Lastly, the delayed recall is a measure of the ability to recall earlier learned information from long-term memory (van der Elst et al., 2005).

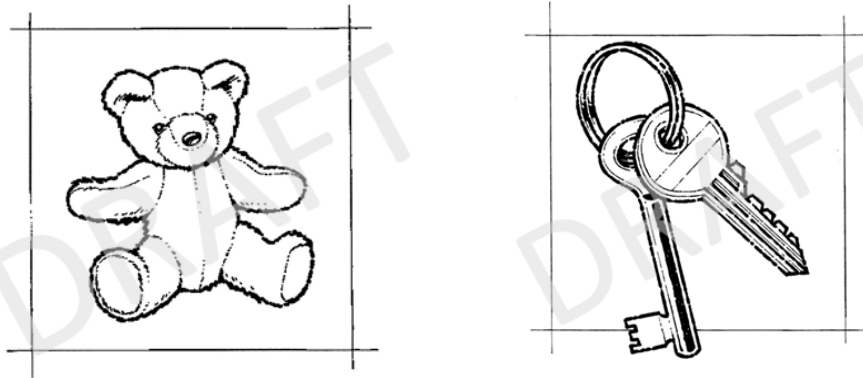


Figure 1. Examples of pictures used in the Pictorial Verbal Learning Test

Statistical analyses

2 (age-group: 1 vs. 2) x 2 (sex: boys vs. girls) Analyses of Variances (ANOVAs) on each of the PVLТ outcomes (immediate recall trial 1, total recall trials 1-3, delayed recall) were conducted. Then, follow-up one-way ANOVAs were performed in each age group separately to assess whether the sex-differences were present in both age groups. These analyses were performed because previous studies showed that the magnitude of sex differences in cognitive abilities can vary as a function of age (e.g., Cross et al., 2011; Camarata & Woodcock, 2006).

The same analyses were performed to evaluate LPE differences in intentional learning. 2 (age-group: 1 vs. 2) x 2 (LPE: moderate-to-low vs. high) ANOVAs on each of the PVLТ outcomes (immediate recall trial 1, total recall trials 1-3, delayed recall) were conducted. Then, follow-up one-way ANOVAs were performed in each age group separately to assess whether the LPE differences were present in both age groups.

The assumptions for homogeneity of covariance matrices (i.e., Levine's test) and normality were approved (i.e., visual inspection of the histograms and the normal probability plots, and skewness <3, kurtosis <10; Kline, 2005). A p -value $\leq .05$ was considered statistically significant. Partial eta's squared were reported for significant findings as a measure for effect sizes. All analyses were performed using SPSS version 23.

RESULTS

Sex differences, age and PVLТ performance

The main effects of age group on immediate recall after trial 1 ($F(1, 148) = 8.32, p < .01, \eta_p^2 = 0.05$), total recall trial 1-3 ($F(1, 148) = 13.33, p < .01, \eta_p^2 = 0.08$) and delayed recall ($F(1, 148) = 14.46, p < .01, \eta_p^2 = 0.09$) were significant, with the older group demonstrating better performance than the younger group.

The main effect of sex on immediate recall after trial 1 ($F(1, 148) = 5.13, p < .03, \eta_p^2 = 0.03$) and on total recall trials 1–3 ($F(1, 148) = 3.99, p < .05, \eta_p^2 = 0.03$) were significant. On both outcome measures, girls demonstrated better performance than boys. The main effect of sex on delayed recall was not significant ($F(1, 148) = 2.14, p = .15$); the same applied to the interaction effects between age group and sex on any of the PVLТ outcomes (immediate recall after trial 1: $F(1, 148) = 2.52, p = .11$; total recall trials 1–3: $F(1, 148) = 2.20, p = .14$; delayed recall: $F(1, 148) = 0.41, p = .52$).

Table 2. Mean and standard error per age-group, sex and level of parental education for each PVLТ outcome measure.

	<i>PVLТ outcomes</i>		
	Trial 1 M (SE)	Trial 1-3 M (SE)	Delayed recall M (SE)
Age-group 1 (8-9.9 years)	7.1 (0.21)	27.9 (0.50)	9.8 (0.22)
Age-group 2 (10-12.9 years)	7.9 (0.22)	30.5 (0.55)	10.9 (0.21)
Boys	7.1 (0.22)	28.4 (0.55)	10.1 (0.23)
Girls	7.8 (0.21)	29.8 (0.52)	10.5 (0.21)
Low-to moderate LPE	6.9 (0.23)	28.1 (0.58)	10.0 (0.24)
High LPE	7.9 (0.20)	29.9 (0.49)	10.6 (0.21)

The follow-up analyses that were performed to compare the performance of girls and boys in each age group revealed a significant difference between boys and girls in the older group on immediate recall after trial 1 ($F(1, 71) = 7.60, p < .01, \eta_p^2 = 0.1$) and on total recall trials 1–3 ($F(1, 71) = 5.71, p = .02, \eta_p^2 = 0.08$). Girls performed better than boys. Means and standard errors for each age group and for boys and girls on the three PVLТ outcome measures are presented in Table 2. Results of the post-hoc analyses are presented in Table 3.

