International Journal of Language & Communication Disorders

ROYAL COLLEGE OF SPEECH & LANGUAGE THERAPISTS

INT J LANG COMMUN DISORD, MARCH–APRIL 2015,
VOL. 50, NO. 2, 144–150

Research Report

Language ability, executive functioning and behaviour in school-age children

Courtney Karasinski*

University of Wisconsin-Madison, Madison, WI, USA

(*Received August 2013; accepted March 2014*)

Abstract

Background: Many children with language impairment present with deficits in other areas, including executive functioning (EF), attention and behaviour. Similarly, many children receiving services for attention or behaviour problems have deficits in language ability.
Aims: To evaluate the relations among EF, language ability and behaviour problems in a sample of school-age children with a wide range of language and behaviour profiles. The following research questions were addressed: Does performance on EF tasks predict language ability? Do language ability and EF predict problems with attention, internalizing and/or externalizing?
Methods & Procedures: EF was defined as referring to the separable, yet related, processes of shifting, updating working memory and inhibition as specified in the latent variable model of EF. Children aged 8–11 years recruited from an urban school district completed standardized language and cognitive assessments and a computerized task assessing EF. Their parents completed standardized questionnaires assessing the children's EF and problem behaviours. Regression analyses were conducted.
Outcomes & Results: Regression analyses revealed that EF did not contribute to language ability beyond the variance accounted for by nonverbal reasoning. Language ability contributed to attention problems when entered as a single predictor, but was no longer significant when the EF measures were added to the model. Language ability did not significantly contribute to internalizing or externalizing behaviour problems. Parent-reported inhibition was a robust predictor of attention, internalizing and externalizing behaviour problems.
Conclusions & Implications: In this sample of school-age children, language ability was related to attention problems, but not to internalizing or externalizing. Children with behaviour problems may have particular difficulty with inhibition.

Keywords: language, executive functions, behaviour, ADHD.

What this paper adds?

What is already known on the subject?

Some children with language impairment have deficits in EF. Many children with language impairment present with attention, internalizing or externalizing behavior problems, and many children receiving services for behavior problems present with significant deficits in language ability.

What this paper adds?

In a sample of school-age children with a wide range of language and behavior profiles, EF did not predict unique variance in language ability beyond that accounted for by nonverbal cognition. Inhibition contributed to attention, internalizing and externalizing behavior problems.

Address correspondence to: Courtney Karasinski, 515 Michigan St. NE, Suite 200 Grand Rapids, MI 49503, USA; e-mail: karasinc@gvsu.edu

*Present address: Grand Valley State University, 515 Michigan St. NE, Suite 200 Grand Rapids, MI 49503, USA.

International Journal of Language & Communication Disorders
ISSN 1368-2822 print/ISSN 1460-6984 online

DOI: 10.1111/1460-6984.12104

Introduction

Children with language impairment (LI) often present with co-morbid deficits, including deficits in executive functioning (EF) (Dibbets *et al.* 2006, Henry *et al.* 2012, Im-Bolter *et al.* 2006). Even after LI seemingly has resolved, subtle deficits in language, cognition and/or behaviour/conduct may persist (Brownlie *et al.* 2004, Rescorla 2009). Miyake *et al.*'s (2000) influential individual differences study of EF in young adults revealed that shifting attention, updating working memory and inhibition of prepotent responses are separate functions sharing an underlying commonality.

Updating working memory is often termed *working memory* in the literature, and will be called *working memory* here. Investigations into the development of EF in children have found evidence of these same latent variables (Lehto *et al.* 2003).

However, van der Sluis *et al.* (2007) revealed only two latent variables: shifting and working memory; conversely, St. Clair-Thompson and Gathercole (2006) identified only working memory and inhibition.

