Title

Two Languages in Mind

Journal

Current Directions in Psychological Science, 23(3)

ISSN

0963-7214

Authors

Kroll, Judith F

Bobb, Susan C

Hoshino, Noriko

Publication Date

2014-06-01

DOI

10.1177/0963721414528511

Published in final edited form as:
Curr Dir Psychol Sci. 2014 June 1; 23(3): 159–163. doi:10.1177/0963721414528511.

Two languages in mind: Bilingualism as a tool to investigate language, cognition, and the brain

Judith F. Kroll,
Pennsylvania State University

Susan C. Bobb, and
Northwestern University

Noriko Hoshino
Kobe City University of Foreign Studies

Abstract

A series of discoveries in the last two decades has changed the way we think about bilingualism and its implications for language and cognition. One is that both languages are always active. The parallel activation of the two languages is thought to give rise to competition that imposes demands on the bilingual to control the language not in use to achieve fluency in the target language. The second is that there are consequences of bilingualism that affect the native as well as the second language. The native language changes in response to second language use. The third is that the consequences of bilingualism are not limited to language but appear to reflect a reorganization of brain networks that hold implications for the ways in which bilinguals negotiate cognitive competition more generally. The focus of recent research on bilingualism has been to understand the relation between these discoveries and the implications they hold for language, cognition, and the brain across the lifespan.

In many locations in the US, English is spoken as the only language, so it comes as a surprise to some people that in most places in the world, and increasingly in the US, the use of two or more languages is prevalent. The past two decades have witnessed a virtual explosion of research on bilingualism (e.g., Kroll & Bialystok, 2013). Bilinguals, long considered a special group of language users because monolinguals were assumed to be the norm, have now become a focus of research in cognitive psychology, linguistics, and cognitive neuroscience (e.g., Kroll, Dussias, Bogulski, & Valdes Kroff, 2012). Much of the new research shows that it is a misconception to think that bilingualism complicates language and cognition, that children raised with input from two languages are disadvantaged, or that mixing two languages is pathological (e.g., Bialystok & Craik, 2010; Byers-Heinlein, Burns, & Werker, 2010; Kroll et al., 2012). To the contrary, the recent evidence demonstrates that bilinguals develop a high level of cognitive control that enables them to negotiate the activity of the two languages. The experience of being bilingual comes

Direct Correspondence to: Judith F. Kroll, 416 Moore Building, Department of Psychology, Center for Language Science, Pennsylvania State University, University Park, PA 16802 USA, jfk7@psu.edu, Phone: 814-863-0126.

to influence not only language but also cognition more generally and the brain networks that support language and cognition.

In this article, we describe three discoveries that we believe reveal the reasons for the recent enthusiasm about research on bilingualism. The first is that both languages are always active. The parallel activity of the bilingual's two languages can be observed in reading, listening to speech, and in preparing to speak one language alone (e.g., Dijkstra, 2005; Marian & Spivey, 2003; Kroll, Bobb, & Wodniecka, 2006). Cross-language activation means that bilinguals are constantly juggling the competition that results when one of the two languages must be selected. The second discovery is that the language system is highly adaptive. Being bilingual is not only about acquiring and using a second language (L2) but also about the ways that the native or dominant first language (L1) changes in response to the L2. These changes have been observed at every level of language use, from the lexicon to the grammar and phonology. Moreover, they do not depend on acquiring both languages from early childhood; we see adaptation on the part of adult L2 learners that shows that cross-language interactions may depend as much or more on proficiency in the L2 than on the age of acquisition. The third discovery is that bilingualism shapes the structure and function of the brain across the lifespan. Learning to negotiate cross-language competition and to use the two languages in a variety of contexts may enable bilinguals to develop special expertise that extends beyond language into cognition, shapes the brain networks that support cognitive control, and provides cognitive resources that are protective when individuals are old or cognitively impaired.

Parallel activation of the bilingual's two languages

There is evidence that both languages are active regardless of a bilingual's intention to use one language only. In reading, the degree of parallel activation of the bilingual's two languages has been examined by using cognates or interlingual homographs. Cognates are words whose form and meaning are similar across two languages (e.g., "piano" in Spanish and English), whereas interlingual homographs are words whose form is similar but meaning is different (e.g., "pie" in Spanish is a foot in English). Many studies have demonstrated that bilinguals recognize cognates more quickly but interlingual homographs more slowly than control words (e.g., Dijkstra, Grainger, & Van Heuven, 1999). Monolinguals do not show these effects. The results suggest that lexical information is activated in both the target and non-target languages. Cross-language co-activation has been observed even when the non-target language is not processed explicitly (e.g., Thierry & Wu, 2007) and when two languages differ in modalities, for example, signers reading English words (e.g., Morford, Wilkinson, Villwock, Piñar, & Kroll, 2011). Moreover, these interactions across the bilingual's two languages are not only seen from the L1 to the L2 but as individuals become more proficient in the L2, they are present from the L2 to the L1 (e.g., Lagrou, Hartsuiker, & Duyck, 2011; Schwartz, Kroll, & Diaz, 2007).