These results indicate that older subjects performed better than younger participants on immediate recall after trial 1, total trials 1–3 and on the delayed recall of the PVLТ. In addition,

sex differences in performance were present in the older subjects but not in the younger group, with girls outperforming boys.

Table 3. Sex differences on PVLТ-performances per age-group.

	Age group 1			Age group 2		
	Boys M (SE)	Girls M (SE)	<i>p</i> -value	Boys M (SE)	Girls M (SE)	<i>p</i> -value
Trial 1	7.0 (0.31)	7.2 (0.28)	.64	7.3 (0.31)	8.5 (0.27)	<.01*
Trial 1-3	27.7 (0.72)	28.1 (0.69)	.71	29.3 (0.84)	31.8 (0.64)	.02*
Delayed Recall	9.7 (0.33)	9.9 (0.28)	.57	10.6 (0.32)	11.3 (0.28)	.14

Note. * $p \leq .05$.

LPE, age and PVLТ performance

The main effects of age on immediate recall after trial 1 ($F(1, 148) = 8.09, p < .01, \eta_p^2 = 0.05$), total recall trials 1–3 ($F(1, 148) = 12.38, p < .01, \eta_p^2 = 0.08$) and delayed recall ($F(1, 148) = 13.34, p < .01, \eta_p^2 = 0.08$) were significant. The older group performed better than the younger group.

The main effect of LPE was significant on trial 1 ($F(1, 148) = 9.24, p < .01, \eta_p^2 = 0.06$) and on total recall trials 1–3 ($F(1, 148) = 5.94, p < .02, \eta_p^2 = 0.04$). The main effect of LPE on the delayed recall approached significance ($F(1, 148) = 3.50, p = .06, \eta_p^2 = 0.02$). The high LPE group performed better than the low-to-moderate LPE group. No significant interactions between age group and LPE were found on any of the PVLТ outcomes (immediate recall after trial 1: $F(1, 148) = 0.03, p = .87$); total recall trials 1–3: $F(1, 148) = 0.62, p = .62$; delayed recall: $F(1, 148) = 0.80, p = .37$).

Table 4. LPE differences on PVLТ-performances per age-group.

	Age group 1			Age group 2		
	<i>Level of Parental Education</i>					
	Moderate- to-low M (SE)	High M (SE)	<i>p</i> -value	Moderate- to-low M (SE)	High M (SE)	<i>p</i> -value
Trial 1	6.5 (0.29)	7.5 (0.28)	.02*	7.4 (0.36)	8.3 (0.26)	.05*
Trial 1-3	27.1 (0.75)	28.5 (0.66)	.16	29.3 (0.88)	31.4 (0.66)	.05*
Delayed Recall	9.6 (0.36)	9.9 (0.26)	.50	10.5 (0.31)	11.3 (0.28)	.05*

Note: * $p \leq .05$.

Follow-up analyses comparing the performance of participants of high and low-to-moderate LPE families in each age group revealed a significant difference in mean performance on immediate recall after trial 1 in the younger group ($F(1, 79) = 5.40, p = .02, \eta_p^2 = 0.07$). In the older group, the differences in performance on the immediate recall after trial 1 ($F(1, 71) = 3.95, p = .05, \eta_p^2 = 0.05$), on the total recall trials 1–3 ($F(1, 71) = 4.00, p = .05, \eta_p^2 = 0.05$) and on the delayed recall ($F(1, 71) = 3.97, p = .05, \eta_p^2 = 0.05$) were significant. Mean performance of the high LPE group was better than the mean performance of the low-to-moderate LPE group. Means and standard errors for each age group and for the low-to-moderate and high LPE groups on the three PVLT outcome measures are presented in Table 2. Table 4 presents the means and standard errors of both LPE groups per age group.

Taken together, a significant difference between the low-to-moderate and high LPE group was found on immediate recall after trial 1 in the younger age group. In the older age group, significant differences in performance between the high and low-to-moderate LPE group were found in immediate recall after trial 1, total recall trials 1–3 and the delayed recall.

