*Author response*

IN SEARCH OF AN INFANT LEARNING MODEL

Marilyn Vihman

University of York

**Abstract**

While the four commentaries reflect a range of different perspectives on my target paper (Vihman, 2017), all basically accept the overall approach, which has been central to my research for 30 years. Each commentary proposes ways of deepening aspects of the ideas expressed or points out limitations and potential areas in which elaboration would be useful. This response takes up each commentary in turn.

**Response to commentaries**

Primarily addressing the topic embedded in my title (sounds vs. words), Swingley (2017) recognizes the divide, in studies of the earliest stages of phonological development, between perception research, based on statistical analyses of group results, and linguistic analysis of individual children’s production patterns; he supports the idea that lexical knowledge begins to accrue early and is part of the developmental process, alongside the learning of sounds. Making the good point that ‘requiring [fully accurate] segmental matches to the lexicon would render much conversation unintelligible’ (p. xxx), Swingley acknowledges – contrary to much of the recent experimental literature on word-form representation in the second year (see Vihman, 2014, Ch. 7) – that children may not represent every aspect of the words they know equally accurately or robustly. However, he goes on to infer that children have ‘awareness of their own abilities’ (see also Menn, 1983); they ‘seek out patterns and use them’ (p. xxx). What I had hoped to make clear instead is that children’s ‘selection’ process is an implicit response to what is familiar, based on input frequency – which includes experience of their own production patterns. ‘Awareness’ need not enter in.

Pascalis, Dole & Loevenbruck (2017) focus on my speculative proposals concerning the joint role of implicit and explicit learning. Drawing on their own research on infant face processing, they find useful parallels with early linguistic advances. Experience with both face and language processing involves ‘perceptual narrowing’, as I also noted, with a loss of discriminatory capacity where experience fails to support the discrimination; both domains also appear to display parallel advances in holistic or ‘configural’ (e.g., whole-word) and more detailed ‘featural’ (sound or segmental) processing. The question is, how does experience support these advances? Pascalis et al. suggest that both configural and featural processing may function from the beginning; however, environmental experience – and, I would add, the child’s capacity to make use of it – may lead to differences in the rate of maturation of these two ways of gaining knowledge of the world.

The summary these authors provide of my model does not entirely correspond to my thinking, however. Indeed, both early word-form recognition and primed word use appear to reflect neocortical learning, with a ‘feeling of familiarity’ growing out of repeated exposure, with no need for focused attention. Only later, with increased hippocampal engagement, do infants begin to show active interest in verbal communication and in learning the ‘names of things’, generalizing their word use to novel situations and extending their vocal patterns to novel adult targets that are not close matches. I do not see this as ‘adult-like word processing’, however. And I do see the early word learning, through passive exposure, as supporting the more active seeking after form-meaning links that emerges in the second year.

While agreeing in principle that production may play a role in shaping perception, Redford (2017) sees my argument as neglecting the important distinction between phonetics and phonology. In her view, the early effects of the ambient language on the child’s production (the ‘babbling drift’ [Brown, 1958] demonstrated in numerous studies: See Vihman, 2014, ch. 4) reflect phonetic advances or phonetic knowledge, not phonological categories, which require meaning distinctions. I do not disagree; indeed, my understanding of such ambient language effects, consistent with Westermann and Miranda (2004), is that infants increasingly favor, in their own production, those patterns that find an echo in the input speech signal. Neurophysiological attunement of the motor output system to the child’s perceptual experience seems to me to best account for those effects.

This is again an implicit learning process, one which strengthens with infant vocal practice and which also proceeds concurrently with the formation of phonological categories through distributional learning. The latter can be taken to involve reference to meaning only to the extent that the phonetic variability associated with repeated mention of the same referent supports the learner’s establishment of non-distinctiveness between those variants (Heitner, 2004). Redford concludes that ‘sounds are acquired before words insofar as phonetic learning precedes phonological development’ (p. xxx). I would not deny that the early months of perceptual experience shape vocal preferences (see the Learning model, Vihman, 2014, ch. 2), but lexical knowledge is gradually forming over that period as well, with infants’ own names and the forms used to refer to their caretakers, for example, eliciting recognition by 6 months even in unfamiliar experimental contexts (Tincoff & Jusczyk, 1999).

The last commentary addresses what may be the most contentious idea I put forward, namely, that advances in production play a role in early speech processing. While Zamuner and Yeung (2017) fully support the idea, they focus on two areas in which further refinement would be needed. First, they suggest that the conceptualization of speech production may require elaboration in view of the hierarchical structure of adult models, which distinguish specific articulatory movements from the overall goal of those movements. This point is well taken; I look forward to future studies that may shed more light on the extent to which hierarchical structure can be discerned in infant production.

Second, Zamuner and Yeung note that not all effects of production on perception are positive; several ‘task-, attentional-, linguistic- and experience-related effects’ (p. xxx) must be taken into account. This point is particularly intriguing. Experimental studies with adults have revealed a disruptive effect of production on the learning of both novel lexical items and non-native sound contrasts (Baese-Berk & Samuel, 2016). Similarly, perhaps, Zamuner, Morin-Lessard, Strahm and Page (2015) found that in learning non-words children are actually hampered by production.

The difference between these learning situations and the natural context of infants’ everyday exposure to speech is notable. To take just the adult case here, Baese-Berk and Samuel argue that the disruptive effect of production on perceptual learning is likely due to the forced division of cognitive resources (e.g., attention, memory) when learners must immediately repeat a novel word (Leach & Samuel, 2007) or CV syllable before being tested. But the relationship between infant production practice and the input they hear is quite different. As noted above, there is a process of gradual attunement of the infant’s own articulatory movements to the perceptual processing of adult speech, with strengthening of neurophysiological connections that serve both (see Thelen & Smith, 1994). In fact, what I see as central to advances in phonological knowledge is infants’ ongoing perceptual experience of repeatedly used word forms that are echoed in their own vocal patterns. The familiarity with a certain number of word forms that is gained in the period before word use means that, once the child has linked these forms with meanings, there need be no division of cognitive resources.

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