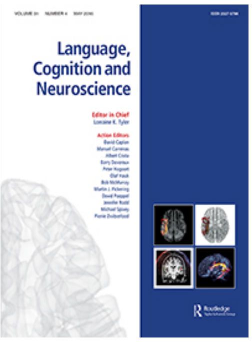

Language, Cognition and Neuroscience

ISSN: 2327-3798 (Print) 2327-3801 (Online) Journal homepage: http://www.tandfonline.com/loi/plcp21

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To cite this article: Bradford Z. Mahon & Eduardo Navarrete (2016) Modelling lexical access in speech production as a ballistic process, Language, Cognition and Neuroscience, 31:4, 521-523, DOI: 10.1080/23273798.2015.1129060

To link to this article: http://dx.doi.org/10.1080/23273798.2015.1129060

Published online: 25 Jan 2016.

LANGUAGE, COGNITION AND NEUROSCIENCE, 2016
VOL. 31, NO. 4, 521–523
http://dx.doi.org/10.1080/23273798.2015.1129060

COMMENTARY

Modelling lexical access in speech production as a ballistic process

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Strijkers and Costa (in press) pull together data and extant theories to frame a new way to think about the dynamics of lexical access in speech production: lexical access does not transpire over a series of temporally dissociable stages, but involves the near simultaneous "ignition" of representations at multiple levels of processing (semantic, lexical, phonological, etc.). Strijkers and Costa's proposal represents a paradigm shift in thinking about lexical access in speech production. The broader issue that Strijkers and Costa's proposal frames is whether cognition should be modelled as a series of computations over representationally distinct levels of processing (Marr, 1982), or as the "recovery" or "ignition" of a network of associated representations (Hebb, 1949). Here we suggest, in agreement with the spirit of Strijkers and Costa's proposal, that the neural data they review compel dropping the assumption that lexical access involves a "decision point" at the lexical level. At the same time, we suggest there is an alternative cognitive model that does not assume that all representational types involved in lexical access are "ignited" at once, and that this alternative model is compatible with the neural data Strijkers and Costa review. According to this alternative, lexical access is a ballistic process: when in a communicative intentional state, access to a lexical semantic representation entails lexicalisation of that concept. We suggest that modelling lexical access as a ballistic process has several advantages: (i) it derives from threshold models of word retrieval developed in the context of error data (Dell, 1986), and thus stands to inherit the ability of those models to explain error data; (ii) it accounts for the spectrum of chronometric phenomena observed in picture naming (for reviews, see Mahon, Costa, Peterson, Vargas, & Caramazza, 2007; Navarrete, Del Prato, Peressotti, & Mahon, 2014), and (iii) a ballistic model of lexical access can account for the neural data that Strijkers and Costa review.

Cell assemblies or ballistic computations: how fast is fast?

The model that Strijkers and Costa propose, whereby multiple representational types become activated near simultaneously, is based largely on neural data indicating that frontal, temporal, and parietal regions become activated at practically the same time during picture naming, and early on (e.g. ~200 ms) after picture onset. What follows from those data for a cognitive model of how words are produced?

As Strijkers and Costa emphasise, there is nothing in the studies that they review to suggest that lexical access during picture naming is anything but semantically driven – and there is simply no coherent theory on offer of non-semantically driven lexical access (so-called "embodied theories of meaning" notwithstanding, for discussion see Mahon, 2015). So we take it as unassailable that lexical access is initiated by access to conceptual information while in a communicative intentional state. The question then becomes whether distinct types of linguistic representations (lexical, phonological, etc.) are accessed in (perhaps very fast) succession, or in parallel as a unit (cf the metaphor of "ignition of a cell assembly"). Note that assuming that lexical access initiates with semantic access does not mean that semantic access must be complete before lexical access can be begin – as Strijkers and Costa review, there is ample evidence of cascading activation dynamics (e.g. Rapp & Goldrick, 2000). Given all of that, there is a strong alternative to Strijkers and Costas proposal that is compatible with the data they review: the system automatically lexicalises lexical concepts as those concepts are accessed. This alternative does not require adopting

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the idea that lexical access involves "parallel access" to distinct representational types of linguistic knowledge. And, critically, ballistic lexicalisation could account for the neural data that Strijkers and Costa review.

We have argued elsewhere (e.g. Mahon, Garcea, & Navarrete, 2012; Navarrete et al., 2014) that there is no decision point at the lexical level: once a lexical concept is accessed the corresponding word is retrieved and phonologically encoded. In this line, one might extrapolate, a la Pulvermüller (2005), that along with lexicalisation of lexical concepts, there is also automatic access of any peripheral representations that are connected to the meaning of the word (e.g. for the word "kick" the motor representation of the foot might be engaged). On this view, lexical "selection" is a misnomer – there is conceptual selection, which is just being in a definite communicative intentional state. Once a definite communicative intentional state is "attained", then lexical access through phonological retrieval is ballistic (see Navarrete et al., 2014). One implication of this view is that one can intentionally interact with language representations at only two levels: the conceptual level and the articulatory level.

Recent research in the chronometric tradition also suggests that lexical access is ballistic – once a threshold is exceeded for the target word, that word is retrieved and phonologically encoded. This view derives from models of word production based on error analyses (e.g. Dell, 1986; Oppenheim, Dell, & Schwartz, 2010), and assumes that there is no "selection" at the lexical level, but rather retrieval of the most activated lexical unit. In contrast to the core prediction of lexical selection by competition (e.g. Indefrey & Levelt, 2004; Roelofs, 1992), a threshold model predicts that, excluding errors in production, lexical retrieval can only be primed (i.e. speeded up) by semantically related contexts. This prediction has been confirmed by chronometric studies with the picture–word interference (Mahon et al., 2007, 2012) and the blocked naming tasks (Navarrete, Del Prato, & Mahon, 2012; Navarrete et al., 2014; Navarrete, Peressotti, & Mahon, 2015).

