Published in final edited form as:

Cognition. 2012 January ; 122(1): 67–73. doi:10.1016/j.cognition.2011.08.003.

Emerging Bilingualism: Dissociating Advantages for Metalinguistic Awareness and Executive Control

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Abstract

The present studies revealed different factors associated with the reported advantages found in fully bilingual children for metalinguistic awareness and executive control. Participants were 100 children in Study 1 and 80 children in Study 2 in the process of becoming bilingual by attending immersion programs. In both studies, *level of proficiency* in the language of testing was related to performance on metalinguistic tasks and *length of time* in the immersion program was related to performance on executive control tasks. This dissociation is consistent with models of lifespan development that distinguish between representational structure and executive control.

Children who are raised with two languages show advantages over monolingual peers in two domains – metalinguistic awareness (Ben-Zeev, 1977; Cummins, 1978; Galambos & Goldin-Meadow, 1990; Galambos & Hakuta, 1988; Ricciardelli, 1992) and nonverbal executive control (Bialystok & Martin, 2004; Bialystok & Viswanathan, 2009; Carlson & Meltzoff, 2008; Mezzacappa, 2004; Yang, Yang, & Lust, in press). The children in these studies have typically been bilingual from birth, so this research has been unable to determine the point at which developmental patterns diverge for monolingual and bilingual children or which features of the bilingual experience are responsible for the reported effects. The outcomes may depend on the achievement of adequate linguistic proficiency or a particular duration for bilingual experience, factors that would lead to different interpretations of the *mechanism* by which bilingualism affects cognition. In fully bilingual children, these factors are confounded. Here, we examine children who are in the process of becoming bilingual to evaluate these factors separately.

Not all children have the opportunity to learn two languages from home. In immersion education, school instruction takes place in a language different from that normally used in the home, creating a controlled setting in which to study the emergence of bilingualism. These programs develop skill in a second language with no cost to the child's first language (Genesee, 1987). Hence, we assessed children in two different immersion programs in Canada for their development of metalinguistic awareness and executive control to determine the features of the bilingual experience that contribute to performance in each domain as children become bilingual.

Study 1

The children attended a school in which Hebrew is the language of instruction. Children varied in home language background, language proficiency, and length of time spent in this immersion environment.

Method

Participants—Participants were 100 children in Grades 2 and 3. Children can enter the program at any time so participants differ in their competence in each language and experience in this environment. For 65 children, English was the exclusive or predominant language of the home; the remaining children spoke primarily Hebrew or Russian at home. All testing was conducted in English with the exception of Hebrew vocabulary.

Tasks

Background Measures: Parents completed a questionnaire in which they rated the use of English and Hebrew in 23 situations on a 4-point scale in which 0 indicated that language was never used and 3 indicated that language was always used, to a maximum of 69. Receptive vocabulary in English was measured with the Peabody Picture Vocabulary Test (PPVT-III, Dunn & Dunn, 1997, Version A), and Hebrew vocabulary was measured using a Hebrew translation of this test (PPVT-III, Version B). In this test children select a picture from four options to match a word given by the experimenter. The English test is standardized with a mean score of 100 and standard deviation of 15, although the Hebrew translation was not standardized. Non-verbal intelligence was assessed by the matrices subtest of the KBIT-2 (Kaufman & Kaufman, 2004). The test consists of 46 items divided into three sections of increasing difficulty. On each trial, the child was presented with visual stimuli representing either drawings of concrete objects or abstract figures. In the first part of the test the child saw one target drawing at the centre of the page with five drawings below it and was asked to identify the option that matched the target image. In the other two sections the child saw an incomplete matrix of visual stimuli with one stimulus missing, and five options below the display. The task was to choose the stimulus to complete the displayed pattern.

Metalinguistic task: In the Wug task (Berko-Gleason, 1958) children are shown cartoon-like images and given a sentence containing a nonsense word which must be manipulated to conform to morphological rules of English. This test assesses children's ability to apply morphological rules of English to unfamiliar forms, therefore reflecting metalinguistic awareness. The items assess morphological agreement for number, 3rd person singular, past tense, comparative/superlative, present progressive and possessive. The maximum score is 33.

