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The influence of babbling patterns on the processing of speech

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ABSTRACT

This study compared the preference of 27 British English- and 26 Welsh-learning infants for nonwords featuring consonants that occur with equal frequency in the input but that are produced either with equal frequency (Welsh) or with differing frequency (British English) in infant vocalizations. For the English infants a significant difference in looking times was related to the extent of production of the nonword consonants. The Welsh infants, who showed no production preference for either consonant, exhibited no such influence of production patterns on their response to the nonwords. The results are consistent with a previous study that suggested that pre-linguistic babbling helps shape the processing of input speech, serving as an articulatory filter that selectively makes production patterns more salient in the input.

1. Introduction

The developmental strands of vocal production and speech perception, which together constitute the critical underpinning for language acquisition, are necessarily deeply interconnected, yet they are traditionally studied in isolation. The primary reason may be methodological. Production studies are typically observational, involving small numbers of infants and a large investment in time per infant. The analysis often concentrates on individual differences. In contrast, perception studies examine groups, using techniques in which individual differences are often treated as noise that obscures the findings based upon group responses. Combining these two methods is difficult, since the attrition rate in perception experiments can be as high as 33% (Jusczyk & Aslin, 1995; Jusczyk, Cutler, & Redanz, 1993; Jusczyk, Houston, & Newsome, 1999), effectively making it risky to invest a good deal of time in each infant. This study combines the observational and experimental approaches to language acquisition by utilizing individual differences in a production study to guide the analysis of perception experiments that examine group differences.

There are compelling reasons to expect the link between perception and action to be strong in the infant. Motor activity is one of the earliest modes used to explore the world in activities such as kicking (Rovee-Collier, 1995), reaching (Witherington, 2005), crawling (Campos et al., 2000), touching (Striano & Bushnell, 2005), and mouthing (Gottfried & Rose, 1980). In the case of the perceptuomotor activity of speech, the action–perception link is supported by a wide range of empirical findings with adults (e.g., Fowler & Dekle, 1991; Kerzel & Bekkering, 2000; McGurk & MacDonald, 1976) and a smaller number of studies with infants.

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For example, Kuhl and Meltzoff (1984) found that infants prefer to look at faces that are seen to be producing the vowels they are listening to than at faces seen to be producing incongruent vowels. Interestingly, this preference is affected by the type of lip movement the infant is making while looking and listening to these vowels (Yeung & Werker, 2013). In addition, the McGurk effect (McGurk & MacDonald, 1976) has been demonstrated in 2- and 5-month-old English learning infants (Burnham & Dodd, 2004; Rosenblum, Schmuckler, & Johnson, 1997). The recent finding that infants shift their gaze away from the eyes to the mouth at about the same time that they begin to babble constitutes further evidence for this link (Lewkowicz & Hansen-Tift, 2012).

Taking these studies as a starting point and considering speech in the context of other motor activities that inform cognitive processes, there is a distinct possibility of a link between an infant's babble and their perception of speech that incorporates elements of that babble. One way to think of such a link is to consider that the early production ability of an infant could provide enhanced accessibility to input that matches his or her production (Locke, 1993, p. 204). This process of matching production to perception has been suggested to act as an 'articulatory filter' (Vihman, 1996, p. 142; see also Vihman, 1991, 1993), making patterns that an individual infant regularly produces more salient in the input.

A recent study by DePaolis, Vihman, and Keren-Portnoy (2011) provided empirical evidence for this link. DePaolis et al. followed the babble of prelinguistic infants with regular recordings. Once there was evidence of a well established or 'favored' consonant, these investigators tested the infants' preference for passages with nonwords containing this favored consonant versus a passage with nonwords containing consonants that the infant was not yet frequently or consistently producing. The infants who were favoring two consonants in their babble exhibited a significant preference for the passage with nonwords comprised of the consonant that they were *not* producing. This effect was interpreted as a novelty response, based on the infants' over-familiarity with the consonants known to them from their own babbling practice. This interpretation was supported in a study by Majorano, Vihman, and DePaolis (in revision), which showed the complementary familiarity effect: Italian infants who show frequent use of only one consonant in babble showed a significant preference for words with that consonant over words with a consonant that they are not yet producing with any consistency.

Since it is possible that the frequency of consonants in the input speech could account for these effects, both DePaolis et al. (2011) and Majorano et al. (in revision) investigated the frequency of consonants used in the input and tested whether mothers' differing consonant use in infant directed speech (IDS) might be the source of their infants' babble patterns. Both studies found that while the infants' babbling patterns were marked by clear differences, the frequency of consonantal use in the mothers' IDS was very similar and not always related to the consonant use in their infant's babble. These findings were consistent with Vihman, Kay, Boysson-Bardies, Durand, and Sundberg (1994), who found, in each of three language groups, that infants' productions were highly variable while the mothers' sound patterns in any given language varied very little.

Nevertheless, since the input frequency of words affects lexical development (Goodman, Dale, & Li, 2008; Hart, 1991) and the production patterns of infants match characteristics of the IDS to which they are exposed (Lee, Davis, & MacNeilage, 2008), it is possible that the infant is affected by the input frequency of consonants. It could be that the frequency of consonants in the infant's environment affects perception in much the same way that the statistical or phonological properties of the language do (Saffran, Aslin, & Newport, 1996; Saffran & Thiessen, 2003). One way to examine this prospectively is to use experimental stimuli which highlight consonants that are either high or low frequency in the ambient language but potentially contrastive in the infants' production (frequently versus infrequently produced in babble).

Accordingly, the purpose of this study was to explore the effect of production on perception by matching the frequency of input-language occurrence of the speech stimuli presented in the experiment. We chose contrasts in Welsh and in British English that had a similar frequency of occurrence, but that we assumed would differ in their frequency of occurrence in the infants' vocal production. First infants' babbling patterns were documented; then the headturn paradigm was used to test for a correlation between an individual infant's production patterns and their responses to these patterns in the perception experiment. We hypothesized that the infants should respond to consonants that are prevalent in their own babble differently than to consonants that are not, as indexed by a difference in looking times to the two types of stimuli. Alternatively, if the frequency of occurrence of consonants in the IDS was a major factor but the infants' production patterns were not, then the infants should show no preference for either contrast.

2. Methods

The study consisted of two parts, a longitudinal observational study and a perception test. The first part was designed to provide a profile of each infant's production patterns so that the subsequent perception test could be analyzed with reference to the individual infant's production.

2.1. Participants

A total of 53 infants from the area around Bangor, Wales participated in the study. Each infant participated in both parts of the study. The English-learning sample included 27 infants (15 males) and the Welsh-learning sample consisted of 26 infants (13 males). Three additional Welsh infants were excluded from the study when it was observed that their parents used English with them during the recording sessions; no other participants had to be excluded. The lack of attrition in the perception experiments was unexpected, but consistent with low attrition in two of three experiments in a previous study (Vihman, Nakai, DePaolis, & Hallé, 2004) with 12 test trials; the current study had only eight test trials (see below).