What cognitive processes are likely to be exercised by bilingualism and does this exercise lead to extra-linguistic cognitive benefits?

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Outline

Some history

Likely exercises in the bilingual gymnasium

Bilingual Advantages? Not BICA; BEPA?

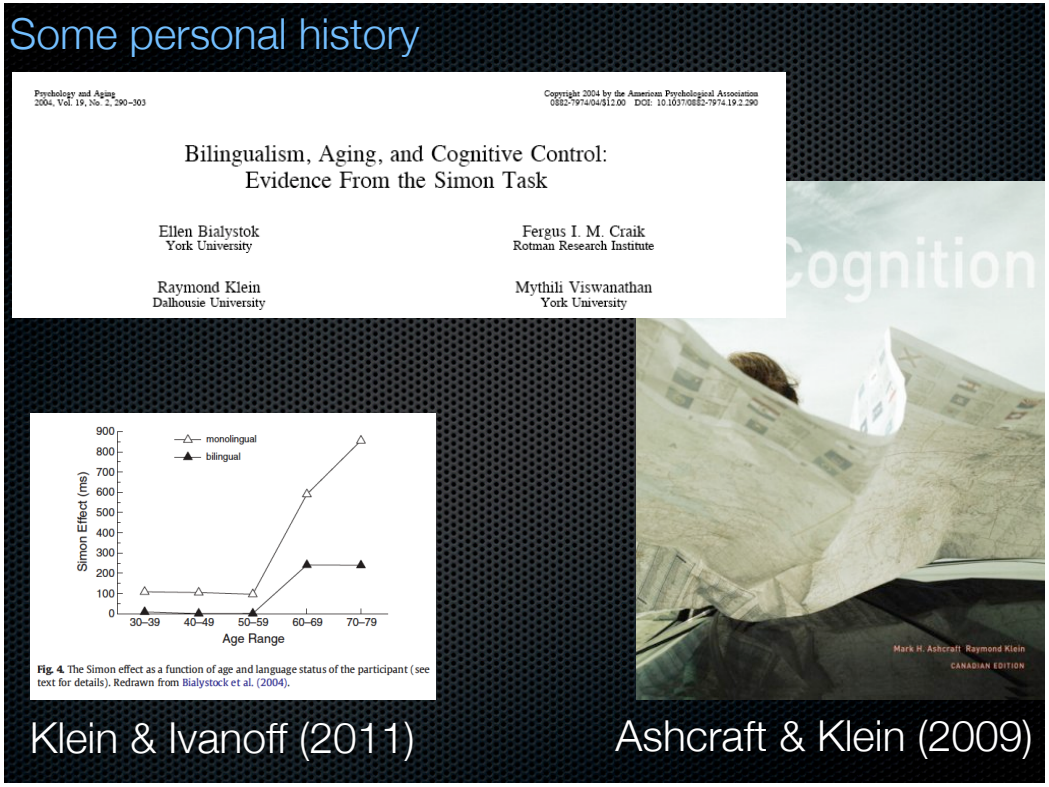
Not BEPA; BSA?...No BA at all!

Lessons from history

Let me begin with some acknowledgement as to why I am speaking at this workshop. I am a cognitive psychologist with expertise in attention and with a neo-Hebbian desire to understand how cognitive processes are implemented in the brain. Although I have had a long-standing interest in reading and dyslexia, my research and teaching has focussed on attention and tended to shy away from language.

I spent my 2000 sabbatical 1/2 time at the Rotman Research Institute to which I had been invited by its then Director Don Stuss. As it turned out my office at the Rotman was next to that of Ellen Bialystok who was also on sabbatical.

Because of my interest in inhibitory control of cognitive processes and expertise in the Simon effect, Ellen and her Rotman collaborator, Gus Craik invited me into their exciting research project exploring the possibility that early mastery of two languages might provide, in later life, an improved inhibitory control system.



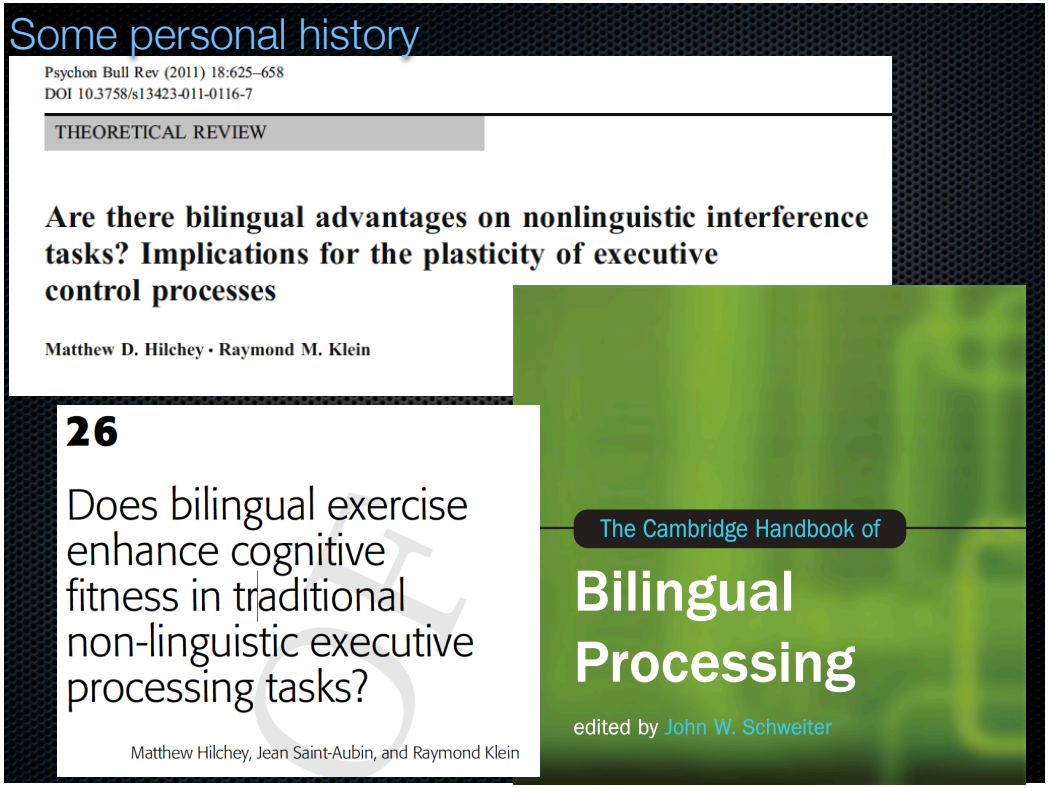
It is fair to say that the positive results reported in the 2004 paper that resulted from that collaboration was an important stimulus for the ensuing interest in the topic of this conference.

In 2010 I encouraged my first-year graduate student Matt Hilchey to write a term paper for a course in applied cognitive psychology on the topic: “Costs & Benefits of Bilingualism.” My encouragement was based on curiosity: despite having highlighted the findings from the 2004 paper in a textbook and an article on attention and the Simon effect, I had not closely followed the literature spawned by that paper.

"...there was a precipitous increase in the Simon effect with age, presumably reflecting a decrease in executive control. Importantly, and supporting the hypothesis, this increase in the Simon effect with increasing age was very much ameliorated in the group of early bilinguals."
Klein & Ivanoff (2011, p. 228)

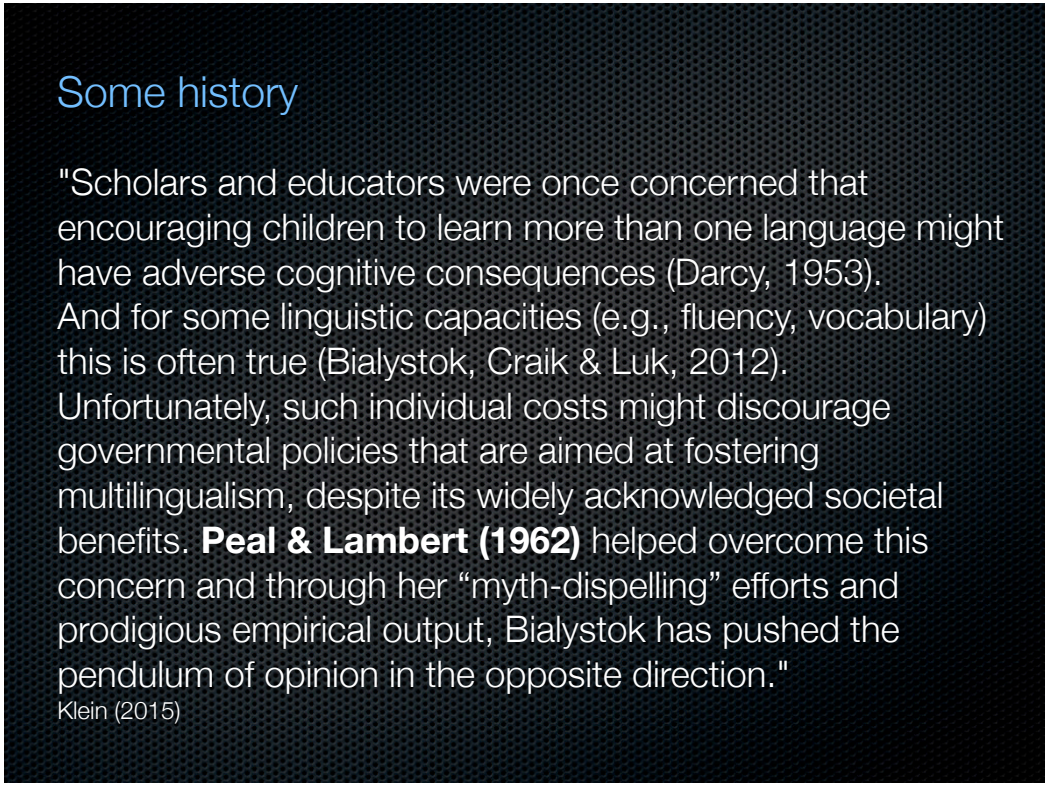
"...bilinguals...will often need to select in which language to express any thoughts they have. These frequent choices, as well as frequent switches between languages, are likely to exercise pre-frontal executive control processes in a uniquely effective manner." (Ashcraft & Klein, 2009)

As you can see from these quotes from the aforementioned sources, prior to Hilchey's analysis of the literature, circa 2010, I was an endorser of the idea that bilingualism generated domain general improvements in executive function. As we will see, and to quote Randy Engle, "I was wrong".



Hilchey's outstanding term paper was refined and transformed into a major, comprehensive review of the literature on bilingualism and executive control (Hilchey & Klein, 2011).

More recently, Hilchey, Jean Saint-Aubin and I updated that review in a chapter we contributed to the Cambridge Handbook of Bilingual Processing. And I presented a precis of both reviews in my commentary on Virginia Valian's recent BLC target article. We have just corrected the proofs of the chapter and are told that the Handbook will be available this summer. Hence, most of the audience will not have seen our chapter which provides much of the material I will be presenting today.



