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# Bilingualism: The good, the bad, and the indifferent*

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*The present paper summarizes research showing that bilingualism affects linguistic and cognitive performance across the lifespan. The effect on linguistic performance is generally seen as a deficit in which bilingual children control a smaller vocabulary than their monolingual peers and bilingual adults perform more poorly on rapid lexical retrieval tasks. The effect on cognitive performance is to enhance executive functioning and to protect against the decline of executive control in aging. These effects interact to produce a complex pattern regarding the effect of bilingualism on memory performance. Memory tasks based primarily on verbal recall are performed more poorly by bilinguals but memory tasks based primarily on executive control are performed better by bilinguals. Speculations regarding the mechanism responsible for these effects are described.*

There is growing evidence that various experiences have a significant effect on behavioral, neuropsychological, and structural aspects of cognitive performance. For example, video game players have been shown to have enhanced visual selective attention (Green and Bavelier, 2003), skills that can be increased by extensive video game training (Feng, Spence and Pratt, 2007), and architects have demonstrated higher levels of visuo-spatial ability than non-architects (Salthouse and Mitchell, 1990). Neural connections can also be modified: Canadian postal workers who continually interpret codes containing both letters and numbers have enhanced pathways between the letter and number representational systems relative to American postal workers who deal only in numeric codes (Polk and Farah, 1998). Structural changes from experience have been documented as well. London taxi drivers who have extensively engaged in route-finding have been shown to have enlarged regions of the hippocampus responsible for spatial navigation (Maguire et al., 2000). Professional musicians who play string instruments for which the sound pitch and quality emanates from control of the four fingers of the left hand have been shown to have increased cortical representation of those fingers (Elbert et al., 1995). Finally, individuals who speak a second language have been shown to have increased density of grey matter in the left inferior parietal cortex, a change that is more pronounced in early bilinguals and those with greater proficiency in the second language (Mechelli et al., 2004). This region has been shown to be responsive to vocabulary acquisition in monolinguals and bilinguals as well as producing enlargements in slightly different areas depending on the two languages of the bilingual (Green, Crinion and Price, 2007). Furthermore, the accumulated effect of stimulating experience across the lifespan translates into cognitive reserve, a concept describing the protective effects of experience against cognitive decline with aging (Stern, 2002; Fratiglioni, Paillard-Borg and Winblad, 2004; Kramer et al., 2004; Staff, Murray, Deary and Whalley, 2004; Valenzuela and Sachdev, 2006). It is evident, therefore, that experience has a powerful effect on cognitive performance and brain organization and structure. Is bilingualism one such experience that leads to these general cognitive outcomes?

The central aspect of the bilingual experience that may be responsible for generalized effects on cognitive performance comes from the well-documented observation that for fluent bilinguals who use both languages regularly, both languages are active and available when one of them is being used (Hernandez, Bates and Avila, 1996; Dijkstra, Grainger and van Heuven, 1999; Marian, Spivey and Hirsch, 2003; Sumiya and Healy, 2004; Rodriguez-Fornells et al., 2005; Chee, 2006; Crinion et al., 2006; Kroll, Bobb and Wodniecka, 2006; Kaushanskaya and Marian, 2007). This situation creates a problem of attentional control that is unique to bilinguals – the need to correctly select a form that meets all the linguistic criteria for form and meaning but is also part of the target language and not the competing system. The need to control attention to the target system in

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the context of an activated and competing system is the single feature that makes bilingual speech production most different from that of monolinguals and is at the same time responsible for both the cognitive and linguistic consequences of bilingualism.

**Language proficiency and verbal fluency: The bad**

It is now well documented that bilinguals generally control a smaller vocabulary in each language than monolinguals (Oller and Eilers, 2002; Perani et al., 2003; Portocarrero, Burright and Donovick, 2007). This finding is especially important for descriptions of children's development because vocabulary size is a central measure of children's progress in both the oral and literate forms of language development. In some sense, vocabulary size serves as a proxy for the representational base of language that the child is constructing, with a richer and more diverse vocabulary reflecting a more elaborate understanding of language. However, developmental research has consistently shown that bilingual children control a smaller vocabulary in each language than their monolingual peers (e.g., Mahon and Crutchley, 2006; Oller and Eilers, 2002). To confirm this reported finding, we combined the standardized Peabody Picture Vocabulary Test scores of 971 children between the ages of 5 and 9 years, about half of whom were bilingual, who had participated in a variety of studies in our lab over several years. The overall analysis showed that the monolinguals had a mean standard score of 105 and the bilinguals had a score of 95, a difference that was highly significant (Bialystok and Feng, in press). The difference was found for children in each age group, and there was no interaction of age and language group, indicating that the vocabulary gap was constant throughout this sample. The bilingual children in these studies were raised in an English-speaking community, attended school and extra-curricular events in English, but spoke a non-English language at home. The older children were in third and fourth grades at school and were following a curriculum that was heavily dependent on English language and literacy. Nonetheless, the average vocabulary size of the bilingual children was smaller than their monolingual classmates.