Nonverbal executive control tasks: The first task was a flanker task (Eriksen & Eriksen, 1974) in which black arrows pointing left or right appeared in the center of the screen. Children indicated the direction of the middle arrow by pressing a mouse on the left or right side of the display. There were 2 control blocks of 24 trials each in which a single arrow appeared in the centre of the screen and 1 conflict block of 48 trials consisting of 24 congruent and 24 incongruent trials in which the central arrow was flanked by 4 distractors. Each block was preceded by practice with feedback. Trials began with a fixation cross for 250 ms, followed by the stimulus for 2000 ms or until the child made a response.

The second task was a test of task switching¹. A blue horse and a red cow appeared on the top of the screen, and on each trial, a red horse or blue cow was presented on the bottom center with a visual cue indicating whether it was to be matched by color or shape to the targets. Children responded by touching the correct picture. There were 200 trials across 2 non-switch blocks (25 trials each) and 3 switch blocks (50 trials each). The stimulus remained on the screen until the child made a response, and the next trial started after 1000 ms.

¹This task was programmed by Dr. Nicholas Cepeda.

Global switch cost was calculated as the difference between mean reaction time (RT) of non-switch trials in the switch and non-switch blocks. Local switch cost was calculated as the difference between mean RT of non-switch and switch trials in the switch blocks (Cepeda, Kramer, & Gonzalez de Sather, 2001). Global costs reflect the ability to maintain task sets and show a U-shaped trajectory across lifespan, indicating changes in executive control. In contrast, local switch costs measure changes in specific stimulus-response associations and remain relatively stable across time (Reimers & Maylor, 2005). Because global switch costs index executive control, bilingualism should be associated with smaller global costs but not local costs, as found by Costa, Hernández, and Sebastián-Gallés (2008).

Results and Discussion

Results for the background measures are reported in Table 1. There was a negative correlation between home usage scores for English and Hebrew, $r(83) = -0.71, p < .001$, indicating a distinction between home language environments. Home use of each language correlated with PPVT score in that language (English, $r(83) = 0.42, p < .001$; Hebrew, $r(83) = 0.53, p < .001$), with no correlation across languages, $r(90) = -0.05, n.s.$ Surprisingly, there was no correlation between Hebrew PPVT and the number of years in day school, $r(86) = 0.20, n.s.$, possibly because some children acquired Hebrew at home irrespective of how long they have spent in the program. Degree of balanced bilingualism was calculated as the ratio of Hebrew PPVT score to English PPVT, in which perfect balance would produce a score of 1².

Descriptive statistics for the experimental tasks are presented in Table 2. Incorrect trials were excluded from RT analyses. Distributions of RT were normal for both tasks (skewness < 1).

Three regression models were tested to determine the relation between features of the bilingual experience and the experimental tasks. The dependent variables were the mean Wugs score, flanker effect (incongruent RT - congruent RT), and global switch cost, and for each model, the same independent variables were entered in the same order. Independent variables were selected to represent relevant background features. The first variable entered was age in months, the second was K-BIT standard score to control for nonverbal intelligence, and the third was PPVT English as a measure of English proficiency and to some extent, verbal intelligence. The fourth variable was the balance ratio to determine whether the relative level of bilingualism, as distinct from English proficiency, influenced performance. Finally, the number of years in the school was entered to test the effect of the duration of the bilingual education experience. Since the child's age was entered in the first step, the length of time in the immersion program is independent of time spent in the education system and is specific to experience in this bilingual environment. Note, too, that time in the program is not identical to the time spent using as second language because some children spoke another language at home. Instead, it reflects the length of time in a formal bilingual education environment where both languages are used at a high level.