This is how I began my recent commentary on Virginia Valian's target article:

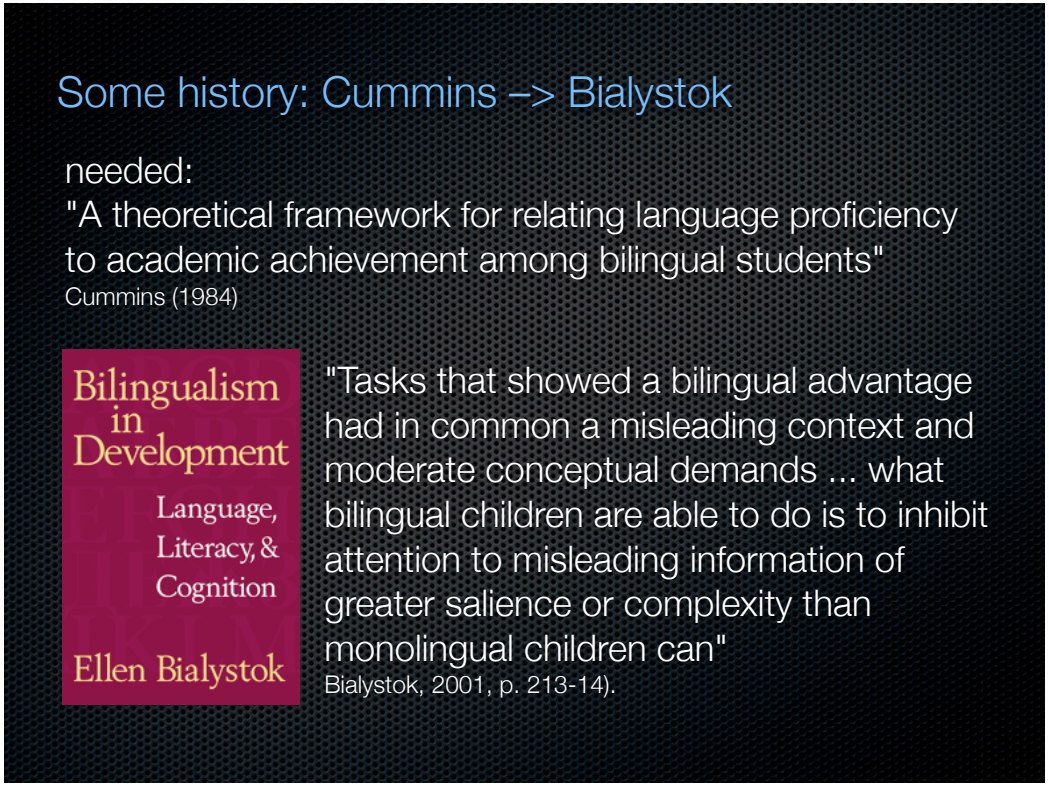
Prior to Peal & Lambert the focus was on global measures of intelligence, measures that were often culturally biased. The results, which most often demonstrated bilingual disadvantages in intelligence, were often viewed through a racist political agenda (here in the USA at least) against immigration. And the studies were characterized by glaring methodological weaknesses.

Some history: Peal & Lambert

"The picture that emerges of **the French-English bilingual in Montreal** is that of a youngster whose **wider experiences in two cultures** have given him advantages which a monolingual does not enjoy. Intellectually his experience with two language systems seems to have left him with a mental flexibility, a superiority in concept formation, and a more diversified set of mental abilities, in the sense that the patterns of abilities developed by bilinguals were more heterogeneous. It is not possible to state from the present study **whether the more intelligent child became bilingual or whether bilingualism aided his intellectual development**, but there is no question about the fact that he is superior intellectually."

Peal & Lambert, 1962, p. 20

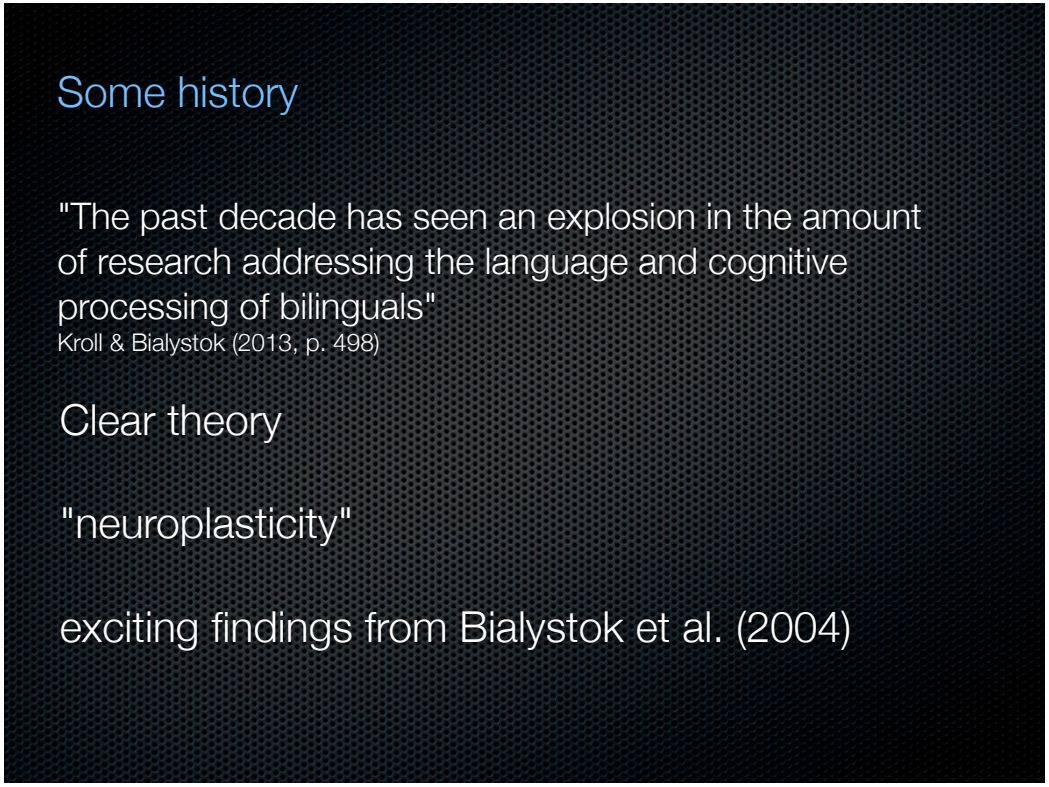
Peal and Lambert's (P&L's) description of bilingual advantages foreshadows recent thinking & the caveats they introduce remain relevant to any discussion of possible differences in cognition between monolinguals and bilinguals. P&L were careful: 1) to restrict their description to the francophone bilingual child in Montreal; 2) to note that "experiences in two cultures", and not merely bilingualism, may have contributed to the observed bilingual advantages, and
3) to warn the reader that no causal path could be inferred.
(Indeed, we were warned yesterday about "reverse causality" and Randy Engle's comment that 2nd language acquisition was better in individuals with high working memory capacity makes reverse causality a likely explanation for many positive findings in this literature.
"Mental flexibility" became a catch phrase for describing the nature of the cognitive advantage that bilinguals might enjoy over monolinguals. While arguably more specific than "intelligence" this term is primarily descriptive and doesn't tell us much about what cognitive representations and/or mental processes might underlie the better scores on particular tests.



Reflecting a dissatisfaction with such a descriptive analysis, Cummins advised the field that
"A theoretical framework" was needed. Because the "cognitive revolution" was still in its infancy when Peal and Lambert wrote their paper it is not surprising that their description of the advantage was somewhat lacking in mechanism(s). As we see it, the most influential effort to follow Cummins' admonition was made by Bialystok, in her book, Bilingualism in Development: Language, Literacy and Cognition (2001). Bialystok's review of the post-Peal & Lambert findings led her to this description which places a considerable emphasis on the concept of selective attention achieved through the inhibition of task-irrelevant information:

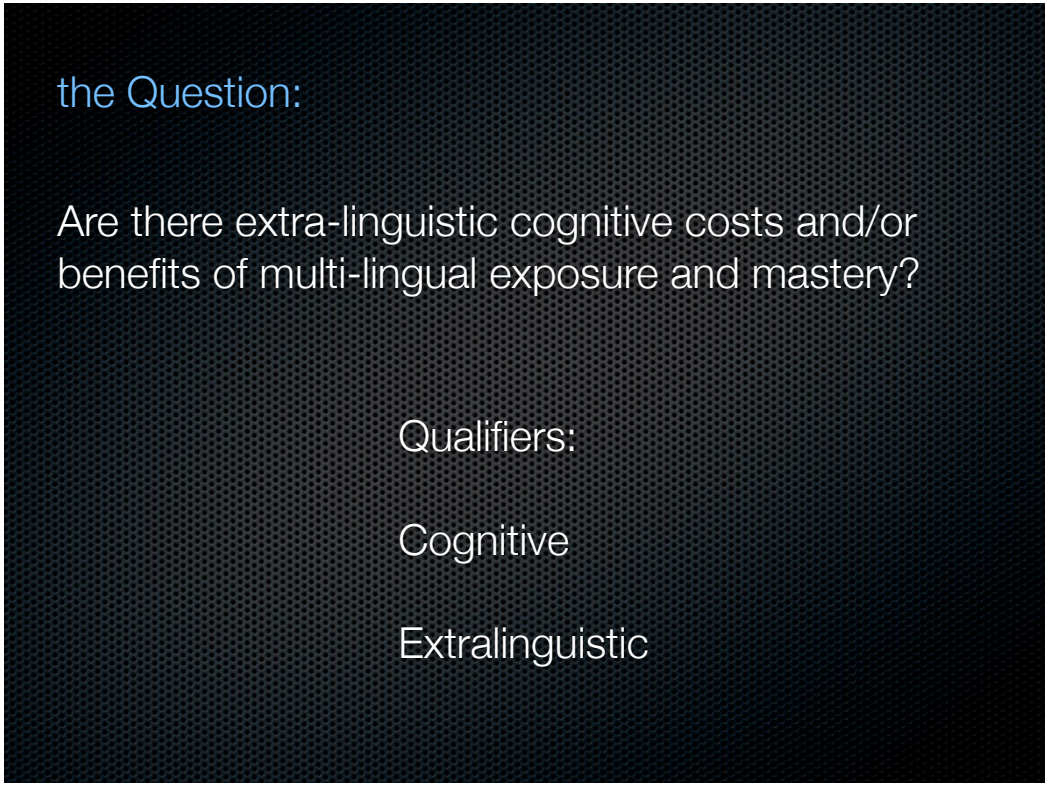
"But if both languages are active, then how do speakers (or listeners, or readers) manage to maintain performance in only one of the languages without suffering from massive intrusions from the other? According to some researchers, the explanation is that there is a constant inhibition of the nonrelevant languages, allowing the desired system to carry out the processing (Green, 1998; Kroll & De Groot, 1997) This inhibition is undoubtedly achieved by means of processes carried out in the frontal lobe. If this model is correct, then bilingual children experience extensive practice of these functions in the first few years of life, at least once both languages are know to a sufficient level of proficiency to offer viable processing systems. It would appear that this practice in inhibiting linguistic processing carries over to processing in highly disparate domains."
Bialystok, 2001, p. 216).