Brownlie *et al.* (2004) and Villamarette-Pittman *et al.* (2002) suggested that executive dysfunction could be the underlying connection between LI and delinquency, although Ford *et al.* (2007) found that receptive language ability was a stronger predictor of behaviour problems than was EF. Children with LI and children with ADHD perform similarly on some measures of language, including mean performance on sentence recall tasks, although they differ in their use of tense marking in sentence recall (Redmond 2005), and lexical diversity and mean length of utterance in conversation (Redmond 2004). Children and adolescents with LI have been shown to perform less accurately than typically developing peers on EF tasks requiring working memory (Henry *et al.* 2012, Im-Bolter *et al.* 2006) or response inhibition (Henry *et al.* 2012). Im-Bolter *et al.* (2006) found that inhibition contributed to language ability via its relation with attention rather than via a direct pathway. Some behavioural data have indicated no significant differences between the children with LI and their typically developing peers on tasks measuring shifting (Dibbets *et al.* 2006, Henry *et al.* 2012, Im-Bolter *et al.* 2006); however, fMRI data suggest shifting may be more demanding for children with LI than for typically developing children (Dibbets *et al.* 2006).

Prior research has found relations between behaviour problems and EF. Deficits in inhibition have been linked to ADHD and externalizing behaviour problems in young children and adolescents (Ford *et al.* 2007, Friedman *et al.* 2007, Riccio *et al.* 2011, Willcutt *et al.* 2005). Investigations are needed to assess the relations between shifting and internalizing and externalizing behaviour problems. Toplak *et al.* (2009) found that adolescents without ADHD performed significantly better on a trail-making task, assessing set-shifting, than adolescents with ADHD. Willcutt *et al.*'s (2005) meta-analysis indicated small effects and inconsistent results when examining the relations between shifting and ADHD. Friedman *et al.* (2007) revealed that lower levels of attention problems significantly predicted better shifting abilities at some ages (7, 9, 10 and 11), but not at others (8, 12, 13 or 14). The literature on the relations between working memory and internalizing and externalizing behaviour problems is limited. Working memory may be indirectly related to risk-taking behaviour via its relation with impulsivity in preadolescents (Romer *et al.* 2009). A relation between working memory deficits and ADHD has been found (Friedman *et al.* 2007, Toplak *et al.* 2009, Willcutt *et al.* 2005); however, Friedman *et al.* (2007) revealed a stronger link between ADHD and inhibition than between ADHD and working memory.

Purpose of the current investigation

The current investigation explores EF in children with a range of linguistic and behaviour profiles relative to the latent variable model of EF (Miyake *et al.* 2000). Research on EF has highlighted the importance of incorporating both laboratory measures and measures that assess performance in real-world settings (Riccio *et al.* 2011). Parent-report measures of EF provide information about an individual's ability to achieve goals, whereas laboratory measures assess cognitive efficiency under optimal conditions (Toplak *et al.* 2013).

Investigations into the relations among language and related constructs traditionally compare individuals with LI to individuals without LI; however, the present study examined these relations using language as a continuous variable, based on the perspective that individuals with LI represent the lower tail of an ability distribution, rather than a distinct category (e.g., Rescorla 2009). The following research questions were addressed: Does performance on EF tasks predict language ability? Do language ability and EF predict attention, internalizing and/or externalizing behaviour problems?

Methods

Participants

The 42 students (22 male, 20 female), aged 8:1–11;7 years;months (mean = 114.78 months, SD = 12.43 months) enrolled in this preliminary investigation were recruited from the after-school programmes of a large, urban school district in the Midwestern United States. The mother's years of education was used as a measure of socioeconomic status (range = 12–20 years, mean = 15 years, SD = 2.56). The racial/ethnic breakdown of the sample was 52% African American, 33% Caucasian and 15% more than one race/ethnicity. All participants were monolingual speakers of English, with normal or corrected to normal vision, normal hearing and no known neurological deficits. Per parent report, three participants had been diagnosed with LI, three received therapy for deficits in articulation, three received services for deficits in reading, two received tutoring for general academic needs and one had been diagnosed with behaviour problems.

The current investigation included children with a broad range of cognitive abilities, although no children fell into the range of intellectual disabilities. Recent research has found similarities between children and adolescents with specific language impairment (SLI), typically defined as LI with nonverbal cognitive scores within the average range, and those with nonspecific language impairment (NLI), who score below the average range on tests of *both* language *and* nonverbal cognition (e.g., Miller *et al.* 2006).

