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The effects of bilingualism on toddlers' executive functioning

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Abstract

Bilingual children have been shown to outperform monolingual children on tasks measuring executive functioning skills. This advantage is usually attributed to bilinguals' extensive practice in exercising selective attention and cognitive flexibility during language use because both languages are active when one of them is being used. We examined whether this advantage is observed in 24-month-olds who have had much less experience in language production. A battery of executive functioning tasks and the cognitive scale of the Bayley test were administered to 63 monolingual and bilingual children. Native bilingual children performed significantly better than monolingual children on the Stroop task, with no difference between groups on the other tasks, confirming the specificity of bilingual effects to conflict tasks reported in older children. These results demonstrate that bilingual advantages in executive control emerge at an age not previously shown.

Keywords

Attention; Cognition; Concepts; Information processing; Language (bilingual); Problem solving

Introduction

There has long been interest in determining whether bilingualism leads to linguistic or cognitive differences in both children and adults. Research over the past two decades has revealed a number of differences that emerge from growing up with at least two languages (Bialystok, 2009a; Grosjean, 1989). In the most general terms, bilingualism leads to the development of strategies that are adaptive to the unique problem space with which bilingual infants are faced. During the early stages of language acquisition, for example, recent research on speech perception in bilingual and monolingual infants has shown that bilingual infants learn similar sounding words in a word learning task a few months later than monolinguals (Fennell, Byers-Heinlein, & Werker, 2007). However, bilingual infants of the

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same age can outperform monolinguals in learning word–object associations when the phonetic conditions favor their input (Mattock, Polka, Rvachew, & Krehm, 2010).

Research on vocabulary development in bilingual first language acquisition has shown that bilingual children produce their first words at around the same time as monolingual children (Genesee, 2003; Patterson & Pearson, 2004; Petitto et al., 2001). However, the evidence for differences in vocabulary development in bilingual and monolingual children is mixed, depending on the ages of the children and whether receptive or productive vocabulary is assessed. A smaller receptive vocabulary in each language compared with monolinguals has been reported in samples of preschool- and school-aged children (Bialystok, Barac, Blaye, & Poulin-Dubois, in press; Bialystok, Luk, Peets, & Yang, 2010; Mahon & Crutchley, 2006), but other studies have shown that the receptive vocabulary of school-aged children is close to that of monolinguals (Cromdal, 1999; Yan & Nicoladis, 2009). With respect to measuring expressive language, school-aged bilinguals tend to have a smaller vocabulary even when both languages are combined (Yan & Nicoladis, 2009). In younger bilinguals (<3 years of age), receptive and expressive vocabulary have been reported to be comparable to that of monolinguals when total or conceptual (total minus translation equivalents) vocabularies are compared even if very young bilinguals tend to have fewer words in each of their productive languages (Junker & Stockman, 2002; Oller & Eilers, 2002; Pearson, Fernández, & Oller, 1993, 1995; Petitto & Kovelman, 2003).

Bilingualism also brings linguistic and cognitive advantages. Early studies showed that bilingual children performed better than monolingual children on a variety of tests of metalinguistic awareness (Ben-Zeev, 1977; Bialystok, 1987, 1988; Edwards & Christophersen, 1988; Galambos & Goldin-Meadow, 1990; Yelland, Pollard, & Mercuri, 1993). Although impressive, it is not completely surprising that a linguistic experience such as bilingualism would lead to an enhanced understanding of the structure and properties of language. More surprising is the evidence showing that bilingualism also leads to the precocious development of cognitive processes not confined to linguistic tasks. In a comprehensive review of the research on cognitive differences between bilingual and monolingual children, Bialystok (2001) concluded that there is growing evidence that bilingual children outperform monolingual children on a variety of tasks that require selective attention and cognitive flexibility tasks. Inhibitory processes are instrumental in such tasks because attention to misleading aspects of a stimulus must be suppressed to attend to the relevant ones. The inhibitory control recruited in such conflict situations is a key element of the executive function, a set of processes that are responsible for the conscious control of thought and action (Miyake et al., 2000; Posner & Rothbart, 2000). Other components of executive function include shifting of mental sets, updating information in working memory, and planning ability. Executive functioning shows age-related improvements well into adolescence, but the most significant enhancements happen during the preschool period (Carlson, 2005; Zelazo & Müller, 2002).