The same pattern emerges for adults, although the measure in this case is not usually vocabulary size but rather access to vocabulary, or lexical retrieval. Using a variety of tasks, bilinguals have been shown to be slower in picture naming (Roberts, Garcia, Desrochers, Hernandez, 2002; Gollan, Montoya, Fennema-Notestine and Morris, 2005; Kaushanskaya and Marian, 2007), obtain lower scores on verbal fluency tasks (Rosselli et al., 2000; Gollan, Montoya and Werner, 2002; Portocarrero et al., 2007), encounter more tip of the tongue experiences (Gollan and Acenas, 2004), demonstrate poorer word identification through noise (Rogers et al., 2006), and experience more interference in lexical decision (Ransdell and Fischler, 1987). In all these studies, there is evidence that at least part of the problem is the interference that must be resolved from the other language. Manipulating the relation between the words in the two languages, for example, by controlling the cognate value or adjusting word frequency, systematically changes bilingual performance (Costa, 2005), suggesting that there is a central role for the relation between the words in these effects.

The bilingual deficits in lexical access and retrieval persist with aging (Gollan, Fennema-Notestine, Montoya and Jernigan, 2007), although a study by Gollan, Montoya, Cera, and Sandoval (2008) showed that the effects of aging interacted with word frequency in that older bilinguals demonstrated a smaller deficit for low-frequency words. In a study of younger and older monolinguals and bilinguals, we administered three tasks to assess verbal knowledge and retrieval: an English vocabulary test (PPVT-III), a version of the Boston Naming Test, and two tests of verbal fluency (Bialystok, Craik and Luk, 2008). The PPVT-III is a standardized test of receptive vocabulary in which the participant is shown four pictures and must indicate which of the four corresponds to a name spoken by the experimenter. In the Boston Naming Test (Kaplan, Goodglass and Weintraub, 1983) participants are asked to name a series of line drawings of objects. In our version we substituted verbal definitions for half of the drawings on the speculative assumption that accessing words would be more difficult from abstract definitions than from relatively concrete drawings because of the contextual support provided by the latter (Craik, 1983). Finally, in the fluency tests, participants had to say as many words as possible within one minute starting with a given letter or conforming to a given category. Following standard procedure the letters were F, A, and S and the category criterion was animals. In all these tasks, the bilinguals at both ages obtained lower scores than their monolingual counterparts.

The reason that bilinguals experience deficits in lexical access is not clear. On one view, the explanation is attributed to the fact that bilinguals use each of their languages less often than monolinguals, creating "weaker links" among the relevant connections required for rapid and fluent speech production (Michael and Gollan, 2005). This explanation follows from connectionist models in which the pathways that underlie the associative networks between words and concepts are distributed across two languages, making those associations with each language less practiced and therefore less fluid. This view is based on bilingual speech production modeling in which these retrieval effects are simulated in a connectionist network (Dijkstra, 2005). Alternatively, Hernandez and Li (2007) propose a sensorimotor account that involves

the age of acquisition of the vocabulary in each language, with different outcomes depending on the age of L2 acquisition. Other views attribute the reduction in lexical access to the conflict that is created by the competition from the corresponding item in the non-target language (Green, 1998). This competition requires a mechanism for controlling attention to the target language, possibly by inhibiting the interfering option. Generally, such conflict is resolved by the executive processes for control, attention, and switching. If these processes are involved in ordinary language production for bilinguals, then it is possible that their constant use in an ordinary and frequent context will have the consequence of transforming those processes through practice, making them more efficient and more available for a variety of applications.

## Conflict resolution and executive control: The good

If bilingual language production requires the constant involvement of the executive control system to manage attention to the target language, then it is possible that this experience enhances that system making it more robust for other functions. Thus, in contrast to the negative effects of bilingualism found for vocabulary size and rapid lexical retrieval, bilingualism should have an advantageous effect on the function of executive control. The primary processes in the executive system are inhibition, shifting of mental sets (task switching or cognitive flexibility), and updating information in working memory (Miyake et al., 2000).