Tasks

The core language composite standard score of the Clinical Evaluation of Language Fundamentals—Fourth Edition (CELF-4; Semel *et al.* 2003) was used as an omnibus measure of language ability. The fluid intelligence composite score of the Leiter International Performance Scale—Revised (Leiter; Roid and Miller 1997) evaluated nonverbal cognition. One student was not administered the Leiter due to early pick-up.

Parents completed the Conners-3P (Conners 2008), a parent-report ADHD index, to assess the students' attention; the Child Behaviour Checklist (CBCL; Achenbach and Rescorla 2001) to evaluate the students' internalizing and externalizing behaviour problems; and the Behaviour Rating Inventory of Executive Function (BRIEF; Gioia *et al.* 2000) to assess the students' EF. The *t*-scores for ADHD index of the Conners-3P, the internalizing and externalizing indices of the CBCL, and the inhibit, shift and working memory scales of the BRIEF were analysed.

The Dimensional Change Card Sort (DCCS; Zelazo 2006) computerized version, developed for children aged 8–11 years, was used as an experimental measure of EF. Children were shown a centred target picture with two side-by-side pictures beneath it on a 15-inch laptop computer using E-Prime® 2.0 software. A touch-screen add-on was connected via the USB port. In the first set of five trials, the children selected the picture that matched the target according to one dimension (e.g., colour). For the next five trials they selected the picture that matched according to the other (e.g., shape). In the third set of trials, the *mixed condition*, the dimension by which they were to select the picture switched, requiring matching by shape on some trials and by colour on others. The word *shape* or *colour* was displayed on the screen and presented auditorally to cue the correct dimension. The children matched by the dominant dimension on 40 trials, and by the non-dominant dimension on 10. Age-residualized scores for mixed condition reaction time were analysed. Due to a technical error, one child did not complete the task. The DCCS has been shown to involve multiple cognitive processes; thus, it is not a 'pure' measure of a single EF component (Waxer and Morton 2011).

Procedure

Prior to recruitment, approval was obtained from the Institutional Review Boards of the University of Wisconsin-Madison and of the participants' school district. The same speech–language pathologist tested each child individually in an empty, quiet room in his or her school. The order of task administration was varied across participants to avoid order effects. Parents completed consent and background forms, the CBCL, the BRIEF and the Conners-3P.

Results

Descriptive data

Table 1 summarizes the scores on the measures. Of the 40 children in the study, 13 (33%) fell within the clinical classification of LI, scoring 1.25 SDs or more below the mean on two or more subtests or composites on CELF-4. On the Conners-3P, three (8%) students earned borderline scores, two (5%) earned high scores and three (8%) earned very high scores; thus, 21% of the students in the study could be considered at risk for attention problems. On the CBCL, none of the students' scores fell into the borderline range for internalizing behaviour problems, and five (13%) fell within the clinical range. On the externalizing index, four (10%) scored within the borderline range and six (15%) scored within the clinical range, with a total of 10 (25%) of the students at risk for externalizing behaviour problems.

Correlations

Table 2 displays the correlations among the measures. The demographic variables of age and SES were significantly correlated only with language scores, and nonverbal cognition was correlated only with language and DCCS. All the parent-report measures (BRIEF inhibit, working memory and shift; CBCL internalizing and externalizing; and Conners-3P ADHD) were significantly correlated with one another. The experimental measure of EF was significantly correlated with language and

Table 1. Descriptives scale

	Range	Mean	Standard deviation (SD)	*N*
Conners-3P ADHD Index[a]	42–90	52.14	13.97	42
CBCL Externalizing[a]	33–77	47.04	13.63	42
CBCL Internalizing[a]	33–72	46.52	12.09	42
CELF-4 Core Language[b]	54–123	90.33	17.76	42
Leiter Fluid Reasoning[b]	73–125	94.76	13.86	41
BRIEF Inhibit[a]	37–87	46.81	10.42	42
BRIEF Shift[a]	36–83	46.47	11.67	42
BRIEF Working Memory[a]	36–83	46.38	10.14	42
DCCS	−1.87 to 3.66	0.72	0.99	41

Notes: [a] *T*-scores: mean = 50, SD = 10.
[ab] Standard scores: mean = 100, SD = 15.

