Learning Disabilities: A Contemporary Journal 11(2), 27-39, 2013 Copyright @ by LDW 2013

Can Executive Functions Help to Understand Children with Mathematical Learning Disorders and to Improve Instruction?

Annemie Desoete*
Frauke De Weerdt
Ghent University, Belgium

Working memory, inhibition and naming speed was assessed in 22 children with mathematical learning disorders (MD), 17 children with a reading learning disorder (RD), and 45 children without any learning problems between 8 and 12 years old. All subjects with learning disorders performed poorly on working memory tasks, providing evidence that they have a deficiency related to simultaneously storage and processing of verbal and/or visuospatial information. In addition, children with MD+RD suffered from problems with quantity naming speed compared to children without MD. Our data revealed the importance to manage working memory loads and give more time to complete homework, exercises, and examinations.

Keywords: Executive functions, working memory, mathematical learning disorders, and math instruction.

Introduction

Specific learning disorders (LD) are common in childhood (Beghi, Cornaggia, Frigeni, & Beghi, 2006; Dirks, Spyer, van Lieshout, & de Sonneville, 2008). The DSM-5 differentiates LD with impairment in reading, written expression, and mathematics. Mathematical disorders (MD) are defined as specific disorders with impairments in math abilities at a level that is significantly below expected given the age and effective teaching. Moreover, the mathematical impairments in MD are not explained by extraneous factors, such as sensory deficits (Landerl et al., 2004; Passolunghi, Vercelloni, & Schadee, 2007), and have to be persistent (Fletcher et al., 2005). In order to be sure of the persistence of MD, it is important to consider consistency in performance over time (Fletcher et al., 2005; Mazzocco & Myers, 2003). Most researchers currently report prevalence of MD in between 3 and 14% of children (Barbaresi, Katusic, Colligan, Weaver, & Jacobsen, 2005; Rubinsten & Henik, 2009; Shalev, Manor, & Gross-Tsur, 2005). Recently, Geary (2011) estimated a prevalence of approximately 7% of all school aged students. Several hypotheses have been studied to identify the origins of MD in children (e.g., Butterworth, 1999; Wolf & Bowers, 1999). A deficit in working memory, inhibition, or naming speed has been proposed to explain the problems in the underlying cognitive system of boys and girls who suffer from MD (Bull & Scerif, 2001; Geary, Hoard, Byrd-Craven, Nugent, & Numtee, 2007; Passolunghi & Siegel, 2004) and or a combined reading disorders (RD) and MD (RD+MD; Pauly et al., 2011; van der Sluis, de Jong, & van der Leij, 2004; Willburger, Fusseneg-

*Please send correspondence to: Annemie Desoete, annemie.desoete@ugent.be.

ger, Moll, Wood, & Landerl, 2008). However, there are studies not supporting the hypothesis of such deficits (e.g., Censabella & Noel, 2005; Kibby, Marks, Morgan, & Long, 2004; Landerl, Bevan, & Butterworth, 2004). Thus, the empirical pattern is far from straightforward.

RD are defined as impairments in reading and/or written expression (spelling abilities). These impairments are at a level that is significantly below expected given the age and the teaching that the children have received (Ziegler et al., 2008). The prevalence of RD in school-aged children is approximately between 5 and 12% (Schumacher, Hoffmann, Schmal, Schulte-Korne, & Nothen, 2007). However, since language and orthography play an important role in reading, prevalence of RD may differ across countries (Callens, Tops, & Brysbaert, 2012). Clear differences are marked between regular and more irregular orthographies and it is assumed that different problems are manifested in RD in languages that embed regular grapheme-phoneme correspondence than in languages with a less transparent orthography and grapheme-phoneme mapping (Bergmann & Wimmer, 2008; Callens, Tops, & Brysbaert, 2012). There are several hypotheses concerning the causes of this phenomenon. Deficits in phonologically related processes are often considered one of the key factors for developing RD (e.g., Peterson & Pennington, 2012; Vellutino et al., 2004), but there is also the double-deficit hypothesis by Wolf and Bowers (1999). This theory focuses both on phonological processing and naming speed. In addition, Stein and Walsh (1997) revealed a general magnocellular deficit in children with RD, meaning that children with RD were unable to correctly process fast incoming visual and auditory information (Stein & Walsh, 1997). Finally, research has found evidence that deficits in working memory are associated with RD (e.g. Savage et al., 2007). In addition, the role of inhibition in the reading process has been stressed (Schmid, Labuhn, & Hasselhorn, 2011). Failures to inhibit improper (though more dominant) pronunciations might impair word recognition performance in a more profound manner (Chiappe, Hasher, & Siegel, 2000).