DISCUSSION

This study investigated whether the child's sex and LPE contributed to individual differences in intentional learning in students aged 8–12 years. Intentional learning was administered with the aid of a newly constructed multi-trial learning task; the PVLT. This task evaluates intentional learning of visually presented pictorial material (line drawings of common animated and unanimated objects and material). Our results revealed that boys and girls differed in PVLT performances. These sex differences were confined to the older age group (i.e., 10.7–12.7 years): Older girls recalled more pictures than older boys after the first presentation of pictures (i.e., Trial 1) and in total (i.e., the number of recalled pictures summed over the three learning trials). Results also revealed LPE differences in PVLT performance in both younger and older children. Children from higher LPE families recalled significantly more pictures directly after the first presentation of pictures. Only in the older group did children of higher LPE families outperform children of moderate-to-low LPE families in total and delayed recall. Sex and LPE differences can thus be considered as two potent factors contributing to individual differences in intentional learning performance in schoolchildren.

Sex differences in intentional learning

Our results suggest that the development of intentional learning in boys is lagging behind that of girls at approximately 10–12 years of age. We performed post hoc analyses to investigate whether the difference in performance after the repeated presentation of information (i.e., Trials 1–3) was the result of the difference in performance after the first presentation of information (i.e., Trial 1). Results showed that this indeed was the case: The shortfall in performance after the presentation of repeated information of boys was due to the difference in performance after the first presentation of information. This result indicates that at the age of 10–12 years, boys have more difficulties with the initial encoding of new procedures and unfamiliar information than girls. This finding is of applied value for education as it suggests that boys need more guidance than girls when a new task is introduced.

The fact that the current study revealed sex differences in older, and not in younger children may have to do with visuospatial processing skills. Quite a few studies have shown that (the majority of) boys are somewhat better than (the majority of) girls in this domain (e.g., Hoyeck et al., 2012; Miller & Halpern, 2014; Voyer et al., 1995). This may have given the young boys some advantage when processing pictorial information presented as to-be-learned information in our study (Miller & Halpern, 2014), while they are normally outperformed by girls who have somewhat better verbal skills at older ages (Hyde & Linn, 1988; Hyde, 2014). Another explanation – which is supported by the earlier findings of Camarata and Woodcock (2006) and Cross and colleagues (2011) – is that the magnitude of sex differences in cognitive abilities varies as a function of age. Sex differences in intentional learning may only be present after the age of 10 years. Our findings therefore substantiate the notion that it is important to use narrow age ranges when investigating sex differences in intentional learning and other cognitive abilities.

Our findings are in line with those of many previous studies that reported boy–girl differences in performance on various cognitive tasks in the period of late childhood and early adolescence (Hyde, 2014; Kontaxopoulou et al., 2017; Lenroot & Giedd, 2010; Miller & Halpern, 2014; Rindermann & Baumeister, 2015; van der Elst et al., 2012). Sex differences in various cognitive abilities may contribute to the sex difference in intentional learning performance as reported in our study (Baars, Bijvank, Tonnaer & Jolles, 2015; Diamond, 2013). For instance, previous studies reported lower levels of attention for boys compared to girls (e.g., van Tetering & Jolles, 2017). Boys may therefore have more difficulties with focusing their attention while performing the PVLVT than girls, which could negatively affect task performance. The sex difference in PVLVT performance may further be explained by differences in motivational factors

between boys and girls. During adolescence, large developments take place in a student's beliefs and academic self-perceptions, such as their perceived competence and the value they place on doing well (see, for instance, Bouchey & Harter, 2005). Adolescent boys were found to have less adaptive school motivation than girls. This could possibly explain their lower achievement in school-related tasks (Dekker et al., 2013; van Houtte, 2004), as well as on the PVLТ. Overall, boy–girl differences in various cognitive abilities can contribute to the sex differences in intentional learning performance as reported in our study. Future research should therefore investigate the importance of various cognitive abilities to intentional learning performance. The existence of sex differences in the cognitive abilities that are important for intentional learning performance could enable the formulation of learning methods and procedures to become more beneficial in learning because previous learning methods can be adjusted to the abilities of boys and girls. For instance, it could be that boys need additional explanation when tasks are presented for the first time because they have lower levels of sustained attention than girls. Adjusting previous learning methods and procedures in a way that boys get additional explanations could be beneficial for the learning outcomes of boys.

LPE differences in intentional learning

In addition to sex differences, we found that children of more highly educated parents outperformed children of parents that attained lower educational levels after the first presentation of information (i.e., Trial 1). This finding suggests that children of more highly educated parents may be better at processing new information and unfamiliar procedures. In the older group, results revealed that children from higher LPE families also outperformed children from lower LPE families after the repeated presentation of the same information (i.e., total recall summed over three learning trials). Nevertheless, the post hoc analyses revealed that this difference in performance after the repeated presentation of information was the result of the difference in performance after the first presentation of information. This finding is important since previous studies reported that there are differences in the cognitive abilities of children from lower and higher LPE families that could contribute to individual differences in school achievement (Carr & Pike, 2012; Evans, Kelley, Sikora & Treiman, 2010; Ganzach, 2000; Rindermann & Baumeister, 2015). The results of our study more specifically suggest that these children differ in their ability to process unfamiliar procedures and information, and not in their learning abilities per se.