Table 2. Correlations

Age	SES	FR	CELF	INH	SHF	WM	DCCS	ADHD	INT	EXT
EXT	0.06	−0.11	−0.10	−0.24	0.76***	0.58***	0.60***	0.20	0.63***	0.72***
INT	0.10	0.14	0.08	−0.03	0.76***	0.63***	0.65***	−0.30	0.59***	
ADHD	0.14	−0.15	−0.24	−0.43**	0.76***	0.71***	0.72***	0.13		
DCCS	0	0.23	−0.35*	−0.35*	−0.21	−0.02	0.02			
WM	0.24	−0.02	−0.21	−0.31*	0.77***	0.82***				
SHF	0.24	0.13	−0.15	−0.19	0.74***					
INH	0.04	−0.03	−0.11	−0.23						
CELF	−0.29*	0.33*	0.60***							
FR	−0.09	0.29								
SES	0.11									
AGE										

Notes: EXT = CBCL Externalizing *t*-score, INT = CBCL Internalizing *t*-score, ADHD = Conners-3P ADHD Index *t*-score, DCCS = Dimensional Change Card Sort, WM = BRIEF Working Memory *t*-score, SHF = BRIEF Shift *t*-score, INH = BRIEF Inhibit *t*-score, CELF = CELF Core Language Standard score, FR = Leiter Fluid Reasoning Index standard score, SES = socioeconomic status.
$^{*}p \le 0.05$, $^{**}p \le 0.01$, $^{***}p \le 0.001$.

nonverbal cognition, but not with the parent-report measures of EF or behaviour problems.

Linear regression modelling

Linear regression modelling was employed using block entry to evaluate predictors of language (table 3), attention problems (table 4), internalizing (table 5) and externalizing (table 6). BRIEF inhibit, working memory and shift *t*-scores and residualized age scores for DCCS reaction time were entered as predictors; CELF-4 was also entered as a predictor for attention problems, internalizing and externalizing. The demographic variables did not improve the model fit when entered as predictors of attention problems, $F(2,38) = 1.36$, $R = 0.26$, $R^2 = 0.07$, $p = 0.27$; internalizing, $F(2,37) = 0.34$, $R = 0.13$, $R^2 = 0.02$, $p = 0.71$; and externalizing, $F(2,37) = 0.35$, $R = 0.14$, $R^2 = 0.02$, $p = 0.71$; thus, the final models for attention problems, internalizing and externalizing did not include the demographic variables. CELF-4 did not significantly contribute to internalizing, $F(1, 38) = 0.03$, $R = 0.03$, $R^2 = 0.001$, $p = 0.87$, or externalizing, $F(1, 40) = 2.40$, $R = 0.24$, $R^2 = 0.06$, $p = 0.13$; thus, the final models for internalizing and externalizing did not include CELF-4. Nonverbal cognition significantly predicted the CELF-4 score. When entered without nonverbal cognition, DCCS and BRIEF Working Memory together were significant predictors of CELF-4, $F(2,37) = 5.07$, $R = 0.48$, $R^2 = 0.19$, $p = 0.008$, but were no longer significant with nonverbal cognition in the model. SES and age were not significant predictors of CELF-4, and were not included in the final model.

CELF-4 was a significant predictor of the Conners-3P ADHD index score when entered as a single predictor, but was no longer significant when the EF measures were added to the model.

The BRIEF Inhibit score significantly predicted the Conners-3P score, and was the sole significant predictor of both internalizing and externalizing behaviour problems.