Executive functioning can be described as the general purpose control mechanisms that coordinate, regulate, and control cognitive processes during the operation of cognitive tasks (Miyake et al., 2000) and are localized in the central executive control system of working memory. According to Baddeley (1986), working memory has to be seen as an active system that regulates complex cognitive behavior. His multi-component model consists of a central executive component, a phonological loop and a visuospatial sketchpad. In this model, the central executive is an attentional control system, which executes the processing aspects of a task. The central executive strongly interacts with one multi-dimensional and two domain-specific storage systems. The phonological loop is responsible for the storage and maintenance of verbal information; the visuospatial sketchpad has similar responsibilities for visual and spatial information. The multi-component model of Baddeley (1986) is used by the main part of LD studies investigating working memory (e.g., Passolunghi & Siegel, 2004; van der Sluis, van der Leij, & de Jong, 2005). And it will also be used in this study. Forward recall tasks can be considered as measures of the phonological loop and the visuospatial sketchpad, while backward recall and dual span tasks are used as measures of the central executive.

In his heuristic taxonomy, Nigg (2000) separates executive inhibition from motivational and automatic inhibition. The former might be considered part of executive functioning. Executive or effortful inhibition is categorized in interference control, behavioral, oculomotor, and cognitive inhibition. Interference control refers to the ability to maintain response performance and suppress competing, distracting, or interfering stimuli that evoke a competing motor response. It is often measured by Stroop (Stroop, 1935) and Flanker (Eriksen & Eriksen, 1974) tasks. In addition, behavioral inhibition is seen as the capacity to suppress a prepotent or dominant response and entails the deliberate control of a primary motor response in compliance with changing context cues. The Go/no-go is a frequently conducted measure of behavioral inhibition (e.g., Friedman & Miyake, 2004; Purvis & Tannock, 2000) and hence will be used in this study.

Naming speed can be defined as those processes that underlie the rapid recognition and retrieval of visually presented linguistic stimuli (Wolf & Bowers, 1999) or as the ability to quickly recognize and name a restricted set of serially presented high frequency symbols, objects, or colors (Heikkila, Narhi, Aro, & Ahonen, 2009; McGrath et al., 2011), and is often measured by a task based on the Rapid Automatized Naming paradigm of Denckla and Rudel (1974). Savage et al. (2005) found that number naming speed discriminated children with RD from those in a control condition. Both groups were between 7 and 10 years old. In addition, D'Amico and Passolunghi (2009) found slower naming speed on both numbers and letters in 9 year old children with MD in comparison with age-matched children in a control condition. Hence, it is also unclear if naming speed problems are related to a deficit in letter or numerosity processing or if the problems are more general.

Although the comorbidity between MD and RD is higher than would be expected by chance, little is known about the question if children with MD, RD, or RD+MD perform poorly on all working memory, inhibition, and naming speed tasks, or if they have a domain-specific deficit related to tasks requiring simultaneous storage and processing of verbal or numerical information. The principal objective of this study was therefore to gain more insight into the (modality-specific or domain-general) cognitive processes underlying MD with and without RD, and into the relationship between learning disorders themselves.

Method

Participants

The participants were 112 children (45 control, 22 MD, 28 RD+MD, and 17 RD) between 8 and 12 years old. The characteristics of the participants are described in Table 1.