It has often been suggested that better cognitive performance of children from higher LPE families is related to a better genetic predisposition for learning (see Sameroff, 2010;

Trzaskowski, Yang, Visscher, & Plomin, 2014; van Soelen et al., 2009). Another possibility is that the difference results from environmental factors such as a more inspiring and intellectually-stimulating atmosphere of the family in which children grow up. It appears that higher education of parents is the driver of that advantage since previous studies reported relations between LPE and the motivational encouragement and intellectual (verbal) stimulation by parents (Carr & Pike, 2012; Ganzach, 2000; Evans et al., 2010; Rindermann & Baumeister, 2015). This may encourage their children to gain more experience in playing with new and unfamiliar games or with reading new books (Rindermann & Baumeister, 2015). Experiences with new materials are relevant, for example, when children have to take a test at school in which the procedures are unfamiliar. Our findings, therefore, suggest that it is important to support parents with lower LPE and guide them to present their children with new learning materials and to stimulate their insights and knowledge about how to stimulate the cognitive development of their children. This could provide their children with the opportunity to gain experience in processing new information and procedures and to develop better learning strategies accordingly.

From a neuropsychological perspective, we investigated LPE differences on separate, distinctive cognitive abilities which were administered using one task. It was expected that LPE could selectively affect some of the outcome measures and not others. It is of special relevance for future research to replicate our findings in a larger study to determine whether the effects of LPE that were found in this study remain significant. Future research should use a more specific measure of LPE. LPE was dichotomized in our study which was the best option given the sample size. Nevertheless, there are considerable differences in the degree to which caregivers create an intellectually-stimulating learning environment for their children within one of the two LPE groups of our study (e.g., between the lowest educated parents and those who obtained moderate educational levels). Also, a more specific measure of LPE should be devised in order to incorporate additional educational credits which the caregivers may have obtained (e.g., in corporate training and post-initial education). Accordingly, future studies should take the current professions of caregivers into account to investigate the importance of past education for intentional learning.

In order to interpret the results presented here correctly, we address three points that are important to be taken into consideration in future studies and in educational practice. First, we took advantage of our large dataset. The use of such a large group has a major advantage of allowing controls for interferences from external variables with our outcome measure, namely: (a) The study was performed at four primary schools with the same educational board to

reduce possible differences in background related to the regional geography or in the educational philosophy of the schools; (b) during the selection of primary schools, the SES background of participants was taken into account in order to include a broad spectrum of students with low to high SES families; (c) the sample was homogenized with respect to confounding variables, such as repeating or skipping a grade, to reduce variance within grades due to age differences (e.g., older children may have advanced cognitive development compared to younger children); and (e) we distributed boys and girls equally among the grades to make sure that the better performance in one of the grades was not caused by differences in the boy–girl distribution since our hypothesis was that girls outperformed boys. Moreover, we performed post hoc analyses (f) to make sure that children of the four schools were equally distributed over the sexes, LPE groups, and age groups; and (g) to investigate whether the unequal number of participants in the moderate-to-low and high LPE groups affected our results. Results of these post hoc analyses were essentially the same (results not published). This strict stratification allowed us to focus evaluation on the core factors, LPE and sex, without external factors interfering.

The second point that needs attention is the size of the significant difference in mean performance on the PVLТ between boys and girls, and between children from higher and lower LPE families. The significant differences in mean performances on Trial 1 of boys and girls is around 0.7 words, and between high and moderate-to-low LPE is around 0.8 words. As we see in our results, the standard errors are larger for boys than girls, and for the group of children with moderate-to-low LPE compared to high LPE. This indicates that the lowest performing boys perform even worse than the lowest performing girls. The same accounts for LPE: The lowest performers in the moderate-to-low LPE group performed even worse than the lowest performers in the higher LPE group. This is an indicator that there are quite a number of substantial individual differences within the groups. The small difference in mean performance could be explained by the fact that there could be boys that perform equally as well as girls, and children with low-to-moderate LPE that perform equally to children with high LPE, even while the variation on PVLТ performances is much greater in boys than in girls, and in children with low-to-moderate LPE compared to children with high LPE.

A final note that needs to be addressed is the fact that results revealed no significant interaction effect between sex and age group and between LPE and age group, which contrasts with the findings of our follow-up analyses. These findings showed sex and LPE differences in one of the separate age groups, but not necessarily in the other. We performed post hoc power analyses to calculate the required sample size to detect possible significant interaction effects.

Calculations (using G-power 3.1) revealed that our sample size was indeed too small to detect a small significant interaction ($\eta_p^2 = 0.02$, i.e., required sample size was 639). It is, therefore, necessary to re-investigate our findings in a future study with a larger sample size. At this moment, the findings from our study are straightforward in that boy–girl differences and LPE differences are dependent upon age.