Then, after identifying the source of this inhibition in the prefrontal cortex and noting that research on bilinguals shows that both languages remain active during language processing, she develops this theory to explain how this bilingual advantage might come about.

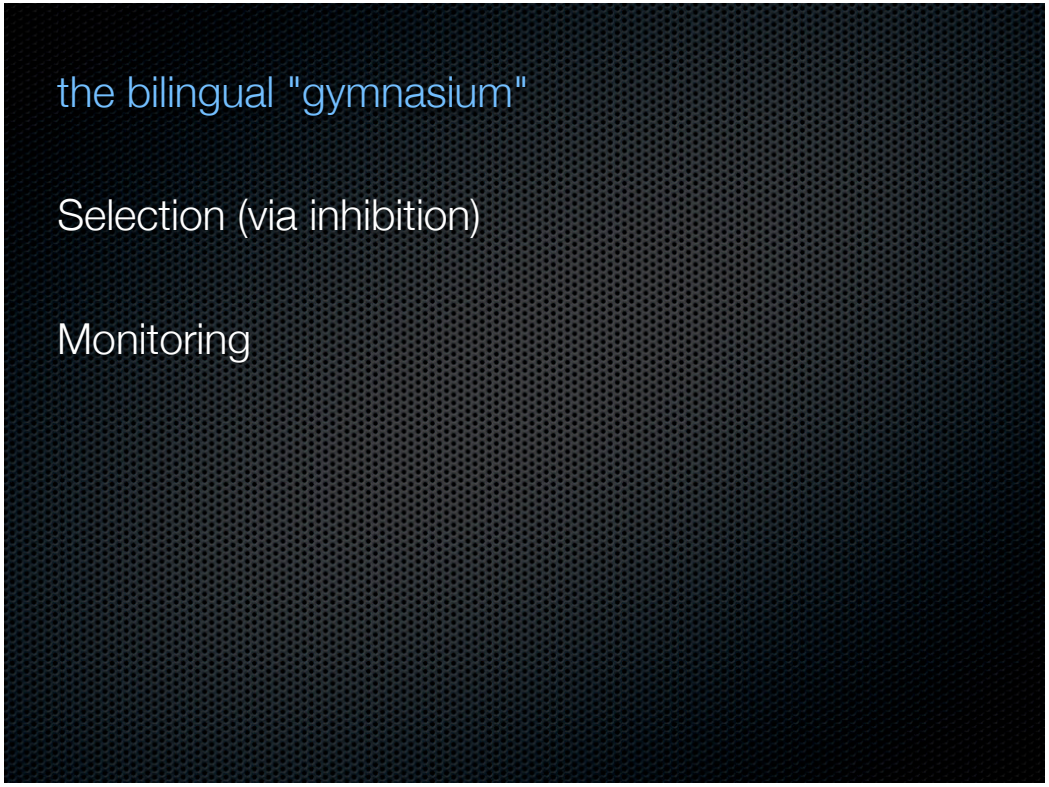


As noted by Kroll and Bialystok (2013), "The past decade has seen an explosion in the amount of research addressing the language and cognitive processing of bilinguals" (p. 498).

This very clear and exciting proposal from Bialystok's important book provided a key stimulus for this explosion of interest. So too did a variety of findings subsumed under the heading of "neural plasticity." Adding fuel to the fire, were the positive results from the seminal study that explored whether these extra-linguistic cognitive benefits carry over into adulthood (Bialystok, Craik, Klein & Viswanathan, 2004).

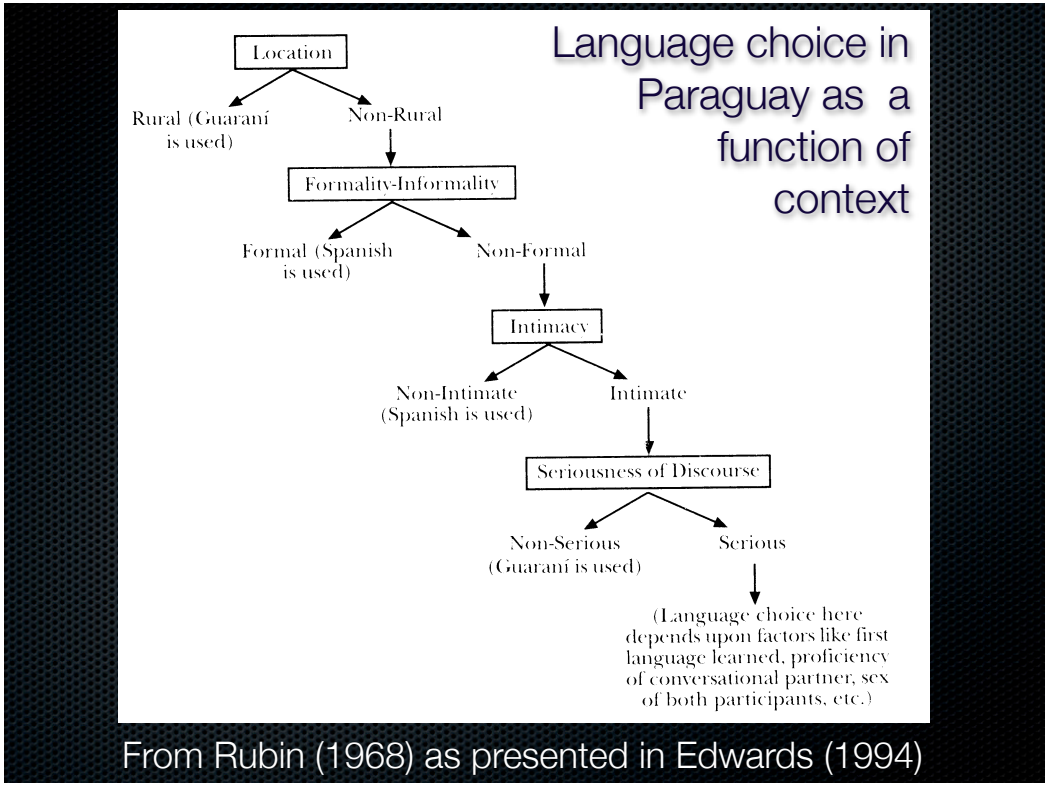


The question addressed in this seminal paper and in my analyses of the literature with Hilchey (including today's presentation) is:
Are there extra-linguistic cognitive costs and/or benefits of multi-lingual mastery?
We use the qualifier "cognitive" to exclude from consideration the possible economic, social and cultural costs and benefits. We believe that in the vast majority of cases for which families make a choice about whether to acquire a second language or encourage their children to do so, the benefits on these dimensions far outweigh the costs. We use the qualifier "extra-linguistic" to exclude from consideration the potential linguistic benefits (e.g. metalinguistic awareness) and costs (e.g., vocabulary) of multi-lingualism which are relatively well-documented.

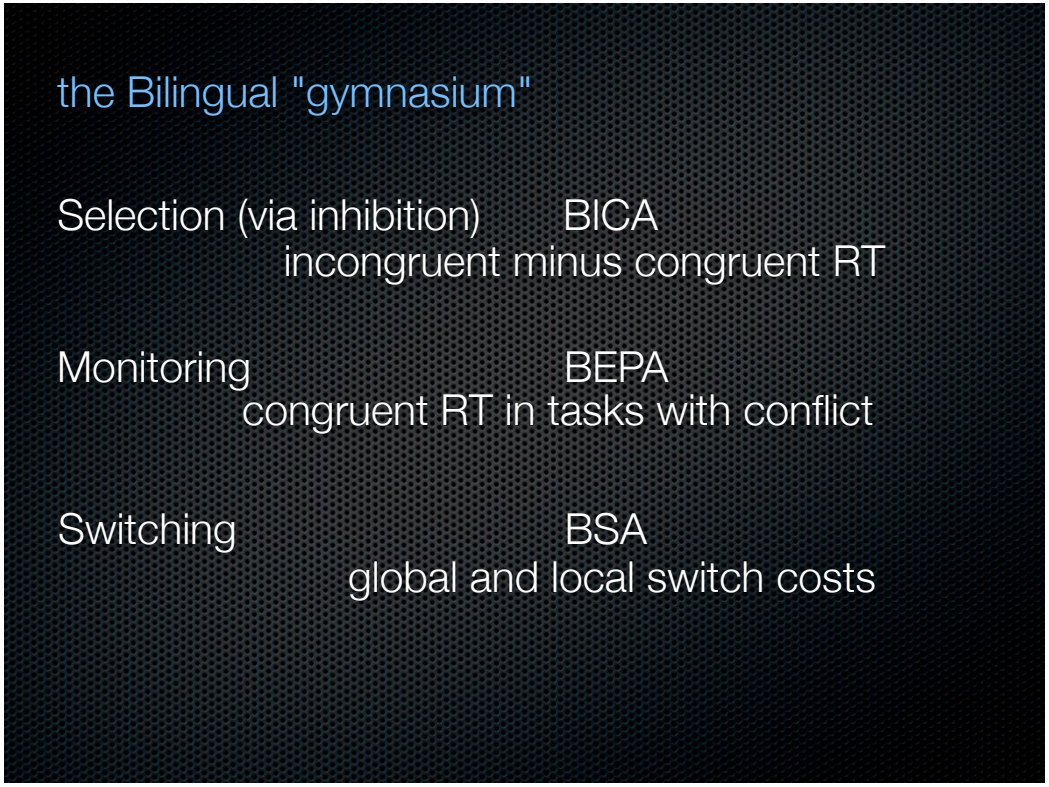


What cognitive processes are likely to be exercised in bilingualism.
In Bialystok's (2001) developmental analysis of the bilingual gymnasium, her emphasis was on selective attention (to avoid intrusions) mediated by inhibition.
Other cognitive processes that have been discussed in the literature can be regarded as a precedent of and a consequent of such selection.

