Published in final edited form as:

J Atten Disord. 2021 April ; 25(6): 865–873. doi:10.1177/1087054719861745.

Bilingualism May Be Protective Against Executive Function and Visual Processing Deficits Among Children With Attention Problems

Lindsay M. Hardy^{1,2}, Meghan Tomb¹, Yoochai Cha¹, Sarah Banker¹, Francisco Muñoz¹, Alexis Paul¹, Amy E. Margolis¹

¹New York State Psychiatric Institute and Columbia University Irving Medical Center, New York City, USA

²Rush University Medical Center, Chicago, IL, USA

Abstract

Objective—The current study examined how the opposing effects of bilingualism and attention problems operate on executive functioning, visual processing, and verbal fluency in children with clinically significant levels of attention problems.

Method—We tested whether bilingualism moderated associations between attention problems and visual processing, executive functioning, and verbal fluency.

Results—Bilingual children ($n = 331$) showed visual processing advantages relative to their monolingual peers ($n = 165$), but only at higher, and not lower, levels of attention problems. Bilingualism did not moderate the association between attention problems and interference control; however, across all children, those with higher levels of attention problems had more difficulty with interference control. Monolingual children demonstrated advantages in verbal fluency relative to bilingual children, but this did not vary with attention problems.

Conclusion—Visual processing advantages in bilinguals are detected among children with heightened attention problems, but advantages in interference control are not; findings may have implications for classroom interventions.

Keywords

executive function deficits; visual-motor integration; child assessment; Latino/Hispanics

Relative to monolingual individuals, bilingual individuals demonstrate enhanced cognitive capacities in executive functioning and visual processing (Bialystok, 2011, 2017). Furthermore, cognitive advantages associated with bilingualism appear to buffer against disadvantages associated with attention problems in typically developing children (Sorge,

Corresponding Author: Amy E. Margolis, Division of Child and Adolescent Psychiatry, Department of Psychiatry, New York State Psychiatric Institute and Vagelos College of Physicians & Surgeons, Columbia University Irving Medical Center, 1051 Riverside Drive, New York City, NY 10032, USA, Amy.margolis@nyspi.columbia.edu.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Toplak, & Bialystok, 2017). Unknown, however, is whether the cognitive advantages associated with bilingualism are protective against the executive functioning and visual processing deficits that are common among children with attention problems. The current study sought to address this gap in the literature by examining executive functioning and visual processing skills in a sample of monolingual and bilingual children with neurodevelopmental disorders that are associated with a range of attention problems.

Bilingual individuals have enhanced abilities in a number of executive functions including set shifting and cognitive flexibility (Bialystok, Craik, & Luk, 2012; Bialystok & Viswanathan, 2009), selective attention (Bialystok, 2001; Friesen, Latman, Calvo, & Bialystok, 2015; Krizman, Marian, Shook, Skoe, & Kraus, 2012), and interference control (Bialystok & Viswanathan, 2009; Esposito, Baker-Ward, & Mueller, 2013). These abilities are thought to be enhanced due to the bilingual experience of simultaneously managing two linguistic systems (Bialystok, Hawrylewicz, Wiseheart, & Toplak, 2017). Specifically, bilingual individuals alternate between speaking two languages, potentially enhancing their cognitive flexibility and set shifting (Adesope, Lavin, Thompson, & Ungerleider, 2010; Bialystok & Viswanathan, 2009). Bilingual individuals also navigate between two vocabularies and grammatical structures, requiring them to selectively attend to one cue while simultaneously suppressing a competing cue (Bialystok & Viswanathan, 2009; Esposito et al., 2013), potentially enhancing their interference control. In contrast, bilingual individuals show diminished abilities in some areas of executive functioning, such as verbal fluency (Bialystok & Feng, 2009; Bialystok et al., 2017; Portocarrero, Burright, & Donovick, 2007). This disadvantage may derive from the fact that bilingual children lag behind their monolingual peers in vocabulary development in a *single* language, as their language growth is divided between two languages (Hoff, 2013). In total, these findings suggest the bilingual advantage is specific to executive functions that are bolstered directly via the bilingual experience.