Table 1. Subject Characteristics of the Sample

Characteristic	Control	RD	MD	MD+RD
	M *(SD)*	M *(SD)*	M *(SD)*	M *(SD)*
Age in months	120.91 (10.37)	119.53 (13.41)	117.55 (9.01)	122.29 (12.43)
Male : female	19:26	10:7	6:16	9:11
IQ	108.42 (9.86)[a]	105.18 (8.47)[ab]	94.82 (9.21)[c]	99.57 (11.45)[bc]
Z-score TTR	0.94 (0.62)[a]	-0.27 (0.61)[b]	-0.27 (0.82)[b]	-0.87 (0.71)[c]
Z-score KRT-R	0.80 (0.39)[a]	0.50 (0.52)[a]	-1.02 (0.64)[b]	-0.92 (0.69)[b]
Z-score PI	0.91 (0.41)[a]	-0.90 (0.57)[c]	0.49 (0.51)[b]	-0.90 (0.49)[c]
Z-score EMT	0.90 (0.65)[a]	-0.78 (0.42)[c]	0.41 (0.70)[b]	-0.79 (0.60)[c]
Z-score Klepel	0.84 (0.63)[a]	-0.81 (0.42)[b]	0.47 (0.84)[a]	-0.89 (0.50)[b]

Note. RD = reading disorders; MD = mathematical disorders; RD+MD = reading and mathematical disorders; TTR = Arithmetic Number Facts Test (fact retrieval skills); KRT-R = Kortrijk Arithmetic Test Revision (procedural mathematical skills); PI = Paedological Institute-dictation (spelling); EMT = One Minute Reading Test (word reading speed).
[a,b,c] posthoc indices at $p < .05$.

Children in the control condition came from regular elementary schools and children diagnosed with MD, RD or RD+MD were referred by paraprofessionals with a clinical diagnosis of a learning disorder. All children were tested on math, reading, and spelling measures to ensure that the relevant criteria were met. Control children had to achieve a score above the 25th percentile on all tests. In congruence with Geary (2011), children with MD had to score ≤ the 10th percentile on at least one of the frequently used standardized math tests, measuring mental arithmetic and number knowledge (procedural skills) and fact retrieval. Children with RD had to achieve a score ≤ the 10th percentile on a spelling and reading tests, measuring word reading speed and pseudo-word reading. Children with RD+MD had to score ≤ the 10th percentile on at least one math test and ≤ the 10th percentile on at least one spelling or reading test (Dirks, Spyer, van Lieshout, & de Sonneville, 2008; Murphy, Mazzocco, Hanich, & Early, 2007).

Instruments and Procedures

Working Memory Measures

Digit and word list recall forward was used to measure the phonological loop. Block recall was used as a measure for the visuospatial sketchpad. In backward digit recall, backward word list recall, and backward block recall, children are required to recall sequences of digits, words or squares in the reverse order as a measure of the central executive component of working memory. In addition, two dual tasks were used to test this construct. In listening recall, children had to verify sentences by stating 'true' or 'false' and memorize the final word for each sentence. In the second dual task, children had to identify whether the shape on the right side was the same or opposite of the shape on the left. In addition, they had to recall the location of a red dot (see De Weerdt, Roeyers, & Desoete, 2013a). Composite scores for the phonological loop, the visuospatial sketchpad and the central executive component were calculated by merging the sum of the raw scores of each working memory component to z-scores.

A Go/no-go paradigm was used to assess behavioral inhibition of non-symbolic and symbolic stimuli. The frequency of go trials was 75%. Moreover, inter-trial interval was kept constant at 2250 ms. The task consisted of two formats (symbolic and non-symbolic) and three conditions, measuring a picture (non-symbolic), a letter (symbolic), or a digit modality (symbolic). Each condition consisted of 45 go trials (the picture of a bird in the first condition, letter 'a' in the second, and number '1' in the third) and 15 no-go trials (a butterfly, 'm' and '6', respectively, see also De Weerdt, Roeyers, & Desoete, 2013b). Mean reaction time of the correct go trials (MRT) and commission errors were used as dependent measures.

Naming Speed Measures

Each task contained 30, pseudo-randomly ordered trials and used four different stimuli. In the first naming speed task, people were asked to read color names written in black ink, as a rough indication of reading ability. During the second naming speed task, naming speed of colors was measured by visualized colored rectangles. For the word and color naming speed tasks, the stimuli were red, green, blue and yellow. In the third naming speed task, the students were asked to read the digits that appeared in the middle of the screen. Finally, the last naming speed task concerned the naming of the quantity of rectangles. For the naming speed tasks concerning numbers and quantities, the stimuli ranged from one to four. A voice key was used to measure reaction time (RT). Since accuracy was very high on all tasks, errors were not analyzed.

Results

ANOVAs were conducted to compare the divergent aspects of working memory.

