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APPENDICES

APPENDIX 1

Experiment 1

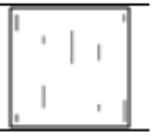
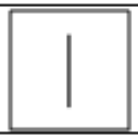
Table A1. List of stimuli used in the proverb retrieval task

Prime	Target	Distractor
se brûler les	plumes	ailes
une taille de	mouche	guêpe
régler comme une	horloge	boussole
chercher la petite	bête	puce
la chair de	poule	canard
manger comme un	ogre	ours
la fin des	haricots	pommes
sage comme une	image	photo
le coup du	lapin	chien
léger comme une	plume	paille
des larmes de	crocodile	grenouille
rester sur sa	faim	peur
dormir comme un	loir	lion
gai comme un	pinson	pigeon
une lune de	miel	sel
muet comme une	carpe	truite
parler entre ses.	dents	lèvres
têtu comme un	âne	bœuf
tomber dans les	pommes	fraises
solide comme un	roc	mur
un marché aux	puces	poux

APPENDIX 2

Experiment 2

Table 2A. List of stimuli used in symbolic and non-symbolic number comparisons

Formats		Quantities [b]								
Arabic numerals		1	2	3	4	5	6	7	8	9
Number-words		un	deux	trois	quatre	cinq	six	sept	huit	neuf
Canonical dots patterns										
Non-canonical dots patterns										
Random sticks patterns [a]	CC									
	CI									
	IC									
	II									

[a] The first capital letter corresponds to the condition of surface control while the second refers to the condition of density control: C=congruent; I=incongruent.
[b] The quantity "5" represented the standard and appeared in all pairs.

APPENDIX 3

Experiment 3

Table A3. Overview of activation peaks for each contrast in children and adults, obtained from random-effect analysis at $p < 0.05$ corrected on cluster level ($p < 0.001$ uncorrected on voxel level)

	MNI coordinates			K_E	Z
	x	*y*	*z*		
Number comparison (vs. rest) in children					
Right inferior orbitofrontal gyrus	48	46	-6	212	4.05
Left intraparietal sulcus	-26	-58	48	232	5.15*
Right inferior parietal lobule	50	-56	42	171	4.03
Right fusiform gyrus	40	-50	-24	115	4.00
Left middle occipital gyrus	-48	-80	-2	257	4.18
Left inferior occipital gyrus	-24	-96	-4	171	4.30
Left caudate nucleus	-18	-18	24	167	4.32
Right calcarine sulcus	20	-94	-6	117	3.85
Left cerebellum	-30	-72	-28	122	3.64
Vermis (6)	0	-62	-22	1059	4.81
Number comparison (vs. rest) in adults					
Left precentral gyrus	-44	-4	44	643	4.65
Right precentral gyrus	46	0	48	410	4.35
Left SMA	-2	8	54	752	4.63
Left intraparietal sulcus	-24	-52	54	529	4.50
Right intraparietal sulcus	32	-46	46	401	4.13
Right superior temporal gyrus	70	-36	16	143	4.33
Right middle occipital gyrus	30	-66	36	78	3.75
Left caudate nucleus	-18	-20	22	176	4.11
Left cerebellum	-34	-58	-26	824	4.75
Right cerebellum	34	-56	-30	714	4.62
Right cerebellum	8	-80	-20	619	4.60
Colour comparison (vs. rest) in children					
Right middle orbitofrontal gyrus	42	46	-8	141	4.06
Left superior frontal gyrus	-16	42	54	114	4.07
Left superior medial frontal gyrus	-8	68	4	232	4.40
Left superior medial frontal gyrus	2	56	24	131	4.41
Left intraparietal sulcus	-26	-58	52	234	4.53
Left angular gyrus	-46	-68	42	237	4.13
Right angular gyrus	52	-64	44	287	5.12*
Left inferior temporal gyrus	56	-14	-24	108	4.10
Right fusiform gyrus	38	-50	-24	712	4.96
Left hippocampus	-38	-24	-12	362	4.61
Vermis (6)	0	-68	-24	3139	5.47*

