

In Memoriam

The Bilingual Brain: Emergent, Dynamic, and Variable. Albert Costa (1970–2018)

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In this piece, we honor the work of Albert Costa. His work focused on how bilinguals manage two languages, the brain mechanisms involved, and the ways in which language and emotion are related. We end by discussing ways in which his work will frame research in the field going forward.

On December 10, 2018, Albert Costa, a prominent researcher in the study of the cognitive and neural bases of bilingualism passed away unexpectedly at the age of 48. Even with his premature death, Albert made an indelible mark on the field and his seminal contributions will pave the way for future research endeavors. In this piece, we offer a concise summary of his theoretical and empirical contributions in three main areas: (i) parallel activation of languages in bilinguals; (ii) language switching and its relationship to cognitive control; and (iii) the ways in which language interacts with emotion. We conclude by discussing how future work might continue to be influenced by his legacy (Figure 1).

Parallel Activation

Albert's early work focused on the fluid nature of language use by bilinguals, suggesting that bilinguals might have access to cross-language meanings without activating them directly during processing. The first paper on this topic coauthored with Miozzo and Caramazza [1] presented a group of bilinguals with a set of pictures that had written words embedded in them. Across a series of

experiments, it was found that bilinguals activated specific target words in a language. This activation would then spread to the words of the same language and other languages of the bilingual. His 2006 paper coauthored with other colleagues investigated whether lexical selection was language specific or whether it spread across languages [2]. This hypothesis stands in contrast with the many claims that bilinguals activate words from the unused language during the processing of one of the other languages.

The finding that lexical selection remains restricted to a single language does not coincide with more recent findings in the literature. In particular, studies have found that bilinguals showed a reduced N400, a neurophysiological marker of semantic relatedness, when they were presented with two words, train and ham, that shared a form relation in Chinese but not in English [3]. Based on these results, Wu and Thierry [3] concluded that automatic activation of the other language occurred. This led the authors to conclude from this finding that bilinguals show activation of the other language even in single-language contexts.

As in his previous experimental work, Costa argued that automatic activation of another language might not be the product of an interconnected lexicon. Rather, the influence was due to the way in which concepts were transferred over to a second language. For example, a Spanish speaker would have a sound-based link between *cama* and *casa*. When learning the English translations, bed and house, the Spanish sounds would transfer and in essence create a link in the mind of the Spanish–English bilingual. Costa proposed that bilinguals do not necessarily have to activate both languages on the spot. Rather, the information from one language could just as easily be transferred from one language to the other during learning.

Language Switching

Albert also made a prominent contribution to the understanding of the nature of bilingual language switching experiences and their effects on cognitive control. He began using behavioral methods to help identify the cognitive mechanisms involved in language switching and task switching. Later he used functional and structural neuroimaging techniques to further develop his research interests. He published many works on the neurobiological basis of the switching mechanism and of language and cognitive control in general in bilingual populations. Indeed, the neural bases of bilingualism is a subarea that emanated from his original interest. In this domain, Albert had several seminal contributions published in journals such as *Nature Reviews Neuroscience* [4], *Cerebral Cortex* [5,6], *Annals of the New York Academy of Sciences* [7] and, of course, in his book, *El Cerebro Bilingüe*, which was published in late 2018. Of particular note is the fact that he could communicate both to the lay public and to the very expert researcher.

An earlier notable contribution from Albert was that he wanted to identify the nature and origin of the 'bilingual advantage', or lack thereof. One can only do this if one clearly identifies the individual cognitive components that make up 'cognitive control' or 'executive function'. In his 2009 *Cognition* paper [8], subtitled as 'now you see it, now you don't', the presence or absence of bilingual effects was beautifully demonstrated through experimental manipulations of the percentage of congruent versus incongruent trials in the task. He and his colleagues found that when the experiment involved highly demanding mixed trials in congruency (e.g., 50% congruent and 50% incongruent trials), bilingual effects would appear (now you see it), but when the experiment had only or mostly (e.g., 92%) congruent or incongruent trials, bilingual advantages would disappear (now you don't). This seminal work pointed to the significance



Trends in Cognitive Sciences

Figure 1. Albert Costa. Photo by Jon Andoni Duñabetia.

of understanding cognitive control from the perspective of task demand, linking the presence or absence of bilingual effects to cognitive ‘monitoring’. This work clearly pioneered the now-popular approach toward the study of individual components of cognitive control in bilingualism.

Albert was also among the first to alert bilingualism researchers that our understanding of the nature of the executive control system, and the interaction among the different components of the system, remains rather limited [4]. He urged us to study the origin of the effects if they appear, for example, the language contexts of the interlocutors, the need to prevent interference from one language to the other, and the need to continuously update working memory during learning. Because these processes and mechanisms are poorly

understood today, many researchers remain confused about the seemingly contradictory findings and lose sight of the actual science by distractions from popular media. The presence or absence of a bilingual advantage often times takes stronger consideration over what other factors might be playing a role [9,10].

Albert’s insights into bilingualism and cognitive control could also be seen in how he was able to connect the distinct pieces of language, cognition, development, and the brain. For example, he and his colleagues pointed out that it is important to consider the development of the neural circuitry underlying bilingual effects, across the life span from infancy to older adulthood. This relates to the long-standing issue of the age of acquisition effects in that early experience tunes

the bilingual brain with not only functional but also structural changes [4,5,10]. Although recent work has begun to investigate different ages using a developmental neurocognitive perspective, research in this domain is severely limited by the particular population types and the age associated with the target experimental population. In this regard, Albert’s work set an example for us to steer away from the narrow view of bilingualism research focusing on college students (or young adults) whose cognitive control ability may have developed to its peak.

Language and Emotion

Albert also made a seminal contribution to the notion that the use of a nonnative language would alter the ways in which emotions were felt. Albert published work suggesting that we think and make decisions differently (such as more rational decisions) if we process the information in a language other than our mother tongue [11]. The results of these studies made it to the popular press, and as an anecdote this news reached even the European Parliament where many delegates would joke saying that only one country in the European Union was NOT using a second language for decision making.

Overall, this line of research was surprising in that it was a departure from Albert’s main work on language switching, language representation, and the bilingual brain. By contrast, it opened up the distancing effect observed in a nonnative language as an extension of his view that bilingualism interfaces with other neural and cognitive aspects, and even with emotions.

Concluding Remarks

Albert laid out a particular legacy focused for the most part on the dynamic nature of language and cognitive processing in bilinguals. Work on the nature of language switching and task switching continues, trying to make sense of whether they are

part of one cognitive control network or whether some neural systems are specialized for language control. The nature of the links between lexical items in each language and the neurocomputational underpinnings of such a process is also a line of research that will continue to benefit from his seminal contributions. Although the beginnings of a more dynamic view that considers the nonlinearities have begun to emerge [12], there is still considerable work to continue along these lines. Of course, no single person or group of people will replace him but through this piece, it is our sincere hope that others will build upon the contributions of his

work and future work that can be carried out with his legacy in mind.

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