Changes in Vocalizations of Infants with Severe Impairments using visiBabble

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Abstract

Children with difficulty producing a full range of speech sounds can benefit from opportunities to practice sounds in play contexts, even before they are using those sounds to form recognizable words. visiBabble is a prototype computer-based program that responds with customized animations to targeted types of infant vocalizations. The program automatically recognizes acoustic-phonetic characteristics of the vocalizations and can selectively respond to utterances with varying levels of complexity (e.g. multisyllable utterances). This poster reports syllable production changes of seven children with physical and speech impairments, ages 2-3, in response to visiBabble reinforcement.

Introduction

The goal of visiBabble is to encourage children with significant delays or impairments in developing speech to produce more speech-like vocalizations. It does this by providing real-time visual and auditory feedback for types of babbling that are associated with later language and cognitive development. Several studies confirm that infant vocalizations are effective predictors of later articulation and language abilities [8, 9, 13]. Neurological and oral/motor impairments can significantly impact speech. A child may not be able to produce a sound when he or she wants to, or may produce a limited range of sounds [2].

As a clinical tool, the program also records the acoustic-phonetic analysis. As a child interacts with visiBabble, the program collects and analyzes the infant's utterances so that it can be used by a child as a toy/trainer or by a practitioner as a clinical or research implement. The techniques involved with visiBabble directly reflect best practice in pre-speech intervention demonstrated in treatment efficacy studies. VisiBabble uses a responsive strategy based on a commonly accepted "play" mode of speech intervention, in which activities are child-initiated and child-focused [14]. The purpose of the visiBabble system is to increase the vocalizations of infants, and to increase the sophistication and variety of such vocalizations by differentially reinforcing syllabic versus non-syllabic productions.

Methods

Subjects: Seven children completed the visiBabble protocol, ranging in age from 24 to 42 months (average 30.6 months). The children had physical impairments resulting from neurological, genetic, and/or developmental conditions including hydrocephaly, cerebral palsy, Goldenhaar syndrome, and oral-motor control impairments. All children fell at least one standard deviation below age expectations on the expressive language subtest of the Battelle Developmental Inventory, and demonstrated intentional communication as measured by the Communication and Symbolic Behavior Scales.

visiBabble Design:

Acoustic-Phonetic Landmark Model

Consonant-like sounds or closants [11] can be detected in the sound waveform from acoustic evidence of abrupt changes in the spectrum of sound. These changes have been called acoustic-phonetic landmarks by some researchers of adult speech. Landmarks [10, 15] that result from the creation or release of a narrow constriction or closure along the vocal tract are also found in pre-linguistic vocalizations.

Vowel-like sounds or vocants [11] appear early in the vocalizations of infants and are characterized by slowly time-varying spectral patterns. These sounds result from movements of the tongue body, the jaw, and the lips, and are usually produced with the vocal folds positioned to vibrate. A variety of vowel-like sounds appear as the infant learns to control the positioning of these articulators. [1]. For the purposes of visiBabble, a syllable consists of a vowel (or vocant), usually preceded and/or followed by a consonant (or closant).

We have applied this method to detect patterns of landmarks in infant vocalizations and performed validity studies that show that our computer results compare favorably with analysis by trained phoneticians [3, 4]. We then used the detected landmark patterns to describe and quantify the syllable types produced. By revising the algorithms for real-time use, we have been able to create the visiBabble prototype to respond to, and not merely measure, a child's vocalizations. The goal of our first development and field tests was to reinforce syllable-like sounds that are clear precursors to speech without reinforcing cries, coughs, and other non-speech productions.

Data Collection:

All children completed six sessions with visiBabble, at approximately 1 week intervals, conducted in their homes. Each visiBabble session consisted of an 8-minute run in A-B format, in which 4 minutes of the A phase (with animation feedback to selected vocalization types) was followed by 4 minutes of a B phase (with a single screen figure that did not change with child vocalizations). Children were seated in a comfortable supported position at a table or on the floor in front of a screen and external microphone, with the remainder of the computer under the control of the experimenter.

Children completed up to five 1-minute test trials of the visiBabble with different reinforcing animations at the first session, to determine preferred reinforcers and engage the child in understanding the effect of their voice on the computer responses. Adults demonstrated the use of vocalizations during test trials and actively prompted children to vocalize under test trials; during the official experimental sampling for 8 minutes, restricted prompting to attention cues to the screen or the child's voice, and limited vocal responses to child actions. In several cases, children held and independently interacted with a non-noisy toy during visiBabble sessions, particularly to keep children engaged during the non-responsive B period in which the computer no longer made interesting responses to children's behavior. Children's interactions with the computer were videotaped and coded for child attention to the computer screen during the various phases of interaction.

Results of Phase II Field Testing

Across subjects, children produced more vocalizations with attention to the computer screen during reinforcement phases than non-reinforcement phases. In several children, there was a brief period of increased vocalization during non-reinforcing phases, interpreted as children's frustration at not being able to make the program response to their vocalizations any longer. The exception to this pattern was the performance of two subjects with primary oral motor control concerns, whose vocal outputs were more variable across sessions.

For those children targeting complexity of utterances, the reinforcement phases elicited more multisyllable utterances than non-reinforcement phases during periods of attention to the computer. Because child attention to the screen was often brief during non-reinforcement phases, complexity of vocalization during phase B was attributed to off-task responses of children and parents not directly associated with visiBabble activities. Future research planned for summer 2007 will provide extended visiBabble trials with families in their homes to determine relative impact of visiBabble practice on changes in child vocalizations over time.

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