In addition to advantages in executive functions, bilingual individuals show visual processing advantages. Compared with monolingual peers, bilingual children demonstrate better visual-perceptual and visual-motor skills (Ben-Zeev, 1977; Garratt & Kelly, 2008). Prior studies suggest that infants can discriminate languages facially, without auditory input, as early as 4 months old, and that bilingual infants have visual processing advantages as early as 6 months old (Singh et al., 2015; Weikum et al., 2007). Thus, visual processing may be enhanced in bilinguals as a result of increased experience discriminating visual language information.

Individuals with attention problems often show reduced performance on executive function and visual processing tasks (Barkley, 2015; Egeland, Ueland, & Johansen, 2012; Fan, Gau, & Chou, 2014; Ozonoff & Jensen, 1999). The cognitive advantages associated with bilingualism may mitigate the association between attention problems and deficits in executive function and visual processing. Such effects would result in a greater bilingual advantage at higher levels of attention problems. Among typically developing children, the bilingual advantage in interference control (flanker task) was greater at higher levels of attention problems (Sorge et al., 2017). However, to our knowledge, no studies have investigated whether the bilingual advantage has similar buffering effects among children

with clinically significant levels of attention problems. Such buffering of the effects of attention problems on executive functions and visual processing could be translated to the classroom to improve the experience of bilingual learners in school.

The current study was designed to address this gap in the literature by studying executive functioning and visual processing among monolingual and bilingual children with a range of neurodevelopmental disorders that are often accompanied by attention problems. Given prior findings (Bialystok et al., 2017; Mor, Yitzhaki-Amsalem, & Prior, 2015), we hypothesized that relative to monolingual children, bilingual children would show greater cognitive advantages in interference control at higher levels of attention problems. We hypothesized a similar interaction in visual processing. Finally, we hypothesized that the monolingual advantage in verbal fluency would be magnified at higher levels of attention problems, reflecting a “double hit” of bilingualism and attention problems on verbal fluency.

Method

Sample

Five hundred and eleven participants between 6 and 17 years old with an intelligence quotient (IQ; Full Scale, General Ability, or Perceptual/Fluid Reasoning index) greater than or equal to 80 were selected from the clinic database (see Figure 1). The clinic provides comprehensive neuropsychological assessments and education coordination to low-income children and adolescents. The median annual household income of the sample was US \$25,000, and 76% of mothers had less than a bachelor's degree. All demographic information (language spoken at home, age, sex, race, ethnicity, maternal employment status, family income, current grade in school) was gathered from a standard demographic questionnaire used in the clinic. Children included in the sample had a range of neurodevelopmental disorders that are often accompanied by attention problems (see Figure 2). The Institutional Review Board of the New York State Psychiatric Institute approved this study.

Language Status

Language status was operationalized by the language spoken in the child's home per parent report on the demographic questionnaire. Because all children attended schools where English was the primary language of instruction and all children were deemed appropriate for an evaluation in English, participants were placed in the bilingual group (BL) if in response to the question “What language/s do you speak at home?” parents reported: “English/Spanish,” “Mostly Spanish,” or “Spanish Only” (BL = 331). In these cases, children were exposed to English at school and Spanish at home and thus classified in the bilingual group. Participants were placed in the monolingual group (ML) if their parents reported that “English Only” was spoken at home (ML = 165; Figure 1).

Assessment Measures

Attention Problems were assessed with the Swanson, Nolan, and Pelham, Fourth Edition (SNAP-IV)—Parent & Teacher Rating Scale, providing a continuous and reliable measure of inattentive and hyperactive/impulsive behaviors (coefficient alphas were .94 and .97,

respectively (Bussing et al., 2008). Parent and teacher SNAP-IV scores were strongly correlated, $r = .398$, $p < .001$; thus, to use all available data, the average of the sum score from parent and teacher rating forms was calculated ($n = 200$). When only parent or teacher ratings were available, the sum score from that form was used ($n = 143$).