Conclusions

The first research question examined the relation between language ability and EF. Scores on CELF were correlated with the experimental measure of EF and with the parent-reported measure of working memory. However, when nonverbal cognition was included in the model, neither was a significant predictor. Language ability was neither correlated with nor predicted by

Table 3. Linear regression models predicting the Core Language Composite Standard score on the Clinical Evaluation of Language Fundamentals—Fourth Edition

Block	Predictor	B	SE B	β
1	Leiter	.77	.17	.59***
	F(1,38)=20.48, R=.59, R^2=.35, p<.001			
2	Leiter	.61	.18	.47**
	BRIEF Inhibit	−.35	.39	−.20
	DCCS	−4.02	2.67	−.22
	BRIEF Working Memory	.42	.47	−.23
	BRIEF Shift	.32	.36	.21
	F(5,34)=5.48, R=.67, R2=.45, R2 Δ=.07, p=.001			

Notes: Leiter = Composite Standard Score on the Fluid Reasoning Index. SES = mother's years of education; DCCS = age-residualized score on the Dimensional Change Card Sort; BRIEF = *t*-score on the Behavior Rating Inventory of Executive Functions.
***$p \leq 0.001$, **$p < 0.01$.

Table 4. Linear regression models predicting Conners-3P ADHD Index *t*-score

Block	Predictor	B	SE B	β
1	CELF	−0.34	0.12	−0.43**
$F(1,39) = 8.46$, $R = 0.43$, $R^2 = 0.18$, $p < 0.01$				
2	CELF	−0.14	0.08	−0.17
	BRIEF Inhibit	0.75	0.22	0.56*
	BRIEF Shift	0.31	0.21	0.26
	BRIEF Working Memory	0.02	0.27	0.01
	DCCS	2.76	1.53	0.19
$F(5,34) = 16.77$, $R = 0.84$, $R^2 = 0.71$, $R^2\Delta = 0.53$, $p < 0.001$				

Notes: CELF = Clinical Evaluation of Language Fundamentals—Fourth Edition Core Language Composite Score; BRIEF = Behavior Rating Inventory of Executive Functions *t*-score.
*$p < 0.05$, **$p < 0.01$.

Table 5. Linear regression models predicting Child Behavior Checklist internalizing *t*-score

Block	Predictor	B	SE B	β
1	BRIEF Inhibit	0.61	0.21	0.53*
	BRIEF Shift	0.13	0.19	0.13
	BRIEF Working Memory	0.16	0.25	0.13
	DCCS	0.13	0.19	0.13
$F(4,35) = 14.58$, $R = 0.79$, $R^2 = 0.63$, $p < 0.001$				

Notes: BRIEF = Behavior Rating Inventory of Executive Functions *t*-score; DCCS = age-residualized reaction time on the Dimensional Change Card Sort.
* $p \leq 0.01$.

Table 6. Linear regression models predicting Child Behavior Checklist externalizing *t*-score

Block	Predictor	B	SE B	β
1	BRIEF Inhibit	0.91	0.25	0.70*
	BRIEF Shift	0.07	0.23	0.06
	BRIEF Working Memory	0.02	0.30	0.01
	DCCS	−0.71	1.63	−0.05
$F(4,35) = 12.72$, $R = 0.77$, $R^2 = 0.59$, $p < 0.001$				

Notes: *$p \leq 0.001$.
BRIEF = Behavior Rating Inventory of Executive Functions *t*-score; DCCS = age-residualized reaction time on the Dimensional Change Card Sort.

parent-reported shifting or the DCCS, which also required the use of shifting to shift attention to the current card-sorting dimension when it changed. The lack of a significant relation between language ability and shifting is consistent with prior behavioural investigations of LI and EF (e.g., Henry *et al.* 2012, Im-Bolter *et al.* 2006). The lack of a significant relation between language ability and inhibition was surprising, given that inhibition has been found to predict scores on tests of reading, spelling, and writing (St. Clair-Thompson and Gathercole 2006), and differences in mean levels of performance in children with LI as compared with children with typical language ability have been found (Henry *et al.* 2012).

Results of the current investigation provide support for the notion that inhibition and language ability may not have a direct relation in school-age children, as suggested by Im-Bolter *et al.* (2006).