As shown in Table 2, analyses revealed significant results for the composite score of the phonological loop ($p < .001$), the visuospatial sketchpad ($p < .001$) and the central executive ($p < .001$). Moreover, significant results were found for MRT on the naming speed task of quantities ($p = .014$), the naming speed task of words ($p = .002$) and on the letter ($p = .011$), and digit modality ($p = .015$) of the Go/no-go task.

Based on the results presented in Table 2, Cohen's d was calculated pairwise between the groups and for each variable (see Table 3). Significant differences were found between the control group and the clinical groups.

Finally, logistic regression analyses were conducted in order to clarify to what extent working memory, behavioral inhibition, and naming speed predicted the probability of MD, and RD+MD. They were also supposed to clarify, which of these cognitive skills were the most influential. Results are presented in Table 4.

Table 2. ***Means and Standard Deviations of Working Memory Composite Scores, and Behavioral Inhibition and Naming Speed tasks***

	Control	RD	MD	MD+RD	
Measures	M *(SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*F*(3,108)
Working memory tasks					
Composite scores					
Phonological loop	0.62 (0.76)^{a}	-0.21 (1.12)^{b}	.00 (0.66)^{b}	-0.23 (0.81)^{b}	8.29***
Visuospatial sketchpad	0.33 (0.63)^{a}	-0.46 (1.14)^{b}	-0.25 (0.76)^{b}	-0.29 (0.69)^{b}	6.64***
Central executive	0.65 (0.82)^{a}	-0.29 (0.83)^{b}	-0.22 (0.83)^{b}	-0.70 (0.87)^{b}	16.76***
Go/no-go task					
Commissions					
Pictures	4.87 (2.98)	4.35 (2.45)	5.23 (3.13)	4.50 (2.84)	0.40
Letters	5.49 (2.81)	7.00 (3.12)	5.82 (3.61)	5.65 (3.17)	1.01
Digits	4.80 (3.41)	6.76 (3.61)	5.14 (2.87)	4.36 (2.67)	2.20
Mean reaction time					
Pictures	365.80 (42.45)	403.26 (73.64)	370.73 (53.82)	382.17 (51.49)	2.29
Letters	371.05 (53.22)^{a}	419.38 (86.10)^{ab}	397.12 (55.68)^{ab}	417.36 (74.77)^{b}	3.92*
Digits	373.80 (61.05)^{a}	417.43 (87.55)^{ab}	394.24 (60.81)^{ab}	425.71 (81.21)^{bc}	3.62*
Naming speed tasks					
Mean reaction time					
Numbers	602.40 (128.91)	664.70 (128.73)	615.20 (113.98)	693.54 (198.14)	2.49
Quantities	663.58 (105.47)^{a}	752.30 (119.14)^{ab}	719.00 (119.06)^{ab}	771.35 (211.69)^{b}	3.69*
Words	584.53 (115.47)^{a}	693.54 (146.22)^{b}	549.28 (71.94)^{a}	613.50 (131.41)^{ab}	5.48**
Colors	740.33 (137.62)	837.21 (212.25)	723.12 (145.31)	760.69 (154.50)	1.87

Note. RD = reading disorders; MD = mathematical disorders; RD+MD = reading- and mathematical disorders.
* $p < .05$; ** $p < .01$; *** $p < .001$
^{a,b}post hoc indices at $p < .05$.

Table 3. ***Effect Sizes of Working Memory Composite Scores, and Behavioral Inhibition and Naming Speed Tasks***

	Cohen's d					
Measures	RD vs. Control	MD vs. Control	MD+RD vs. Control	MD vs RD	MD+RD vs. RD	MD+RD vs. MD
Working memory tasks						
Composite scores						
Phonological loop	-0.97**	-0.86*	-1.11***	0.24	-0.02	-0.31
Visuospatial Sketchpad	-1.01**	-0.87*	-.96**	0.23	0.20	-0.06
Central executive	-1.16***	-1.07***	-1.63***	0.08	-0.49	-0.57
Go/no-go task						
Commissions						
Pictures	-0.19	0.12	-0.12	0.32	0.06	-0.25
Letters	0.53	0.11	0.05	-0.36	-0.44	-0.05
Digits	0.58	0.11	-0.14	-0.52	-0.80	-0.29
Mean reaction time						
Pictures	0.07	0.11	0.36	-0.53	-0.36	0.22
Letters	0.77	0.49	0.75*	-0.32	-0.03	0.31
Digits	0.64	0.34	0.76*	-0.32	0.10	0.44
Naming speed tasks						
Mean reaction time						
Numbers	0.64	0.13	0.63	-0.51	0.10	0.49
Quantities	0.73	0.44	0.58*	-0.29	0	-0.22
Words	0.86**	-0.27	0.24	-1.24	-0.57	0.52
Colors	0.64	-0.13	0.13	-0.65	-0.44	0.23