Research with children (Bialystok, 2005) and adults (Bialystok, Craik, Klein, & Viswanathan, 2004) has shown that bilinguals show better control over these executive processes than their monolingual counterparts. In children as young as 4 years of age, this advantage has been demonstrated with a range of tasks typically used to assess executive

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functioning. For example, Bialystok and her colleagues demonstrated a bilingual advantage in 4- and 5-year-olds using the Dimensional Change Card Sort (DCCS), a task in which children are given a series of cards to sort by one of two dimensions (color or shape) and then are asked to switch and sort by the other dimension (Bialystok, 1999; Bialystok & Martin, 2004). Thus, children need to ignore the color of the stimulus and attend to its shape to classify the cards correctly. This bilingual advantage in selectively attending to one cue in the context of a conflicting cue has also been reported for the Simon task (spatial conflict between stimulus and response) (Martin-Rhee & Bialystok, 2008), the ambiguous figure task (conflict between competing interpretations of a line drawing) (Bialystok & Shapero, 2005), and the global–local task (spatial competition between overall and constituent shapes) (Bialystok, 2010). A recent study by Carlson and Meltzoff (2008) comparing English–Spanish bilinguals with English 6-year-old monolinguals tested the generality of a bilingual advantage to a wide range of executive function measures by administering a battery of tasks. The main findings revealed a significant bilingual advantage on tasks that call for managing conflicting attentional demands (conflict tasks) but no such advantage on impulse control (delay tasks). It is noteworthy that the effect was robust even after controlling for socioeconomic factors such as parent education level. This pattern of findings suggests that conflict inhibition plays a role in the link between bilingualism and executive function and that precocious effects of bilingualism in executive functioning should be found in conflict tasks but not necessarily in delay tasks.

The prevailing interpretation of the bilingual advantage in executive control is that bilinguals have extensive practice in exercising selective attention and cognitive flexibility. This practice effect is assumed to derive from the fact that both languages are active when one of them is being used (Beauvillain & Grainger, 1987; Colomé, 2001; Costa, 2005; De Groot, Delmaar, & Lupker, 2000; Green, 1998; Rodriguez-Fornells et al., 2005). The management of attention to the target language may take place either by lowering the activation of the nontarget language (Finkbeiner, Gollan, & Caramazza, 2006) or by using domain-general suppression mechanisms to inhibit the nontarget language (Green, 1998). Empirical evidence for the effect created by the activation of two competing language systems comes from a number of sources. First, bilingual adults tend to name pictures more quickly and with fewer tips of the tongue when they know the translation equivalents (Finkbeiner et al., 2006; Gollan & Acenas, 2004; Gollan, Montoya, Fennema-Notestine, & Morris, 2005). This facilitory translation effect has recently been replicated with bilingual toddlers (Poulin-Dubois, Bialystok, Blaye, Polonia, & Yott, 2010). In a study on bilingual toddlers using event-related potentials (ERPs), Conboy and Mills (2006) reported differences in ERP latencies, amplitudes, and scalp distributions across mixed-language versus single-language conditions even after controlling for age and vocabulary size. Second, a recent study on bimodal bilinguals, a special population of bilinguals forwhomthere is less conflict for selection, supports the conflict hypothesis with behavioral evidence. Bimodal bilinguals are speech–sign bilinguals who frequently replace code blending (signs produced simultaneously with spoken words) with code switching (changing from one language to another) because both languages can be produced simultaneously (Emmorey, Borinstein, Thompson, & Gollan, 2008). Using a flanker task in which inhibition of attention to an irrelevant stimulus was required for efficient performance, speech

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bilinguals performed more rapidly than monolinguals, but bimodal bilinguals performed the same as monolinguals (Emmorey, Luk, Pyers, & Bialystok, 2008). Presumably, the opportunity for code blending reduces the conflict and decreases the need for executive control in managing language production.