The second research question addressed predictors of behaviour problems. The results of the current investigation provide further evidence of a relation between inhibition and behaviour problems. Parent-reported inhibition significantly predicted attention problems and internalizing and externalizing behaviour problems. Language ability had a significant relation with attention problems, but this relation was no longer significant when the EF measures were added to the model. It was contrary to expectations that language was not a significant predictor of internalizing or externalizing behaviour problems, and was not significantly correlated with either. It may be the case that a significant relation between language and behaviour problems was not found due to the small number of children in the study falling into the borderline or clinical ranges for behaviour problems. Other investigations into the relation between language ability and behaviour problems have used clinically referred populations. The nature of the relation between language and behaviour problems may differ in individuals with severe behaviour problems.

EF has been proposed as a potential link between decreased language ability and behaviour problems (Brownlie *et al.* 2004, Villamarette-Pittman *et al.* 2002). The current findings suggest that inhibition and language ability both contribute to attention problems, with EF (inhibition) being the stronger predictor. However, language ability was neither predicted by nor correlated with inhibition; thus, it seems unlikely that EF provides a link between language ability and attention problems. Language ability did not have significant relations with internalizing and externalizing behaviour problems, whereas inhibition contributed to both.

These findings have clinical relevance for children with attention and/or behaviour problems. Children with attention problems, internalizing behaviour problems or externalizing behaviour problems may benefit from interventions that include focusing on inhibitory processes. Additionally, children with attention problems may benefit from intervention targeting language ability.

It should be noted that the limitations of the current investigation prevent the drawing of strong conclusions, given the relatively small sample size and the use of an EF task that taps multiple cognitive processes. Future studies should assess the relations among language, EF, and behaviour problems in a larger sample using multiple tasks, including tasks considered 'purer' indices of the components of EF. Additionally, measures of higher-level language processes, such as the comprehension and production of spoken and written discourse, might be assessed relative to EF and behaviour problems.

Acknowledgements

Funding for this research was provided by the National Institute on Deafness and Other Communication Disorders (NIDCD) (Grant Number T32DC005359). The author would like to thank the team leaders and staff at Milwaukee Public Schools Community Learning Centers as well as Maureen MacVane for their recruitment assistance. The author extends her thanks to the children who participated in the study and their parents. ***Declaration of interest:*** The author report no conflicts of interest. The author alone is responsible for the content and writing of the paper.

References

ACHENBACH, T. M. and RESCORLA, L. A., 2001, *Manual for ASEBA School-Age Forms & Profiles* (Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families).

BROWNLIE, E., BEITCHMAN, J., ESCOBAR, M., YOUNG, A., ATKINSON, L., JOHNSON, C., WILSON, B. and DOUGLAS, L., 2004, Early language impairment and young adult delinquent and aggressive behavior. *Journal of Abnormal Child Psychology*, **32**, 453–467.

CONNERS, C., 2008, *The Conners 3rd Edition (Conners 3)* (North Tonawanda, NJ: Multi-Health System).

DIBBETS, P., BAKKER, K. and JOLLES, J., 2006, Functional MRI of task switching in children with specific language impairment (SLI). *Neurocase*, **12**, 71–102.

FORD, S., FARAH, M., SHERA, D. and HURT, H., 2007, Neurocognitive correlates of problem behavior in environmentally at-risk adolescents. *Journal of Developmental Behavioral Pediatrics*, **28**, 376–385.

FRIEDMAN, N., HABERSTICK, B., WILLCUTT, E., MIYAKE, A., YOUNG, S., CORLEY, R. and HEWITT, J., 2007, Greater attention problems during childhood predict poorer executive functioning in late adolescence. *Psychological Science*, **18**, 893–900.

GIOIA, G., ISQUITH, P., GUY, S. and KENWORTHY, L., 2000, *Behavior Rating Inventory of Executive Function: Professional Manual* (Lutz, FL: Psychological Assessment Resources).