Note. RD = reading disorders; MD = mathematical disorders; RD+MD = reading- and mathematical disorders.
* $p < .05$; ** $p < .01$; *** $p < .001$

Table 4. ***Multinomial Logistic Regression Model for Predicting Learning Disorders based on Working Memory Composite Scores, and Behavioral Inhibition and Naming Speed Tasks, in Control of Gender, Age and Intelligence***

			95% CI for OR		
Group comparison	Model	OR	Lower	Upper	Wald *(df)*
RD vs. Control[a]	Gender[d]	1.52	0.39	6.00	0.36
	Age	1.05	0.98	1.12	1.58
	IQ	0.97	0.90	1.04	0.67
	NS Quant	1.00	1.00	1.01	2.01
	NS Words	1.01	1.00	1.01	0.79
	Acc CE	0.24	0.10	0.57	10.23***
MD vs. Control	Gender	0.61	0.15	2.48	0.47
	Age	1.03	0.96	1.10	0.61
	IQ	0.88	0.82	0.95	12.24***
	NS Quant	1.01	1.00	1.02	5.00*
	NS Words	0.99	0.98	1.00	4.44*
	Acc CE	0.19	0.07	0.52	10.47***
MD+RD vs. Control	Gender	0.43	0.11	1.70	1.45
	Age	1.09	1.02	1.16	5.94*
	IQ	0.92	0.86	0.99	5.20*
	NS Quant	1.01	1.00	1.02	6.11*
	NS Words	1.00	0.99	1.00	0.82
	Acc CE	0.10	0.04	0.25	22.77***
MD vs. RD[b]	Gender	0.40	0.08	1.94	1.29
	Age	0.98	0.91	1.06	0.20
	IQ	0.91	0.84	0.98	5.88*
	NS Quant	1.00	1.00	1.01	0.76
	NS Words	0.99	0.98	1.00	8.17**
	Acc CE	0.82	0.31	2.14	0.17
MD+RD vs. RD	Gender	0.28	0.07	1.21	2.91
	Age	1.04	0.97	1.02	1.36
	IQ	0.95	0.89	1.11	1.77
	NS Quant	1.00	1.00	1.01	1.29
	NS Words	0.99	0.99	1.00	4.30*
	Acc CE	0.40	0.17	0.94	4.39*
MD+RD vs. MD[c]	Gender	0.70	0.17	2.85	0.24
	Age	1.06	1.00	1.12	3.32
	IQ	1.05	0.99	1.12	2.34
	NS Quant	1.00	1.00	1.01	0.08
	NS Words	1.01	1.00	1.02	2.55
	Acc CE	0.49	0.22	1.11	2.94

Note. OR = odds ratio; CI = confidence interval; MD = mathematical disorders; RD = reading disorders; MD+RD = mathematical and reading disorders; NS = naming speed; quant = quantities; Acc CE = accuracy central executive.
[a] control group as reference category; [b] reading disorders group as reference category; [c] mathematical disorders group as reference category; [d] girls as reference category.
* $p < .05$; ** $p < .01$; *** $p < .001$

The best model consisted of naming speed of words, naming speed of quantities, and the composite score of the central executive. Model fit was significant, χ^2 (18, N = 112) = 97.06, p < .001, and Nagelkerke R^2= .62. Log-likelihood-tests showed significant results for naming speed of words (χ^2 (3, N = 112) = 12.10, p = .007), of quantities (χ^2 (3, N = 112) = 7.89, p = .048), and for the composite score of the central executive (χ^2 (3, N = 112) = 39.40, p < .001).