Interference Control was measured via the Inhibition–Inhibition subtest of the Developmental NEuroPSYchological Assessment, Second Edition (NEPSY-II; Korkman, Kirk, & Kemp, 2007). In this task, the child is presented with a series of shapes or arrows and instructed to provide a competing response (e.g., “down” when presented with an up facing arrow, and vice versa, or “circle” when presented with a square, and vice versa). Thus, similar to a flanker task, this task requires the resolution of conflict in service of controlling an automatic response and suppressing attention to distraction in favor of providing a less common, alternate response. Subtest scaled scores have a mean of 10 and a standard deviation of 3. Cronbach’s alpha ranges from .73 to .96 depending upon age group (Korkman et al., 2007).

Visual Processing was measured via the Visual Perception subtest of the Beery–Buktenica Developmental Test of Visual-Motor Integration (Beery, Buktenica, & Beery, 2010). Children must select from up to five possible choices the figure that exactly matches the target shape. The subtest yields a standard score with a mean of 100 and a standard deviation of 15. Cronbach’s alpha has been found to be .89 (Beery et al., 2010).

Verbal Fluency was measured via the Associational Fluency subtest of the Kaufman Test of Educational Achievement, Third Edition (KTEA-3). Children are tasked with rapidly naming words from various semantic categories (e.g., foods, colors); thus, the subtest is thought to measure initiation and rapid intrinsic response generation (Abrahams et al., 2003). The subtest yields a standard score with a mean of 100 and standard deviation of 15. The mean split-half reliability coefficient for this measure is .62 (Kaufman, Kaufman, & Breaux, 2014).

Analytic Plan

Hierarchical linear regression analyses were conducted using SPSS 24. Language status was entered as a dichotomous predictor (ML or BL). Attention problems (SNAP-IV) and the language-by-attention interaction term were entered as continuous predictors. Linear regression analyses generated multiple correlation coefficients (R^2) and unstandardized multiple regression coefficients (β) were used to analyze adjusted associations between language status, attention problems, and cognitive functioning. Mean SNAP-IV scores were centered so that each variable had a mean of zero. Interaction terms were computed by multiplying centered SNAP-IV scores with bilingual status. Given potential associations between age, sex, and ethnicity and dependent measures (interference control, visual processing, verbal fluency), these variables were included as covariates at the first step in all regression models. Bilingual status and centered SNAP-IV scores were entered at the second step. The interaction term was entered at the third step. Regression models were conducted separately for each dependent variable: Inhibition–Inhibition, Visual Perception, and Associational Fluency.

Results

Participants

Children from ML and BL backgrounds differed in ethnicity and race (Table 1). They did not differ in age, grade, sex, IQ, maternal employment status, paternal employment status, or ADHD diagnosis (Table 1). Attention problems in the sample ranged from typical to atypical levels (Figure 3). As expected, at higher levels (highest quartile) of attention problems, ADHD, developmental coordination disorders, and disruptive behavior disorders were more prevalent than at lower levels (lowest quartile) and conversely, specific learning disorders and language disorders were less prevalent at higher versus lower levels of attention problems (Figure 4).

Interference Control

Attention problems were associated with performance. As attention problems increased, task performance decreased ($\beta = -.72$, $p = .02$; Table 2). Language status was not related to performance (Table 3). The addition of the interaction term did not increase the variance explained by the model. Neither age, sex, nor ethnicity were significant.

Visual Processing

Neither language status nor attention problems were significantly associated with performance. The language-by-attention interaction term increased significantly the amount of variance explained ($\beta = 5.23$, $p = .015$; $R^2 = 2\%$; Table 2). At lower levels of attention problems, monolingual children performed better than bilingual children; however, at higher levels of attention problems, bilingual children performed better than their monolingual peers (Figure 5 and Table 3). Age emerged as a significant control variable ($\beta = -.82$, $p = .001$; $R^2 = 5\%$).

Verbal Fluency

Language status was associated with performance on the verbal fluency task ($\beta = -8.45$, $p = .04$; Table 2), such that monolingual children performed better than bilingual children. Attention problems were not related to performance. The addition of the interaction term did not increase the variance explained by the model. Ethnicity emerged as a significant control variable such that children who did not identify as Hispanic outperformed those who did ($\beta = 9.59$, $p = .002$).