HENRY, L., MESSER, D. and NASH, G., 2012, Executive functioning in children with specific language impairment. *Journal of Child Psychology and Psychiatry*, **53**, 37–45.

IM-BOLTER, N., JOHNSON, J. and PASCUAL-LEONE, J., 2006, Processing limitations in children with specific language impairment: the role of executive function. *Child Development*, **77**, 1822–1841.

LEHTO, J., JUUJÄRVI, P., KOOISTRA, L. and PULKKINEN, L., 2003, Dimensions of executive functioning: evidence from children. *British Journal of Developmental Psychology*, **21**, 59–80.

MILLER, C., LEONARD, L., KAIL, R., ZHANG, X., TOMBLIN, J. and FRANCIS, D., 2006, Response time in 14-year-olds with language impairment. *Journal of Speech, Language, and Hearing Research*, **49**, 712–728.

MIYAKE, A., FRIEDMAN, N., EMERSON, M., WITZKI, A. and HOWERTER, A., 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.

REDMOND, S., 2004, Conversational profiles of children with ADHD, SLI, and typical development. *Clinical Linguistics and Phonetics*, **18**, 107–125.

REDMOND, S., 2005, Differentiating SLI from ADHD using children's sentence recall and production of past tense morphology. *Clinical Linguistics and Phonetics*, **19**, 109–127.

RESCORLA, L., 2009, Age 17 language and reading outcomes in late-talking toddlers: support for a dimensional perspective on language delay. *Journal of Speech, Language, and Hearing Research*, **52**, 16–30.

RICCIO, C., LOCKWOOD, L. and BLAKE, J., 2011, Relation of measures of executive function to aggressive behavior in children. *Applied Neuropsychology*, **18**, 1–10.

ROID, G. and MILLER, L., 1997, *Leiter International Performance Scale—Revised* (Wood Dale, IL: Stoelting Co.).

ROMER, D., BETANCOURT, L., GIANNETTA, J., BRODSKY, N., FARAH, M. and HURT, H., 2009, Executive cognitive functions and impulsivity as correlates of risk taking and problem behavior in preadolescents. *Neuropsychologia*, **47**, 2916–2926.

SEMEL, E., WIIG, E. and SECORD, W., 2003, *Clinical Evaluation of Language Fundamentals—Fourth Edition* (San Antonio, TX. Psychological Corporation).

ST. CLAIR-THOMPSON, H. and GATHERCOLE, S., 2006, Executive functions and achievements in school: shifting, updating, inhibition, and working memory. *Quarterly Journal of Experimental Psychology*, **59**, 745–759.

TOPLAK, M., BUCCIARELLI, S., JAIN, U. and TANNOCK, R., 2009, Executive functions: performance-based measures and the behavior rating inventory of executive function (BRIEF) in adolescents with attention deficit/hyperactivity disorder (ADHD). *Child Neuropsychology*, **15**, 53–72.

TOPLAK, M., WEST, R. and STANOVICH, K., 2013, Practitioner Review: Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry*, **54**, 131–143.

VAN DER SLUIS, S., DE JONG, P. and VAN DER LEIJ, A., 2007, EF in children, and its relations with reasoning, reading, and arithmetic. *Intelligence*, **35**, 427–449.

VILLAMARETTE-PITTMAN, N., STANFORD, M. and GREVE, K., 2002, Language and executive function in self-reported impulsive aggression. *Personality and Individual Differences*, **34**, 1533–1544.

WAXER, M. and MORTON, J., 2011, Multiple processes underlying dimensional change card sort performance: a developmental electrophysiological investigation. *Journal of Cognitive Neuroscience*, **23**, 3267–3279.

WILLCUTT, E., DOYLE, A., NIGG, J., FARAONE, S. and PENNINGTON, B., 2005, Validity of the executive function theory of attention-deficit/hyperactivity disorder: a meta-analytic review. *Biological Psychiatry*, **57**, 1336–1346.

ZELAZO, P., 2006, The Dimensional Change Card Sort (DCCS): a method of assessing Executive function in children. *Nature Protocols*, **1**, 297–201.