Canonical Babbling: A Complex Melodic and Rhythmic Journey to Infant's First Words

Review Article

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ABSTRACT

Background: Canonical babbling has a complex melody and a characteristic rhythmic pattern. It is a hallmark among different babbling phenomena in the child's first year. In the first 6 months, in cry and non-cry infant vocalizations, melody develops and becomes more complex. When canonical babbling develops, it marks the beginning of rhythm in the infant's vocalizations, in the form of repetitive consonant-vowel syllables. Simultaneously, melody complexity increases significantly. These syllables with their rhythm and melody diversify to merge into intonation and syllable segmentation in the infant's early language development. Delayed or decreased canonical babbling has been linked to delayed or disordered language development.

Objectives: The aim of this article is to review the musical and social role of canonical babbling as a link between development of rhythm and melody in infant's vocalizations in the first six months, and development of prosody in the child's language afterwards.

Patients and Methods : Melody and rhythm patterns, that begin to be perceived in intrauterine life, undergo development in pre-canonical and canonical intervals. The canonical babbling has both a musical and a social role. It is a pre-speech requirement, linking melodic non-syllabic infant vocalizations in the first 6 months to rhythmic complexly melodic segmentations of language.

Conclusions: The canonical babbling, with its unique melodic and rhythmic pattern, is a practice of syllables. Syllables continue to be the musical units of words on which prosody acts. That is why its frequency and time of occurrence should be considered pertinent in the developmental history of children with delayed language development.

Key Words: Canonical babbling, infant's vocalizations, melody, prosody, rhythm.

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INTRODUCTION

Canonical babbling is a hallmark in the infant's prelexical development. It is a sequence of syllables highlighting a transitional period between the vocalizations of solitary syllable-like consonants with intonated vowels (marginal babbling) and the emergence of meaningful words[1]. The production of canonical syllables in a repeated symmetric (reduplicated) then asymmetric (variegated) rhythm is a principal audiological and articulatory training to the infant before venturing into the phonological jungle of syllables-words-sentences. This phenomenon occurs in the second half of the first year[2].

The language prosodic envelope to which the infant's human ear has special affinity, allows him/her to discriminate rhythmic pattern[3], and pitch contour or shape of melody over time[4]. Melody and rhythmicity form prosodic boundaries that illuminate the syntactic divisions[5]; and by 4-6 months, word segmentations in sentences[6,7]. It is as if the infant gradually perceives a syntactic melody and a semantic melody. This is achieved by the infant's innate ability of categorical perception. It allows categorization of similar structures out of the auditory signal, which is both variable and complex[8].

Acquiring a well-developed supra-segmental level of speech in an infant and reaching the plateau of first word utterance requires maturation of rhythm and melody creating a certain prosody which is analogous to his/her mother's language. This process doesn't begin only since birth, but it also starts within the intrauterine life of an infant, exactly at the time of the hearing system maturation (33rd week of gestation) and gets to mature along with the embryological development process[9,10]. During this period, the infant hears all musical components (rhythm, melody and tempo) of his/her mother's voice and heartbeat; transmitted through amniotic fluid and bone conduction. In fact, the auditory system requires external auditory stimulation for its development[11].

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Following birth, the infant continues to hear more clearly the auditory messages that had begun to penetrate his/her intrauterine environment[12].

Influenced by them, he starts to produce auditory messages of his/her own. Amid speech, music, and other environmental sounds; the mother's voice continues to be the most effective stimulus[13].

Many articles have previously described canonical babbling, as a charactersitic prelinguistic stage, regarding its 'continuity' link to meaningful words[14-17], its consonant content[18], its vowels and consonant-vowel combinations[19] and possible implications if it is delayed[20,21]. Its rhythm and melody, however, were not a focal point although they carry on to the prosody of the infant's first words. Canonical babbling has a characteristic music to it. It marks the repetition of the building blocks of language; the syllables. These syllables are the basic consonant-vowel syllables that are well-defined and rhythmically repeated by the infant for the first time. They are actually consonant-vowel like syllables, because consonants and vowels do not yet serve a phoneme function. This practice, neverthless, is instrumental as syllables continue as the 'keys' that produce the musical 'notes' of language prosody.

OBJECTIVE

The aim of this article is to review the musical and social role of canonical babbling as a link between development of rhythm and melody in infant's vocalizations in the first six months, and development of prosody in the child's language afterwards.

CONTENT

What is Canonical Babbling?