The regression models are reported in Table 3. For the metalinguistic task, the model explained almost 40% of the variance, $F(5, 83) = 9.74, p < .0001$, with significant contributions from age, intelligence, and English vocabulary. For the flanker test of executive control, the model explained about 25% of the variance, $F(5, 80) = 4.99, p < .0005$, with significant contributions from age, degree of balanced bilingualism, and length of time spent in the bilingual educational environment. There was no relation between global switch cost (or local switch cost) and any predictor variable, $F_s < 1$.

²One child obtained a ratio greater than 1 indicating stronger proficiency in Hebrew, and was excluded from analyses.

All the dependent measures had previously shown precocious development in bilingual children, but the present findings showed that progress in metalinguistic ability and nonverbal executive control were associated with different aspects of the bilingual experience. For the metalinguistic task, performance was related to levels of intelligence and English vocabulary, both plausible predictors given that the test assessed sensitivity to English morphology. In contrast, performance on the flanker test was determined by the *degree* of bilingualism, with both balanced proficiency and time in a bilingual education environment contributing to performance. Although the results of the task-switching test conformed to previous research showing higher global switch costs than local switch costs, there was no relation between performance on this task and any of the independent measures.

These results indicate a dissociation between the factors that predict improvement in a metalinguistic task and an executive control task for children who are becoming bilingual. To determine the generalizability of this pattern, a second study was conducted in which children receiving a different kind of immersion education were given different tests of metalinguistic awareness and executive control.

Study 2

This study was conducted in a private school in which children from primarily English-speaking homes are instructed through French. As in the Hebrew school, children can enter the program at any time and new students are given intensive language instruction. Children were examined at two grade levels using different tasks from those administered in Study 1³.

Method

Participants—Participants were 80 children in Grade 2 ($n = 48$) and Grade 5 ($n = 32$). Descriptive statistics are reported in Table 4. For the majority of children ($n = 38$ in Grade 2; $n = 24$ in Grade 5), English was the exclusive or predominant language of home. About one-third of the children in each grade also had minimal home exposure to a language other than English or French (Chinese, Urdu, Estonian, Italian, Polish, Turkish, Bengali, Persian, or Vietnamese) but parents reported children's proficiency in these languages to be “poor” or “fair”.

Tasks—Parents completed a Language Background Questionnaire similar to that used in Study 1. As in Study 1, K-BIT was used to assess fluid intelligence, PPVT to assess English receptive vocabulary, and the standardized French version of PPVT, *Echelle de Vocabulaire en Images Peabody* (EVIP; Dunn, Theriault-Whalen, & Dunn, 1993) to assess French vocabulary. The nonverbal executive control task was the task-switching paradigm from Study 1.

Metalinguistic task: A sentence judgment task incorporating manipulations introduced by Bialystok (1986) assessed metalinguistic awareness. Sentences from Atchley and colleagues (Atchley et al., 2006) were adapted to build 120 sentence frames that were grammatically correct, grammatically incorrect but meaningful, or semantically anomalous but grammatical. Thus, a correct sentence such as, “Where does a horse like to run?” could be syntactically incorrect, “Where does a horse like to runs?”, or semantically anomalous, “Where does a horse like to sail?”

³These data were collected as part of another study and then examined for their consistency with the results of Study 1. For that reason, the tasks used were different.

Three stimulus lists were created, each containing 40 sentences for each of the three conditions. Items were counterbalanced such that only one version of each sentence was presented on a given list. Thus, each participant heard 120 sentences. Sentences were recorded by a female speaker in a soundproof booth. Trials began with a fixation cross that appeared for 500 ms after which a sentence was presented auditorally. Children were told to decide if the sentence was said the right way or not (that is, whether it was grammatically correct), even if it was silly, and were trained with 12 practice sentences that included feedback. Two response buttons, counterbalanced for position across participants, were used for the child's judgments of correct or incorrect.

Results and Discussion

Results of background measures are reported in Table 4 and descriptive statistics for the experimental tasks are presented in Table 5. RT data were normally distributed for Grade 5 (skewness < 1) but not in Grade 2 (skewness = -2.3) so those results must be interpreted with caution.