Implications and conclusion

In this study, the PVLT has been used to assess intentional learning performance (Meijs et al., 2009; Meijs et al., 2013; Meijs et al., 2016). This assessment tool is easy to use in applied settings such as school or in clinical settings. The PVLT is a multi-trial list-learning task in which pictures (line drawings) should be remembered. A major advantage of the PVLT is that it assesses gnostic information processing which requires the subject to recall a visual presentation of objects or materials without the interference of reading difficulties. This is an advantage since there is evidence that during late childhood and young adolescence, many children experience some problems in learning to read, and there are major differences in the pace at which reading skills develop between children (e.g., Cecilia, Vittorini, Cofini, & di Orio, 2014). The PVLT could, therefore, be more useful than traditional learning tests (e.g., AVLT) (Rey, 1964) to evaluate intentional learning performance in children who lag somewhat behind in normal development of reading abilities as well as in children with hearing difficulties. As found in the present study, the PVLT appears to be a relevant instrument which is applicable in a school context and in clinical settings.

In conclusion, this study offers important new insights into factors which can contribute to individual differences in intentional learning in the transition period from childhood to adolescence. Intentional learning is a major aspect of learning at school and in daily life outside of school. The findings of the present study indicate that the sex of the child and the learning environment, as created by parents and school, are factors which can be important determinants to the development of individual differences in intentional learning. These findings suggest that children of less educated parents and boys should be given special attention and guidance in situations which require intentional learning, especially when new procedures and tasks are presented for the first time.

REFERENCES

- Ahmed, S. (2017). Intentional Learning Vs Incidental Learning. *Journal of Psychology and Clinical Psychiatry*, 7(2), 00426. Retrieved from: <https://pdfs.semanticscholar.org/704f/4a0908d12592778f629d89ff573079103989.pdf>
- Baars, M. A., Bijvank, M. N., Tonnaer, G. H., & Jolles, J. (2015). Self-report measures of executive functioning are a determinant of academic performance in first-year students at a university of applied sciences. *Frontiers in Psychology*, 6.
- Berlin, L., & Bohlin, G. (2002). Response inhibition, hyperactivity, and conduct problems among preschool children. *Journal of Clinical Child and Adolescent Psychology*, 31(2), 242-251. doi:10.1207/S15374424JCC P3102_09
- Blachstein, H., & Vakil, E. (2016). Verbal learning across the lifespan: an analysis of the components of the learning curve. *Aging, Neuropsychology, and Cognition*, 23(2), 133-153. doi: 10.1080/13825585.2015.1063579
- Bouchey, H. A., & Harter, S. (2005). Reflected appraisals, academic self-perceptions, and math/science performance during early adolescence. *Journal of Educational Psychology*, 97(4), 673. doi: 10.1037/0022-0663.97.4.673
- Brand, N., & Jolles, J. (1985). Learning and retrieval rate of words presented auditorily and visually. *The Journal of general psychology*, 112(2), 201-210. doi:10.1080/00221309.1985.9711004
- Camarata, S., & Woodcock, R. (2006). Sex differences in processing speed: Developmental effects in males and females. *Intelligence*, 34(3), 231-252. doi: 10.1016/j.intell.2005.12.001
- Carr, A., & Pike, A. (2012). Maternal scaffolding behavior: links with parenting style and maternal education. *Developmental psychology*, 48(2), 543. doi:10.1037/a0025888
- Cecilia, M. R., Vittorini, P., Cofini, V., & di Orio, F. (2014). The Prevalence of Reading Difficulties among Children in Scholar Age. *Styles of Communication*, 6(1).
- CBS Central Bureau for Statistics. (2016a). *Statistics Netherlands: Proximity of Neighborhood Facilities 2016* [Database: Nabijheid voorzieningen buurtcijfers 2016]. Retrieved from <https://www.cbs.nl/nlnl/maatwerk/2017/32/nabijheid-voorzieningen-buurtcijfers-2016>
- CBS Central Bureau for Statistics. (2016b). *Statistics Netherlands: Status Scores* [Database:Statusscores]. Retrieved from https://www.scp.nl/Onderzoek/Lopend_onderzoek/A_Z_alle_lopende_onderzoeken/Status_scores
- Chiu, J., Economos, J., Markson, C., Raicovi, V., Howell, C., ... Inserra, A. (2016). Which matters most? Perceptions of family income or parental education on academic achievement. *New York Journal of Student Affairs*, 16(2), 3-16.
- Correia, A., & Osorio, I. (2013). The rey auditory verbal learning test: Normative data developed for the Venezuela population. *Archives of clinical neuropsychology*, 29(2), 206-215. doi: 10.1093/arclin/act070
- Cross, C. P., Copping, L. T., & Campbell, A. (2011). Sex differences in impulsivity: a meta-analysis. *Psychological bulletin*, 137, 97. doi: 10.1037/a0021591
- Davis-Kean, P. E. (2005). The influence of parent education and family income on child achievement: The indirect role of parental expectations and the home environment. *Journal of Family Psychology*, 19, 294-304. doi: 10.1037/0893-3200.19.2.294
- Dekker, S., & Jolles, J. (2015). Teaching about "brain and learning" in high school biology classes: effects on teachers' knowledge and students' theory of intelligence. *Frontiers in psychology*, 6.
- Dekker, S., Krabbendam, L., Aben, A., de Groot, R., & Jolles, J. (2013). Coding task performance in early adolescence: a large-scale controlled study into boy-girl differences. *Frontiers in Psychology*, 4(550), 10-3389.
- Dekker, S., Krabbendam, L., Lee, N. C., Boschloo, A., de Groot, R., & Jolles, J. (2013). Sex differences in goal orientation in adolescents aged 10-19: The older boys adopt work-avoidant goals twice as often as girls. *Learning and Individual Differences*, 26, 196-200. doi: 10.1016/j.lindif.2012.07.011
- Diamond, A. (2013). Executive functions. *Annual review of psychology*, 64, 135-168. doi: 10.1146/annurev-psych-113011-143750
- Emami, A., Nunez, A., Favela, S., Strauss, & G. Allen, D. (2017). Serial Position Effects of the Emotional Verbal Learning Test and California Verbal Learning Test-Second Edition in Individuals with Schizophrenia. *Archives in Clinical Neuropsychology*, 32(6), 667-765. doi: 10.1093/arclin/acx076.78
- Eric, M. (1987). California verbal learning test-children's version. doi: 10.1007%2F978-0-387-79948-3_1538