Canonical babbling occurs in the second half of the first year (6-10 months) and marks the development of clearly delineated syllables[15]. There is some disagreement in literature about age of onset and structure of canonical babbling. The age of onset of canonical babbling is usually reported as 6[22-25] or 7 months[26-28]. Long *et al.*[21] stated that it starts at 6 months and is well stablished at 7 months. Some researchers reported onset after 8 months[29,30], while Oller[31] reported that it could start between 5-10 months. In a systematic review by Morgan[17]including 13 studies, 12 studies reported the onset was at around 7 months with gradual increase in reduplicated babbling[26], or reduplicated and variegated babbling[27] until 12 months. This is followed by decrease concurrent with the onset of first words[26,23]. Mitchell & Kent[27] and Smith *et al*.[32] have focused only on non-reduplicated (variegated) babbling, and noted that it starts with reduplicated babbling and is stable up till 11 months. At 12-14 months, it increases in frequency[32]. Vihman *et al*.[33] have recognized this early period of vocal development as marked with individual variations.

Canonical babbling is a prominent developmental milestone, occuring when infants produce well-formed syllables of consonants and vowels[34]. There is a rapid transition between them. The syllables are repetitive in a sequence; consequently doubling, tripling, or quadrupling them. Pertaining to the structure of canonical babbling, some researchers have identified canonical babbling as reduplicated babbling only[15,21,31,35], or reduplicated and non-reduplicated (variegated) babbling[36]. Reduplicated babbling starts first, but they occur simultaneously from then on. Some studiess as Oller[31], described them as sequential phenomena; whereas other studies considered them concurrent[27,37]. The consonant-vowel form of syllables is the simplest in words and connected speech. Syllables are the rhythmic unit of language and the building block of speech. That is why engagement in such an activity for some time and repeatedly is a 'bridge' that crosses from infant vocalizations to meaningful speech[38].

Canonical syllables are adult-like in their composition; with complete or near-complete supraglottic closure (consonant), transition, and fully resonant nucleus (vowel). This makes their appearance acoustically striking to parents[35]. Three phenomena were specified by Holmgren *et al*. [39] to give the adult-syllable-like impression. These are the supraglottic closure, pollysyllabicity, and consistent rhythmic time pattern. Rhythmicity or temporal regularity is the effect of cyclic alternation between articulatory closure and opening to produce consonants and vowels. Rhythmicity was reported during motoric development in the first year involving limbs, fingers, and trunk[40]. Interestingly, as reported by Meier *et al*.[41] and Rouge *et al*.[29], some parents have noticed rhythmic up and down jaw movements days before the onset of audible reduplicated syllables (silent babbling).

Before the emergence of canonical babbling, pre-canonical or marginal babbling takes place from 4 to 6 months. The infant during this period is either attracting the attention of caregivers or interacting with them, using syllable-like combinations of consonant-vowel or vowel-consonant with slow transition between both[31]. The vowels are prolonged, intonated, and variable in length each time. True syllables have a specific duration according to their structure. In Egyptian language, for instance, vowels are either short or elongated, and syllables end in vowel, consonant, or consonant cluster. Therefore, the beat that

each type of syllable imparts according to its structure, [CV], [CV:C], [CVC], [CV:C], or [CVCC] is stable[42]. That makes the emergence of the beat of [CV] syllables in canonical babbling characteristic.

Canonical babbling is the repetition of canonical syllables in a reduplicated or a non-reduplicated (variegated) pattern[43]. The redublicated part of it is formed of identical consonant-vowel syllables, repeated over and over (bababa, dadada, and gagaga). They impart a characteristic rhythmic auditory pattern with low front, mid, and central vowels[20,44-50] together with stop, nasal, and glide consonants[51,52, 53]. In the period between 8-12 months, they are overlapped with non-reduplicated babbling. The sounds and syllables here are more variable. The consonants or vowels may differ from one syllable to another (gadada, babi). The infant is gaining more control over his/her oral motor system, allowing variability in the rhythm; but researches considered reduplicated and variegated babbling to be at the same level of complexity[37,54].

How do Melody and Rhythm emerge in Pre-canonical Babbling?

The From birth infants are programmed and ready to perceive auditory information from the surrounding environment, based on melodic cues[55-57]. The most obvious acoustic cue for infants is the melody (the time-varying fundamental frequency[58, 59]. This does affect the newborn's crying, which is shaped by the melody of the surrounding language. It is also affected by neurophysiological maturation and learning[60-62].

Wermke and Mende described melody of infant's cry and non-cry vocalizations in the first 6 months according to Melody Development (MD) model[63-65]. Vocalizations develop from a single arc melody contour evident in infant cry pattern in the first 2 months, to a multiple arc melody contour from 2-6 months. The complexity of melody increases from the third to the twelfth month, with the appearance of marginal and canonical babbling. The single arc is the basic building unit of melody, while complex melodies are the building blocks of syllables, words and sentences[66].