Discussion

All children were tested with (backward) digit-, word list-, block-, and listening-recall, spatial span, backward word list recall, and backward block recall. Large effect sizes were found between the control group and all clinical groups on all working memory components. As shown in Table 3, none of the other cognitive skills had such large effect sizes. Moreover, the logistic regression analysis with predictors of the working memory, behavioral inhibition, and naming speed tasks revealed that the composite score of the central executive appeared to be the most crucial cognitive predictor (see Table 4). Although naming speed of words and quantities were found to be significant predictors as well, their odds ratios were near to 1.00 and hence they only added value to the model to a very limited degree (see Table 2).

In line with previous studies (Passolunghi & Siegel, 2004; Siegel & Ryan, 1989; Swanson, Zheng, & Jerman, 2009), we can conclude that working memory, and central executive functioning in particular, is of importance in specific learning disorders and may to a certain extent prevent children with learning disorders from developing age-adequate skills in reading and mathematics. The central executive overruled the importance of for instance behavioral inhibition.

Inhibition has to be seen as one of the most crucial executive functions (Miyake et al., 2000). Behavioral inhibition - the capacity to suppress a prepotent or dominant response (Nigg, 2000) - was measured with a Go/no-go task. The analyses showed that children with MD did not experience any behavioral inhibition or interference control deficits compared to peers with age-adequate mathematical abilities.

These findings are in congruence with e.g, Censabella and Noel (2008). These authors investigated both interference control and behavioral inhibition in 10 year old children (20 children with MD and 20 in the control condition). They did not find any differences between both groups and concluded that children with MD do not seem to suffer from inhibition deficits (Censabella & Noël, 2008). However, these results are contrary to several other studies reporting inhibition problems in children with MD. For instance, Zhang and Wu (2011) described problems in children with MD on both a color-word and a numerical Stroop. Moreover, a study by Bull and Scerif (2001) emphasized a significant correlation between mathematical performance and the level of interference control on the quantity Stroop task (the lower the mathematics ability, the higher the interference).

Naming speed can be defined as those processes that underlie the rapid recognition and retrieval of visually presented linguistic stimuli (Wolf & Bowers, 1999) or as the ability to quickly recognize and name a restricted set of serially presented high frequency symbols, objects, or colors (Heikkilä et al., 2009; McGrath et al., 2011). To draw conclusions regarding which aspect of naming speed is impaired in children with learning disorders, four naming speed tasks have been employed with a rapid automatic naming paradigm.

Children with MD+RD performed slower on the quantity naming speed task than children without MD, so naming speed tasks differentiated between MD+RD vs. controls, but not between MD vs. controls. These findings made us propose, in line with e.g., Willburger et al. (2008) and Landerl et al. (2004) that deficits in naming speed are domain-specific in children with MD+RD.

Conclusion

This study provided information into working memory, inhibition, and naming speed in children with LD. All children with LD performed poorly on working memory tasks, providing evidence that they have a deficiency related to simultaneously storage and processing of verbal and/or visuospatial information. In addition, children with MD+RD suffered from problems with quantity naming speed compared to children without learning disorders.

In addition, the differences between children with isolated MD (impairment in mathematics), and combined MD+RD (impairment in mathematics and/or impairments in reading or written expression) were analyzed. In this study, it seems that the two profiles (MD and MD+RD) were not so different. Both groups of children differed from controls on working memory tasks. However, children with MD+RD differed also from controls on inhibition (using letters and digits) and on naming speed tasks (with quantities), whereas children with MD did not differ from controls on this respect. In addition, the most significant differences and the largest effect sizes were found between the RD+MD group and the control condition, pointing to the fact that the profile of children with MD+RD might be seen as the additive combination of problems due to RD and MD.

Since working memory components revealed the largest effect sizes, it may in particular be relevant, in line with Gathercole et al. (2006), to manage working memory loads in structured learning activities in the classroom or at home. Due to problems with retrieval and processing of information, children with MD or RD+MD may need more time to complete homework, exercises, and examinations compared to peers without learning disorders.

References

Baddeley, A. (1986). Working memory. Oxford, UK: Clarendon Press.

Barbaresi, W. J., Katusic, S. K., Colligan, R. C., Weaver, A. L., & Jacobsen, S. J. (2005). Learning disorder: Incidence in a population-based birth cohort, 1976-1982, Rochester, Minn. *Ambulatory Pediatrics, 5*, 281-289.