Across a range of studies investigating a variety of abilities, it is clear that bilingualism is an experience that has significant consequences for cognitive performance. However, until recently, research on the cognitive performance of bilingual children had been tested only in children above 4 years of age. At what point do the inhibition and selective attention abilities of bilingual children deviate from the developmental trajectory of monolingual children? In one study, Bialystok and colleagues (in press) reported that 3-year-old bilinguals outperformed monolinguals on three tests of executive functioning, and new evidence has been reported suggesting that even 7-month-old bilinguals show a cognitive benefit in a switch task that requires inhibitory control (Kovacs & Mehler, 2009). However, these intriguing findings are based on a single task, and the percentage of exposure to the second language was not specified. More important, a recent study based on a similar paradigm with 8-month-old Spanish–Catalan bilinguals reported that both bilinguals and monolinguals were able to inhibit looking at the wrong location, although bilinguals showed a slight tendency to show inhibition earlier (Ibanez-Lillo, Pons, Costa, & Sebastian-Galles, 2010). These new results raise the exciting possibility that cognitive modifications from two environmental languages can be detected during the first 2 years of life. The current study contributes to this new direction by comparing 24-month-old bilinguals and monolinguals on a large battery of executive functioning tasks adapted for that age (Carlson, 2005) and documenting more complete information about the language history and cognitive level of the children than is usually undertaken in such research.

For the management of attention to two languages to lead to modifications in executive functioning, it would be necessary for children to differentiate between the two languages. There is evidence supporting the claim that bilingual children develop differentiated grammatical systems from the very beginning (Meisel, 2001). Prior to grammatical differentiation, research on early lexical development has shown that young bilingual children acquire translation equivalents or doublets (words in each language that have the same referent) from the time they first begin to speak or by the middle of the second year (Genesee & Nicoladis, 2007). The presence of a sizable set of doublets in very young bilinguals supports the hypothesis that bilinguals have two distinct lexical systems, making it necessary to switch across the two systems (Patterson & Pearson, 2004).

Further evidence for the distinct lexical systems during the early stages of language development in bilingual children comes from research on code mixing. Bilingual children in the one- and early two-word stages of language development are able to adjust their language use appropriately with parents who speak only their native or dominant language with them as well as with strangers (Comeau, Genesee, & Lapaquette, 2003; Genesee, Boivin, & Nicoladis, 1996; Nicoladis & Genesee, 1996; Petitto et al., 2001). The ability to make on-line adjustments to accommodate interlocutors' language preferences or abilities confirms that language switching experience starts early in bilingual development. Finally, in the area of speech perception, discrimination and separation of bilingual infants' two

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languages have recently been demonstrated, suggesting that separate representations for each language might begin within the first year of life (Bosch & Sebastián-Gallés, 1997; Byers-Heinlein, Burns, & Werker, 2010; Werker & Byers-Heinlein, 2008).

Taken together, these findings on the language abilities of very young bilingual children suggest that language organization differs in monolingual and bilingual infants and that separation of the two language systems is evident very early in language acquisition. Whether these nascent differences in perception and production involve practicing inhibition in the same way as required by language production in older children and adults remains unknown. Nevertheless, the combined evidence that by 24 months of age bilingual children have already separated their two languages and have already gained some experience in switching between their two languages leads to the prediction that cognitive benefits of bilingualism should be observed much earlier than previously reported.

Method

Participants

A total of 75 children were tested. Of these, 6 were excluded due to fussiness, 1 was excluded due to language delay, and 5 were excluded because their dominant language (L1) was neither English nor French. The remaining 63 children were divided into monolinguals and bilinguals based on exposure to their L1. Children whose exposure to their L1 was equal to or greater than 80% were included in the monolingual group (n = 30, 12 French speaking and 18 English speaking, mean age = 24.4 months, SD = 0.8, 15 girls and 15 boys). Percentages of exposure to a second language (L2) varied from 0 to 19.2% (M = 7.2, SD = 6.7). Children whose exposure to their L1 was less than 80% were included in the bilingual group (n = 33, mean age = 24.1 months, SD = 0.8, 20 girls and 13 boys). The average percentage of exposure to their L2 was 35.5% (range = 20.2–49.5). Bilinguals were exposed to their L2 for an average of 38.6 h per week. Monolinguals' average exposure to a second language was 5.7 h per week. Because the participants lived in a multilingual city, the selection criterion is similar but somewhat less conservative than the one used in other early bilingualism studies (David & Wei, 2008; Pearson, Fernandez, Lewedeg, & Oller, 1997). Nearly all of the children were from Caucasian families who lived in the same middle-class neighborhood in a large Canadian city. All bilinguals had been exposed to two languages from birth. Based on exposure data, French or English was the L1 for all bilingual children (n = 19 English and n = 14 French), and 6 children had a language other than French or English as their L2 (n = 1 Hebrew, n = 1 Turkish, and n = 4 Italian).[1] Mean maternal education was 17.1 years (SD = 2.3) in monolingual families and 17.8 years (SD = 3.1) in bilingual families, $t(60) = 0.98$, *ns*, $d = 0.26$. Families were recruited through birth lists. Parents were given $50 for completing both laboratory visits with their children and completing the questionnaires. Children were given a small gift for their participation.