The following are the four basic shapes of melody:

- The falling (F) curve consists of a rapid rise of f0 in the first part of the time interval followed by a slow descent till the end.

- The rising (R) curve has a slow climb of f0 up to the last part of the interval, where there is a steep decrease.

- The rising—falling or symmetrical (S) curve is described by an increasing-decreasing trend of f0 around a maximum approximately positioned in the middle of the curve.

- A flat curve or Plateau (P) is described by a nearly constant f0 with a variation lower than few tens of Hz around its median value.

These categories are the basic variations of simple melody shapes. Várallyay[67] found up to 77 different shapes. So, there is a rich variety. The basic melody shapes could combine in any sequence, thus increasing melody complexity. Precursors of vowels and consonants (vocants, closants) are originally rehearsed on simple, single-arc melodies before functional vowels and consonants are purposefully produced in expressions with complex melody contours[68].

As canonical babbling sets in, rhythmicity becomes the prominent pattern in the musical envelope. Although development of melody in infant's vocalizations precedes the development of rhythmic repeated canonical sylables, rhythmicity is present in infant's motoric movements in the early months of the first year. Many studies have commented on the ability of infants to go along the rhythm of speech using their body movements[69,70-74]. This is more evident when listening to the regular rhythm of music and nursery rhymes[75-77]. These movements have been linked to the infant's perception of rhythmicity in speech and musical rhymes[78]. The movement of the infant aligned with the rhythm of music, documents that the rhythm has been perceived and put to effect. Prior to this stage, the caregiver usually sings to the infant while rocking him/her; a very impressive buildup of rhythm awareness. Infant-directed (ID) songs are also helpful in this learning process by being higher in fundamental frequency, more emotionally expressive, and having a slow and regular tempo[79-81]. By listening to the same songs repeatedly, the infant is musically more attentive to them and socially more interactive with the caregiver.

The rhythm of music has two temporal criteria: rhythmic pattern and meter[82]. The rhythmic pattern is a series of temporal intervals in a sequence, having a distinctive pattern; as a series of long and short intervals. Meter is the abstract temporal structure of music; the most conspicuous feature of which is the beat, to which people tap their fingers and feet to music. Meter is perceived from the periodic regularities in the musical aspect[83,84]. Infants recognize melody on basis of meter. A two- months old can differentiate between familiar and unfamiliar melodies. Infants have a good memory for melodies[85]. When a five-months old infant is exposed to a certain melody for one or two weeks, he can remember it 8 months later[86]. Also at this age, the infant can move rhythmically to music,

indicating a good perception of tempo and rhythm[87]. So, the infant's mind extracts melody and rhythm from songs and musical stimuli [88].

The infant's brain is perceptive of musical organizations[89]. An electroencephalography study done to newborn infants have detected their sensitivity to onset, offset, and tempo of musical sequences[90]. Infants, 7-15 months old, have been found to perceive pulse (evenly spaced beats) as well as meter (hierarchical organization of strong and weak beats) of rhythmic patterns. The pulse is steady and repeated consistently, like tapping the foot to music[91]. It could be audible or implied. Both terms beat and pulse could be interchangeable. They give the music its tempo[92] and rhythm[93,94]. Even when the caregiver is speaking to the infant, the infant's mind extracts the music in the language. Language is a musical activity, and its music is called prosody. This prosody is processed by the infant's brain bilaterally, and emotions make it more evident. The processing occurs in the superior temporal and the inferior frontal lobes. The period between 3 and 7 months is a sensitive period for this tempro-frontal processing to occur[95].

What is the Rhythmic and Melodic Contour in Canonical Babbling?

Supraglottic closure, that occurs in canonical babbling, adds to the melody that already developed from a simple arc in the early months of life by increasing its complexity. So, melody continues to build up combinations of many patterns. These are related to the ability to produce changes in the dimensions of the supraglottic compartment. It is an act of deformation, with all the possible combinations of complex melody. Melody is significantly more complex in canonical babbling from the 7th to 12th month[38]. But what about rhythmicity? Well, it is an inherent pattern in canonical babbling, both acoustically and motorically. The rhythm added by canonical babbling completes the musical picture, the musical picture that extends into prosody of speech.

Let's take the train of thought from the beginning. Acoustic perception of rhythmicity was first introduced to the intrauterine fetus by hearing the mother's heartbeats[95-99]. Rhythmicity continued in repetitive movements as rocking the infant, and manually shaking a rattle or any other object[101-103]. Then canonical babbling emerged with its reduplicated syllables. That's a rhythmic repetition. It involves both motoric movement (repetitive mandibular closing and opening) and acoustic segmentation (consonant-vowel syllables said repeatedly)[104,105]. So, as Iverson *et al*.[106] denoted, it is a phenomenon of both. It is both a speech and a language development, with proprioceptive and acoustic consequences. Motorically, the articulatory movements in syllable production increase gradually in complexity[29,31].They start with consonant-vowel syllables that are completely alike (da da da), then variations occur (ga da da).

