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Phonemes and Production

Gary S. Dell

University of Illinois, Urbana-Champaign

Abstract

This comment offers observations that support Hickok's claim that phoneme sized representations are involved more in speech production than speech perception, but notes that languages may vary with regard to the importance of the phoneme.

Hickok claims that phonemic representations in somatosensory cortex guide the production, but not the perception, of speech. His paper presents a functional argument for why this might be true, and cites evidence for it (e.g. damage to somatosensory cortex is associated with phonemic production errors in aphasia, Schwartz et al., 2012; see also Dell et al., 2013).

Speech errors have long provided intuitive evidence for phoneme-sized units in production. The slip "heft lemisphere" instead of "left hemisphere" (Fromkin, 1973) is a classic example of an exchange of phonemes. The fact that such errors are not uncommon (e.g. Nootboom & Quené, 2013) has inspired production theories in which elements such as /h/ and /l/ are fundamental units. It seems that during the production of *left*, the /h/ from *hemisphere* was retrieved instead of the /l/. Then the mistakenly passed over /l/ gets its chance for expression in the next syllable, presumably because the /h/ was already said in the previous syllable. Each phoneme goes in the other's onset slots and not elsewhere in the words, because they are known to be onsets. This characterization of phonemic exchanges is the basis of all formal accounts of these errors, from the symbolic scan-copier model of Shattuck-Hufnagel (1979) to the many connectionist approaches to phonological encoding in production (e.g. Dell, 1986; Stemmer, 1985; Vowles, Brown, & Harley, 2000).

It is difficult to imagine an account of slips such as "heft lemisphere" that does not use phonemes, or other subsyllabic segmental units such as syllabic constituents. One cannot explain the error by appealing to the substitution, addition, or deletion of a single feature or gesture because /h/ and /l/ are not articulated similarly at all. Moreover, characterizing the error as the fortuitous replacement of the word or syllable *left*, with the word or syllable *heft* makes little sense, as it fails to explain where the *heft* came from. Even if one could explain *heft* without assuming some kind of /h/ unit, why then does the next word come out exactly as *lemisphere*, which isn't even a word? The "fearful symmetry" of the phoneme exchange, in which an initial substitution of X for Y is followed by the reverse of Y for X, strongly suggests not only that there exist X's and Y's which can move around, but also that there exist X/Y sized slots that they can inhabit (Shattuck-Hufnagel, 1979).

Other psycholinguistic research supports the role for phoneme sized units in production. For example, Goldrick (2004) showed that speakers become sensitive to newly experienced phonotactic patterns at both the phonemic and the feature levels. That is, the system might learn that the phoneme /f/ can be a syllable onset, and that knowledge is distinct from

knowing that labiodentals or fricatives can be onsets. The phoneme also seems to be an important unit in production planning as assessed by the implicit priming technique (Meyer, 1991). Advance knowledge that a word to be retrieved begins with a particular phoneme speeds production of the word. Crucially, advance knowledge of just the features of the word onset does not (Roelofs, 1999).

These observations are consistent with Hickok's proposal about the role of phonemes in speech production. But what about perception? If phoneme sized units are less influential in speech perception as proposed by Hickok, one would not expect slips of the ear to involve such clear cases of phonemic manipulation. Slips of the ear are common and often involve substitutions that look like slips of the tongue and can be analyzed as phonemic. For example, Garnes and Bond (1980) cite the error in which "grew up in Philadelphia" was misheard as "threw up in Philadelphia." Although one can describe the error as the replacement of /g/ with /θ/, one does not need to assume that the slip is phonemic. Instead, perceptual errors nearly always involve the replacement of the target material with one or more words (e.g. Felty, Buchwald, & Pisoni, 2008), particularly words that fit in the context (e.g. "throw" with "up"). Contrast this with the "heft lemisphere" production error. There are two key differences, both of which apply generally when comparing slips of the ear to slips of the tongue. First, production errors, unlike slips of the ear, often result in nonwords (e.g., "lemisphere"), that is, novel assemblages of sublexical units. Second, in slips of the ear phonemes rarely if ever appear to have exchanged, leaving intervening material intact.¹ Thus, the compelling arguments for phonemes in production from phonemic exchanges that result in novel sequences have no clear counterpart in perceptual slips. In this respect, the slips data are supportive of Hickok's claim that phoneme sized units may be more important in production than perception.

Although a great deal of data support a role for phoneme sized units in production, nearly all of that data comes from languages that, it could be argued, would be expected to emphasize phonemic units rather than an alternative such as the syllable. All of the studies mentioned above were carried out in English and Dutch, two closely related languages that have over 12,000 possible syllables (Schiller, 1997), and whose syllables differ greatly in length and complexity (compare "a" and "strengths"). What about languages with fewer, more uniform, syllables? Mandarin Chinese, for example, has around 400 segmental syllables (1200 if tone is taken into account) all of which are relatively simple compared with English. It turns out that the production of Mandarin is more oriented toward syllabic than phonemic units. Studies of speeded word retrieval show priming for word-onset consonants in English and Dutch, but not in Mandarin (e.g. Chen, Chen, & Dell, 2002; O'Seaghdha, Chen, & Chen, 2010). There is some evidence that the production of Mandarin does involve phonemic units somewhere in the system (Qu, Damian, & Kazanina, 2012), but these representations do not contribute to onset priming. Hickok's dorsal stream does production planning both in terms of syllabic (auditory) and phonemic (somatosensory) units. If production processes differ across languages, an intriguing question within Hickok's framework is whether linguistic differences result in different emphases on auditory and somatosensory targets (e.g. auditory targets are relatively more important in Mandarin), or instead different associations between linguistic units and brain regions (e.g. somatosensory regions code more syllabic level information in Mandarin). To address this question, we could, for example, compare the brain correlates of syllabic and phonemic production errors in aphasia in the contrasting languages.

¹The closest example that I know of is "science" heard as "sinus", which can be analyzed as a shift of the /n/, or an exchange of /n/ and schwa (Garnes & Bond, 1980).

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