[1]Although a perfectly homogeneous bilingual group would have been desirable, multiple language pairings increase the generalizability of the data. All of the main analyses were done with and without these 6 children, and the results were the same.

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Procedure and measures

Children visited the laboratory with their parents on two occasions that lasted approximately 1 h each. Sessions were scheduled a maximum of 2 weeks apart, with an average of 1 week. During the first session, parents completed a language exposure interview and children were administered five executive functioning tasks with the parents sitting behind them to minimize interference. During the second visit, the same experimenter administered the cognitive scale of the Bayley Scales of Infant and Toddler Development (BSID-III) (Bayley, 2006). All tasks were administered in the children's L1. Parents were also asked to complete the MacArthur–Bates Communicative Development Inventory: Words and Sentences (MCDI) between the two visits and to return them on the second visit (Fenson et al., 1993).

Language exposure questionnaire

At the beginning of the first laboratory visit, parents completed a language exposure interview with the experimenter. Infants' language exposure was measured by the Language Exposure Questionnaire, which has been used to classify bilinguals in previous published research (Bosch & Sebastián-Gallés, 1997; Fennell et al., 2007). The questionnaire requires parents to provide precise estimates of their infants' exposure to both languages. An estimate is given for each major caregiver in an infant's life (e.g., parents, grandparents, child-care workers), which is critical for quantifying bilingual exposure (De Houwer, 1995). A global estimate of percentage of exposure was determined for each of the languages to which the child was exposed.

Vocabulary measures

The MCDI questionnaire was completed by parents to obtain measures of total vocabulary for both monolingual and bilingual infants as well as the proportion of translation equivalents present in bilingual infants' vocabulary (Fenson et al., 1993). Translation equivalents are pairs of words that children know in both their L1 and L2. If a word in one language had more than one translation in the other language and a child knew both translations, this was counted as two translation equivalents. The original American English MCDI, used in the current study, is a parent-report vocabulary checklist consisting of 680 words containing nouns, verbs, and adjectives that measures children's language production. Parents were instructed to indicate which words their children had used in the past. The French Canadian adaptation (Trudeau, Frank, & Poulin-Dubois, 1999) was used to measure vocabulary and translation equivalents of the monolingual and bilingual French-speaking children. The Hebrew (Maital, Dromi, Sagi, & Bornstein, 2000), Italian (Caselli & Casadio, 1995), and Turkish (Küntay et al., 2009) adaptations of the MCDI were used to measure the translation equivalents of the six children whose L2 was one of these languages. The proportion of translation equivalents for each child was calculated by multiplying the total number of translation equivalents by 2, dividing this number by total vocabulary (L1 + L2), and then subtracting the cognates (e.g., *soup* vs. *soupe*), semicognates (e.g., *mittens* vs. *mitaines*), and nonequivalents. A nonequivalent is a word that does not have a translation in a child's L2.

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Executive functioning tasks

The five executive functioning tasks used were modified from a battery of tasks that has been used to assess executive functioning abilities in toddlers (Carlson, 2005). The battery included both delay and conflict categories of executive function, allowing a comparison with studies that reported a benefit only for the latter (Carlson & Meltzoff, 2008). The tasks were presented in a fixed order (Multilocation, Shape Stroop, Snack Delay, Reverse Categorization, and Gift Delay) that alternated difficulty levels. All responses were recorded.