What next?

The potential pitfalls in developing a neurobiological model of language production are many. Strijkers and Costa are right to criticise the form of reverse inference (Poldrack, 2006) that infers the representational stages at which effects originate from the time-point at which a deflection in the EEG signal is observed. For instance, if the Indefrey and Levelt model states that lemma access occurs at *x* ms after picture onset, then any activity that occurs at *x* ms, it has been argued, it taken to reflect lemma access. But we should be equally sceptical, and as Strijkers and Costa forewarn, of employing reverse inference in the spatial domain: that is, concluding that because temporal, parietal, and frontal areas are activated at the same time it follows that multiple representational types are accessed in parallel (see e.g. Miozzo, Pulvermüller, & Hauk, 2015; Pulvermüller, 2013). More broadly, as a field, scepticism is healthy when mapping cognitive stages onto neural stages, because we have (as a field) a major mapping problem (for detailed discussion, see Poeppel, 2012). In fact, to call it a problem might give it too much credit. Problems have solutions that we would recognise were we to see them – it is not clear we are there yet with the mapping problem as it pertains to the neurobiology of language. Nevertheless, as Strijkers and Costa demonstrate, real progress can be made while bracketing the big questions about how to relate cognition and the biology of the brain, and focusing on how cognitive models can be situated in the context of available neural data, and even how the dynamics of large-scale brain systems may relate to dissociable representational stages at the cognitive level. Key to the success of this enterprise is that the neural data are not given precedent over the cognitive data – the neural data have no ontological priority over the cognitive data (Poeppel, 2012).

As Strijkers and Costa note, the power of the Indefrey and Levelt (2004) framework derived from the simplicity of its assumptions about the dynamics of activation flow in the system, and the commitment that cognitive processes map one-to-one to neural regions and time epochs. While those assumptions are likely incorrect, for the reasons that Strijkers and Costa discuss and reasons discussed elsewhere, the model did a great service by providing a theoretical framework within which research could get off of the ground. Strijkers and Costa's new framework points the way towards a more nuanced understanding of how speech production unfolds in real time in the brain.

Acknowledgements

We acknowledge Alfonso Caramazza for his discussion of these issues over the years, and for initially framing the idea of lexical access as a ballistic process.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This article was supported in part by NIH [grant number NS089609] to BZM, and NSF [grant number BCS-1349042] to BZM and EN.

References

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review*, *3*, 283–321.

Hebb, D. O. (1949). *The organization of behavior. A neurophysiological theory*. New York: Wiley.

Indefrey, P., & Levelt, W. J. (2004). The spatial and temporal signatures of word production components. *Cognition*, *92*(1), 101–144.

Mahon, B. Z. (2015). What is embodied about cognition? *Language, Cognition and Neuroscience*, *30*, 420–429.

Mahon, B. Z., Costa, A., Peterson, R., Vargas, K. A., & Caramazza, A. (2007). Lexical selection is not by competition: A reinterpretation of semantic interference and facilitation effects in the picture-word interference paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*(3), 503–535.

Mahon, B. Z., Garcea, F. E., & Navarrete, E. (2012). Picture-word interference and the response exclusion hypothesis: A response to Mulatti and Coltheart. *Cortex*, *48*, 373–377.

Marr, D. (1982). *Vision: A computational approach*. San Francisco, CA: Freeman & Co.

Miozzo, M., Pulvermüller, F., & Hauk, O. (2015). Early parallel activation of semantics and phonology in picture naming: Evidence from a multiple linear regression MEG study. *Cereb Cortex*, *25*(10), 3343–3355.

Navarrete, E., Del Prato, P., & Mahon, B. Z. (2012). Factors determining semantic facilitation and interference in the cyclic naming paradigm. *Frontiers in Psychology*, *3*, 1–15.

Navarrete, E., Del Prato, P., Peressotti, F., & Mahon, B. Z. (2014). Lexical selection is not by competition: Evidence from the blocked naming paradigm. *Journal of Memory and Language*, *76*, 253–272.

Navarrete, E., Peressotti, F., & Mahon, B. Z. (2015). The relation between repetition priming and semantic context in picture naming: Implications for models of lexical access. Manuscript submitted for review.

Oppenheim, G. M., Dell, G. S., & Schwartz, M. F. (2010). The dark side of incremental learning: A model of cumulative semantic interference during lexical access in speech production. *Cognition*, *114*, 227–252.

Poeppel, D. (2012). The maps problem and the mapping problem: Two challenges for a cognitive neuroscience of speech and language. *Cognitive Neuropsychology*, *29*, 34–55.

Poldrack, R. A. (2006). Can cognitive processes be inferred from neuroimaging data? *Trends in Cognitive Sciences*, *10*, 59–63.

Pulvermuller, F. (2005). Brain mechanisms linking language and action. *Nature Reviews Neuroscience*, *6*, 576–582.

Pulvermüller, F. (2013). Semantic embodiment, disembodiment or misembodiment? In search of meaning in modules and neuron circuits. *Brain and Language*, *127*, 86–103.

Rapp, B., & Goldrick, M. (2000). Discreteness and interactivity in spoken word production. *Psychological Review*, *107*, 460–499. doi:10.1037/0033-295X.107.3.460

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, *42*, 107–142.

Strijkers, K., & Costa, A. (in press). The cortical dynamics of speaking: Present shortcomings and future avenues. *Language, Cognition and Neuroscience*. doi:10.1080/23273798.2015.1120878