Beginning with children, early studies showed that bilingual children performed better than monolingual children on metalinguistic tasks that required controlled attention and inhibition, but not on comparable tasks that were more based on knowledge of grammar (e.g., Bialystok, 1988). For example, in a grammaticality judgment task, all the children were equally successful in detecting grammatical violations (e.g., "Apples growed on trees"), but bilingual children were more successful than monolinguals in accepting that anomalous sentences ("Apples grow on noses") were grammatically correct (Bialystok, 1986; Cromdal, 1999). This judgment of grammaticality requires effortful attention to ignore the misleading distraction from meaning that seduces the child to say that the sentence is not correct.

An important extension of this research was to demonstrate that this distinction between tasks that depend on selective attention and comparable problems that do not involve these processes was also effective in identifying problems that were solved better by bilinguals in nonverbal domains (Bialystok and Majumder, 1998). This finding set the stage for a more detailed set of investigations to determine how extensively the bilingual advantage could be found in nonverbal tasks and the conditions that led to this difference.

The research with children has shown that bilingual children develop the ability to solve problems that contain conflicting or misleading cues at an earlier age than monolinguals. One example of this difference is in their performance on the dimensional change card sort task developed by Zelazo and colleagues (Zelazo, Frye and Rapus, 1996). In this task, children sort a set of bivalent stimuli by one feature (for example, color) and then immediately need to re-sort them by the other feature (for example, shape). The typical error found until children are about 4 or 5 years old is that they continue sorting by the original criterion on the second round, in spite of being able to correctly state the new rule. However, the problem in the second round is not simply in knowing or remembering the rule, but in being able to attend to the feature that is now relevant and ignore attending to the obsolete feature, a feature that continues to be present. Because the obsolete feature was the basis for performance in the first round, it is highly salient and likely used to interpret the stimulus, for example, "the red one". This ability to switch criteria for the sorting decision and attend to the new feature while the irrelevant feature remains salient is an aspect of executive control. In several studies, we have found that bilingual children master this problem earlier than monolinguals (Bialystok, 1999; Bialystok and Martin, 2004).

This advantage has been demonstrated in other tasks as well, such as theory of mind (Goetz, 2003; Bialystok and Senman, 2004), and reversing ambiguous figures (Bialystok and Shapero, 2005). However, a comprehensive study by Carlson and Meltzoff (2008) in which they administered nine executive function tasks to children helps to isolate the specific aspects of these executive control tasks that are more advanced for the bilingual children. The children in their study were in kindergarten, and were monolingual, bilingual, or English language learners (ESL). There were two notable results: first, the nine tasks clustered into two factors in a factor analysis, representing conflict tasks and delay tasks; and second, bilingual children performed better than children in the other two groups on conflict tasks, but there were no differences on delay tasks. The design of the study provides a control over the effect of individual differences: it was not the case that the bilingual children were simply faster, or smarter, or more developmentally advanced; instead, they performed better than the other two groups on precisely the tasks that presented conflict for competing options that needed to be resolved for a correct response. This parallels the situation in which two competing language systems create a conflict for selection in bilingual speech production.

The Simon task (reviewed in Lu and Proctor, 1995) incorporates the type of conflict that is more easily

resolved by bilinguals and illustrates their advantage in executive processing. In this task, stimuli contain both target information that indicates the correct response, such as color cues for the left or right response key, and position information that is irrelevant to the correct response, such as presentation of the stimulus on the left or right side of the display. The conjunction of these features creates trials that are congruent, because both features converge on the same response, or incongruent because they indicate contrary responses. Moreover, the task is usually presented with congruent and incongruent trials occurring in a randomly sequenced mixed block, necessitating as well the executive control processes for monitoring and switching. Following from the interpretation that the bilingual advantage is in resolving conflicting response options, bilinguals have been shown to perform this task more easily than monolinguals and produce shorter reaction times for both congruent and incongruent trials. This difference has been shown for children (Martin-Rhee and Bialystok, 2008), young adults (Bialystok, 2006), and middle-aged and older adults (Bialystok, Craik, Klein and Viswanathan, 2004).