The co-activation of the bilingual's two languages has also been demonstrated in listening comprehension. Marian and Spivey (2003) asked Russian-English bilinguals to look at objects on a display while they heard a spoken word. They examined eye fixations to objects in the display. The critical comparison was the condition in which the display included a

between-language competitor, an object whose name in the non-target language (e.g., “plat’e” [dress]) was phonologically similar to the name of a target object in the target language (e.g., “plug”) and the condition in which there was no object whose name was phonologically similar to the name of a target object in either language. The result showed that bilinguals looked longer at between-language competitors than controls, suggesting parallel activation of the non-target.

Although speech production is initiated by a bilingual’s intention to speak in a given language, cross-language interactions are also present when speech is planned. Because speaking requires that one language be selected, bilinguals must develop a means to control the language not in use. One option is to inhibit the activation of the language not to be spoken (e.g., Green, 1998). The evidence for inhibition comes from studies on language mixing (e.g., Christoffels, Kirk, & Schiller, 2007). In this paradigm, bilinguals name pictures only in their L1 or in their L2 (blocked naming) or in both their L1 and L2, depending on the presentation of a cue (mixed naming). If the L1 is active when speech is planned in the L2, then forcing it to be active in the mixed condition should incur a cost to L1 relative to blocked picture naming but should have little effect for the L2. It is precisely this asymmetric pattern of results that has been reported in mixed language naming experiments and under conditions of language switching (e.g., Meuter & Allport, 1999). Moreover, when the L1 is spoken after the L2 has been produced for a period of time, there is inhibition that for some bilinguals appears to reflect global suppression of the entire L1 (e.g., Misra, Guo, Bobb, & Kroll, 2012; Van Assche, Duyck, & Gollan, 2013).

The bilingual’s language system is adaptive

When we think of adult L2 learning, we immediately think of the difficulty of the process, and how the L1 phonology or syntactic structure leave their mark on the L2 in the form of an accent or incomprehensible sentence. What may be surprising for some is that it is not only the L2 that changes during learning. The language system is permeable in both directions so that L2 learning comes to affect the L1, especially when the learner achieves L2 proficiency. Dussias and Sagarra (2007) investigated sentence parsing preferences of Spanish-English speakers while reading Spanish complex sentences. Given the sentence, *El policía arrestó a la hermana del criado que estaba enferma desde hacía tiempo*, “The police arrested the sister of the young man who was ill for some time”, a native Spanish speaker would say that it was the sister who had been ill. In English, however, the sentence would indicate that the young man had been ill. Dussias and Sagarra found that bilingual Spanish-English speakers adopted a parsing strategy in L1 Spanish that was consistent with L2 English (i.e., that the young man had been ill), but only after being immersed in an English environment for a long time. The native language changed in response to L2 use. These results strongly suggest that the newly learned lexicon of words and its syntactic structure are not built up in isolation, but interact with the existing language in a dynamic way to change the language system as a whole. A common finding is that the two languages begin to converge, with changes to the L1 as well as the L2 (e.g., Ameel, Storms, Malt, & Sloman, 2005). In effect, each language begins to resemble the other, with bilinguals looking less like monolinguals in either language as cross-language contact and proficiency increase.

To see these bi-directional language effects on the bilingual language system, L2 learners may need to first develop high levels of L2 proficiency. One such situation occurs when students study abroad in an L2 environment. A study by Linck, Kroll, and Sunderman (2009; and see Baus, Costa, & Carreiras, 2013) compared L2 learning in an immersion and classroom context. They tested native English speakers learning Spanish on comprehension and production tasks. Although immersed learners were matched on overall L2 proficiency to the classroom-only learners, they performed the tasks in a different way from their classroom-only counterparts. Comprehension results suggested that L2 immersion experience had changed the way the learners processed their L1. Immersed learners also had more difficulties speaking English than classroom learners, suggesting that immersed learners suppress the native language. Strikingly, these effects on the L1 persisted 6 months after returning to the L1 environment, but only for the comprehension task. In spoken production in the L1, performance rebounded. Linck et al. interpreted the findings as supporting the idea that L2 learners attenuate L1 activation while immersed in the L2, and that the same degree of L1 suppression does not occur in the classroom.