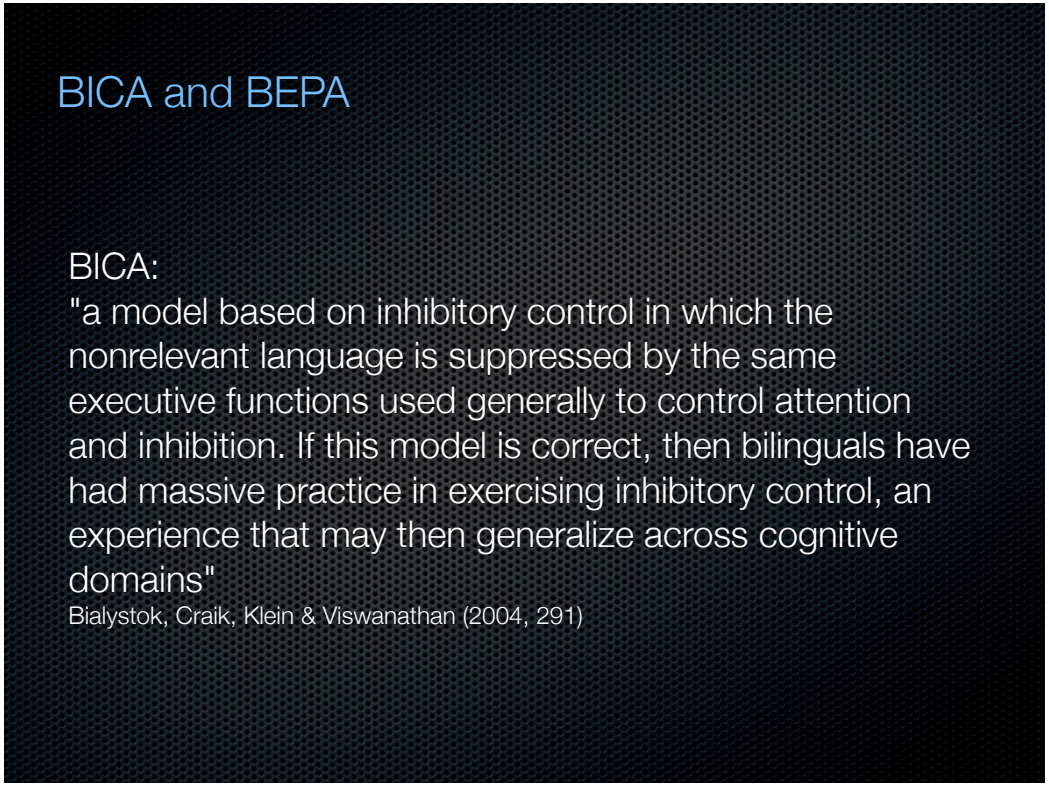
Preceding selection is monitoring the context to ensure that the language selected is the correct one given the context.



I think of this as a form of "attentional radar". For an example of how complex this monitoring and decision process can be, consider Rubin's (1968) flowchart of language choice as a function of context in Paraguay.



Selecting a language – to use, for example, in a social interaction – will sometimes entail switching from the language used most recently. Thus a possible consequence of selection is switching.
These 3 domain general components of executive functioning might be especially exercised in bilingualism.
If there are bilingual advantages, following Hilchey & Klein we can call the first two: bilingual inhibitory control advantage (BICA) and bilingual executive processing advantage (BEPA). Lets call the third one bilingual switching advantage (BSA). The first two have been most thoroughly explored using the Simon task (as pioneered by Bialystok et al. (2004), the flanker task (often embedded in the ANT) and the spatial Stroop task (which, like the Simon effect, requires indicating the direction of an arrow while ignoring its location).



In the seminal 2004 paper, the key rationale was rooted the proposal of Green and later Bialystok of "a model based on inhibitory control in which the nonrelevant language is suppressed by the same executive functions used generally to control attention and inhibition. If this model is correct, then bilinguals have had massive practice in exercising inhibitory control, an experience that may then generalize across cognitive domains."
To test this hypothesis the Simon effect was selected for two reasons. Firstly, like the famous Stroop effect, the Simon effect is thought to be due to the conflict between two simultaneously activated responses: the task irrelevant, automatically activated tendency to respond in the direction of stimulation and the task relevant response. But, secondly, unlike the vocal/lingustic Stroop effect, the Simon effect is non-linguistic and uses manual responses. Finally, it is often assumed that participants who are more efficient at inhibiting task-irrelevant, pre-potent responses would show smaller Simon effects.

BICA and BEPA

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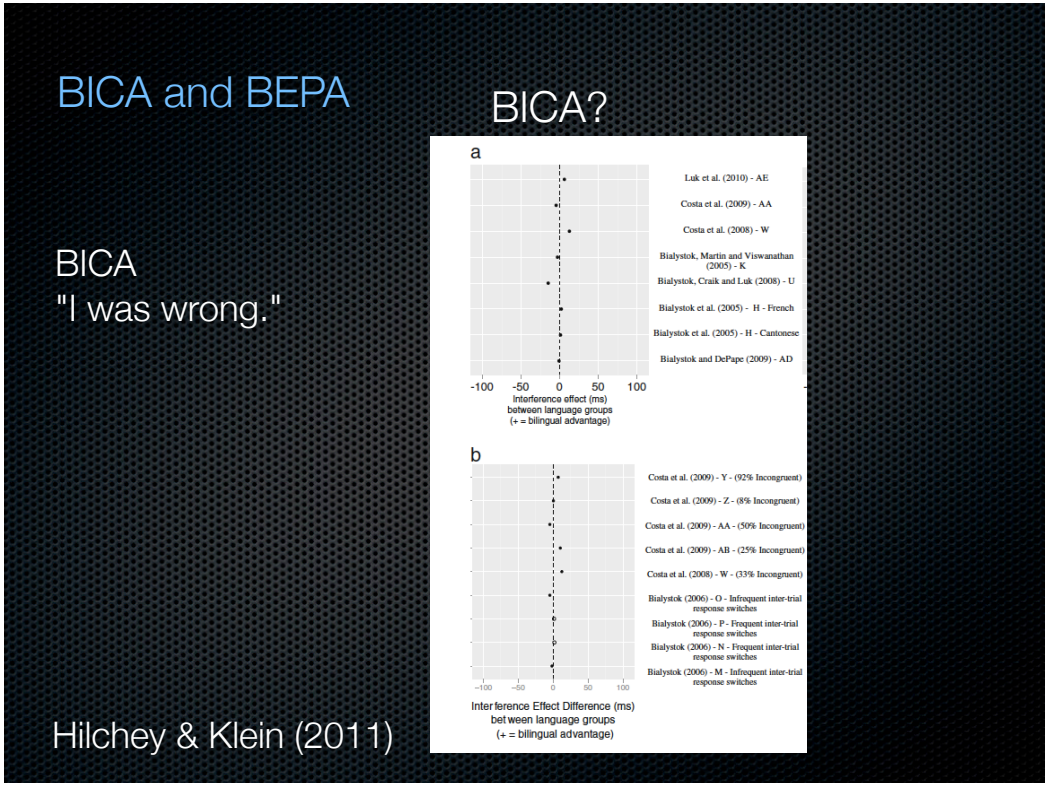
THEORETICAL REVIEW

Are there bilingual advantages on nonlinguistic interference tasks? Implications for the plasticity of executive control processes

Matthew D. Hilchey · Raymond M. Klein

When Hilchey & Klein (2011) reviewed the considerable number of studies spawned by the exciting hypothesis of a bilingual inhibitory control advantage (BICA) and by the positive support for it provided by Bialystok et al (2004), we found a methodologically variable and empirically messy literature.



and, on balance scant support for BICA. As a guide, in all my figures representing the literatures data points to the right of the vertical line represent a mathematical bilingual advantage while data points to the left of the line represent a monolingual advantage. Because this presentation is in the "young adults" section of the workshop it will focus on the results from young adults. But, as will be noted later, the story is not much clearer when we examine the results from studies of children or older adults.

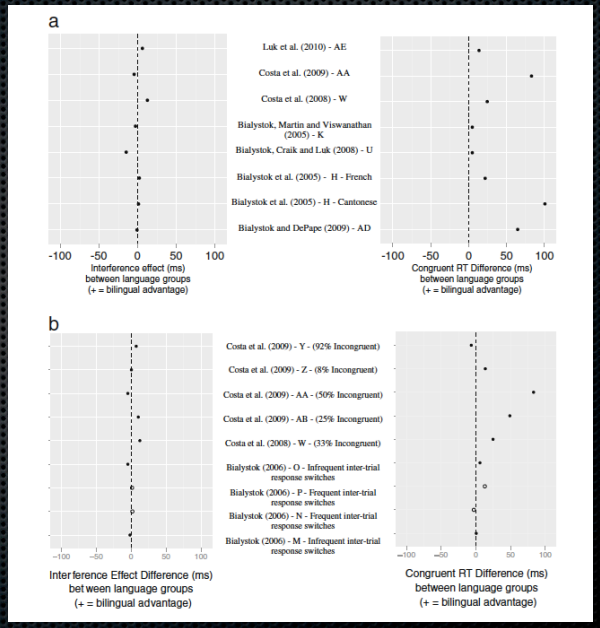
BICA and BEPA

BEPA
"the constant strain of language management on the conflict-monitoring system might strengthen the extent to which bilinguals can focus processing on task-relevant stimuli (via cognitive control)."
Hilchey & Klein (2011, p. 647)

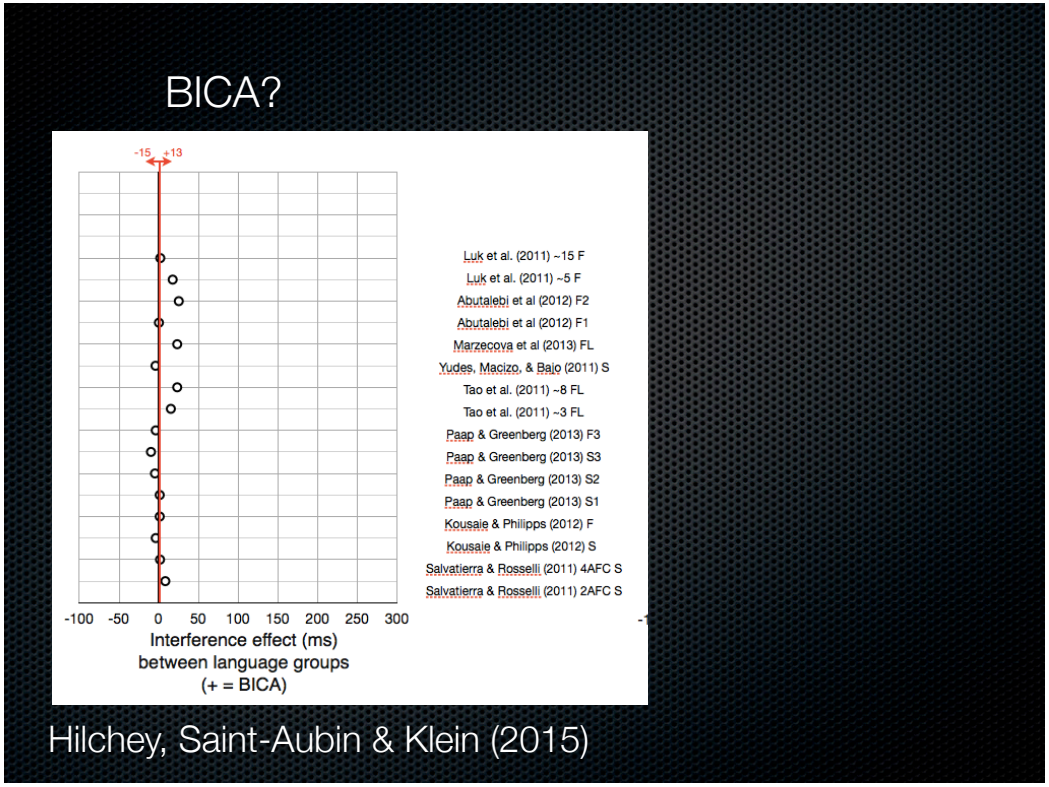
Hilchey & Klein (2011)

BICA?