Colour comparison (vs. rest) in adults					
Left superior frontal gyrus	-16	30	46	325	4.40
Right superior frontal gyrus	28	-4	60	295	4.11
Left SMA	-8	12	50	145	4.28
Left SMA	-2	-4	74	146	3.91
Left precentral gyrus	-50	-2	48	347	4.74
Left superior parietal lobule	-22	-60	52	401	5.18*
Right superior parietal lobule	32	-54	50	170	3.93
Left angular gyrus	-52	-64	40	194	3.99
Right inferior temporal gyrus	46	-74	-6	988	4.85
Left fusiform gyrus	-32	-56	-20	1138	5.01*
Left cerebellum	-8	-84	-24	348	4.51
Left putamen	-26	4	-4	112	4.24
Number vs. colour comparison in children					
		No suprathreshold cluster			
Number vs. colour comparison in adults					
		No suprathreshold cluster			
Colour vs. number comparison in children					
Left lingual gyrus	-32	-86	-14	89	3.97
Left fusiform gyrus	-28	-50	-10	98	3.56
Right fusiform gyrus	22	-44	-12	218	4.13
Colour vs. number comparison in adults					
Left superior medial frontal gyrus	2	62	14	67	3.62
Left angular gyrus	-50	-70	36	533	4.38
Right angular gyrus	52	-68	38	144	4.13
Left anterior cingulate gyrus	-12	42	-4	169	4.36
Left middle cingulate gyrus	-4	-40	46	83	4.28
Right superior occipital gyrus	20	-98	4	64	3.80
Left middle occipital gyrus	-18	-92	-4	371	4.51
Numerical distance (small vs. large) in children					
Left middle occipital gyrus	-26	-70	40	163	3.76
Left superior parietal lobule	-20	-60	50	163	3.76†
Numerical distance (small vs. large) in adults					
Right SMA	8	-22	48	70	4.13
Right intraparietal sulcus	50	-40	54	79	4.23
Left intraparietal sulcus	-20	-58	52	63	4.15
Right supramarginal gyrus	58	-42	24	63	4.07
Large vs. small numerical distance in children					
Right medial orbitofrontal gyrus	10	48	-4	87	4.69
Large vs. small numerical distance in adults					
		No suprathreshold cluster			

Colour distance (close vs. far) in children					
Left lingual gyrus	-8	-76	-4	142	4.20
Left superior occipital gyrus	-18	-86	28	154	4.39
Left middle occipital gyrus	-36	-86	6	82	4.20
Colour distance (close vs. far) in adults					
		No suprathreshold cluster			
Far vs. close colour in children					
		No suprathreshold cluster			
Far vs. close colour in adults					
		No suprathreshold cluster			

Note. Coordinates are reported in MNI space as given by SPM2 and correspond only approximately to Talairach and Tournoux space (Talairach & Tournoux, 1988). Anatomical labels are based on the AAL (automated anatomical labelling) atlas (Tzourio-Mazoyer et al., 2002).

*$p < 0.05$ at FWE, corrected for multiple comparisons over the whole brain on voxel level.

† Activation is part of the previous bigger cluster.

APPENDIX 4

Experiment 4

Table A4. Overview of activation peaks for each contrast in control children and children with DD, obtained from random-effect analysis (at $p < 0.001$, uncorrected threshold, > 20 voxels).