These studies illustrate cross-language interaction at the level of words as well as the grammar. The scope of the changes to the native language is broad, with related evidence that has been reported for other grammatical structures (Dussias & Cramer Scaltz, 2008) and for the phonology of the native language (e.g., Chang, 2013). Research on priming also shows that sentence processing is changed by a recent occurrence of a similar syntactic structure, even when the prime and target sentences cross from one of the bilingual's languages to the other (Bernolet, Hartsuiker, & Pickering, 2007; Kantola & Van Gompel, 2011). The presence of cross-language syntactic priming suggests that aspects of the grammar are shared across the bilingual's two languages. The evident permeability of the bilingual language system, both with respect to language co-activation and language reorganization, raises the possibility that the influence of bilingualism is not isolated to the linguistic system but effectively reconfigures the cognitive network as a whole (Kroll & Bialystok, 2013).

The consequences of bilingualism for cognition and the brain

An early observation in neuroimaging research was that the same neural tissue supports the function of both of the bilingual's two languages (e.g., Abutalebi, Cappa, & Perani, 2005). Given the behavioral evidence we have reviewed, that finding may not seem surprising. When there are differences in brain activity in using the two languages, it is more likely that they arise from the requirement to engage control mechanisms that regulate the use of the more dominant language and enable the engagement of the weaker language (e.g., Abutalebi & Green, 2007). Critically, brain areas that control language overlap with areas that control cognitive functioning more generally (e.g., Garbin et al., 2010; and see Abutalebi & Green, 2007). Behavioral research has shown that there are correlations between the ability to switch between languages and to switch between non-linguistic tasks, suggesting that they tap into the same mechanisms of cognitive control (e.g., Prior & Gollan, 2011). An interesting observation is that language processing in multilinguals, who use more than two languages, appears to follow similar patterns of parallel activation and control as observed for bilinguals, with the relative effects of the three or more languages determined by

proficiency and language dominance (e.g., Linck, Schweiter, & Sunderman, 2012; Van Hell & Dijkstra, 2002).

Recent neuroimaging studies suggest that not only are control areas of the brain activated in both linguistic and non-linguistic tasks, but bilinguals appear to use these control networks more efficiently than monolinguals, even when the task is purely cognitive. For example, Abutalebi et al. (2012) compared brain activity in bilinguals and monolinguals as they performed a nonverbal conflict monitoring task (see Bialystok, Craik, & Luk, 2012, for an illustration of some of the tasks that have been used in these studies). Abutalebi et al. found that both bilinguals and monolinguals revealed activity of the anterior cingulate cortex (ACC), a brain region that has been implicated in cognitive control, but bilinguals were more efficient than monolinguals, with reduced activation required to resolve the same level of conflict. Although comparisons of bilinguals and monolinguals are necessarily constrained by potential differences between groups, the research to date suggests that bilingualism has consequences for cognitive control beyond other factors that might also influence cognition, such as socioeconomic status (e.g., Calvo & Bialystok, 2014).

The differences between bilinguals and monolinguals appear to grow as individuals age and as cognitive resources become more difficult to recruit. Gold, Kim, Johnson, Kriscio, and Smith (2013) conducted an fMRI study using a non-linguistic switching task to compare younger and older adult bilinguals and monolinguals. They found little evidence for a bilingual advantage for younger adults, but a clear effect for older adults on both behavioral and neural measures. Like the Abutalebi et al. (2012) results, the pattern of brain activation for older bilinguals suggested that they were more efficient than monolinguals in resolving conflict. That efficiency has been demonstrated in healthy aging bilinguals, but in what is arguably the most dramatic evidence on the cognitive consequences of bilingualism, recent studies show that in the presence of pathology, such as dementia, these more efficient control mechanisms may play an important role to protect bilinguals from the symptoms of disease (e.g., Bialystok, Craik, and Freedman, 2007). Bilinguals present with symptoms of Alzheimer's type dementia 4–5 years later than monolinguals (e.g., Alladi et al., in press) and their brains at the point of diagnosis are more diseased than those of monolinguals (e.g., Schweizer, Ware, Fischer, Craik, & Bialystok, 2012).

