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Perceptual uncertainty is a property of the cognitive system

Manuel Perea
Departamento de Metodología
Universitat de València
Av.Blasco Ibáñez, 21
46010 Valencia (Spain)
Tel.: +34 963 864512
mperea@uv.es
http://www.uv.es/mperea

Manuel Carreiras
Basque Center on Cognition, Brain and Language
Paseo Mikeletegi, 69
20009 San Sebastián-Donostia (Spain)
Tel.: +34 943 309300
m.carreiras@bcbl.eu
http://www.bcbl.eu/people/staff/manuel_carreiras

ABSTRACT

We qualify Frost's proposals regarding letter position coding in visual-word recognition and the universal model of reading. First, we show that perceptual uncertainty regarding letter position is not tied to European languages –instead it is a general property of the cognitive system. Second, we argue that a universal model of reading should incorporate a developmental view of the reading process.

MAIN TEXT

In his target article, Frost claimed that flexibility in letter position coding is "is a variant and idiosyncratic characteristic of some languages, mostly European" –mainly on the basis that root-based words in Semitic languages do not show transposed-letter effects

(Velan & Frost, 2011; see also Perea, Abu Mallouh, & Carreiras, 2010). Here we re-examine Frost's claim under one critical criterion: how letter position coding is developed during reading acquisition. But first, it is important to briefly re-examine the origins of the assumption of perceptual uncertainty that underlie most of the recently implemented models of visual-word recognition.

When implementing a model of visual-word recognition, cognitive modelers face one basic challenge: Models should be kept as simple as possible while providing both a reasonable account of the phenomena and heuristic power to predict new phenomena. In the most influential models of word recognition of the 80s and 90s (the interactive activation model: Rumelhart & McClelland, 1982, and its successors), modelers assumed, for simplicity purposes, that letter position coding occurred hand in hand with letter identity. However, a large number of experiments have revealed that letter-position coding is rather flexible and that items like JUGDE and JUDGE are perceptually very similar (i.e., the so-called transposed-letter effect). This phenomenon, together with other phenomena (e.g., relative-position effects [blcn activates BALCONY], see Carreiras, Duñabeitia, & Molinaro, 2010), falsify a slot-coding scheme. It is important to bear in mind that letter transposition effects have been reported not only in the Roman script, but also in other very different orthographies: Japanese Kana (Perea, Nakatani, & van Leeuwen, 2011), Korean Hangul (Lee & Taft, 2009), or Thai (Perea, Winskel, & Ratitamkul, in press); furthermore, letter transposition effects have also been reported in Semitic languages (e.g., for morphologically simple words in Hebrew, see Velan & Frost, 2011; see also Perea, Abu Mallouh, & Carreiras, 2010).

In our view, letters are visual objects, and as such, they are subject to some degree of perceptual uncertainty regarding their position within an array (e.g., via randomness of neuronal activity in the visual system, see Barlow, 1956; Li, Klein, & Levi, 2006). As Logan (1996) indicated in his model of visual attention, "the representation of location is distributed across space" (p. 554). Indeed, Rumelhart and McClelland (1982) acknowledged that "information about position and information about the identity of letters may become separated in the perceptual system if the set of retinal features for a particular letter end up being mapped onto the right set of canonical features but in the wrong canonical position" (p. 89). Thus, is it not surprising that a number of recently-proposed models of visual-word recognition have incorporated the assumption of perceptual uncertainty (e.g., overlap model, Bayesian Reader, overlap open-bigram model, spatial coding model).

Let us now turn to the key issue in the present commentary: the role of letter position coding in the acquisition of reading –which is an aspect which is missing in the target article. The human brain has not been specifically designed to read. Structural brain changes occur during learning to read (Carreiras et al., 2009) and unsurprisingly, the brain areas that are initially activated by letter/words are very close to the brain areas that are activated by objects or faces (Dehaene & Cohen, 2011). Given that letters/words are visual objects, it is reasonable to assume that, in the initial stages of reading, an immature reading system adopts a higher degree of perceptual uncertainty in assigning letter position within words. As Castles, Davis, Cavalot, and Forster (2007)

indicated, orthographic development may be regarded as "proceeding from a broadly tuned mechanism to a very precisely tuned mechanism" (pp. 180-181). Consistent with this view, transposition letter errors are greater for younger children than for older children (see Acha & Perea, 2008; Castles et al., 2007; Perea & Estévez, 2008). Importantly, lack of an appropriately tuned mechanism may lead to so-called developmental letter position dyslexia (Friedman & Rahamim, 2007). Two questions for future research are: the specification of the mechanisms by which some young readers are differently sensitive to perceptual uncertainty in the process of visual-word recognition (see Andrews & Lo, in press) and ii) why skilled adult readers still show letter transposition effects –and how this may modulated by reading skill (or any other potentially relevant factors).

One critical aspect here is that the way a written language is initially learned may induce a different flexibility in letter position coding. On the one hand, because of the inherent characteristics of Semitic languages (i.e., vowel information is typically omitted and the root plays a critical role), flexibility in letter position coding may be quite rigid in root-based words, relative to Indo-European languages (Velan & Frost, 2011; but see Duñabeitia, Perea, & Carreiras, & Perea, 2009, for lack of transposed-letter priming with word-word stimuli [e.g., causal-casual] in Spanish). On the other hand, orthographies like Thai in which some vowels may be misaligned and there are no spaces between words may lead to a particularly flexible process of letter position coding (see Perea et al., in press). Thus, one relevant issue is the differences between the flexibility of letter position coding across languages –in particular, for bilinguals of different families of languages. This should be investigated not only for reading acquisition in children, but also for adult learners of a second/third language (see Perea, Abu Mallouh, García-Orza, & Carreiras, 2011).

In sum, while we agree with Frost in the sense that the characteristics of a given language shape the way it is processed, we would like to stress that perceptual uncertainty regarding letter position is not tied to a particular family of languages. Instead, it is a general property of the cognitive system. In addition, we believe that a universal model of reading should account not only for results obtained from different languages but should also incorporate a developmental view of the reading process. Finally, more attention should be devoted to considering how the acquisition of two languages shapes the process of reading in the current multilingual world.

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