	MNI coordinates			K_E	Z
	x	*y*	*z*		
Number comparison (vs. rest) in control children					
Left superior orbitofrontal gyrus	-28	62	-6	22	3.85
Right inferior orbitofrontal gyrus	48	46	-6	212	4.05
Left superior medial frontal gyrus	-8	54	16	44	4.02
Left intraparietal sulcus	-26	-58	48	232	5.15*
Left intraparietal sulcus	-52	-44	46	45	3.62
Right inferior parietal lobule	50	-54	56	55	3.63
Right inferior parietal lobule	50	-56	42	171	4.03
Right inferior temporal gyrus	56	-14	-24	73	3.88
Right fusiform gyrus	40	-50	-24	115	4.00
Left middle occipital gyrus	-48	-80	-2	257	4.18
Left inferior occipital gyrus	-24	-96	-4	171	4.30
Left caudate nucleus	-18	-18	24	167	4.32
Left caudate nucleus	-8	4	16	64	3.81
Right calcarine sulcus	20	-94	-6	117	3.85
Left cerebellum	-30	-72	-28	122	3.64
Vermis (6)	0	-62	-22	1059	4.81
Vermis (4, 5)	0	-46	-6	30	3.45
Number comparison (vs. rest) in children with DD					
Left superior frontal gyrus	-20	4	70	36	3.82
Right superior frontal gyrus	26	2	54	29	3.44
Right superior medial frontal gyrus	12	52	34	56	3.55
Left middle frontal gyrus	-38	50	14	41	3.50
Right middle frontal gyrus	32	48	22	45	3.42
Right middle frontal gyrus	50	50	6	36	3.42
Left inferior frontal operculum	-44	20	32	244	4.13
Left precentral gyrus	-44	-4	46	141	4.39
Right anterior cingulate gyrus	4	38	26	121	3.65
Right superior parietal lobule	38	-64	60	39	3.92
Left superior parietal lobule	-30	-66	58	141	3.80
Right inferior parietal lobule	30	-48	44	28	3.63
Right anterior temporal pole	44	10	-20	26	3.49
Left middle temporal gyrus	-64	-36	-2	86	3.58
Right fusiform gyrus	36	-62	-14	142	4.56
Right lingual gyrus	22	-86	-10	166	4.00
Left middle occipital gyrus	-50	-78	2	390	4.35
Left inferior occipital gyrus	-20	-90	-8	104	3.82
Right caudate nucleus	24	12	24	28	4.02
Right putamen	18	12	0	23	3.43

Left insula	-42	10	-4	123	3.68
Left thalamus	-2	-20	-12	229	4.40
Right cerebellum	12	-72	-24	432	4.22
Colour comparison (vs. rest) in control children					
Left superior orbitofrontal gyrus	-28	64	-4	52	3.77
Left middle orbitofrontal gyrus	-44	46	-4	104	3.90
Right middle orbitofrontal gyrus	42	46	-8	141	4.06
Left superior frontal gyrus	-16	42	54	114	4.07
Left superior frontal gyrus	-18	58	34	69	3.76
Right superior frontal gyrus	14	62	36	37	3.59
Left superior medial frontal gyrus	-8	68	4	232	4.40
Left superior medial frontal gyrus	2	56	24	131	4.41
Right superior medial frontal gyrus	14	38	58	61	3.85
Right middle frontal gyrus	44	56	2	20	3.96
Left intraparietal sulcus	-26	-58	52	234	4.53
Left angular gyrus	-46	-68	42	237	4.13
Right angular gyrus	52	-64	44	287	5.12*
Left middle temporal gyrus	-40	8	-30	73	3.85
Right middle temporal gyrus	64	-42	-8	25	3.64
Left inferior temporal gyrus	56	-14	-24	108	4.10
Right fusiform gyrus	38	-50	-24	712	4.96
Left parahippocampal gyrus	-12	-14	-22	65	3.98
Left hippocampus	-38	-24	-12	362	4.61
Vermis (6)	0	-68	-24	3139	5.47*
Colour comparison (vs. rest) in children with DD					
Left inferior orbitofrontal gyrus	-20	38	0	23	3.64
Left inferior orbitofrontal gyrus	-48	32	-14	51	3.59
Left superior frontal gyrus	-18	50	44	60	3.81
Left superior frontal gyrus	-24	16	66	29	3.44
Left superior medial frontal gyrus	-4	64	30	29	3.80
Right superior medial frontal gyrus	6	54	42	332	3.95
Right superior medial frontal gyrus	4	66	18	45	3.57
Left precentral gyrus	-44	-12	62	112	4.07
Right middle frontal gyrus	36	56	26	28	3.76
Right middle frontal gyrus	40	18	58	45	3.59
SMA	-6	8	62	44	3.70
Left superior parietal lobule	-22	-68	58	384	4.75
Right superior parietal lobule	46	-48	62	35	3.65
Right superior parietal lobule	26	-66	64	137	3.97
Left inferior parietal lobule	-58	-54	44	125	3.81
Left angular gyrus	-48	-56	34	211	4.08
Left anterior temporal pole	-22	4	-22	70	4.15
Left anterior temporal pole	-50	8	-30	59	4.15
Left middle temporal gyrus	-62	-40	-2	286	3.95
Right middle temporal gyrus	50	-26	-12	71	3.80
Right middle temporal gyrus	60	-36	-10	39	3.53
Left hippocampus	-40	-30	-8	21	3.48
Left parahippocampal	-22	-30	-18	94	3.85
Right lingual gyrus	20	-86	-2	441	4.32
Left middle occipital gyrus	-28	-76	26	68	4.21