Two regression models, reported in Table 6, were tested for each grade using sentence judgment accuracy (Grade 2) or RT (Grade 5) and global switch cost as the dependent variables⁴. Independent variables were entered in the same order as in Study 1. For accuracy on the metalinguistic test in Grade 2, the model explained about 42% of the variance, $F(5, 40) = 5.75, p < .0001$, with significant contribution only from English vocabulary; for RT on this task in Grade 5, the model explained about 41% of the variance and again, only English vocabulary was significant. Unlike Study 1, age was not significant, presumably because the range of ages in this study was smaller.

For global switch cost in Grade 5, the model explained about 30% of the variance. Although the overall model was not significant, $F(5, 18) = 1.52, n.s.$, there was a significant contribution from time spent in the bilingual environment, $t = -2.16, p < .04$. Because the model may not have had sufficient power for the number of variables (because of the small sample size), a simpler model consisting only of nonverbal intelligence and time spent in the school was run. This model explained 24.3% of the variance, $F(2, 24) = 3.84, p < .04$, with a significant contribution from time in the program, $t = -2.77, p < .01$. None of the models testing predictors of global switch cost was significant in Grade 2. As in Study 1, there was no relation between local switch cost and any predictor variable, $F_s < 1$.

General Discussion

The present studies aimed to identify features of the bilingual experience that contribute to performance on metalinguistic and executive function tasks as children become bilingual. The results of the regression analyses were remarkably consistent: metalinguistic performance improved with increased knowledge of the language of testing and executive control performance improved with increased experience in a bilingual education environment. This pattern was found across different samples of children in different types of immersion education programs performing different tasks. The consistency of these results is shown in Figure 1 indicating the relation between the predictor and outcome groups of factors in the two studies. This dissociation between factors in the regression models associated with metalinguistic awareness and executive control has implications for three issues.

⁴RT in Grade 2 was too long to interpret and accuracy in Grade 5 was too close to ceiling.

First, these findings extend previous research demonstrating a benefit of bilingualism on children's executive control by calibrating improvements in executive function tasks to the time spent in a bilingual education program. Although many studies have shown that fully bilingual children outperform monolingual children in executive function tasks (Bialystok, 2005), this benefit has not been found for children in immersion programs (Bialystok & Majumder, 1998; Carlson & Meltzoff, 2008). It may seem, then, that fully balanced bilingualism is necessary for modifications in executive functioning to be observed. The present studies show that is not the case: the accumulation of experience in a formal bilingual setting contributes to the development of executive control for those children. Similarly, a recent study with adults shows a relationship between number of years spent actively bilingual and decreased cost in the flanker effect (Luk, de Sa, & Bialystok, in press). Thus, the bilingual profile for executive control in both children and adults emerges with experience in a bilingual environment.

Second, the results advance our understanding of the relationship between bilingualism and metalinguistic performance. Unlike executive control, metalinguistic advantages have been reported at modest levels of bilingualism (Bialystok, 1988; Bialystok & Majumder, 1998; Yelland, Pollard, & Mercuri, 1993). What made children progress further in this development, however, was not more bilingualism but more language proficiency. It is not surprising that knowledge of English was associated with metalinguistic performance in English; that relation would be expected in monolingual children as well. What is surprising is that being "more bilingual" did not further advance this performance. How then do we interpret the metalinguistic advantages reported in the literature for bilingual children? One possibility is that bilingualism gives children a boost into figuring out structural relations within language but beyond that initial insight, more bilingual experience does not move that development forward. This may explain why bilingual advantages in phonological awareness disappear in first grade when reading is introduced (Bruck & Genesee, 1995) and metalinguistic advantages in bilingual children depend on such factors as the relation between the languages and the language of education (Barac & Bialystok, in press; Bialystok, Majumder & Martin, 2003).