A compelling demonstration of the bilingual advantage for young adults in conflict tasks has been reported by Costa, Hernández and Sebastián-Gallés (2008). They tested Catalan–Spanish bilinguals and Spanish monolinguals on the attentional network task (ANT), a version of the flanker task developed by Fan et al. (2002). In addition to the measure of conflict resolution as the response time difference between congruent and incongruent trials, the task also provides measures of overall speed of responding from the benefit provided by an alerting cue, and switch costs from the slower response times on switch than on non-switch trials. Their results showed that the bilinguals responded faster overall and showed a smaller conflict effect, a greater benefit from the alerting cue, and smaller switch costs.

Finally, the most important task demonstrating executive control and conflict resolution is the Stroop task. We presented this task to the younger and older monolinguals and bilinguals who had participated in the verbal proficiency and retrieval tasks described above (Bialystok et al., 2008). The design included two control conditions in which participants either named a color word printed in black as rapidly as possible or named the color in which a row of Xs was printed. In both these conditions, there was no difference in the performance by members of the two language groups. In the experimental conditions, participants named the ink color of a color word in congruent conditions when the ink color was either the same as the color word or incongruent conditions in which the color conflicted with the word. For these conditions, bilinguals at both ages showed a smaller cost in naming the ink color in the incongruent trials than did the monolinguals.

**Free recall and working memory: The indifferent**

It is not clear *a priori* whether bilingualism should affect the development and functioning of memory in general, and working memory in particular. Both language proficiency, especially in terms of lexical access, and attention control in terms of conflict resolution from competing systems are directly involved in bilingual speech production. Language use does not inherently seem to rest on memory, but working memory at least is normally considered to be part of the executive function. Therefore, an enhancement in executive control in general may have the consequences of also boosting the working memory system which is part of it.

Consider first the evidence for verbal memory as measured by free recall. In a study in which younger and older monolinguals and bilinguals were asked to recall lists of 20 words under various conditions, bilinguals recalled fewer words at both ages and under all conditions (Fernandes et al., 2007). Again, this might not be surprising – if memory is equivalent but bilinguals are disadvantaged by the verbal task, then it would be expected that they would perform more poorly than monolinguals. A more interesting test, therefore, would be to compare monolinguals and bilinguals on a memory that is either nonverbal, or requires the involvement of executive control, or both. The working memory system is generally considered to be an aspect of executive functioning in which information must be sustained in memory while manipulations are performed on that information in conformity to some rule or goal.

In its simplest form when there is no need to manipulate the activated information, working memory is more properly called short-term memory, and is often based on verbal material. Using a short-term memory task in which children were asked to recall increasingly long strings of animal names, a combined analysis of several studies that included a total of 190 children showed no evidence for any difference between monolingual and bilingual children (Bialystok and Feng, in press). A similar composite analysis from several studies including 544 participants who were younger or adults and were monolingual or bilingual also showed no difference in performance on a simple working memory task for participants in the two language groups. In this case, the task was to listen either to increasing strings of words and re-order them alphabetically or to two-digit numbers and re-order them in ascending sequence. Neither task was solved differently by participants in the two language groups.

The results of these two composite analyses provide no evidence that short-term or working memory is enhanced in bilinguals, in spite of it being part of the executive function. However, in both cases, the material to be held in mind for the short-term memory task, and re-ordered

in the working memory task is verbal, a domain that is generally compromised for bilinguals. What would happen if working memory were assessed in a non-verbal domain?

The participants in the study by Bialystok et al. (2008) who showed disadvantages in lexical retrieval and advantages in cognitive control on the Stroop task were also given two tests of working memory. One task was the self-ordered pointing task (Petrides and Milner, 1982) in which participants viewed a 12-page booklet, each page containing 12 abstract drawings, and had to update a mental list of these images by pointing to a different drawing on each page without repetition. Working memory is calculated as the number of repetitions errors committed. Although older participants made more errors than younger ones, there were no effects of language group at either age. The second task was the Corsi blocks test (Milner, 1971) in which 10 wooden blocks are spread out in a random array. The experimenter touches a sequence of blocks and the participant's task is to reproduce the sequence in either the same (forward span) or reverse (backward span) order. There were no differences attributable to either age or language group for the forward span data task, but the more difficult backward span task was performed significantly better by younger adults, and among the young adults, by the bilinguals.