- Evans, M. D., Kelley, J., Sikora, J., & Treiman, D. J. (2010). Family scholarly culture and educational success: Books and schooling in 27 nations. *Research in social stratification and mobility*, 28(2), 171-197. doi: 10.1016/j.rssm.2010.01.002
- Ganzach, Y. (2000). Parents' education, cognitive ability, educational expectations and educational attainment: Interactive effects. *British Journal of Educational Psychology*, 70(3), 419-441. doi: 10.1348/000709900158218/full
- Giedd, J. N. (2008). The teen brain: insights from neuroimaging. *Journal of Adolescent Health*, 42(4), 335-343. doi: 10.1016/j.jadohealth.2008.01.007
- Hampshire, A., Hellyer, P. J., Parkin, B., Hiebert, N., MacDonald, P., ... Rowe, J. (2016). Network mechanisms of intentional learning. *NeuroImage*, 127, 123-134. doi: 10.1016/j.neuroimage.2015.11.060
- Hoff, E. (2003). The specificity of environmental influence: Socioeconomic status affects early vocabulary development via maternal speech. *Child development*, 74(5), 1368-1378. doi:10.1111/1467-8624.00612
- Hoff, E., Laursen, B., Tardif, T., & Bornstein, M. (2002). Socioeconomic status and parenting. *Handbook of parenting Volume 2: Biology and ecology of parenting*, 8(2), 231-52.
- Hoff-Ginsberg, E. (1991). Mother-child conversation in different social classes and communicative settings. *Child development*, 62(4), 782-796. doi:10.2307/1131177
- Hoyek, N., Collet, C., Fargier, P., & Guillot, A. (2011). The use of the Vandenberg and Kuse Mental Rotation Test in children. *Journal of Individual Differences*, 33, 62-67. doi:10.1027/1614-0001/a000063
- Hurks, P. P. M., Vles, J. S. H., Hendriksen, J. G. M., Kalff, A. C., Feron, F. J. M., ... Jolles, J. (2006). Semantic category fluency versus initial letter fluency over 60 seconds as a measure of automatic and controlled processing in healthy school-aged children. *Journal of Clinical and Experimental Neuropsychology*, 28(5), 684-695. doi:10.1080/13803390590954191
- Hyde, J. S. (2014). Gender similarities and differences. *Annual review of psychology*, 65, 373-398. doi: 10.1146/annurev-psych-010213-115057
- Hyde, J. S., & Linn, M. C. (1988). Gender differences in verbal ability: A meta-analysis. *Psychological Bulletin*, 104(1), 53-69. doi: 10.1037/0033-2909.104.1.53
- Inspection of Education the Netherlands. (2015). De staat van het onderwijs: onderwijsverslag. Retrieved from de-staat-van-het-onderwijs-2014-2015%20(1).pdf
- Jolles, J. (2016). *Het tienerbrein: over de adolescent tussen biologie en omgeving*. Amsterdam University Press.
- Juraska, J. M., & Willing, J. (2017). Pubertal onset as a critical transition for neural development and cognition. *Brain research*, 1654, 87-94. doi:10.1016/j.brainres.2016.04.012
- Kautz, T., Heckman, J. J., Diris, R., Ter Weel, B., & Borghans, L. (2014). *Fostering and measuring skills: Improving cognitive and non-cognitive skills to promote lifetime success*. National Bureau of Economic Research. Retrieved from: <http://www.nber.org/papers/w20749.pdf>
- Kline, R. B. (2005). *Principles and practice of structural equation modeling (2nd ed.)*. New York: The Guildford Press
- Kontaxopoulou, D., Beratis, I. N., Fragkiadaki, S., Pavlou, D., Yannis, G., ... Papageorgiou, S. G. (2017). Incidental and Intentional Memory: Their Relation with Attention and Executive Functions. *Archives of Clinical Neuropsychology*, 1-14. doi: 10.1093/arclin/acx027
- Lawrence, K., Campbell, R., & Skuse, D. (2015). Age, gender, and puberty influence the development of facial emotion recognition. *Frontiers in Psychology*, 6.
- Lenroot, R. K., & Giedd, J. N. (2010). Sex differences in the adolescent brain. *Brain and cognition*, 72(1), 46-55. doi:10.1016/j.bandc.2009.10.008
- Lenroot, R. K., & Giedd, J. N. (2011). Annual Research Review: Developmental considerations of gene by environment interactions. *Journal of Child Psychology and Psychiatry*, 52(4), 429-441. doi: 10.1111/j.1469-7610.2011.02381.x
- Lezak, M. D., Howieson, D. B., Bigler, E. D., & Tranel, D. (2012). *Neuropsychological assessment (5th ed.)*. New York, NY: Oxford University Press.
- Linschoten, J. (1963). De la Court's frequentietelling van Nederlandse woorden, Rapport no. 6301. *Psych. Lab. RU Utrecht (1963), lijst c*, 145-217.
- Meijer, W. A., De Groot, R. H., Van Boxtel, M. P., Van Gerven, P. W., & Jolles, J. (2006). Verbal learning and aging: Combined effects of irrelevant speech, interstimulus interval, and education. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 61(5), 285-294. doi:10.1093/geronb/61.5. P285