BEPA?



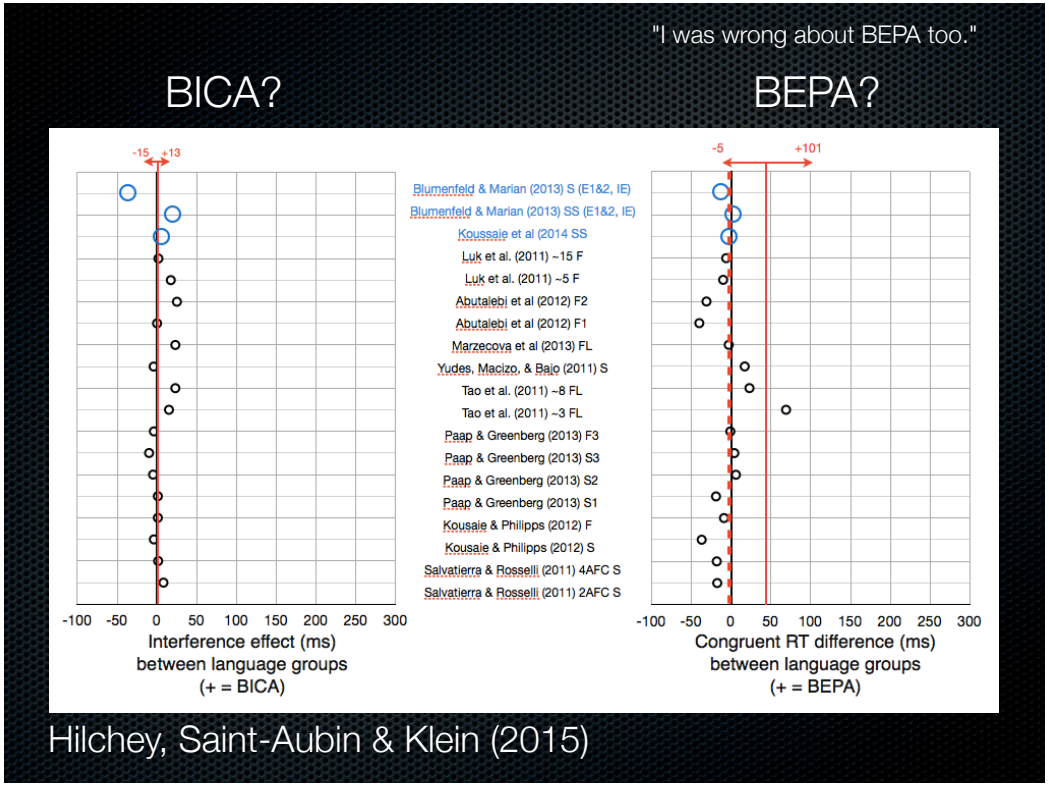
As was noted by Bialystok et al. and later by Costa et al. (2009) "Bilinguals were faster as well on congruent trials...". What we thought we had uncovered in our 2011 review was that this finding of a "global" advantage (in contrast to the overall absence of a BICA illustrated here) was a robust one. Although we introduced BEPA as theoretically neutral, in our general discussion, we offered this concrete theoretical proposal. Consequently, BEPA came to be associated with enhanced monitoring and we (prematurely, as I will show) concluded that "the relative ubiquity of the bilingual advantage in global RTs provides strong support for the BEPA hypothesis."



A few years later, when John Schwieter invited me to contribute a chapter to the Cambridge University Handbook of Bilingual Processing, I thought an update to our 2011 paper would be timely because so many new studies using the non-linguistic conflict tasks covered in our previous review had appeared. I teamed up with Hilchey and my colleague at U. de Moncton, Dr. Jean Saint-Aubin to review this literature and write this chapter.

There were 31 new experiments using Simon, Flanker and spatial Stroop tasks, 18 of which tested monolingual and bilingual young adults.

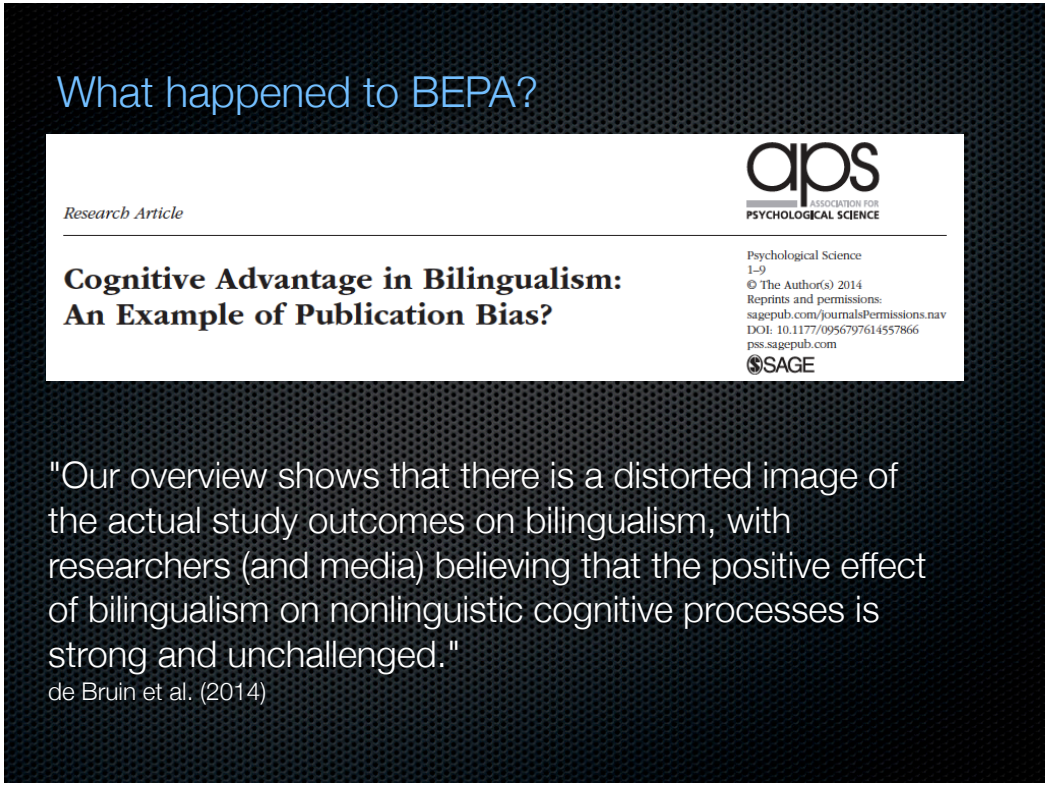
The measures that targeted BICA (interference effects) closely replicated what we had found in 2011: no evidence for a bilingual advantage. Note the red vertical line represents the mean unweighted effect from the 2011 review (only the new studies are plotted here) and the double arrow at the top represents the range of scores from the 2011 review.



Here I have added (in blue) the few studies that have appeared since we conducted our followup review.
Much to our surprise, and repudiating the conclusion of our 2011 review, the new studies revealed no evidence for BEPA either. The dashed red line represents the unweighted mean of the BEPA effect in studies published since 2011.

"...we tentatively conclude...that **childhood** bilingualism may enhance executive processing (BEPA) but not inhibitory control (no BICA), in flanker & Simon tasks. However, because social factors, potentially co-varying with bilingualism in different samples, have been insufficiently considered, these executive processing differences cannot be confidently attributed to bilingualism."
"...the most common finding in [the **elderly**] is a bilingual advantage on the interference effect. The most frequent expression of it, however, is comparable performance between language groups on conflict trials and slower bilingual responding on non-conflict trials...thus overall the monolinguals tend to outperform bilinguals in the Simon and spatial-Stroop tasks...we believe that this particular pattern (which can hardly be called a bilingual advantage) requires additional replications better controlling for potentially relevant sociolinguistic factors.
Hilchey, Saint-Aubin & Klein, 2015

Because it was implied during the meeting that while bilingual advantages in executive processing may not regularly be seen in young adults they are robust in children and the elderly, it is worthwhile noting what we said about these two age groups in our most recent review.



What happened to the BEPA that seemed so robust in 2011? An anonymous reviewer suggested that data in the years preceding 2011 may have tended strongly toward bilingual processing advantages because of publication or outcome reporting biases: Perhaps the widespread popularity of the bilingual advantage idea discouraged researchers from attempting to publish null effects. And perhaps Hilchey and Klein's comprehensive, critical and challenging review of this literature facilitated the publication of null results. We agreed in our chapter that biases may account for the divergence between the pre-and post-2011 research reports and we suggested that the bias hypothesis "warranted a more formal mathematical and complete treatment". Just such a treatment, by de Bruin, Treccani and Della Sala (2014) recently appeared in Psychological Science. Converging evidence led them to conclude that this literature is biased. We do not think that the response to this paper by Craik et al. will convince many readers that the "biased literature" inference was wrong. It is worth noting, however, as did de Bruin et al., that the presence of bias in a literature does not tell that the claims asserted in this literature are necessarily false.