Conflict tasks

Multilocation—This task was originally designed by Zelazo, Reznick, and Spinazzola (1998). A wooden box with five drawers side by side was shown to the child. The far left, far right, and center drawers had different animal knobs (e.g., a giraffe). The other two drawers did not have knobs and were locked. The experimenter first put a treat (a goldfish cracker) in the middle drawer out of the child's view, told the child where it was hidden, and then showed the child how to get the cracker. After a second warm-up trial, the preswitch training started. The experimenter hid a cracker in the middle drawer, pointed to the correct location and said "the treat is here," and pointed to each of the wrong drawers sequentially and said "the treat is not here." She then covered the box with an opaque towel, pushed the box toward the child, and asked the child to find the treat. This procedure was repeated until the child opened the middle drawer first three times in a row or for a maximum of 8 trials. During the postswitch phase of the experiment, the treat was hidden in a different location and a 10-s delay was imposed before inviting the child to find the treat. As in the preswitch trials, the child was told where the correct location of the treat was. Trials were repeated until the child opened the correct new drawer first. The number of trials required for the child to look at the correct postswitch location first was coded.

Shape Stroop—This task was adapted from Kochanska, Murray, and Harlan (2000). The experimenter aligned three colored images of fruits (apple, banana, and orange) and placed smaller images of the same fruits below. She labeled each of the six images by size and name (e.g., "Look! I have a big apple and a little apple"). She then removed the small images and asked the child to point to each of the fruits (e.g., apple) and congratulated the child for correct answers and corrected his or her mistakes. This was the identification phase. During the following Stroop phase, the experimenter placed images of the small fruits embedded in different larger fruits such that each of the three original fruits (apple, banana, and orange) was represented in a small size and a big size but never on the same image (e.g., a small banana in a big apple). The child was asked to point to each of the small fruits (e.g., "Show me the small apple"). No feedback was given. Proportions of correct responses in the identification and Stroop phases were recorded.

Reverse Categorization—In this task (adapted from Carlson, Mandell, & Williams, 2004), two different-sized buckets were presented to the child as the "small and big buckets" and then put away. The child was then presented with 12 cubes (6 small and 6 big) and given approximately 1 min to play with the blocks. The blocks were then removed and the buckets were placed back on the table, one on each side of the experimenter. The

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experimenter demonstrated, along with a verbal explanation, putting the big blocks in the big bucket and putting the small blocks in the small bucket. She then asked the child for his or her help over 6 trials. For each trial, the experimenter repeated the rule and then identified the current block, gave it to the child, and placed the two buckets in front of the child. The child was given positive feedback or was corrected depending on his or her response. Next, the experimenter proposed playing a "silly game" and suggested that they put the big blocks in the small bucket and the small blocks in the big bucket. A total of 12 trials similar to the previous 6 were administered but without any feedback given. The proportions of correct responses in pre- and postswitch trials were recorded.

Delay tasks

Snack Delay—This task was adapted from Kochanska and colleagues (2000). The experimenter placed a piece of cereal on a plastic plate, covered it with a transparent plastic cup, and then offered it to the child. She then told the child that he or she would get more snacks afterward but that for now the child needed to wait for the bell to ring before getting the piece of cereal. This sequence was repeated. The experimenter then administered 4 trials with delay times increasing from 5 to 20 s or until the child ate the treat. The timing began when the plate with the treat and cup was placed in front of the child. The rule about waiting for the bell was repeated prior to every trial, but no feedback was given after the delay time had begun. The number of trials in which the child waited the full delay time and the child's average waiting time were recorded.

Gift delay—Following Kochanska and colleagues' (2000) procedure, on completion of the other tasks, the experimenter congratulated the child for playing well and said that she had a gift for the child. The experimenter then put an attractive gift bag on the table, looked at it, and said, "Oh no, I forgot the bow. I will go get it. Don't open the gift before I come back. Wait for me before opening the gift." The experimenter left the room for 3 min or until the child took the gift out of the bag. The length of time that the child delayed touching the bag and taking out the gift was recorded.