More complex consonant-vowel-consonant syllables (conversational babbling) then emerge, with diversity in consonants. Complex articulatory movements with their proprioceptive sensations lead to more phonetic sound productions. So, a 'babbling drift' occurs at the end of the first year that resembles the sound inventory of the target language. Although canonical babbling is both a motoric and a language skill, yet the unique pattern of well-formed syllables makes the linguistic part more prominent. It is a rhythm of repeated syllables, in the form of a segmented utterance. Both rhythm and segmentation are linguistic phenomena[107].

It was also reported that rhythmic hand movement increased with the increase in canonical babbling[106].The rhythmic motoric and linguistic pattern could be centrally related. Broca's area (Brodmann's area 44, 45, and 46) is related to both linguistic and motoric tasks involving hand movement[108]. Broca's area plays a role in sequential movements, whether in speech or gestures. So, the motoric and linguistic rhythmic components in reduplicated babble have a common neural substrate. Also, the inferior lateral cerebellum is typically related to motor function but is also anatomically related to language areas[109,110].

Is Canonical Babbling an Essential Pre-speech Stage?

Obstructive In delayed language development, clinicians are often concerned with behaviors that reduce social interactions as excessive screen watching. Let's take it one step backwards and study the social interaction in the first year of life. The infant is dependent on social interaction from caregivers and is actively seeking it. Sometimes the infant is seeking it to an extent that causes exhaustion to the caregiver. The typical infant is a human being in a stage of social seeking and facial recognition. The rhythm and melody of the infant's vocalization are the venue to achieve his/her social interaction with adults. The infant exists in a stage of human development that is waiting to devour any social experience he can attain, with excitement and relish. In fact, infants prefer faces to other visual stimuli, voices to other auditory stimuli, and they are very sensitive to eye-contact with their caregiver[87]. Caregivers talk and sing, bounce and rock infants. Rhythmic and melodic social interactions are the source of social information to infants[110]. Musical engagement creates a bond between infants and caregivers that sets the path to social, cognitive, and language development.

Oller *et al*.[112,113] has pointed out that 'canonical syllables' are an essential step before emergence of speech. In fact, the consonant-vowel syllables are universally the basic syllables in any language. Canonical syllables

resemble those. Adult overlookers identify speech elements in these syllables. These elements, as was stated by Oller[113] , are well formed syllables with rapid transition between consonant-like and vowel-like sounds (contoids and vocoids).

Syllables besides being a building unit in language structure, are the stratum on which prosody performs. The intonation that the infant performs in the canonical babbles resemble an outlay of emotions and enthusiasm. Even stress could be performed by elongating the syllable's nucleus (vowel). The rhythm is there and clear. The consonant-vowel syllables are not merged, but clearly segmented. The syllables then get more complicated, with complex melody and prosody patterns, paving the way into language. Between age of 9-12 months, the first words and the first gestures emerge[106].

Delayed onset of canonical babbling may be an early sign toward a delay in language development in the absence of an evident cause[111]. The ability of the infant to form basic syllables repeatedly in a clearly segmented rhythm logically precedes the words. It also precedes the more diversified syllables in conversational babbling, imparting the melodic contour of the child's environmental language. Some authors as Oller *et al*.[112] suggested a cutoff point (10-months) for delay in canonical babbling to be carefully followed-up for possibility of language delay.

Unfortunately, late onset of canonical babbling could be overlooked by parents[114]. The relationship is probabilistic meaning that the presence of significant delay in canonical babbling, is predictable of a delay along the course of speech and language[115,116]. This is a likelihood that might not happen, but is worthy of investigation.

CONCLUSION

The emergence of canonical or reduplicated consonant-vowel babbling, marks a major achievement in the infant's vocal maturation. When the infant reaches this level of segmentation of utterance, it is the result of an interplay between months of high affinity to perception of melody and rhythmic behavior, as well as a neurophysiological development. Before this stage, infants produce single syllables, or repeat single sounds as vowels[117]. Repeated strings of well-formed syllables form a rhythmic behavior that precedes real segmentation in language. Language is built on segmentation; sentences are segmented into words and words are segmented into syllables. Syllables are an important building unit of the language structure, and the simplest form of syllables universally is consonant-vowel. As a musical precursor to language, it is a channel that the child must pass through before meaningful words. In developmental history review, it should be included. Inquiring about the time of its occurrence is as enlightening as the time of the child's first words.

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