Discussion

This study assessed whether bilingualism mitigated cognitive deficits in executive function and visual processing that are associated with attention problems in a sample of children with neurodevelopmental disorders. Relative to their monolingual peers, bilingual children showed a cognitive advantage in visual-perceptual skills, but only at higher levels of attention problems. In this sample, bilingualism was not associated with interference control; however, increased attention problems were associated with reduced interference control across all children. Monolingual children demonstrated the expected cognitive advantage in verbal fluency relative to their bilingual peers at all levels of attention problems. This study

represents an initial step toward understanding how the opposing effects of bilingualism and attention problems operate on executive functioning, visual processing, and verbal fluency in a sample of children that included those with clinically significant levels of attention problems.

Consistent with our hypothesis, bilingual children showed advantages in visual processing relative to monolingual children at higher, but not at lower, levels of attention problems. Our finding suggests that with increasing attention problems, the associated increase in visual processing problems is attenuated by the effects of bilingualism on cognition. These findings converge somewhat with prior studies suggesting that bilingual children have visual processing advantages (Ben-Zeev, 1977; Garratt & Kelly, 2008) that are detected as early as 6 months of age (Singh et al., 2015; Weikum et al., 2007). This strength of bilingual learners who nonetheless have challenges in attention can be built upon by appointing these students as positive peer models in class during tasks that tap these skills. At lower levels of attention problems, however, monolingual children performed better than bilingual children. The sample of children in the clinic database with low levels of attention problems may represent a unique sample of monolingual and bilingual children with neurocognitive problems other than attention problems that interact with bilingualism and negatively influence visual processing.

Our hypothesis that bilingualism would buffer the executive function deficits associated with attention problems was not supported. Although one prior study reported that among typically developing children, the bilingual advantage was greatest with the highest levels of attention problems (Sorge et al., 2017), in our sample of children with clinically significant levels of attention problems, we did not detect such an advantage. Higher levels of attention problems were associated with reductions in interference control, regardless of language status. Our results suggest that at clinically significant levels of attention problems, deficits in interference control are primary and there are no detectable advantages of bilingualism. Similarly, in prior studies of adults with ADHD, bilingualism did not buffer executive function deficits and on some tasks magnified deficits associated with ADHD (Bialystok, 2017; Mor et al., 2015). Thus, the potentially protective effects of bilingualism on interference control appear not to operate at the clinically significant extreme of the attention spectrum. Children who display higher levels of behaviors associated with attention disorders may have difficulty in the classroom when activities and skills require interference control, such as inhibiting a common, prepotent response and instead selecting a less habitual one. For example, instead of simply responding to a question as one would in a conversation (inhibiting the response), raising one's hand to add to a class discussion (executing a less habitual behavior).

Our hypothesis that the monolingual advantage on verbal fluency tasks would be magnified with increasing levels of attention problems was not supported. Relative to their bilingual peers, monolingual children demonstrated better verbal fluency, but this was not exacerbated at higher levels of attention problems. Thus, we did not find evidence to support a “double hit” of bilingualism and attention problems on verbal fluency in this sample of children with neurodevelopmental problems. Our finding that regardless of attention capacity, monolingual children demonstrated advantages in verbal fluency relative to bilingual

children suggest that teachers should be aware of bilingual children's potential difficulties generating words and ideas during class discussion or during in-class writing assignments. Prompts with target words may help bilingual children generate ideas more quickly; extended time for completing exercises requiring verbal initiation may potentially help these children.

The current study has several limitations. There was no direct measure of participants' Spanish language proficiency. In addition, bilingualism was measured categorically; however, it may be better studied continuously via degree of bilingualism (Luk & Bialystok, 2013). The age at which bilingual children were first exposed to English was also unavailable and this may affect the potential buffering effects of bilingualism on cognition. Finally, the sample in this study included students from low-income backgrounds, thus limiting the generalizability of results to children from other socio-economic backgrounds.

In summary, bilingualism appears to have a protective or buffering effect on visual processing among children with clinically significant levels of attention problems. Among children with neurodevelopmental disorders with lower levels of attention problems, there does not appear to be a bilingual advantage in visual processing. Furthermore, no bilingual advantage in interference control was detected at any level of attention disorder, although attention problems were associated with interference control across all children. Finally, relative to their monolingual peers, bilingual children did not appear to have greater deficits in verbal fluency at higher levels of attention problems. Thus, the opposing effects of bilingualism and attention problems on cognitive processes appear to operate differently among children with neurodevelopmental problems with and without clinically significant levels of attention problems than they do among typically developing children.