Results

We first analyzed the vocabulary and Bayley scores of the two language groups to compare their basic language and cognitive skills. The MCDI was available in both L1 and L2 for 27 of the 33 bilingual children. As expected, the groups differed significantly on verbal ability as measured by vocabulary in L1. Monolingual children produced an average of 338.6 words (SD = 162.7), whereas bilingual children produced an average of 193.4 words (SD = 142.9), $t(55) = 3.56$, $p < .00$, $d = 0.95$. The two groups had a similar vocabulary size when all words from L1 and L2 were combined for the bilingual group (M = 292.1, SD = 215.4), $t(55) = 0.93$, *ns*, $d = 0.24$, but bilinguals had a smaller total conceptual vocabulary (total vocabulary minus translation equivalents: M = 229.6, SD = 162.9) than monolinguals, $t(55) = 2.52$, $p < .01$. The average proportion of translation equivalents was 36.8% (range = 1.2–72.2). There was no difference between the groups on the Bayley test (monolinguals: M = 11.6, SD = 1.9; bilinguals: M = 10.7, SD = 2.1), $t(55) = 1.75$, $p < .08$, $d = 0.45$, confirming that children in the two groups were equivalent on basic cognitive skills. Finally, children

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were the same age on their first visit (monolinguals: $M = 24.4$, $SD = 0.8$; bilinguals: $M = 24.2$, $SD = 0.7$), $t(55) = 1.16$, *ns*, $d = 1.38$. Because there were no significant effects of gender, all analyses are reported collapsing across gender except for the Gift Delay task.

Multilocation task

The mean number of trials to meet the criterion for passing each phase is reported in Table 1. A two-way analysis of variance (ANOVA) with phase (preswitch vs. postswitch) and language group as between-participant factors was conducted on the mean number of trials to succeed on 3 consecutive trials during the preswitch phase. There was a main effect only of phase, indicating that the two groups performed more poorly on the postswitch trials ($M = 2.2$, $SD = 1.5$) than on the preswitch trials ($M = 3.5$, $SD = 1.2$), $F(1, 57) = 27.15$, $p < .00$, $\eta^2 = .32$.

Shape Stroop task

The mean numbers of correct responses are reported in Table 1. The two-way ANOVA (Phase × Language Group) revealed a main effect of phase as well as an interaction between phase and language group, $F(1, 53) = 4.04$, $p < .05$, $\eta^2 = .07$. Post hoc pairwise comparisons between the scores revealed that the performances of the two groups were equivalent on the pre-Stroop trials but differed on the post-Stroop trials, with bilingual children correctly identifying the small fruit more often than monolingual children ($p < .05$).

Reverse Categorization task

The mean numbers of correct responses during the pre- and postswitch phases are reported in Table 1. The mixed-design two-way ANOVA revealed a main effect of phase but no interaction with language group, $F(1, 28) = 15.14$, $p < .00$, $\eta^2 = .35$. Performances were high and similar for the two groups during the preswitch phase, with 73% and 76% success rates (out of 6 trials) for bilinguals and monolinguals, respectively. As in previous research, the postswitch task was difficult for such young children, and only a small number of children completed the task (monolinguals: $n = 20$; bilinguals: $n = 10$). The performance declines during the postswitch phase were similar for both language groups, as revealed by the main effect of the ANOVA. These data, however, should not be overinterpreted given the small sample size, especially in the bilingual group.

Snack Delay task

Table 1 reports the mean reaction times of delay to eat the snack. There was no main effect of gender or language group on these reaction times, and the interaction also was not statistically significant. Similar results emerged when the proportion of trials with a full wait (out of 4) was examined; there was no effect of language group or gender or any interaction between these variables.

Gift Delay task

The mean latency to open the gift for each group is presented in Table 1. Consistent with research on self-regulation, a main effect of gender was observed, with girls ($M = 124.3$ s, $SD = 74.3$) being more likely to wait longer before opening the gift than boys ($M = 72.0$ s,

SD = 76.6), $F(1, 55) = 8.30$, $p < .01$, $\eta^2 = .13$. There was no effect of language group or interaction.

Finally, to provide additional evidence for the role of exposure to the two languages on performance on the executive function tasks, we correlated the degree of exposure to L2 of bilinguals with their scores on all executive function tasks. The only significant correlation was between L2 exposure and the proportion of correct Stroop trials ($r = .23$, $p = .04$, one-tailed). Although this single significant correlation (out of 10) should be interpreted with caution, the finding of a graded advantage on the Stroop task based on degree of exposure to L2 is an interesting topic for future research.

