Bilingualism: Language and Cognition 22 (4), 2019, 701–702 © Cambridge University Press 2018 doi:10.1017/S136672891800072X

COMMENTARY

Language membership as a gradient emergent feature

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(Received: April 24, 2018; accepted: May 21, 2018)

In their keynote article, Dijkstra, Wahl, Buytenhuijs, van Halem, Al-jibouri, de Korte, and Rekké (2018) introduce the Multilink model representing an integrated bi/multilingual lexicon. This proposal builds upon both previous and recent research on an integrated cognitive architecture underlying the language faculty (for a summary, see e.g., Putnam, Carlson & Reitter, 2018). In our view, the adjustments proposed by the authors are an improvement on previous instantiations of similar models such as those discussed in the present article. In our remarks we explicate how the Multilink model may be further enhanced, by making any appeal to language-specific nodes or representations epiphenomenal. To achieve this, we propose a novel approach to representing language membership as the result of gradient emergent principles that builds upon the integrated lexicon underlying the Multilink model.

As the authors discuss, little evidence now exists for the separation of the two (or more) languages of a multilingual. The authors also argue that an integrated lexicon is more "parsimonious" and "compatible with empirical data" (p. 40). We agree that an integrated approach to bilingual lexical representation is indeed more theoretically and empirically sound; however, we note two instances in which the integrated nature of the Multilink model falls short, and how it can be expanded. First, many models of multilingual word production and comprehension assume the existence of abstract *language nodes*; the current model is no exception. While this is a straightforward solution to an undoubtedly complex problem, the integrated nature of the Multilink model could be improved upon by accounting for language membership as a gradient, rather than absolute, property. Second, as opposed to the "simple holistic units" used to capture semantic representations (p. 15), the incorporation of semantic features into the semantic layer allows for a more fine-grained level of integration across lexical items. We propose that a single unified process could be used to enhance the semantic and language levels of the model, merging them such that language membership is represented not as a distinct level, but rather as a gradient and emergent property of the lexico-semantic system.

Solving the problem of language membership can be addressed together with the enrichment of semantic representations. One possible mechanism may be CROSS-SITUATIONAL LEARNING (CSL; see Smith & Smith, 2012 for a review). In CSL, a situation refers to any instance where both linguistic and non-linguistic input are present. The learner must form associations between word forms and their non-linguistic referents via repeated exposure to multiple different situations. Such a process is gradual, allowing for the emergence of rich semantic representations as the learner comes to associate non-prototypical features that co-occur in the situation with the word form. For example, the word *cup* can be associated not only with *juice* but also other concepts such as *lunch*, *plate*, or even *table*, all of which may co-occur with *cup* in any given situation. Thus, the novel word retains non-zero associations to referents that co-occurred in the various situations, and importantly these associations can be not only to referents in the environment, but also social and linguistic cues, such as phonetic information and speaker identity. Fazly, Alishahi and Stevenson (2010) successfully implemented a computational model of a cross-situational learner: drawing on general cognitive abilities, the model was able to learn the meaning of a word as the probabilistic association between the word and potential referents that co-occured in the input. Such a method coupled with the use of semantic features would undoubtedly enrich the semantic level of the Multilink model.

CSL may also capture language membership: since novel words can be associated with various linguistic and extralinguistic features, language membership could emerge in much the same way as more prototypical semantic features. Specifically, the learner could come to associate words with particular contexts (some only heard in the home, and some only heard in public), unique phonetic features (e.g., aspirated vs. unaspirated stops), and different speakers (some only spoken by family, and others only by friends). Coupled with

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https://doi.org/10.1017/S136672891800072X Published online by Cambridge University Press

developing metalinguistic knowledge, the learner may come to create an abstract representation of language membership grounded in overlapping sets of features as opposed to singular concepts. The result would be a representation of the lexico-semantic system that no longer requires language nodes, instead relying on probabilistic distributional properties of the input to organize the lexicon. This, we believe, would provide a strong foundation to implement word association, semantic priming, and even object naming in the Multilink model, as the authors have proposed. In addition, this application of the Multilink model is congruent with Christiansen and Chater's (2016) call for rapid compression of linguistic representations which can be lossy or imperfect in nature.

In conclusion, the elimination of nodes and elements attributed to individual source grammars from the Multilink model brings it closer to capturing the gradient nature of lexico-semantic access and production observed in the behavior of bilinguals.

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https://doi.org/10.1017/S136672891800072X Published online by Cambridge University Press