Left inferior occipital gyrus	-42	-78	-4	1562	5.00*
Right inferior occipital gyrus	44	-80	-12	598	4.29
Vermis	2	-74	-16	360	4.38
Left cerebellum	-4	-40	-18	305	4.23
Number vs. colour comparison in control children					
Left Rolandic operculum	-50	-12	12	99	3.33
Left thalamus	-12	-6	14	32	3.19
Left caudate nucleus	-18	-20	24	34	3.44
Left insula	-44	12	-2	46	3.37
Right insula	30	28	6	34	3.26
Number vs. colour comparison in children with DD					
Left postcentral gyrus	-62	-18	18	35	3.68
Right thalamus	8	-18	12	99	3.87
Right cerebellum	8	-32	-14	33	3.34
Colour vs. number comparison in control children					
Left superior frontal gyrus	-20	44	50	26	3.92
Right superior parietal lobule	16	-64	64	71	3.75
Right angular gyrus	36	-58	22	29	4.26
Left precuneus	-6	-44	40	30	3.44
Right precuneus	18	-54	18	52	3.77
Left lingual gyrus	-32	-86	-14	89	3.97
Left fusiform gyrus	-28	-50	-10	98	3.56
Left fusiform gyrus	-20	-42	-14	20	3.51
Right fusiform gyrus	22	-44	-12	218	4.13
Right superior occipital gyrus	22	-94	4	60	4.30
Left cerebellum	-24	-58	-18	29	4.49
Colour vs. number comparison in children with DD					
Left fusiform gyrus	-24	-82	-18	52	4.19
Right fusiform gyrus	32	-76	-16	22	3.71
Numerical distance (small vs. large) in control children					
Right inferior orbitofrontal gyrus	34	22	-8	34	4.92
Right middle frontal gyrus	30	12	58	25	4.05
Right middle cingulate gyrus	6	22	30	39	4.08
Left middle cingulate gyrus	-6	24	32		3.56†
Right intraparietal sulcus	42	-50	56	44	3.68
Left middle occipital gyrus	-26	-70	40	163	3.76
Left superior parietal lobule	-20	-60	50		3.64†
Left insula	-34	20	2	44	4.08
Numerical distance (small vs. large) in children with DD					
Left middle frontal gyrus	-20	16	34	24	2.90
Left supramarginal gyrus	-44	-44	28	163	4.00
Large vs. small numerical distance in control children					
Right medial orbitofrontal gyrus	10	48	-4	87	4.69
Right medial orbitofrontal gyrus	8	66	-2	21	3.48