Beghi, M., Cornaggia, C. M., Frigeni, B., & Beghi, E. (2006). Learning disorders in epilepsy. *Epilepsia, 47*, 14-18.

Bergmann, J., & Wimmer, H. (2008). A dual-route perspective on poor reading in a regular orthography: Evidence from phonological and orthographic lexical decisions. *Cognitive Neuropsychology, 25*, 653-676.

Callens, M., Tops, W., & Brysbaert, M. (2012). Cognitive profile of students who enter higher education with an indication of Dyslexia. *Plos One, 7*, e38081.

Censabella, S., & Noel, M. P. (2005). The inhibition of exogenous distracting information in children with learning disabilities. *Journal of Learning Disabilities, 38*, 400-410.

Censabella, S., & Noel, M. P. (2008). The inhibition capacities of children with mathematical disabilities. *Child Neuropsychology, 14*, 1-20.

Chiappe, P., Hasher, L., & Siegel, L. S. (2000). Working memory, inhibitory control, and reading disability. *Memory & Cognition, 28*, 8-17.

D'Amico, A., & Passolunghi, M. C. (2009). Naming speed and effortful and automatic inhibition in children with arithmetic learning disabilities. *Learning and Individual Differences, 19*, 170-180.

Denckla, M. B., & Rudel, R. G. (1974). Rapid "automatized" naming of pictured objects, colors, letters, and numbers by normal children. *Cortex, 10*, 186-202.

De Weerdt, F., Desoete, A., & Roeyers, H. (2013a). Working memory in children with reading and/or mathematical disabilities. *Journal of Learning Disabilities, 46*, 461-472.

De Weerdt, F., Desoete, A., & Roeyers, H. (2013b). Behavioral inhibition in children with learning disabilities. *Research in Developmental Disabilities, 34*, 1998-2007.

Eriksen, B. A. & Eriksen, C. W. (1974). Effects of noise letters upon the identification of target letters in a nonsearch task. *Perception & Psychophysics, 16*, 143-149.

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology-General, 133*, 101-135.

Fletcher, J. M., Francis, D. J., Morris, R. D., & Lyon, G. R. (2005). Evidence-based assessment of learning disabilities in children and adolescents. *Journal of Clinical Child and Adolescent Psychology, 34*, 506-522.

Geary, D. C. (2011). Consequences, characteristics, and causes of mathematical learning disabilities and persistent low achievement in mathematics. *Journal of Developmental and Behavioral Pediatrics, 32*, 250-263.

Geary, D. C., Hoard, M. K., Byrd-Craven, J., Nugent, L., & Numtee, C. (2007). Cognitive mechanisms underlying achievement deficits in children with mathematical learning disability. *Child Development, 78*, 1343-1359.

Geary, D. C., Hoard, M. K., Nugent, L., & Bailey, D. H. (2012). Mathematical cognition deficits in children with learning disabilities and persistent low achievement: A five-year prospective study. *Journal of Educational Psychology, 104*, 206-223.

Heikkilä, R., Narhi, V., Aro, M., & Ahonen, T. (2009). Rapid automatized naming and learning disabilities: does ran have a specific connection to reading or not? *Child Neuropsychology, 15*, 343-358.

Kibby, M. Y., Marks, W., Morgan, S., & Long, C. J. (2004). Specific impairment in developmental reading disabilities: A working memory approach. *Journal of Learning Disabilities, 37*, 349-363.

Landerl, K., Bevan, A., & Butterworth, B. (2004). Developmental dyscalculia and basic numerical capacities: a study of 8-9-year-old students. *Cognition, 93*, 99-125.

Mazzocco, M. M. M., & Myers, G. F. (2003). Complexities in identifying and defining mathematics learning disability in the primary school-age years. *Annals of Dyslexia, 53*, 218-253.

McGrath, L. M., Pennington, B. F., Shanahan, M. A., Santerre-Lemmon, L. E., Barnard, H. D., Willcutt, E. G., DeFries, J. C., & Olson, R. K. (2011). A multiple deficit model of reading disability and attention-deficit/hyperactivity disorder: searching for shared cognitive deficits. *Journal of Child Psychology and Psychiatry, 52*, 547-557.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49-100.

