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# Fusing languages in the bilingual cognitive architecture

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Research on bilingualism has documented profound brain plasticity by which the bilingual experience reconfigures the cognitive system. These effects include temporary as well as more enduring ones, and parallel activation of a bilingual's two languages may well be a key factor at the root of these observed changes. Recent recommendations (Green, 2011) have emphasized that research on code-switching in particular could provide a fruitful avenue for investigating the nature of how a bilingual speaker selects words and ultimately produces an utterance. Findings to date illustrate that if anything, the reach of co-activation is more extensive than previously thought, extending to the phonology and syntax of languages. While the degree of permeability may compound the perceived difficulty of the selection process, it is also a testament to the documented mental agility of bilinguals.

In the present keynote article, Goldrick, Putnam and Schwarz (2016) take the evidence for the co-activation of mental representations in what they call blend representations, and propose a computational model integrating distributed representations with graded activation and grammatical principles. In particular, their proposal formalizes the idea that co-activation extends beyond lexical representations to the very grammars of a bilingual. They apply the model to doubling constructions in code mixing by using Gradient Symbolic Computation formalism. A strength of their proposal is that they assess the usability of such a framework, and the empirical evidence for blend representations, across multiple processing contexts. While the actual implementation of the model focuses specifically on code mixing, we see great promise for adaptations to the very environments they consider in documenting the psychological reality of blends in the bilingual language system.

As such, the proposal by Goldrick and colleagues holds broader implications for the field. Goldrick et al. review some of the key findings supporting the view that there is co-activation of languages during bilingual speech production. An equally striking result in the recent literature is the finding that the bilingual language system is adaptive, with bidirectional language effects that reconfigure both the L2 and the L1. These cross-language interactions show for instance that L2 learners can adopt the L2 syntactic parsing strategy in their L1 (Dussias & Sagarra, 2007), and that L2 immersion experience changes how learners access their L1 lexicon (Linck, Kroll & Sunderman, 2009). The impact of the L2 on the L1 has even been documented at the earliest stages of L2 learning (Bice & Kroll, 2015). Furthermore, as L2 proficiency increases, the use of L2 grammar restructures leaners' cognition (Aopoulos Athanasopoulos & Kasai, 2008). The ability to model these adaptive changes to grammar and cognition as they happen, not only in situ as a function of the discourse context, but also developmentally over time as language exposure and proficiency changes, would seem a valuable extension to the present proposal. We believe the structure of the proposed model would readily allow future developments to take into account the demands of different interactional contexts that may modulate the relative activation of each of the languages, in-line with recent proposals such as the adaptive control hypothesis (Green & Abutalebi, 2013). In the present model, the authors assume that learners acquire the weightings of constraints based on their experience with a given language and its grammatical forms. In order to model the potential interaction of the two languages, not only are there language-specific weightings that influence the grammar, but also a blended weighting of the individual language weightings. Future directions could clarify how these weightings would dynamically change, either in response to the demands of discourse, or as a result of language experience, and could account for the gradient activation of elements in the input and their influence on blends. Being explicit about these assumptions would allow a developmental perspective to be incorporated into the model, integrating how the language system shifts in response to cumulative and real-time language use.

The proposal by Goldrick and colleagues provides a first framework that not only acknowledges the dynamic properties of the language system to all levels of representation but formalizes how the interplay between blend representations and grammar can function. This computational account of code mixing recognizes a language system that is fundamentally open to cross-language interaction (Kroll, Bobb & Wodniecka, 2006) while taking into account grammatical

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constraints that influence language processing. Future extensions of this work can be used to contribute to a comprehensive account of how variables such as language proficiency/dominance and context influence the component processes and relative activation of both languages and their grammatical constraints.

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