Finally, the results contribute to understanding the mechanism by which bilingualism affects cognitive and linguistic outcomes by pointing to two aspects of bilingual experience as being responsible for developmental differences between monolingual and bilingual children. The outcomes of bilingualism depend on both the achievement of adequate linguistic proficiency and experience over a sufficient amount of time using two languages. These factors can be understood in terms of the distinction proposed by Bialystok (1993, 2001) between the representational structure of knowledge and control of attention. Cognitive development proceeds as children build more structured *representations* of knowledge and gain greater *control* over attentional procedures, a framework that applies equally to cognitive change across the lifespan (Baltes, 1987; Craik & Bialystok, 2006). However, each of these processes may be promoted by different experiences. Representational structure is sensitive to increasing knowledge; metalinguistic tasks place a premium on linguistic representations, so to the extent that knowing two languages enhances knowledge of abstract linguistic structure, bilingualism improves metalinguistic performance. It is the absolute level of linguistic knowledge and not the relative degree of bilingualism that is most important in this development. Control, in contrast, is sensitive to accumulating experience; executive control tasks rely on domain-general systems that are also recruited in bilingual language processing, but it takes time for these systems to reach sufficient levels to influence non-linguistic domains. Hence, the length of time in a bilingual environment determines the extent to which executive control is affected. Thus, the two domains for which bilingual advantages have been documented are influenced by different aspects of experience – the representation of linguistic systems in the case of metalinguistic

awareness and the accumulated practice of attentional procedures for language selection in the case of executive control.

These results provide a framework for understanding the relation between experience and ability in children's development. Children in the process of becoming bilingual are a fertile test case for examining the mechanisms that promote development not only in bilingual children but also in general as children accumulate experience and build knowledge.

Acknowledgments

This research was partially supported by grant R01HD052523 from the US National Institutes of Health and by grant A2559 from the Natural Sciences and Engineering Research Council of Canada to EB. We thank Ava Klemensberg for her assistance in setting up Study 1 and collecting the data, and Sylvain Moreno and Kathleen Peets for their contribution to the design of Study 2. Lynn Luo and Deanna Friesen provided valuable comments on an earlier version of the manuscript.

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Metalinguistic Tasks**Study 1 Wugs: R Sq = 38.4%** Executive Control Tasks**Study 1 Flanker: R Sq = 25%** **Study 2 Judgment: R Sq = 40.9%** **Study 2 GSC: R Sq = 29.7%**

Figure 1.
Percentage of variance related to language proficiency and degree or duration of bilingualism for metalinguistic and executive control tasks in the two studies.

Table 1
Descriptive statistics for background measures in Study 1^a

Variable	N	Mean	SD
Age in months	100	98	6.6
PPVT English (Standard)	100	103.1	13.4
PPVT Hebrew	90	48.0	10.1
Balance ratio	89	0.47	0.13
K-BIT (Standard)	98	104.3	15.3
Home English ^b	83	62.5	12.0
Home Hebrew ^b	83	8.1	13.4
Years in day school	83	4.7	1.3

^a Some children did not complete all tasks and 17 parents did not complete the language background questionnaire.

^b Home English and Home Hebrew are scores out of 69 indicating the extent to which that language is used in the child's environment.

Table 2
Mean (and standard deviation) number correct for Wugs task and mean reaction time
(and standard deviation) for (flanker task and switch costs for task switching in Study 1

Task	Condition	N	Mean	SD
Wugs (max = 33)		97	22.7	5.5
Flanker Accuracy	Control	96	95%	8
	Congruent	96	95%	9
	Incongruent	96	90%	18
Flanker RT (ms)	Control	96	563	97
	Congruent	96	693	138
	Incongruent	96	735	179
Task switching costs (ms)	Local cost	92	109	362
	Global cost	92	603	457

Table 3
Regression models showing variables affecting performance in Wugs task and flanker task in Study 1