Discussion

The current results explored the emergence of the bilingual advantage in executive functioning by investigating a group of 2-year-olds. Previous research using a comprehensive battery of tasks found such effects in 3-year-olds (Bialystok et al., in press), and another study using only a single task reported greater flexibility in bilinguals at 7 months of age (Kovacs & Mehler, 2009). The current study bridges these earlier results by administering a variety of tasks assessing different executive functioning skills and including measures of language and cognitive levels for all of the children. Thus, the current results extend the previous research for bilingual advantages in specific executive control abilities to children who have had considerably less experience in controlled language production. Extending these effects to such a young sample challenges the interpretation that the source of the difference is solely in the inhibitory control over the nontarget language during language use.

One goal was to use a battery of tasks that measured both the ability to suppress a motor response, as in delay of gratification, and to inhibit attention to a prepotent or distracting stimulus. Previous research with older children has shown that the effect of bilingualism is not found on all measures involving inhibition (Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008), with the largest group differences being found on tasks in which the correct response is embedded in a misleading context and the conceptual demands are moderate (Bialystok & Martin, 2004). In fact, the source of processing differences in bilingual children seems to change as a function of the development of their linguistic competencies. More specifically, older bilingual children seem to outperform their monolingual counterparts on conflict tasks that require inhibition of attention to a prepotent/distracting response but not on delay tasks (Carlson & Meltzoff, 2008) or on tasks that require the ability to suppress a motor response (Martin-Rhee & Bialystok, 2008). A recent study suggests that the locus of the bilingual advantage in younger bilinguals appears to include the inhibition of a salient response (Bialystok et al., in press).

To examine these relations, the battery of tasks included both delay and conflict tasks. Based on previous research with older children, we expected that if any cognitive benefit has emerged by 24 months of age, it would more likely be detected in the conflict tasks than in the delay tasks (Bialystok & Martin, 2004; Carlson & Meltzoff, 2008). The results confirmed our hypothesis given that the language groups differed only on the Stroop task, a

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task that requires children to make a novel response while inhibiting a conflicting prepotent response. This pattern is consistent with previous research with older children that identified conflict inhibition as the executive function that discriminated between the performances of the two language groups. The current demonstration shows that the link between bilingualism and executive function is first expressed in conflict inhibition.

The absence of the expected effect for the other two conflict tasks could be due to a number of factors. In the case of the Reverse Categorization task, only roughly half of the children completed this task. This poor performance replicates previous research with 24-month-olds in which approximately 25% of the children of a large sample (N = 118) passed the same task (Carlson, 2005). The combination of inhibition and working memory demands to succeed on this task might explain the floor effect observed at this age. As for the Multilocation task, our sample performed more poorly than previously reported for that age group (>80% correct on first postswitch trial [Carlson, 2005]). The fact that in our version of this task infants needed to remove a towel covering the display to retrieve the toy added an additional step that is known to increase the demand of this task (Zelazo et al., 1998). In addition, the insertion of a delay before the response may have increased memory demands and decreased the need for executive control. In a study by Bialystok and Martin (2004), bilingual 4-year-olds outperformed monolinguals on a Simon task when the response was required immediately but not on conditions in which a delay was inserted before the response could be made. Regardless of the low performance of our two groups, the absence of benefit of bilinguals on this specific task is puzzling and calls for replication. It could be that the Stroop task is a closer match to the standard one used with older children, whereas the other conflict tasks might not be as isomorphic as those used in older children (e.g., Attention Network test [ANT], Simon task, DCCS).

What could be the source of the bilingualism advantage reported in this very young sample? Recall that one hypothesis for the more rapid development of inhibition and selective attention in bilinguals is the necessity to prevent language intrusions by holding in mind the relevant language and inhibiting the nontarget language. This is necessary because both languages are activated in parallel and compete for selection during speech production (Colomé, 2001; Costa, Miozzo, & Caramazza, 1999; Kroll, Bobb, Misra, & Guo, 2008). According to this hypothesis, bilinguals have extensive practice with inhibitory control in a linguistic context compared with their monolingual counterparts, and this experience enhances inhibitory control over attentional resources in a nonlinguistic context. One would assume that young bilinguals with less experience at cross-language competition would benefit less at the cognitive level than older bilinguals with more experience. Our findings support this prediction given that 24-month-olds who have had less experience in language production demonstrate fewer bilingual advantages than older and more experienced preschool children who have been shown to display stronger cognitive benefits in previous research.