Acknowledgments

The authors would like to thank Lauren Thomas and Jackson Quinn for their assistance in preparing this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the DeHirsh-Robinson Fellowship, the Promise Project at Columbia, and the National Institute of Environmental Health Sciences (NIEHS) K23ES026239.

Author Biographies

Lindsay M. Hardy is currently an assistant professor in the Department of Psychiatry (Division of Behavioral Sciences) at Rush University Medical Center, where she specializes in comprehensive neuropsychological evaluations for children and adolescents presenting with a range of neurodevelopmental and medical conditions. She was previously an instructor of Medical Psychology (in Psychiatry) at Columbia University Irving Medical Center.

Meghan Tomb is a child and adolescent psychologist and neuropsychologist at Columbia University Irving Medical Center. She specializes in comprehensive neuropsychological evaluations of youth and young adults with learning, attention, and developmental

disabilities, as well as complex medical conditions. Dr. Tomb is the director of a clinic for underserved children with learning disabilities.

Yoochai Cha is a former research assistant at the New York State Psychiatric Institute. She received her MA in clinical psychology from Teachers College, Columbia University.

Sarah Banker is a Neuroscience PhD student in the Graduate School of Biomedical Sciences, Icahn School of Medicine at Mount Sinai. Her research interests involve understanding the neural mechanisms of emotional regulation and social functioning.

Francisco Muñoz is a recent graduate of Teachers College, Columbia University with an MA in Clinical Psychology. His interest lies in how socioeconomic status affects the learning and language of children. He plans to pursue a doctorate degree with hopes of becoming a pediatric neuropsychologist.

Alexis Paul completed her MA in Clinical Psychology at Teachers College, Columbia University in 2016. She is now a doctoral candidate in La Salle University's PsyD program in Clinical Psychology.

Amy E. Margolis is assistant professor of Medical Psychology (in Psychiatry) at Columbia University Irving Medical Center and Director of the Environment, Brain, and Behavior Laboratory. She specializes in clinical assessment and treatment of learning and attention disorders. Her research program uses neuroimaging to document the effects of prenatal exposure to neurotoxic chemicals on learning, attention, and social function.

References

- Abrahams S, Goldstein LH, Simmons A, Brammer MJ, Williams SC, Giampietro VP, & Leigh PN (2003). Functional magnetic resonance imaging of verbal fluency and confrontation naming using compressed image acquisition to permit overt responses. *Human Brain Mapping*, 20, 29–40. [PubMed: 12953304]
- Adesope OO, Lavin T, Thompson T, & Ungerleider C (2010). A systematic review and meta-analysis of the cognitive correlates of bilingualism. *Review of Educational Research*, 80, 207–245. doi:10.3102/0034654310368803
- Barkley RA (2015). Emotional dysregulation is a core component of ADHD In Barkley RA (Ed.), *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment* (pp. 81–115). New York, NY: Guilford Press.
- Beery KE, Buktenica NA, & Beery NA (2010). *The Beery–Buktenica developmental test of visual–motor integration: Administration, scoring, and teaching manual* (6th ed.). Minneapolis, MN: Pearson.
- Ben-Zeev S (1977). The influence of bilingualism on cognitive strategy and cognitive development. *Child Development*, 48, 1009–1018.
- Bialystok E (2001). *Bilingualism in development: Language, literacy, and cognition*. Cambridge, UK: Cambridge University Press.
- Bialystok E (2011). Reshaping the mind: The benefits of bilingualism. *Canadian Journal of Experimental Psychology/Revue Canadienne de Psychologie Expérimentale*, 65, 229–235. [PubMed: 21910523]
- Bialystok E (2017). The bilingual adaptation: How minds accommodate experience. *Psychological Bulletin*, 143, 233–262. [PubMed: 28230411]
- Bialystok E, Craik F, & Luk G (2012). Bilingualism: Consequences for mind and brain. *Trends in Cognitive Sciences*, 16, 240–250. doi:10.1016/j.tics.2012.03.001 [PubMed: 22464592]