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin, 126*, 220-246.

Passolunghi, M. C., & Siegel, L. S. (2004). Working memory and access to numerical information in children with disability in mathematics. *Journal of Experimental Child Psychology, 88*, 348-367.

Passolunghi, M. C., Vercelloni, B., & Schadee, H. (2007). The precursors of mathematics learning: Working memory, phonological ability and numerical competence. *Cognitive Development, 22*, 165-184.

Peterson, R. L., & Pennington, B. F. (2012). Developmental dyslexia. *Lancet, 379*, 1997-2007.

Purvis, K. L., & Tannock, R. (2000). Phonological processing, not inhibitory control, differentiates ADHD and reading disability. *Journal of the American Academy of Child and Adolescent Psychiatry, 39*, 485-494.

Rubinsten, O., & Henik, A. (2009). Developmental dyscalculia: Heterogeneity might not mean different mechanisms. *Trends in Cognitive Sciences, 13*, 92-99.

Savage, R. S., Frederickson, N., Goodwin, R., Patni, U., Smith, N., & Tuersley, L. (2005). Relationships among rapid digit naming, phonological processing, motor automaticity, and speech perception in poor, average, and good readers and spellers. *Journal of Learning Disabilities, 38*, 12-28.

Savage, R., Lavers, N., & Pillay, V. (2007). Working memory and reading difficulties: What we know and what we don't know about the relationship. *Educational Psychology Review, 19*, 185-221.

Schmid, J. M., Labuhn, A. S., & Hasselhorn, M. (2011). Response inhibition and its relationship to phonological processing in children with and without Dyslexia. *International Journal of Disability Development and Education, 58*, 19-32.

Schumacher, J., Hoffmann, P., Schmal, C., Schulte-Korne, G., & Nothen, M. M. (2007). Genetics of dyslexia: The evolving landscape. *Journal of Medical Genetics, 44*, 289-297.

Shalev, R. S., Manor, O., & Gross-Tsur, V. (2005). Developmental dyscalculia: A prospective six-year follow-up. *Developmental Medicine and Child Neurology, 47*, 121-125.

Siegel, L. S., & Ryan, E. B. (1989). The development of working memory in normally achieving and subtypes of learning disabled children. *Child Development, 60*, 973-980.

Stein, J., & Walsh, V. (1997). To see but not to read; The magnocellular theory of dyslexia. *Trends in Neurosciences, 20*, 147-152.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643-662.

Swanson, H. L., Zheng, X. H., & Jerman, O. (2009). Working memory, short-term memory, and reading disabilities: A selective meta-analysis of the literature. *Journal of Learning Disabilities, 42*, 260-287.

van der Sluis, S., de Jong, P. F., & van der Leij, A. (2004). Inhibition and shifting in children with learning deficits in arithmetic and reading. *Journal of Experimental Child Psychology, 87*, 239-266.

van der Sluis, S., de Jong, P. F., & van der Leij, A. (2007). Executive functioning in children, and its relations with reasoning, reading, and arithmetic. *Intelligence, 35*, 427-449.

van der Sluis, S., van der Leij, A., & de Jong, P. F. (2005). Working memory in Dutch children with reading- and arithmetic-related LD. *Journal of Learning Disabilities, 38*, 207-221.

Vellutino, F. R., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): What have we learned in the past four decades? *Journal of Child Psychology and Psychiatry, 45*, 2-40.

Willburger, E., Fussenegger, B., Moll, K., Wood, G., & Landerl, K. (2008). Naming speed in dyslexia and dyscalculia. *Learning and Individual Differences, 18*, 224-236.

Wolf, M., & Bowers, P. G. (1999). The double-deficit hypothesis for the developmental dyslexias. *Journal of Educational Psychology, 91*, 415-438.

Zhang, H. Y., & Wu, H. R. (2011). Inhibitory ability of children with developmental dyscalculia. *Journal of Huazhong University of Science and Technology-Medical Sciences, 31*, 131-136.

Ziegler, J. C., Castel, C., Pech-Georgel, C., George, F., Alario, F. X., & Perry, C. (2008). Developmental dyslexia and the dual route model of reading: Simulating individual differences and subtypes. *Cognition, 107*, 151-178.