Variable	B	SE B	β	ΔR^2	t
(a) Wugs task: $R^2 = 38.4\%$					
Age	0.27	0.08	0.30	12.8%	3.20**
K-BIT	0.10	0.04	0.26	12.8%	2.90**
PPVT English	0.14	0.04	0.34	11.8%	2.55**
Balance	0.02	0.03	0.07	0.1%	-0.44
Years in School	0.85	1.02	0.08	1.0%	1.10
(b) Flanker task: $R^2 = 25.0\%$					
Age	-5.05	2.06	-0.26	13.7%	-2.46**
K-BIT	-1.01	0.87	-0.12	0.5%	-1.17
PPVT English	2.29	1.24	0.25	0.0%	1.86
Balance	-261.03	122.99	-0.28	2.7%	-2.12*
Years in School	-69.95	24.50	-0.30	8.2%	-2.91**

* $p < .05$

** $p < .001$

Table 4
Descriptive statistics for background measures in Study 2

Variable	Grade 2			Grade 5		
	N	Mean	SD	N	Mean	SD
Age in months	48	92.9	3.4	32	127.7	4.1
PPVT English (Standard)	47	112.8	13.4	32	114.3	18.5
EVIP French (Standard)	48	83.8	15.8	28	79.8	18.6
Balance	47	0.74	0.1	28	0.69	0.2
K-BIT (Standard)	47	105.2	19.1	32	106.3	12.2
Home language environment ^a	48	15.4	6.7	32	15.2	6.7
Months in the program	48	36.2	17.7	32	55.9	27.3

^a Home language environment represents a cumulative score that incorporates 9 variables such as home language spoken by the child and home language spoken to the child. Each of the 9 variables is quantified using a 5-point scale where 1 represents the exclusive use of English, 5 represents the exclusive use of the non-English language and 3 represents a balanced use of the two languages. Consequently, the values for the home language environment variable can range between a minimum of 9 indicating a monolingual environment in English and a maximum of 45 indicating exclusive use of the non-English language.

Table 5
Mean (and standard deviation) accuracy and reaction time for sentence judgment task and mean reaction time (and standard deviation) for switch costs in task switching task

Task	Grade 2				Grade 5			
	Condition	N	Mean	SD	N	Mean	SD	
Sentence Judgment Proportion correct		50	0.76	0.17	33	0.88	0.12	
Sentence Judgment		50	3197	536	33	2821	256	
Reaction time								
Task switching costs (ms)	Local cost	46	189	353	28	82	169	
	Global cost	46	724	649	28	464	237	

Table 6
Regression models showing variables affecting performance on (a) sentence judgment task accuracy in Grade 2, (b) sentence judgment RT in Grade 5, (c) global switch costs in Grade 5, and (d) the reduced model for global switch costs in Study 2

Variable	B	SE B	β	ΔR^2	t
(a) Grade 2 Sentence judgment accuracy: $R^2 = 41.83\%$					
Age	0.008	0.006	0.15	1.44%	1.22
K-BIT	0.0001	0.001	0.01	1.52%	0.09
PPVT English	0.008	0.002	0.62	37.03%	4.73**
Balance	-0.17	0.19	-0.12	1.74%	-0.91
Months in the program	-0.0004	0.001	-0.04	0.11%	-0.27
(b) Grade 5 Sentence judgment RT: $R^2 = 40.92\%$					
Age	4.05	7.88	0.09	4.59%	0.51
K-BIT	-1.11	2.89	-0.07	5.74%	-0.38
PPVT English	-6.33	2.28	-0.55	29.59%	-2.78**
Balance	84.26	236.06	0.07	0.06%	0.36
Months in the program	-0.78	1.36	-0.11	0.93%	-0.57
(c) Grade 5 Global switch cost: $R^2 = 29.71\%$					
Age	14.95	11.14	0.27	8.89%	1.34
K-BIT	-0.28	4.40	-0.01	2.24%	-0.06
PPVT English	2.68	3.27	0.19	0.22%	0.82
Balance	194.79	350.43	0.12	0.20%	0.56
Months in the program	-4.08	1.89	-0.48	18.15%	-2.16*
(d) Grade 5 Global switch cost: $R^2 = 24.23\%$					
K-BIT	-1.38	3.52	-0.07	0.08%	-0.39
Months in the program	-4.36	1.58	-0.49	24.15%	-2.77*

* $p < .05$

** $p < .001$