- Bialystok E, & Feng X (2009). Language proficiency and executive control in proactive interference: Evidence from monolingual and bilingual children and adults. *Brain and Language*, 109, 93–100. doi:10.1016/j.bandl.2008.09.001 [PubMed: 18834625]
- Bialystok E, Hawrylewicz K, Wiseheart M, & Toplak M (2017). Interaction of bilingualism and Attention-Deficit/Hyperactivity Disorder in young adults. *Bilingualism: Language and Cognition*, 20, 588–601. doi:10.1017/S1366728915000887
- Bialystok E, & Viswanathan M (2009). Components of executive control with advantages for bilingual children in two cultures. *Cognition*, 112, 494–500. doi: 10.1016/j.cognition.2009.06.014 [PubMed: 19615674]
- Bussing R, Fernandez M, Harwood M, Hou W, Garvan CW, Eyberg SM, & Swanson JM (2008). Parent and teacher SNAP-IV ratings of attention deficit hyperactivity disorder symptoms: Psychometric properties and normative ratings from a school district sample. *Assessment*, 15, 317–328. [PubMed: 18310593]
- Egeland J, Ueland T, & Johansen S (2012). Central processing energetic factors mediate impaired motor control in ADHD combined subtype but not in ADHD inattentive subtype. *Journal of Learning Disabilities*, 45, 361–370. doi:10.1177/0022219411407922 [PubMed: 21685345]
- Esposito AG, Baker-Ward L, & Mueller ST (2013). Interference suppression vs. response inhibition: An explanation for the absence of a bilingual advantage in preschoolers' Stroop task performance. *Cognitive Development*, 28, 354–363. [PubMed: 24453405]
- Fan L, Gau SS, & Chou T (2014). Neural correlates of inhibitory control and visual processing in youths with attention deficit hyperactivity disorder: A counting Stroop functional MRI study. *Psychological Medicine*, 44, 2661–2671. doi:10.1017/S0033291714000038 [PubMed: 24451066]
- Friesen DC, Latman V, Calvo A, & Bialystok E (2015). Attention during visual search: The benefit of bilingualism. *International Journal of Bilingualism*, 19, 693–702. doi:10.1177/1367006914534331
- Garratt LC, & Kelly TP (2008). To what extent does bilingualism affect children's performance on the NEPSY? *Child Neuropsychology*, 14, 71–81. doi:10.1080/09297040701218405 [PubMed: 17852119]
- Hoff E (2013). Interpreting the early language trajectories of children from low-SES and language minority homes: Implications for closing achievement gaps. *Developmental Psychology*, 49, 4–14. [PubMed: 22329382]
- Kaufman AS, Kaufman NL, & Breaux KC (2014). *Kaufman Test of Educational Achievement (KTEA-3) technical & interpretive manual* (3rd ed.). Bloomington, MN: Pearson.
- Korkman M, Kirk U, & Kemp S (2007). *NEPSY-II: A developmental neuropsychological assessment* (2nd ed.). San Antonio, TX: Psychological Corporation.
- Krizman J, Marian V, Shook A, Skoe E, & Kraus N (2012). Subcortical encoding of sound is enhanced in bilinguals and relates to executive function advantages. *Proceedings of the National Academy of Sciences*, 109, 7877–7881.
- Luk G, & Bialystok E (2013). Bilingualism is not a categorical variable: Interaction between language proficiency and usage. *Journal of Cognitive Psychology*, 25, 605–621. [PubMed: 24073327]
- Mor B, Yitzhaki-Amsalem S, & Prior A (2015). The joint effect of bilingualism and ADHD on executive functions. *Journal of Attention Disorders*, 19, 527–541. doi:10.1177/1087054714527790 [PubMed: 24681900]
- Ozonoff S, & Jensen J (1999). Specific executive function profiles in three neurodevelopmental disorders. *Journal of Autism and Developmental Disorders*, 29, 171–177. doi:10.1023/A:1023052913110 [PubMed: 10382139]
- Portocarrero JS, Burright RG, & Donovan PJ (2007). Vocabulary and verbal fluency of bilingual and monolingual college students. *Archives of Clinical Neuropsychology*, 22, 415–422. doi:10.1016/j.acn.2007.01.015 [PubMed: 17336036]
- Singh L, Fu CS, Rahman AA, Hameed WB, Sanmugam S, Agarwal P, ... Rifkin-Graboi A (2015). Back to basics: A bilingual advantage in infant visual habituation. *Child Development*, 86, 294–302. [PubMed: 25074016]
- Sorge GB, Toplak ME, & Bialystok E (2017). Interactions between levels of attention ability and levels of bilingualism in children's executive functioning. *Developmental Science*, 20(1), e12408.