- Meijer, W. A., Van Gerven, P. W., De Groot, R. H., Van Boxtel, M. P., & Jolles, J. (2007). The benefit of deep processing and high educational level for verbal learning in young and middle-aged adults. *Aging clinical and experimental research*, *19*(5), 372-380. doi: 10.1007/BF03324717
- Meijs, C. J. C., Hurks, P. P. M., Kalff, A. C., Slaats-Willemse, D. I. E., Rozendaal, N., & Jolles, J. (2009). Differential development of learning strategies on a Pictorial Verbal Learning Test (PVL) in primary-school children. *Child Neuropsychology*, *15*(3), 247-261. doi:10.1080/09297040802403708
- Meijs, C., Hurks, P. P., Wassenberg, R., Feron, F. J., & Jolles, J. (2016). Inter-individual differences in how presentation modality affects verbal learning performance in children aged 5 to 16. *Child Neuropsychology*, *22*(7), 818-836. doi:10.1080/09297049.2015.1044891
- Meijs, C., Hurks, P., Rozendaal, N., & Jolles, J. (2013). Serial and subjective clustering on a verbal learning test (VLT) in children aged 5–15: The nature of subjective clustering. *Child Neuropsychology*, *19*(4), 385-399. doi:10.1080/09297049.2012.670215
- Miller, D. I., & Halpern, D. F. (2014). The new science of cognitive sex differences. *Trends in cognitive sciences*, *18*(1), 37-45. doi:10.1016/j.tics.2013.10.011
- Noble, K. G., Houston, S. M., Kan, E., & Sowell, E. R. (2012). Neural correlates of socioeconomic status in the developing human brain. *Developmental science*, *15*(4), 516-527. doi:10.1111/j.1467-7687.2012.01147.x
- Nunez, A., Emami, A., San, M.L., & Allen, D. (2017). Auditory Verbal Learning and Memory in a Clinical Sample of Spanish-speaking Hispanic Adults. *Archives in Clinical Neuropsychology*, *32*(6), 667-765. doi:10.1093/arclin/acx076.63
- OECD Organisation for Economic Cooperation and Development. (2015). The ABC of gender equality in education: Aptitude, behaviour, confidence. Paris, France: PISA, OECD Publishing. Retrieved from <http://dx.doi.org/10.1787/9789264229945-en>
- Raznahan, A., Shaw, P., Lalonde, F., Stockman, M., Wallace, G. L., Greenstein, D., ... & Giedd, J. N. (2011). How does your cortex grow? *Journal of Neuroscience*, *31*(19), 7174-7177. doi:10.1523/JNEUROSCI.0054-11.2011
- Rey, A. (1964). *L'examen clinique en psychologie*. Paris: Presses Universitaires de France.
- Rindermann, H., & Baumeister, A. E. (2015). Parents' SES vs. parental educational behavior and children's development: A reanalysis of the Hart and Risley study. *Learning and Individual Differences*, *37*, 133-138. doi:10.1016/j.lindif.2014.12.005
- Sameroff, A. (2010). A unified theory of development: A dialectic integration of nature and nurture. *Child development*, *81*(1), 6-22. doi:10.1111/j.1467-8624.2009.01378.x
- Schnack, H. G., Van Haren, N. E., Brouwer, R. M., Evans, A., Durston, S., Boomsma, D. I., ... & Hulshoff Pol, H. E. (2014). Changes in thickness and surface area of the human cortex and their relationship with intelligence. *Cerebral cortex*, *25*(6), 1608-1617. doi:10.1093/cercor/bht357
- Steinberg, L., & Silverberg, S. B. (1986). The vicissitudes of autonomy in early adolescence. *Child development*, *57*, 841-851. doi:10.2307/1130361
- Stoet, G., & Geary, D. C. (2015). Sex differences in academic achievement are not related to political, economic, or social equality. *Intelligence*, *48*, 137–151. doi: 10.1016/j.intell.2014.11.006
- Thomas, J. W., & Rohwer Jr, W. D. (1986). Academic studying: The role of learning strategies. *Educational psychologist*, *21*(1-2), 19-41. doi: 10.1080/00461520.1986.9653022
- Trzaskowski, M., Yang, J., Visscher, P. M., & Plomin, R. (2014). DNA evidence for strong genetic stability and increasing heritability of intelligence from age 7 to 12. *Molecular psychiatry*, *19*(3), 380-384. doi: 10.1038/mp.2012.191
- Rijksoverheid. (2017). Wie bepaalt of mijn kind blijft zitten of overgaat naar de volgende groep of klas? Retrieved from: <https://www.rijksoverheid.nl/onderwerpen/basisonderwijs/vraag-en-antwoord/wie-bepaalt-of-mijn-kind-blijft-zitten-of-overgaat-naar-de-volgende-klas>
- Singh J. P. (2010). *United Nations Educational, Scientific, and Cultural Organization (UNESCO): Creating Norms for a Complex World*. Abingdon: Routledge
- Van der Elst, W., Dekker, S., Hurks, P., & Jolles, J. (2012). The letter digit substitution test: demographic influences and regression-based normative data for school-aged children. *Archives of Clinical Neuropsychology*, *27*(4), 433-439. doi: 10.1093/arclin/acs045
- Van Der Elst, W. I. M., Van Boxtel, M. P., Van Breukelen, G. J., & Jolles, J. (2005). Rey's verbal learning test: normative data for 1855 healthy participants aged 24–81 years and the influence of age, sex, education, and