To pursue these results, we created a nonverbal task that could be adapted for use with both children (Feng, Diamond and Bialystok, 2007) and adults (Bialystok and Feng, in preparation) and included conditions that varied in their demands for executive control. The task is based on a matrix consisting of 9 squares arranged in a $3 \times 3$ pattern for children or 25 squares arranged in a $5 \times 5$ pattern for adults. Strings are created by indicating series of marked squares. For the children, the markings are images of a frog that the children are told is jumping through ponds (the squares) and they are told that they will need to remember where the frog jumped; for adults, the indicated squares are simply filled in with red and they are asked to recall the indicated squares according to some rule. In the simplest condition, the designated squares are indicated and participants are asked to recall them in the same order; in the most difficult condition, the designated squares need to be recalled according to an ordering rule, such as left to right along each row and moving through the rows top to bottom. For both children and adults, the monolinguals and bilinguals achieved the same recall scores in the simple conditions, but as the executive control demands increased making the working memory component more difficult, the bilinguals maintained their performance level better than the monolinguals and outperformed them on those conditions. The difference was not in memory ability, or even in short-term or simple working memory as both groups performed the same on these conditions; rather, the difference was in conditions that included more stringent demands for control and inhibition. In this case, the monolinguals declined more from their earlier performance than the bilinguals did.

## The bilingual experience

Across a wide range of studies investigating a variety of abilities, it is clear that bilingualism is an experience that has significant consequence for cognitive performance. The nature and direction of that consequence, however, is less clear. Studies investigating language proficiency and lexical retrieval show deficits for bilinguals in both the extent of their representational base and the efficiency with which specific lexical items can be retrieved. Studies investigating executive control abilities show bilingual advantages throughout the lifespan, with these processes developing earlier in children, maintaining more efficient performance in adulthood, and declining less severely with aging. Finally, studies investigating memory abilities, both from the perspective of recall and working memory are more equivocal. For tasks based on verbal recall, there tend to be disadvantages for bilinguals, but the involvement of nonverbal material or more controlled processing requirements either equalizes the performance of the two groups or even gives advantages to the bilinguals. Moreover, these three types of effects were all demonstrated in the same sample of younger and older monolinguals and bilinguals (Bialystok et al., 2008).

It is tempting to search for a single explanation that can incorporate all these effects. One candidate is the central conflict created by the joint activation of the two competing language systems. Evidence from neuroimaging studies supports the claim that frontal regions are activated when bilinguals are switching or selecting languages (Price, Green and von Studnitz, 1999; Fabbro, Skrap and Aglioti, 2000; Hernandez, Dapretto, Mazziotta and Bookheimer, 2001; Rodriguez-Fornells et al., 2005). This constant conflict both compromises lexical access because each selection is more effortful and enhances executive control through its continuous involvement in language production. On its own, there is little impact on memory, but to the extent that memory performance relies on either linguistic processing, which is disadvantaged, or executive processing, which is advantaged, monolinguals and bilinguals will perform differently.

The architecture underlying the processes affected by bilingualism is likely to be based on networks of connections. One model for such a network presented by Abutalebi and Green (2007) describes evidence for a series of connections between prefrontal cortex, anterior cingulate cortex, inferior parietal region, and basal ganglia, all of which are implicated in language production for bilinguals. The extensiveness of these networks in which linguistic and nonlinguistic processing

are controlled by networks of activation means that experiences like bilingualism affect the entire network, allowing the impact of the experience to be felt broadly over a wide range of processes, including nonverbal ones. The organization of this network is such that the occurrence of a conflict for selection in language production signals the need to involve the systems normally specialized for conflict resolution, namely, dorsolateral prefrontal cortex and anterior cingulate gyrus. Because this conflict occurs during language production, the inferior parietal cortex, in particular Broca's area, is also involved. All these cortical areas are connected through the subcortical structures in the basal ganglia, in particular, the caudate nucleus which is also responsible for conflict resolution.

The outcome of this configuration is that bilinguals are resolving verbal conflict with activation in two areas that monolinguals use to resolve nonverbal conflict, namely, dorsolateral prefrontal cortex and caudate nucleus, as well as involving Broca's area. What areas are involved when bilinguals perform tasks involving nonverbal conflict? Bialystok et al. (2005) studied monolingual and bilingual young adults performing a Simon task using magneto-encephalography (MEG) and found that fast reaction time for monolinguals was related to activation of dorsolateral prefrontal cortex, the usual finding in the literature, but fast reaction time for bilinguals was related to activation of Broca's area. Thus, it appears that bilinguals have both more resources (Broca's area) and more efficient resources (other frontal regions) for performing tasks that are based on nonverbal conflict. The irony is that a linguistic experience appears to have its greatest benefit for nonlinguistic processing and its greatest cost for language production.

