Cognitive and Brain Effects of Bilingualism: What's the Evidence?

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There has been much interest in the possibility that bilingual experience affects cognitive ability and brain function, with the primary outcome being enhancement of specific cognitive processes. This discussion is taking place in the context of a lively debate about whether these effects are reliable. The skepticism about the claims follows from the inconsistency of some research results and the absence of a broadly-accepted explanation for their occurrence. To evaluate the state of these ideas, therefore, it is instructive to examine the nature and scope of the evidence that has been offered.




Behavioral	✓1. Visual Language ✓2. Facial Scanning ✓3. Visual Attention	✓1. Conflict & other EC tasks RT/Acc O 2. Response inhibition ✓3. Flexibility/ shifting ✓4. Nonverbal working memory	O 1. Conflict & other EC tasks RT/Acc O 2. Noverbal working memory	✓1. Conflict & other EC tasks RT/Acc ✓2. Dementia symptoms o 3. Dementia incidence
Imaging		✓5. ERP in EC tasks ✓6. Structural MRI grey and white	✓2. ERP for EC tasks ✓3. fMRI for EC tasks ✓4. Structural MRI	✓4. ERP for EC tasks ✓5. fMRI for EC tasks ✓6. Structural MRI

✓ Group differences
o No group differences

In the figure above, the research in bilingualism has been organized along three dimensions: (a) lifespan stage, (b) behavioral vs. imaging evidence, and (c) targeted process/outcome. Each entry indicates a class of research that may represent any number of individual studies, from a small handful (e.g., visual language in infants) to a substantial number (e.g., conflict and EC tasks in young adults). An overall judgment about the most frequent outcome of each *class* of research is indicated by a green check if the majority of studies reveals a language group difference in favor of bilinguals or a red circle if the majority of studies indicates no group differences. Although it is theoretically possible that monolinguals could outperform bilinguals on a class of studies, that does not occur for the cognitive research compiled here, although it does occur in studies on bilingual language processing.

Several features of this summary table are notable. First, the majority of cells contains check marks, indicating significantly better outcomes for bilinguals than monolinguals. Second, the areas of no difference are confined to behavioral studies, with all the reported imaging entries showing group

differences. Differences in brain structure and function cannot be interpreted as better or worse but merely indicate differences between groups. However, since most behavioral differences favor bilinguals, then it is reasonable to infer that the brain structure and function corresponding to bilinguals is associated with performance benefits. Finally, tasks that show group differences at some stages (executive control tasks for children and older adults) may not produce group differences at another stage (the same tasks for young adults), even though it appears that the same processes are assessed.

What is the pattern? Although the tasks are different, they all include some type of conflict, interference, selection, or flexibility. For this reason, executive control was identified early as a relevant domain that was impacted by bilingualism. But executive control itself is in need of definition, limiting its utility as an explanatory construct. Adding to the dilemma, behavioral studies with young adults rarely show language group effects, yet neuroimaging evidence consistently reveals language group differences at all ages. Most important are functional differences in the networks recruited by monolinguals and bilinguals to perform these tasks, even when behavioral measures are equivalent. Therefore, essential networks involved in these tasks are reconfigured in bilinguals.

The absence of a compelling explanation for these effects has made these patterns difficult to interpret. The standard view was that the effects must be traceable to some aspect of language use, such as selecting the target language or switching between languages, but investigations of those possibilities have not been fruitful. A different kind of explanation comes from focusing two areas where language group differences are reliable: infant studies and neuroimaging results.

Evidence from infants is consistent with the idea of managing conflict but rules out language use as the triggering factor. Following from evidence that infants discriminate between the languages, a compelling explanation for the effect of bilingualism is that infants in a complex linguistic environment develop attention strategies to deal with that environment. In other words, the demands created by the linguistic complexity of a bilingual environment lead to the development of attention networks that can respond to those demands. These attention networks become the basis for attentional processes throughout life. As children develop executive control, the reconfigured attention networks for bilingual children are helpful and make this development precocious, but in young adulthood when the tasks are simple, there is no behavioral difference despite differences in functional recruitment.

The most dramatic benefit comes in older age. For reasons that are not yet clear, the attention network of bilinguals is able to compensate for cognitive decline and allows bilinguals to maintain functioning even when there is neuropathology associated with dementia. In the absence of any effective treatment of dementia, including Alzheimer's disease, postponement of symptoms is currently the best defense. Retrospective studies are consistent in showing a delay in symptom onset and diagnosis for bilinguals, although prospective incidence studies confirm that bilinguals still succumb to the disease. However, those studies rarely report the age at which the disease was diagnosed, so there is no contradiction with the retrospective studies.

The impact of bilingualism on cognitive and brain outcomes changes through the lifespan. An explanation based on an adaptation in attention networks to cope with the demands of bilingual language environment helps to make sense of the myriad effects.

Further Reading: Bialystok, E. (2017). The bilingual adaptation: How minds accommodate experience. *Psychological Bulletin, 143,* 233-262.