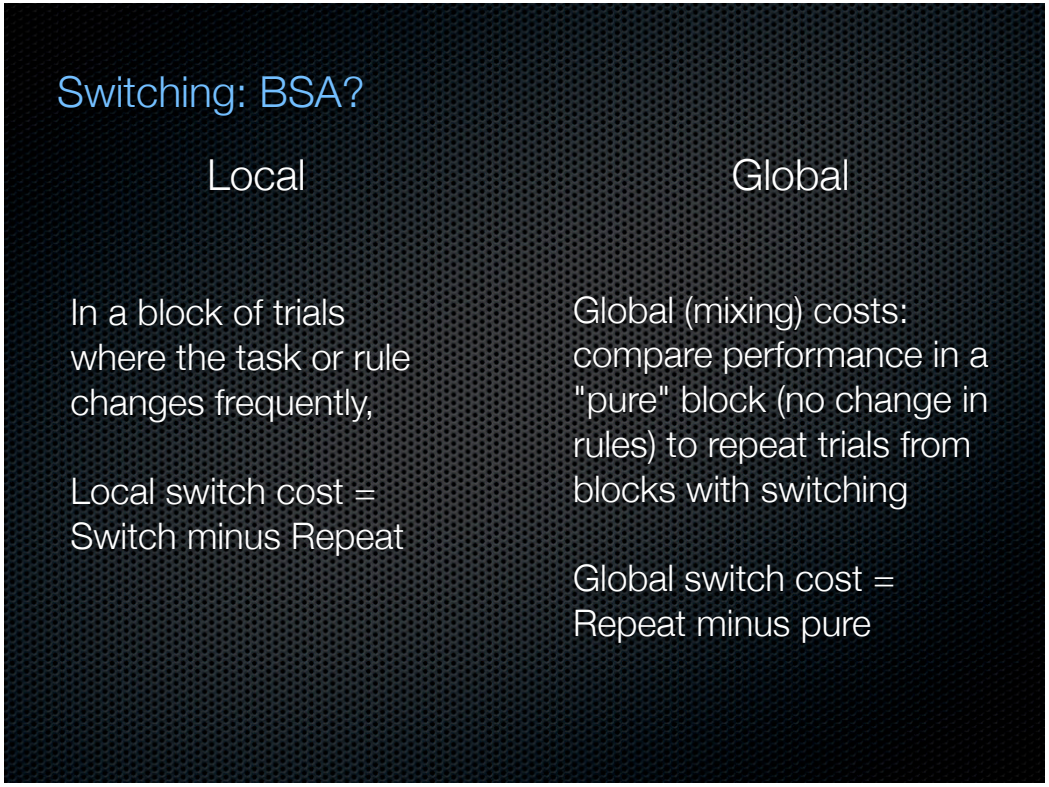
From Prior & MacWhinney (2010)

Design and procedure

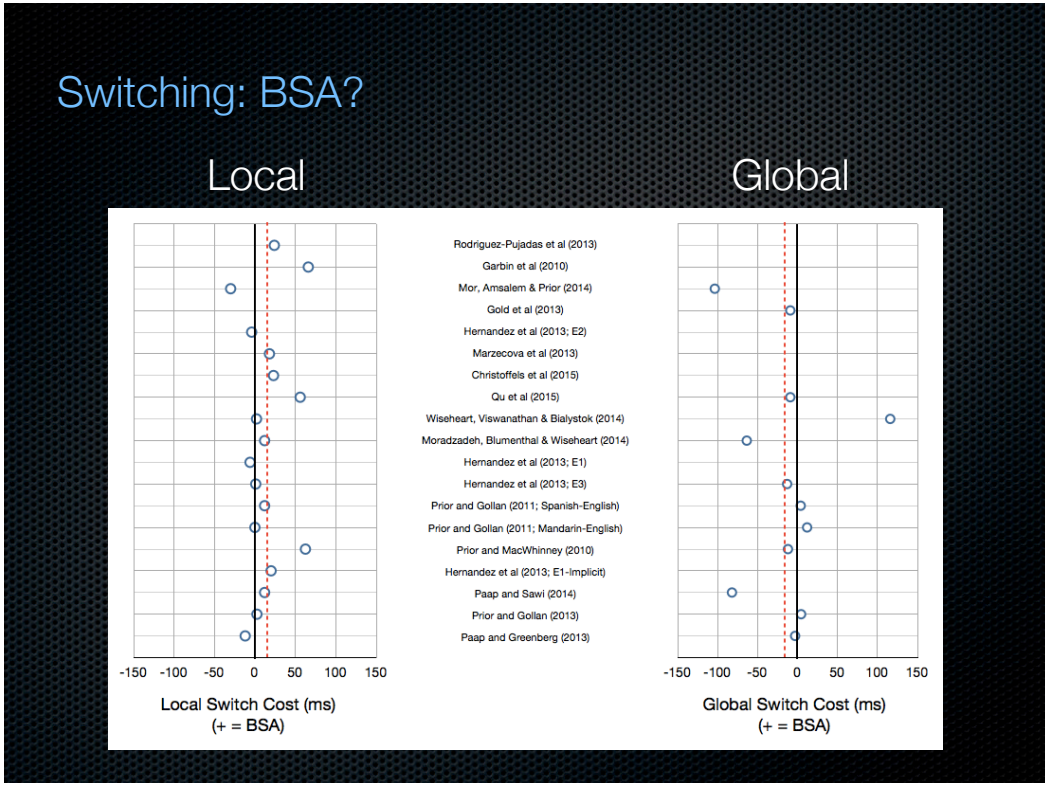
All participants completed the following tasks in a single experimental session that lasted approximately 90 minutes.[1] The tasks were presented in the same order to all participants.

[1] Participants also completed a Color Flanker task and a Simon task, the results of which are not reported in this paper. There were no significant differences between the language groups on either task.

For a salient example of such a bias (against the reporting of null results) consider this FN from Prior and MacWhinney (2010), a study that we will turn to shortly.

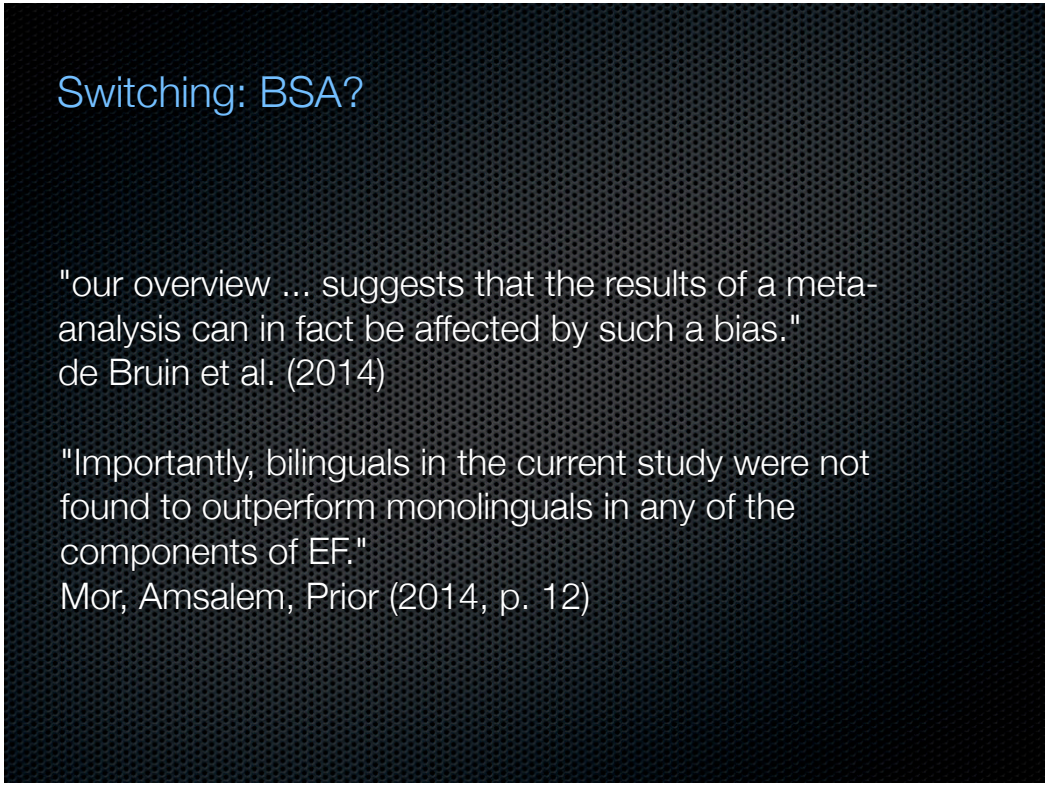


When we conducted our 2011 review, we recognized that task-switching had such a substantial surface similarity to switching between languages that it might be reasonable to hypothesize that bilinguals would be more efficient at switching between tasks than monolinguals. At that time, however, there were scant studies that could be used to test this Bilingual Switching Advantage (BSA) hypothesis. Now, however, no doubt stimulated in part by the positive results reported by Prior & McWhinney (2010), there is a substantial corps of such studies with local switch costs reported for almost all studies and global switch costs reported for most.

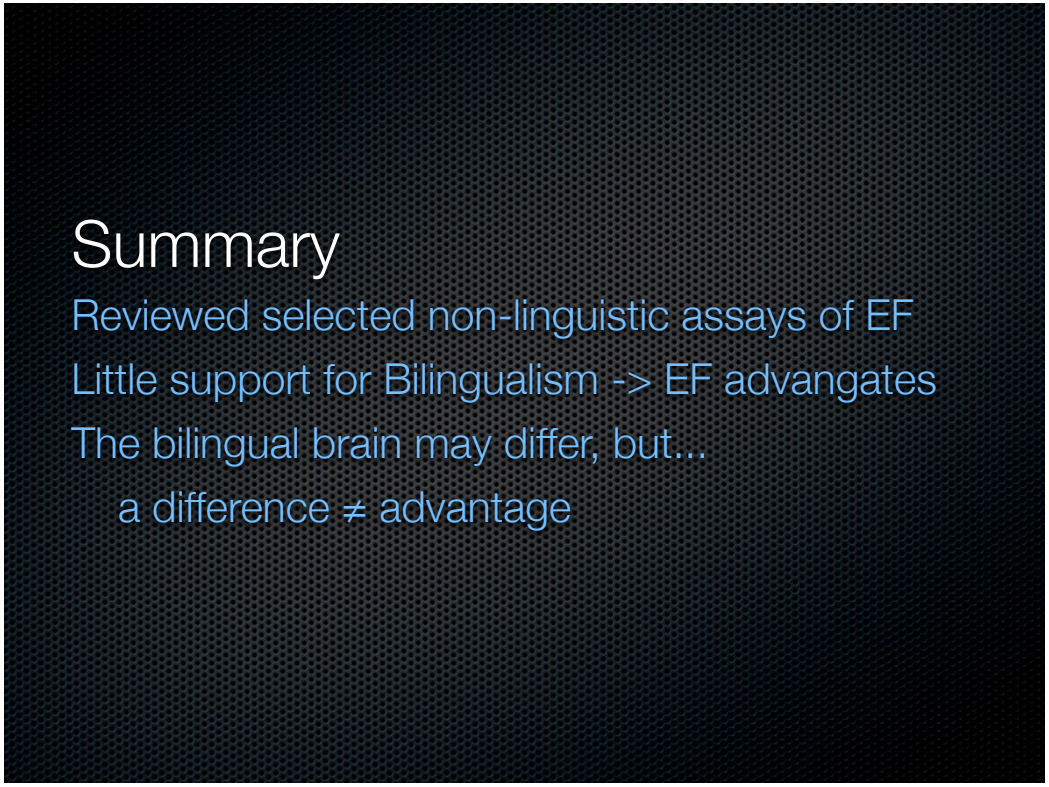


At this point in time, with 18 studies reporting local costs 4 reported differences favoring monolinguals while 13 reported differences favoring bilinguals. If you are a "true believer" in the proposition that bilingualism leads to executive processing advantages (BSA in this instance), and you I recommend you restrain any enthusiasm you might be experiencing because of the 13 data points to the right of the line.

