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Why repetition? Repetitive babbling, auditory feedback, and cochlear implantation



Mary K. Fagan

Department of Communication Science and Disorders, University of Missouri, Columbia, MO 65211, USA

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ABSTRACT

This study investigated the reduplicated, or repetitive vocalizations of hearing infants and infants with profound hearing loss with and without cochlear implants using a new measure of repetition in order to address questions not only about the effects of cochlear implantation on repetitive babbling, but also about the reason repetitive vocalizations occur at all and why they emerge around 7 or 8 months of age in hearing infants. Participants were 16 infants with profound hearing loss and 27 hearing infants who participated at a mean age of 9.9 months and/or a mean age of 17.7 months. Mean age at cochlear implantation for infants with profound hearing loss was 12.9 months, and mean duration of implant use was 4.2 months. The data show that before cochlear implantation, repetitive vocalizations were rare. However, 4 months after cochlear implant activation, infants with hearing loss produced both repetitive vocalizations and repetitions per vocalization at levels commensurate with their hearing peers. The results support the hypothesis that repetition emerges as a means of vocal exploration during the time when hearing infants (and infants with cochlear implants) form auditory–motor representations and neural connections between cortical areas active in syllable production and syllable perception, during the transition from nonlinguistic to linguistic vocalization.

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E-mail address: faganmk@missouri.edu

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Introduction

Hearing infants (infants with normal hearing thresholds) regularly produce characteristic strings of repetitive syllables (e.g., [dadada]) during a peak period in the second half of the first year (Fagan, 2009; Locke, 1993; Mitchell & Kent, 1990; van der Stelt & Koopmans-van Beinum, 1986). These well-noted vocal behaviors emerge around 7 or 8 months of age on average and are widely recognized by parents and nonparents alike. Despite their wide recognition, the reason these syllable strings emerge at all remains puzzling after decades of investigation and varied hypotheses regarding their role in the context of infant development (Kent, 1984). Ideas about their emergence and function have included that they have little or no relationship to later language (Lenneberg, 1967), that repetitive vocalizations and limb movements occur as part of a general period of cyclic organization (Kent, 1984; Thelen, 1981), and that they contribute to motor coordination and control (Ejiri & Masataka, 2001). Little research has directly examined repetitive babbling in the context of infants' general interest in generating auditory feedback from their own vocalizations or the developmental timing of repetitive babbling in the context of neurocognitive connections that form around the same time.

Infants who receive cochlear implants at an early age present opportunities to evaluate repetition in the context of access to auditory feedback before and after cochlear implantation. Furthermore, because strings of syllable repetition are uncommon in spoken English words (Crystal, 2003) and infants with profound hearing loss do not hear spoken input before cochlear implantation (Northern & Downs, 2002), vocalizations that occur soon after cochlear implantation can in part address the relative influence of auditory feedback and linguistic input on vocal behavior immediately following cochlear implantation. Thus, investigating repetitive vocalizations in infants with profound hearing loss before and after cochlear implantation will potentially address infants' motivation to generate auditory feedback as the reason repetitive vocalizations occur at all, and the timing of their emergence in relation to the formation of cognitive representations as the reason they occur when they do.

Repetitive babbling in hearing infants

Although canonical babbling is the term often used for single, well-formed consonant–vowel (CV) syllables (Oller, 2000) without regard to repetition, *reduplicated* (or repetitive) babbling is the term specifically used to describe vocalizations produced with two or more consecutive CV repetitions (e.g., [dadada]). Reduplicated babbling, a notable milestone in infant development, typically emerges around 7 or 8 months of age (Fagan, 2009; Mitchell & Kent, 1990; van der Stelt & Koopmans-van Beinum, 1986). Studies of both canonical and reduplicated vocalizations have typically focused on age of onset, using a proportional measure for canonical syllable onset and documented observations of repetitive vocalization for reduplicated babble onset.

However, a relatively new measure of repetition, the discrete number of repetitions per reduplicated vocalization, was first examined in a longitudinal study of hearing infants (Fagan, 2009). This measure showed that repetitions per vocalization rose abruptly, peaked at 9.5 months of age, and unexpectedly declined within 2 or 3 months of emergence. Repetitions per vocalization declined with the emergence of word production and, in fact, were infrequent in early words as well. Just 18% of 13-month-old infants' first words contained two reduplicated syllables (e.g., [dada]; Winitz & Irwin, 1958; see also Vihman, 1996). Thus, although nonword strings of CV repetition peaked before the end of the first year, they continued to occur in smaller numbers.

Substantially increased motor control and flexibility enables infants to produce CV repetitions during the second half of the first year (Kent, 1981; Stark, 1978); however, infants did not continue to produce long strings of repetition in substantial numbers at older ages when they had even greater motor control. Thus, the reason that infants repeated CV syllables during the early interval and not at later ages cannot be explained by motor competence alone.

Repetitive babbling: Effects of hearing loss

As with studies of hearing infants, studies of vocal development and hearing loss have typically focused on age of canonical syllable onset using proportional criteria (Eilers & Oller, 1994; Kent,

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