- mode of presentation. *Journal of the International Neuropsychological Society*, 11(03), 290-302. doi: 10.1017/S1355617705050344
- Van Houtte, M. V. (2004). Why boys achieve less at school than girls: The difference between boys' and girls' academic culture. *Educational studies*, 30(2), 159-173. doi:10.1080/0305569032000159804
- Van Loon-Vervoorn, W. A. (1989). Voorstelbaarheidswaarden van Nederlandse woorden [Intelligibility ratings of Dutch words]. Lisse: Swets & Zeitlinger.
- Van Soelen, I. L., van den Berg, S. M., Dekker, P. H., van Leeuwen, M., Peper, J. S., Pol, H. E. H., & Boomsma, D. I. (2009). Individual differences in dynamic measures of verbal learning abilities in young twin pairs and their older siblings. *Learning and Individual Differences*, 19(4), 440-444. doi:10.1016/j.lindif.2009.03.005
- Van Tetering, M. A.J., & Jolles, J. (2017). Teacher Evaluations of Executive Functioning in Schoolchildren Aged 9–12 and the Influence of Age, Sex, Level of Parental Education. *Frontiers in Psychology*, 8. doi:10.3389/fpsyg.2017.00481
- Voyer, D., Voyer, S., & Bryden, M. P. (1995). Voyer, D., Voyer, S., & Bryden, M. P. (1995). Magnitude of sex differences in spatial abilities: A meta-analysis and consideration of critical variables. *Psychological Bulletin*, 117(2), 250-270. doi:10.1037/0033-2909.117.2.250
- Voyer, D., & Voyer, S. D. (2014). Gender differences in scholastic achievement: A meta-analysis. *Psychological Bulletin*, 140(4), 1174. doi:10.1037/a0036620
- Williams, J., Meredith-Duliba, T., McWilliams, K., & Osipowicz, K. (2015). Sex Differences in Brain Development By Comparison of Diffusion Tensor Imaging, Language and Behavior Control. *Archives in Clinical Neuropsychology*, 30(6), 562-563. doi:10.1093/arclin/acv047.202

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