Conclusions

The pattern of cognitive consequences associated with bilingual experience across the lifespan suggests that bilinguals use language in ways that exercise brain networks responsible for cognitive control. It is appealing to think that the discoveries we have described, including the openness of the language system, the cross-language competition present at all levels of language processing, and the adaptive nature of each of the bilingual's two languages, create a dynamic system that modulates the demands on cognitive resources. But there may not be a single way in which the juggling of the two languages produces the observed consequences (e.g., Baum & Titone, in press; Green & Abutalebi, 2013; Kroll & Bialystok, 2013). As Green and Abutalebi (2013) note, bilinguals who are equally proficient may differ in the demands placed on control networks depending on whether they frequently code switch between their two languages and the context in which

code switching occurs. Bilinguals often speak to others who themselves are not bilingual or not bilingual in the same languages. Being bilingual therefore requires skill in negotiating the discourse context for both speakers and listeners. The research agenda for investigating the demands and benefits associated with bilingualism is broad and complex but the implications are exciting. The ways that bilinguals' minds and brains change provides a model for investigating aspects of adult plasticity that would otherwise be obscured in speakers of one language alone.

Acknowledgments

The writing of this paper was supported in part by NIH Grant HD053146 and NSF Grants BCS-0955090 and OISE-0968369 to J.F. Kroll.

References

Abutalebi, J.; Cappa, SF.; Perani, D. What can functional neuroimaging tell us about the bilingual brain?. In: Kroll, JF.; De Groot, AMB., editors. Handbook of Bilingualism: Psycholinguistic Approaches. New York: Oxford University Press; 2005. p. 497-515.Lexical access in bilingual production

Abutalebi J, Della Rosa PA, Green DW, Hernandez M, Scifo P, Keim R, Cappa SF, Costa A. Bilingualism tunes the anterior cingulate cortex for conflict monitoring. Cerebral Cortex. 2012; 22:2076–2086. [PubMed: 22038906]

Abutalebi J, Green D. Bilingual language production: The neurocognition of language representation and control. Journal of Neurolinguistics. 2007; 20:242–275.

Alladi S, Bak TH, Duggirala V, Surampudi B, Shailaja M, Shukla AK, Chaudhuri JR, Kaul S. Bilingualism delays age at onset of dementia, independent of education and immigration status. Neurology. in press.

Ameel E, Storms G, Malt BC, Sloman SA. How bilinguals solve the naming problem. Journal of Memory and Language. 2005; 53:60–80.

Baum S, Titone D. Moving towards a neuroplasticity view of bilingualism, executive control, and aging. Applied Psycholinguistics. in press.

Baus C, Costa A, Carreiras M. On the effects of second language immersion on first language production. Acta Psychologica. 2013; 142:402–409. [PubMed: 23435116]

Bernolet S, Hartsuiker RJ, Pickering MJ. Shared syntactic representations in bilinguals: Evidence for the role of word-order repetition. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2007; 33:931–949.

Bialystok E, Craik FIM. Cognitive and linguistic processing in the bilingual mind. Current Directions in Psychological Science. 2010; 19:19–23.

Bialystok E, Craik FIM, Freedman M. Bilingualism as a protection against the onset of symptoms of dementia. Neuropsychologia. 2007; 45:459–464. [PubMed: 17125807]

Bialystok E, Craik FI, Luk G. Bilingualism: Consequences for mind and brain. Trends in cognitive sciences. 2012; 16:240–250. [PubMed: 22464592]

Byers-Heinlein K, Burns TC, Werker JF. The roots of bilingualism in newborns. Psychological Science. 2010; 21:343–348. [PubMed: 20424066]

Calvo A, Bialystok E. Independent effects of bilingualism and socioeconomic status on language ability and executive functioning. Cognition. 2014; 130:278–288. [PubMed: 24374020]

Chang C. A novelty effect in phonetic drift of the native language. Journal of Phonetics. 2013; 41:520–533.

Christoffels IK, Firk C, Schiller NO. Bilingual language control: An event-related brain potential study. Brain Research. 2007; 1147:192–208. [PubMed: 17391649]

Dijkstra, T. Bilingual word recognition and lexical access. In: Kroll, JF.; De Groot, AMB., editors. Handbook of bilingualism: Psycholinguistic approaches. New York: Oxford University Press; 2005. p. 179-201.

Dijkstra A, Grainger J, Van Heuven WJB. Recognition of cognates and interlingual homographs: The neglected role of phonology. Journal of Memory and Language. 1999; 41:496–518.