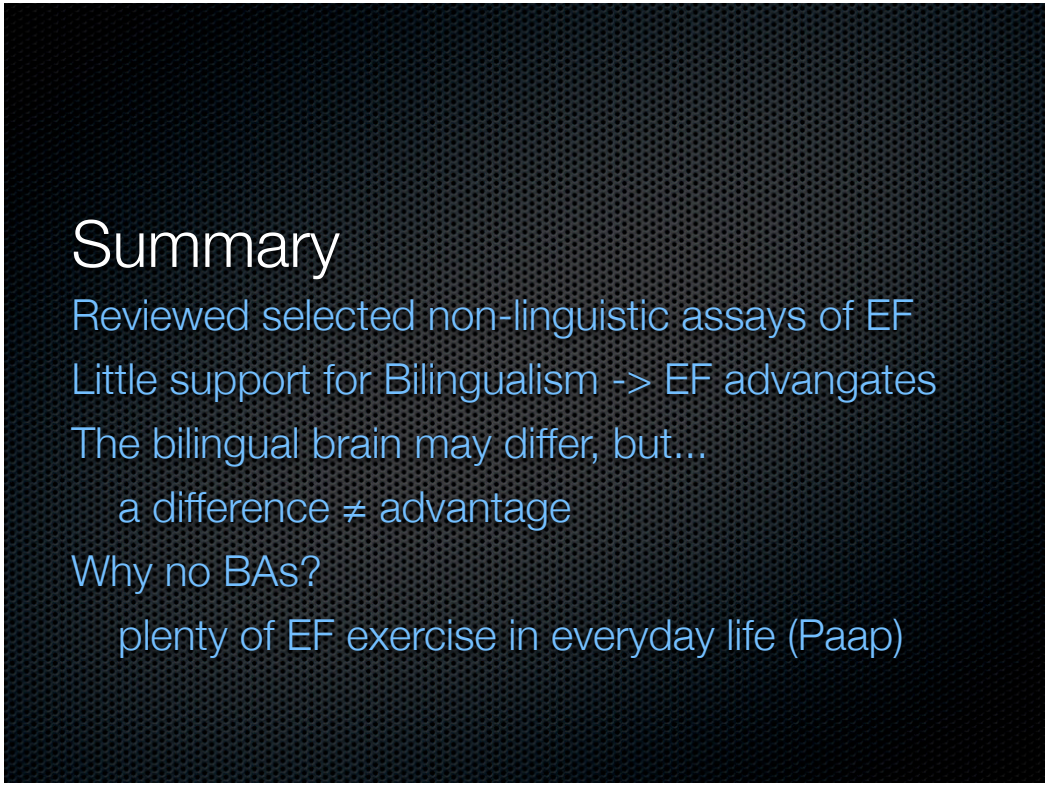
First, in contrast to the pattern with local switch costs, of the 12 studies reporting global switch costs, 8 found a monolingual mathematical advantage while only 4 found a bilingual advantage.



Second, consider the implications of de Bruin's conclusion that the literature is biased: "our overview shows the number of actually conducted unpublished null-effect studies and suggests that the results of a meta-analysis can in fact be affected by such a bias."
Third, Anat Prior, whose study with MacWhinney launched this literature, found no bilingual advantage in either local or global switch costs in her 2 most recent papers, and in her most recent one, concluded: "Importantly, bilinguals in the current study were not found to outperform monolinguals in any of the components of EF." Finally, consider what we learned from Ken Paap's poster yesterday:
Fourth, almost none of the mathematical differences shown here were statistically significant, and
Fifth, in Paap's large-N study there was no evidence for a BSA.



Let's summarize. Despite multiple biases (confirmation, publication, reporting) that favour the publication of positive findings for BAs
– our analyses of a huge swath of the pertinent literature, has revealed no BICA, no BEPA and no BSA in young adults. Essentially, no bilingual advantages in: inhibitory control, monitoring and switching; No BAs in extra-lingustic cognitive processing. I have focussed in this presentation on young adults, but our two reviews suggest that similar conclusions apply across the lifespan.
That is not to say that bilingualism does not uniquely configure the central nervous system or that the executive network, specifically, is not affected by bilingualism. Indeed, neuroimaging data tend to reveal unique neurocognitive landscapes between language groups... [But] a different neurocognitive architecture should only be considered cognitively advantageous if it translates into objectively measurable performance gains on measures of cognitive functioning.

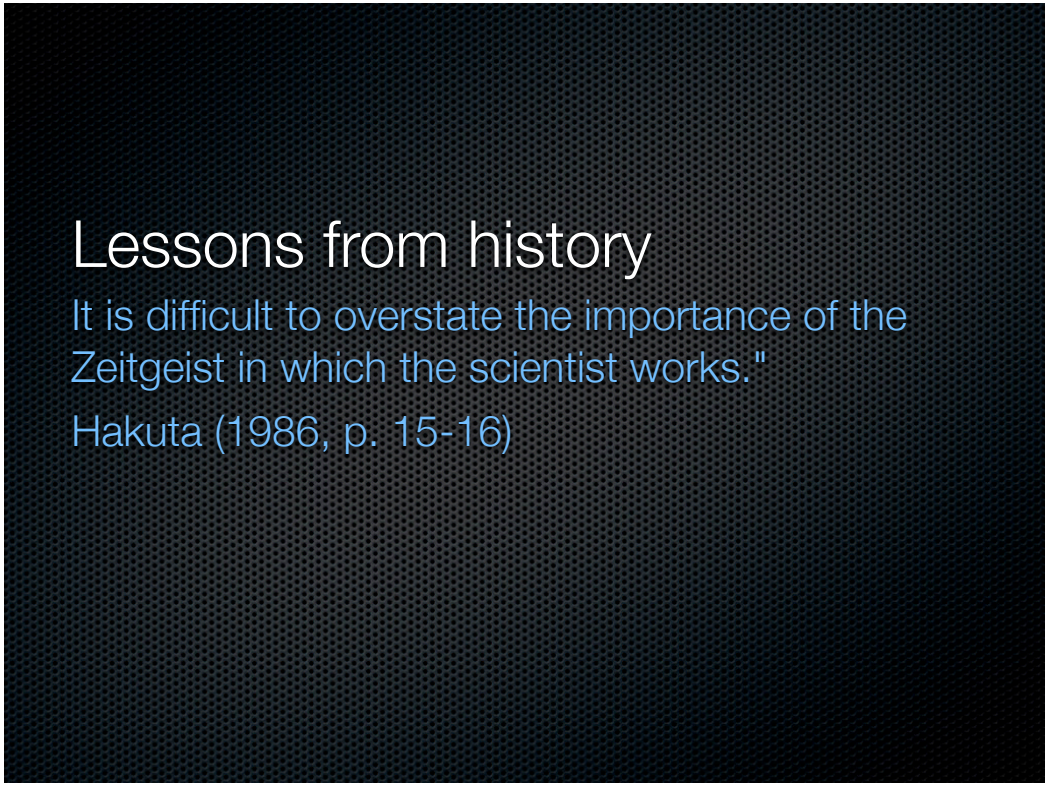


Why might there not be such BAs? As noted by Paap and Greenberg (2013) the demands on executive functioning associated with managing two languages may not appreciably exceed those involved in speaking a single language. For example, "within a single language conversational partners must monitor for signals regarding turn-taking, misunderstandings, possible use of sarcasm and changes of topic or register. Similarly monolinguals must incessantly make choices among activated lexical candidates during production and suppress the irrelevant meaning of homophones during comprehension. If general cognitive control mechanisms are required for the monitoring, switching and conflict resolution required within a single language, then it may be the total amount of language use, not the number of languages that determines the degree to which language enhances EF."

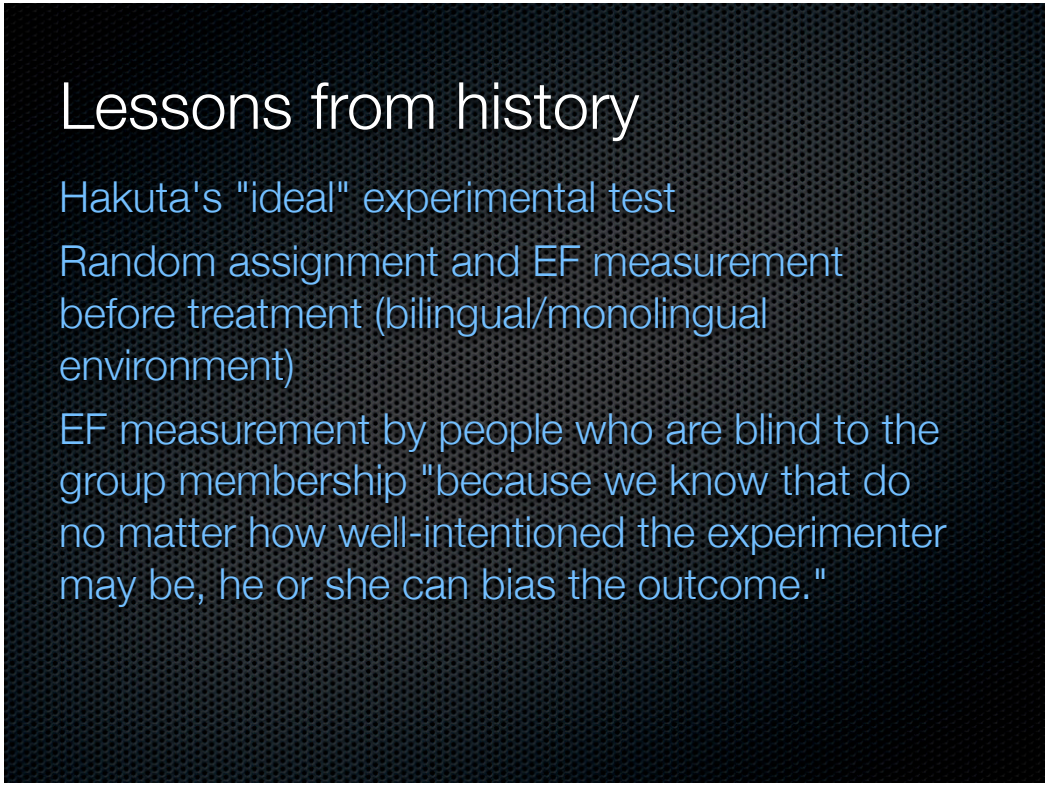
Lessons from history

"Of all of the connections made between bilingualism and other features of individual life, none is more central or contentious than the presumed link between bilingualism and intelligence."