Weikum WM, Vouloumanos A, Navarra J, Soto-Faraco S, Sebastián-Gallés N, & Werker JF (2007). Visual language discrimination in infancy. *Science*, 316, 1159–1159. [PubMed: 17525331]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Figure 1.
Flowchart depicting the sample selection strategy.

Figure 2.
Distribution of comorbid diagnoses.
Coord = coordination; NOS = not otherwise specified.

Figure 3.
Distribution of SNAP-IV scores across the sample.
SNAP-IV = Swanson, Nolan, and Pelham, Fourth Edition.

Figure 4.
Diagnoses by quartile of attention problems.

Figure 5.
Interaction plot. VMI-Visual = Visual Motor Integration-Visual.

Table 1.

Sociodemographic Characteristics.

	Participants				Analysis
	ML (<i>n</i> = 165)		BL (<i>n</i> = 331)		
Characteristic	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>p</i>
Age, years	10.15	2.90	9.85	2.84	.26
Grade	5.08	3.84	4.50	3.09	.07
IQ (WISC-IV, 5 combined, nonverbal)	95.11	10.77	93.92	10.27	.24
	<i>N</i>	%	<i>N</i>	%	<i>p</i>
Sex					.72
Male	108	65	222	67	
Female	57	35	109	33	
Ethnicity					<.01
Hispanic	57	35	313	95	
Non-Hispanic	106	65	11	5	
Race					<.01
American Indian/Alaskan	1	<1	1	<1	
Asian	1	<1	0	0	
African American	89	61	13	6	
White	32	22	102	50	
More than one	23	16	90	44	
Maternal employment					.053
Employed	99	65	188	62	
Unemployed	53	35	113	38	
Paternal employment					.33
Employed	75	80	199	88	
Unemployed	19	20	26	12	
ADHD diagnosis	107	65	185	56	.06

Note. BL = bilingual; IQ = intelligence quotient; ML = monolingual; WISC-IV, 5 = Wechsler Intelligence Scale for Children, Fourth Edition, Fifth Edition.

Table 2.

Factors Predicting Performance on Neuropsychological Tasks.

Predictor	R^2	β	t
Interference control			
Step 1	0.03		
Age (centered)		-0.12	-1.62
Sex		-0.09	-.22
Ethnicity		-0.95	-1.96
Step 2	0.02		
Language status		0.40	0.68
Attention/hyperactivity		-0.72	-2.36 *
Step 3	0.00		
Language $\times$ attention/hyperactivity		0.17	0.28
Visual processing			
Step 1	0.05		
Age (centered)		-0.82	3.36 **
Sex		-1.48	-1.01
Ethnicity		-2.52	-1.49
Step 2	0.00		
Language status		-1.03	-0.51
Attention/hyperactivity		-0.25	-0.23
Step 3	0.02		
Language $\times$ attention/hyperactivity		5.23	2.43 *
Verbal fluency			
Step 1	0.08		
Age (centered)		-0.51	-1.06
Sex		-1.81	-.62
Ethnicity		9.59	3.10 **
Step 2	0.04		
Language status		-8.45	-1.99 *
Mean attention/hyperactivity		-3.14	-1.56
Step 3	0.00		
Language $\times$ attention/hyperactivity		2.93	0.715

Note. Attention and age scores are centered.

* $p < .05$.

** $p < .01$

Table 3.

Mean Task Scores by Language Group, Controlling for Level of Attention Problems.

	Interference control ^a	Visual processing ^b	Verbal fluency ^b
Monolingual	6.71	97.48	103.59
Bilingual	6.88	95.80	95.14

^a Scaled scores have a mean of 10 and a standard deviation of 3.

^b Standard scores have a mean of 100 and a standard deviation of 15.