Dussias PE, Cramer Scaltz TR. Spanish-English L2 speakers' use of subcategorization bias information in the resolution of temporary ambiguity during second language reading. Acta Psychologica. 2008; 128:501–513. [PubMed: 18001689]

Dussias PE, Sagarra N. The effect of exposure on syntactic parsing in Spanish–English bilinguals. Bilingualism: Language and Cognition. 2007; 10:101–116.

Garbin G, Sanjuan A, Forn C, Bustamante JC, Rodriguez-Pujadas A, Belloch V, Hernandez M, et al. Bridging language and attention: brain basis of the impact of bilingualism on cognitive control. NeuroImage. 2010; 53:1272–1278. [PubMed: 20558314]

Gold BT, Kim C, Johnson NF, Kriscio RJ, Smith CD. Lifelong bilingualism maintains neural efficiency for cognitive control in aging. Journal of Neuroscience. 2013; 33:387–396. [PubMed: 23303919]

Green DW. Mental control of the bilingual lexico-semantic system. Bilingualism: Language and Cognition. 1998; 1:67–81.

Green DW, Abutalebi J. Language control in bilinguals: The adaptive control hypothesis. Journal of Cognitive Psychology. 2013; 25:515–530. [PubMed: 25077013]

Kantola L, Van Gompel RPG. Between- and within-language priming is the same: evidence for shared bilingual syntactic representations. Memory & Cognition. 2011; 39:276–90. [PubMed: 21264625]

Kroll JF, Bialystok E. Understanding the consequences of bilingualism for language processing and cognition. Journal of Cognitive Psychology. 2013; 25:497–514.

Kroll JF, Bobb S, Wodniecka Z. Language selectivity is the exception, not the rule: Arguments against a fixed locus of language selection in bilingual speech. Bilingualism: Language and Cognition. 2006; 9:119–135.

Kroll, JF.; Dussias, PE.; Bogulski, CA.; Valdes-Kroff, J. Juggling two languages in one mind: What bilinguals tell us about language processing and its consequences for cognition. In: Ross, B., editor. The Psychology of Learning and Motivation. Vol. 56. San Diego: Academic Press; 2012. p. 229-262.

Lagrou E, Hartsuiker RJ, Duyck W. Knowledge of a second language influences auditory word recognition in the native language. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2011; 37:952–965.

Linck JA, Kroll JF, Sunderman G. Losing access to the native language while immersed in a second language: Evidence for the role of inhibition in second language learning. Psychological Science. 2009; 20:1507–1515. [PubMed: 19906121]

Linck JA, Schwieter JW, Sunderman G. Inhibitory control predicts language switching performance in trilingual speech production. Bilingualism: Language and Cognition. 2012; 15:651–662.

Marian V, Spivey MJ. Competing activation in bilingual language processing: Within- and between-language competition. Bilingualism: Language and Cognition. 2003; 6:97–115.

Meuter RFI, Allport A. Bilingual language switching in naming: asymmetrical costs of language selection. Journal of Memory and Language. 1999; 40:25–40.

Misra M, Guo T, Bobb SC, Kroll JF. When bilinguals choose a single word to speak: Electrophysiological evidence for inhibition of the native language. Journal of Memory and Language. 2012; 67:224–237.

Morford JP, Wilkinson E, Villwock A, Piñar P, Kroll JF. When deaf signers read English: Do written words activate their sign translations? Cognition. 2011; 118:286–292. [PubMed: 21145047]

Prior A, Gollan TH. Good language-switchers are good task-switchers: Evidence from Spanish-English and Mandarin-English bilinguals. Journal of the International Neuropsychological Society. 2011; 17:682–691. [PubMed: 22882810]

Schwartz AI, Kroll JF, Diaz M. Reading words in Spanish and English: Mapping orthography to phonology in two languages. Language and Cognitive Processes. 2007; 22:106–129.

Schweizer TA, Ware J, Fischer CE, Craik FI, Bialystok E. Bilingualism as a contributor to cognitive reserve: evidence from brain atrophy in Alzheimer's disease. Cortex. 2012; 48:991–996. [PubMed: 21596373]

Thierry G, Wu YJ. Brain potentials reveal unconscious translation during foreign language comprehension. Proceeding of National Academy of Sciences. 2007; 104:12530–12535.

Van Assche E, Duyck W, Gollan TH. Whole-language and item-specific control in bilingual language production. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2013; 9:1781–1792.

Van Hell JG, Dijkstra T. Foreign language knowledge can influence native language performance in exclusively native contexts. Psychonomic Bulletin & Review. 2002; 9:780–789. [PubMed: 12613683]