The argument assembled here is based on evidence from studies employing different methodologies and addressing different questions, but the interpretation that the source of the observed pattern comes from the need to resolve a conflict in lexical selection is speculative. Precisely because the system is assumed to be organized in a network, it is difficult and perhaps impossible to identify a single source for the widespread effects of bilingualism. However, one situation helps to isolate this conflict between languages as the mechanism responsible for the greater involvement of executive control in bilinguals and the consequent enhancement of those processes.

Although bilingualism is inevitably accompanied by the joint activation of both language systems, thereby creating the conflict that is the course of these cascading effects, there is one situation in which that may not be strictly the case. The most visible evidence of joint activation and conflict for selection by bilinguals is in code switching – sometimes bilinguals will insert a word or phrase from the other language, having either intentionally or unintentionally chosen the non-target form. The choice is necessary because only one of the two forms can be produced at one time. However, this pressure to select is not as compelling for speech–sign bilinguals; in this case, code-blending replaces code-switching because some combination of the form from each language can be produced simultaneously (Emmorey, Borinstein, Thompson & Gollan, 2008). Thus, the difference between individuals who are bilingual in two spoken languages and those who are bilingual in a spoken and signed language, all else being equal, is the extent to which speech production in one of the languages is accompanied by conflict and pressure to select one of them from competing activated alternatives. Therefore, a comparison of speech–speech bilinguals and speech–sign bilinguals should indicate the role of this competition on the pressure for selection in bilingual language production on cognitive performance.

We presented a flanker task to 45 participants with a mean age of 48 years, of whom 15 were monolingual, 15 were bilingual, and 15 were speech–sign bilinguals (Emmorey, Luk, Pyers and Bialystok, in press). The latter group were all hearing children of deaf parents who learned both sign and speech from childhood and worked as sign interpreters, thereby regularly using both languages to a high level of proficiency, just as was the case for the speech bilinguals. As usual, the bilinguals were faster than the monolinguals on both the congruent and in-congruent trials, but the speech–sign bilinguals performed exactly the same as the monolinguals on both trial types. This pattern supports the interpretation that the conflict for selection between two active languages is central to the enhancement of executive control found in bilinguals.

There is one final suggestion for a broadly-based consequence of the particular experience of bilingualism on cognitive functioning. Following the idea that cognitive reserve builds up from extended experience with stimulating activities and that this cognitive reserve protects against the onset of dementia (Stern, 2002; Stern et al., 2005), we investigated the possibility that bilingualism is one such experience that contributes to cognitive reserve (Bialystok, Craik and Freedman, 2007). We compared the age of onset of symptoms of dementia for 184 people who had visited a memory clinic and had been diagnosed with dementia. Half of these individuals were bilingual, having spent the vast majority of their lives using two languages on a regular basis. There was no difference in the duration of their symptoms or their cognitive function as indicated by the Mini Mental State Exam (Folstein, Folstein and McHugh, 1975) at the time they visited their clinic. The monolinguals had more years of formal education (12.4) than the bilinguals (10.8), a difference that should offer protection against dementia to the monolinguals (Valenzuela and Sachdev, 2006). However, the bilinguals showed signs of dementia four years later than the monolinguals – with a mean age of 71.4

and 75.5 for monolinguals and bilinguals, respectively. This difference was significant, providing preliminary evidence for the generalized power of bilingualism to sustain cognitive functioning even with the challenges of impending disease.

The effect of bilingualism on cognitive functioning as evidenced by lexical access, executive control, and working memory, is part of a growing body of research demonstrating the powerful role of experience on cognitive function and cognitive organization. The highly integrated architecture of the cognitive system means that activities emanating from one domain, such as language, have consequences throughout the network. Such generalized effects are not easily reconcilable with modular views of cognition in which specific knowledge representations and dedicated processes are responsible for performance. Instead, there are strong interactions across knowledge representations and control processes that define broad domains of expertise that are not confined to a single source but reflect the interaction of experience and ability (Craik and Bialystok, 2006).

The overall conclusion from these various studies is that bilingualism is one of the experiences capable of influencing cognitive function and, to some extent, cognitive structure. The effects, however, are not simple; the language deficit and the control advantage interact to create a complex picture of cognition that is different for bilinguals and monolinguals, but not in a way that can be simply defined as better, worse, or indifferent. Moreover, all the research reported in these studies was based on individuals who were fully bilingual and used both languages regularly (often daily) to a high level of proficiency. Clearly, deviations from this ideal would modify the effect of the experience. How much bilingualism is necessary, what type of bilingualism is required, and what particular language pairs maximize these influences are all questions that are still waiting to be answered.

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