Right inferior frontal gyrus	54	24	16	42	3.60
Large vs. small numerical distance in children with DD					
Right middle frontal gyrus	30	34	34	31	4.18
Right supramarginal gyrus	54	-28	30	25	3.95
Left middle cingulate gyrus	-10	-30	46	54	3.91
Colour distance (close vs. far) in control children					
Left inferior temporal gyrus	-48	2	-34	49	4.85
Left lingual gyrus	-8	-76	-4	142	4.20
Left superior occipital gyrus	-18	-86	28	154	4.39
Left middle occipital gyrus	-26	-78	14	39	3.71
Left middle occipital gyrus	-30	-74	26	35	3.43
Left middle occipital gyrus	-36	-86	6	82	4.20
Vermis (10)	-4	-46	-28	28	3.78
Colour distance (close vs. far) in children with DD					
No suprathreshold cluster					
Far vs. close colour in control children					
No suprathreshold cluster					
Far vs. close colour in children with DD					
No suprathreshold cluster					

Note. Coordinates are reported in MNI space as given by SPM2 and correspond only approximately to Talairach and Tournoux space (Talairach & Tournoux, 1988). Anatomical labels are based on the AAL (automated anatomical labelling) atlas (Tzourio-Mazoyer et al., 2002).

*$p < 0.05$ at FWE, corrected for multiple comparisons over the whole brain at voxel level.

[†]described here for reference though belonging to the same voxels cluster.

APPENDIX 5

Experiment 2: Additional analyses

In order to disentangle the access and representation deficit hypotheses in developmental dyscalculia, an additional analysis was performed. As defined in the literature on language, inconsistent performances support the hypothesis of an access deficit whereas consistency in performances favours the hypothesis of a representation deficit. In line with this view, if the connection between symbols and the number representation is impaired in MD children, then a high variability should appear in their performances during number processing. On the contrary, if MD children access a number representation characterised by a greater overlap between analog magnitudes, their difficulties in activating a specific number magnitude should be relatively constant. Furthermore, while the access deficit hypothesis predicts a greater variance for MD than control children in symbolic formats only, the representation deficit hypothesis postulates a similar (or a lack of) difference in variance between MD and control children for both symbolic and non-symbolic number processing.

To test a possible distinction between access and representation deficits, we conducted a repeated measures ANOVA on standard deviation measures (for correct trials only) from performances of MD and control children in comparing symbolic and non-symbolic numbers (Experiment 2). The group (control or MD) was the between-subject factor, and format (Arabic numbers, number words, canonical dot patterns, non-canonical dot patterns, random stick patterns) and quantity (from 1 to 9, expect 5) were the within-subject factors.

Table A5. Median of standard deviation measures in MD and control groups for each number format

Format	**Control group**	**MD group**	**ANOVA**	
	Median	*Median*	*F*	*P*
Arabic numerals	113	139	3.2	.082
Number words	195	199	<1	n.s.
Canonical dot patterns	131	151	1.7	n.s.
Non-canonical dot patterns	138	170	4.1	.053
Random stick patterns	177	173	<1	n.s.

The main effect of format ($F(4, 112) = 31.57$, $p < .001$) was highly significant, showing that the variance increased from Arabic numerals to number words (Arabic numerals: 126 ms, canonical dot patterns: 141 ms, non-canonical dot patterns: 153 ms, random stick patterns: 175 ms, number words: 197 ms). The effect of quantity ($F(7, 112) = 24.42$, $p < .001$) indicated a higher variance for quantities far from the standard five compared to quantities close to the standard (128 ms, 140 ms, 142 ms, 150 ms, 152 ms, 173 ms, 185 ms, and 198 ms, for the quantities 1, 2, 9, 3, 8, 7, 6 and 4 respectively). More importantly, the effect of group was not significant ($F(1, 28) = 1.11$, $p > .05$), nor the group $\times$ format interaction ($F(4, 112) = 2.23$, $p > .05$), nor the group $\times$ format $\times$ quantity ($F<1$). Despite the lack of interaction, we further examined the group differences in each of the number formats. As reported in Table A5, the variance was globally higher for children with MD than for control children. However, the difference was not significant for number words, canonical dot patterns, and random stick patterns, and was only marginal for Arabic numerals and non-canonical dot patterns. These findings did not favour a greater variance for numerical symbols in dyscalculia, as expected by the access deficit hypothesis.