John Edwards, 1994, p. 67

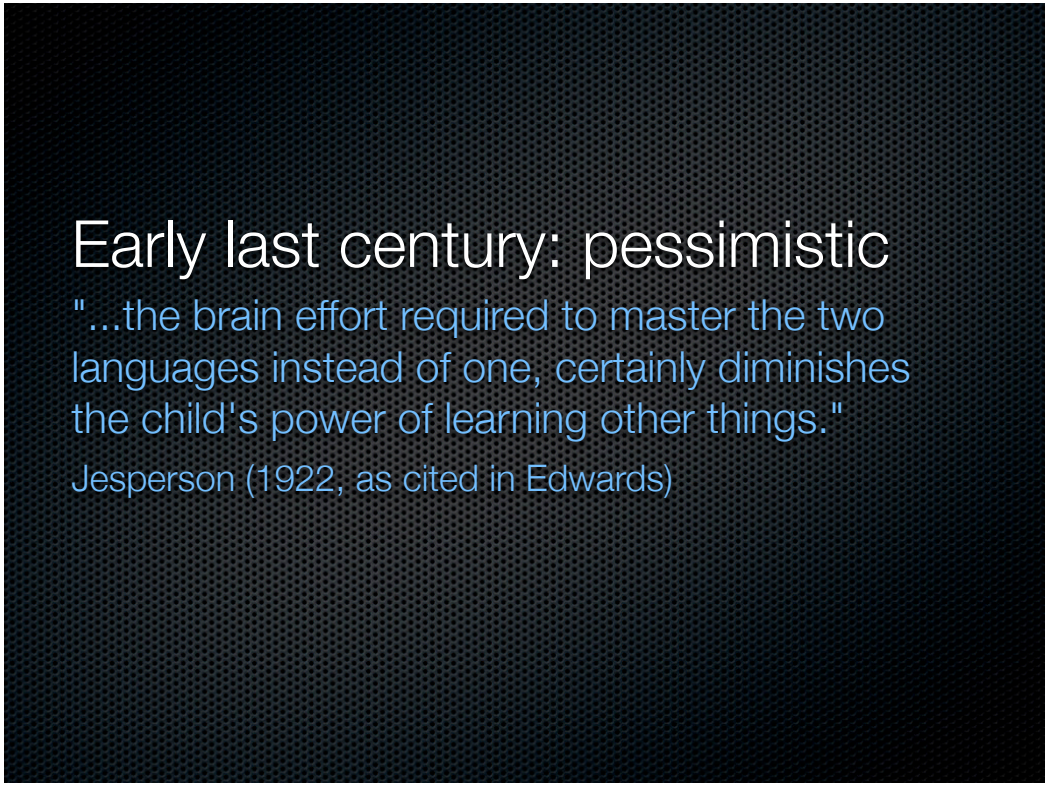


In commenting on the "hundreds of studies that compared the performance of bilinguals with monolinguals on various measures of intelligence" Hakuta noted that different "...researchers were working under different sociological circumstances. They differed in what moved them to look at the relationship between bilingualism and intelligence in the first place. They chose different methodologies that reflected their motivations. And their motivations markedly influenced their interpretations of their findings. It is difficult to overstate the importance of the Zeitgeist in which the scientist works."



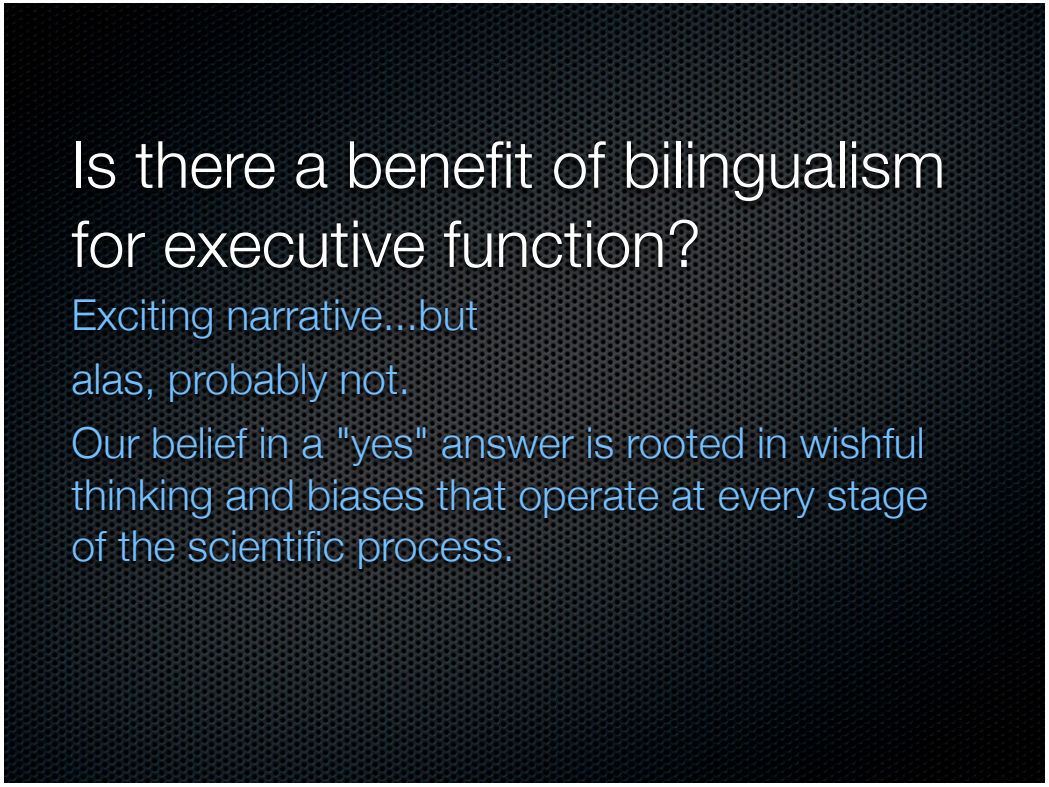
I didn't have time in my presentation to relate Hakuta's description of the "ideal" experiment. It is admittedly not one that can be done, but it highlights that and how the results from any experiment that departs from this standard is limited in some way.

"You begin by taking a random sample of individuals and assigning them to either an experimental group or a control group, thereby controlling for any background "noise" in sampling. You test both groups before their treatment, to ensure that they do not differ on your measures of cognitive flexibility. The experimental group is then placed in an environment that fosters bilingualism while the control group remains in a monolingual enviornment. Once the treatment has had time to take effect – that is, once the subjects in the experimental group have become balanced bilinguals you administer your dependent variables. As a good experimentalist, you make sure that the person who administers the dependent measure does not know whether the subject being tested is in the treatment or the control group because we know that no matter how well intentioned the experimenter may be, he or she can bias the outcome of the study if this procedure is not followed."



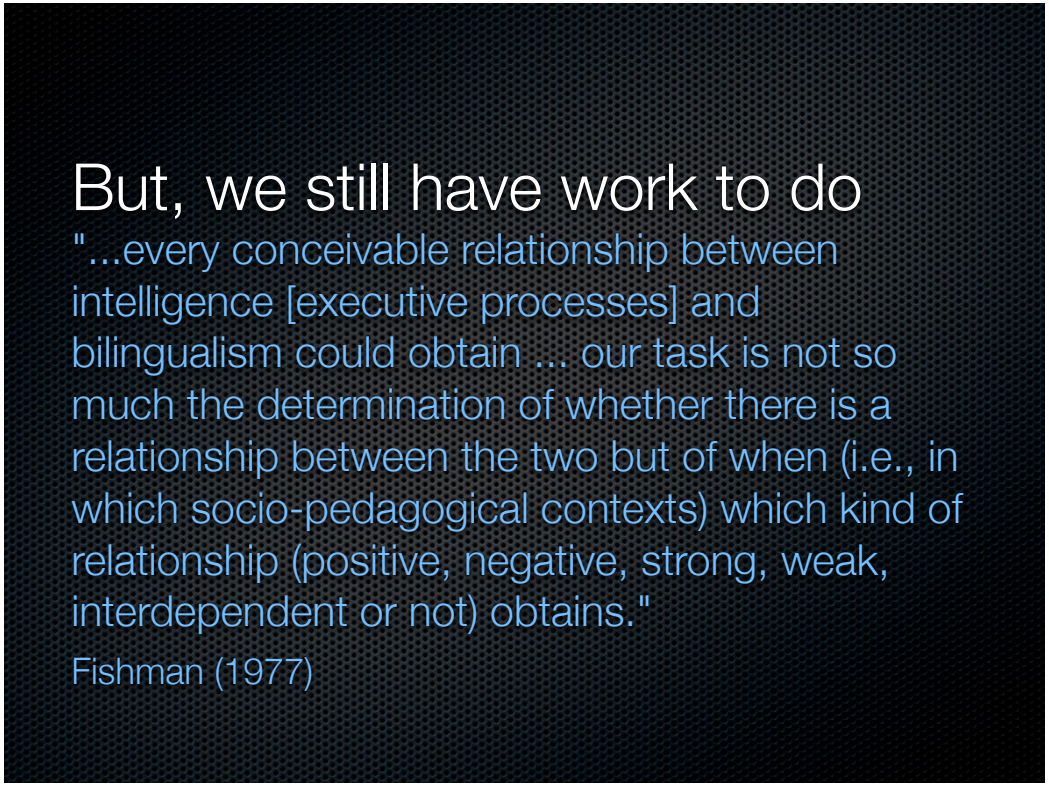
Near the beginning of the last century the Zeitgeist fostered a pessimistic view:
Here is one example from Jesperson:
"It is of course an advantage for a child to be familiar with two languages; but without doubt the advantage may be, and generally is, purchased too dear. First of all the child in question hardly learns either of the two languages as perfectly as he would have done if he had limited himself to one...Secondly, the brain effort required to master the two languages instead of one, certainly diminishes the child's power of learning other things."

Peal and Lambert's landmark study, the cognitive revolution, exciting ideas about neuro-plasticity, Bialystok's concrete proposal and new socio-cultural forces laid the groundwork for a dramatic change in zeitgeist to a much more optimistic view. A view in which exposure to two or more languages might bestow a variety of extra-linguistic cognitive benefits.



In line with this more optimistic Zeitgeist, and as I noted in my commentary on Valian's target article in Bilingualism: Language & Cognition: "There is an exciting narrative here that meshes nicely with adages from both popular culture – “use it or lose it”, “practice makes perfect” – and contemporary cognitive neuroscience – “neurons that fire together wire together,” derived from Hebb’s cell-assembly theory." Like many other scholars, I too wanted to believe that the answer to this question is "yes". But, alas, it is not.

Our belief in a "yes" answer is rooted in wishful thinking and biases that operate at every stage of the scientific process.



In conclusion: This doesn't mean we are out of a job.

As noted by Joshua Fishman in 1977, there is still plenty of work to be done: "...every conceivable relationship between intelligence [executive processes] and bilingualism could obtain ... our task is not so much the determination of whether there is a relationship between the two but of when (i.e., in which socio-pedagogical contexts) which kind of relationship (positive, negative, strong, weak, interdependent or not) obtains."

The end

Thanks to Matt Hilchey.