It is possible that the limited cognitive benefits observed in infant bilinguals is because their experience has been primarily in receptive language rather than expressive language. Despite evidence for cross-language interference being present in the receptive language of bilingual adults (e.g., spoken or visual word recognition), the processes involved in each

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modality are somewhat different. Word recognition has a primarily bottom-up component in which some basic properties of the stimulus are automatically processed. In word production, top-down processes are involved as the speaker intentionally chooses the target language and exerts control on which representations to activate according to the communicative context (Costa, 2005; Costa & Santesteban, 2004). Nevertheless, the small bilingual advantage that we observed in our 24-month-old bilinguals is probably due to a combination of infants' experience using their two languages in production and comprehension. By that age, the expressive vocabulary of bilingual children already includes an average of 40% translation equivalents, so switching between two languages has been experienced for at least a few months (David &Wei, 2008; Lanvers, 1999; Nicoladis & Secco, 2000; Pearson et al., 1995). The recent evidence for a similar inhibitory control advantage in 7-month-olds raises the possibility that speech processing of two languages might be sufficient to generate such advantage (Kovacs & Mehler, 2009). Relatedly, a relationship between infants' speech perception skills and nonlinguistic cognitive abilities has been demonstrated in monolingual infants (Conboy, Sommerville, & Kuhl, 2008; Diamond, Werker, & Lalonde, 1994; Lalonde & Werker, 1995). Infants (8–11 months of age) who failed to discriminate a non-native speech contrast performed better on tasks that measured domain-general inhibitory control processes (e.g., A-not-B, detour-reaching object retrieval). In contrast, native speech discrimination was not linked to performance on the cognitive control tasks. Thus, it seems that the better infants are able to ignore variation in speech that is irrelevant to the native language, the better they are at inhibiting a prepotent response in a nonlinguistic task. Similarly, because bilingual infants need to switch between two native language systems on a regular basis, one might expect a similar or greater cognitive benefit in comparison with monolingual infants even during the first few months of life. If this finding is replicated and extended to older infants with similar standard executive functioning tasks, it might indicate that there is continuity in the cognitive advantages that exposure to two languages bring.

The results of the current study reveal less dramatic differences between monolingual and bilingual children in executive control than those reported in previous research. In addition to these children being much younger than those in previous studies, the distinction between monolingual and bilingual was less categorical. Unlike previous studies comparing children who had encountered only one language with those who had been raised with two languages, some of our monolingual children were exposed to a second language to some degree. Thus, the comparison of children in these two groups provides a very conservative test of the hypothesis in that their bilingual experience is more limited than that of the children in many studies. For this reason, systematic differences between groups on the executive control conflict task are especially impressive.

In sum, the current results demonstrate that some form of bilingual advantage in executive control emerges much earlier than previous research has reported. This finding has both theoretical and practical implications. At a theoretical level, it contributes unique empirical support for interpreting the advantages seen in bilingual children as stemming from greater experience in attentional control rather than other factors such as socioeconomic sources (Bialystok, 2009b). At a more practical level, given the centrality of executive processes in cognitive life, the remarkable precocity of the bilingual advantage on these processes has significant implications for parents and educators who might be concerned with the effect of exposing their children to a second language early in life.

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Table 1

Mean scores and standard deviations on each of the executive function tasks for monolinguals and bilinguals. Language group Monolingual Bilingual

Language group	**Monolingual**		**Bilingual**	
	M	***SD***	***M***	***SD***
Multilocation task				
Number of trials needed to get three in a row (preswitch)	3.44	1.25	3.50	1.08
Number of trials needed to get new location (postswitch)	2.04	1.48	2.31	1.51
Shape Stroop task				
Proportion of correct pre-Stroop trials	.90	.23	.84	.29
Proportion of correct Stroop trials	.31	.36	.50	.33*
Reverse Categorization task				
Proportion of correct responses preswitch	.76	.21	.73	.22
Proportion of correct responses postswitch	.52	.26	.41	.29
Snack Delay task				
Average reaction time to eat snack (s)	9.28	7.21	6.75	5.29
Proportion of trials with a full wait	.30	.34	.17	.27
Gift Delay task				
Average latency to open gift (s)	115.10	76.84	86.10	80.04

*$P < .05$.