The Impact of Early Onset Otitis Media on Prelinguistic Speech Development

L'incidence de l'otite moyenne précoce sur le développement du langage au stade prélinguistique

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Abstract

Numerous studies have shown that otitis media (OM) during infancy has a negative impact on language development later in life. Few studies have examined the effect of OM on prelinguistic behaviour during infancy. The purpose of this study was to investigate the impact of OM on the development of canonical babble in children who experienced at least one episode during the period of birth through six months of age, in comparison with children who did not experience OM during this period. The results show a consistently lower rate of canonical babble among children with early onset OM, when compared to children with later onset OM, during the period six through 12 months of age.

Abrégé

D'innombrables études ont démontré que l'otite moyenne (OM) chez le nourrisson a une incidence négative sur le développement du langage plus tard au cours de la vie. Peu d'études ont porté sur l'effet de l'OM sur le comportement prélinguistique à l'âge du nourrisson. Cette étude visait à faire enquête sur l'incidence de l'OM sur le développement du babillage canonique chez les enfants ayant eu au moins une episode avant l'âge de six mois, par comparaison avec les enfants qui n'ont pas fait d'OM au cours de cette période. Les résultats témoignent d'un taux constamment moins élevé de babillage canonique chez les enfants atteints d'OM d'origine précoce, par comparaison avec les enfants chez qui l'OM survient plus tard, pendant la période de six à 12 mois.

Numerous studies have shown that otitis media (OM) during infancy has a negative impact on language development later in life. When compared to children who have negative or minimal histories of OM, those children who have suffered recurring or chronic OM have demonstrated difficulties with speech perception skills (Brandes & Ehinger, 1981; Clarkson, Eimas, & Marean, 1989; Gravel & Wallace, 1992; Menyuk, 1986), central auditory processing (Moore, Hutchings, & Meyer, 1991; Pillsbury, Grose, & Hall, 1991; Welsh, Welsh, & Healy, 1983), phonological abilities (Chalmers, Stewart, Silva, & Mulvena, 1989; Roberts, Burchinal, Koch, Footo, & Henderson, 1988), and other aspects of language development (Friel-Patti & Finitzo, 1990; Teele, Klein, & Rosner, 1984).

Not all investigators have concluded that OM is associated with delayed or deviant language development (e.g., Black et al., 1988; Webster, Bamford, Thyer, & Ayles, 1989). This lack of clarity has been attributed to methodological error and lead some readers to conclude that the literature is uninterpretable (Paradise, 1981,1983; Ventry 1980). However, research regarding OM outcomes has become increasingly sophisticated in recent years. The studies cited above are large scale prospective research projects that have dealt with most, if not all, of the design flaws listed by the most fervent critics of OM research. It is now possible to conclude with some confidence that OM in early childhood is related to poorer language ability later in life. However, methodological variations continue to result in variations in outcomes that are instructive in terms of identifying variables that mediate the relationship between

OM and outcomes. Variations in OM-related outcomes may be attributed to environmental variables such as socioeconomic status and the therapeutic interventions available to the child. OM outcomes also depend upon subject variables such as age of child at time of testing, amount of time with OM, and age of onset of the OM.

Friel-Patti and Finitzo (1990) suggest that the relationship between OM, hearing, and language changes over time: the effects of OM vary with the developmental challenges that are specific to the child at age of testing. Roberts et al. (1988) found that the number of days with OM during the first three years of life was related to the number of phonological processes used by the children during the years 4.5 through 8. Chalmers et al. (1989) and Menyuk (1986) also report a relationship between OM early in life and later phonological skills. A relationship between OM history and phonological ability was not observed for younger children by Roberts et al. (1988), Teele et al. (1984), or Bishop and Edmundson (1986). A large number of phonological errors are commonly observed in 2- and 3-year-old children, regardless of their middle-ear health in infancy.

Prospective studies have found that the risk of negative speech and language outcomes increases with earlier age of onset and a greater number of episodes of middle-ear effusion (Feagans, Sanyal, Henderson, Collier, & Appelbaum, 1987; Friel-Patti & Finitzo, 1990; Gravel & Wallace, 1992; Kaplan, Fleshman, Bender, Baum, & Clark, 1973; Klein, Chase, Teele, Menyuk, & Rosner, 1987; Menyuk, 1986; Roberts et al., 1988). For example, Teele, Klein, and Rosner (1984) found that time spent with OM during the first 12 months of life was significantly correlated with language performance at three years of age; OM during the second and third years of life did not seem to impact on later language development. Grievink, Peters, van Bon, and Schilder (1993) also found that OM during the period two through four years of age does not place children at risk for poor language performance in kindergarten.

There are at least three possible explanations for the relationship between OM during infancy and later language development. First, age of onset and chronicity of OM are correlated with each other (Marchant et al., 1984) and consequently it is possible that children who experience an episode of OM during infancy are more likely to experience recurrent or chronic OM in the early preschool period when rapid expansion of language abilities typically occurs.

Second, it is possible that OM has an effect on the child's auditory processing skills that persist beyond infancy and into the period of early language development, even in cases where the middle-ear effusion has resolved. Some evidence to support this hypothesis is found in studies that have examined the binaural masking level difference or auditory brainstem responses in children with OM histories (Gunnarson & Finizto, 1991; Moore, Hutchings, & Meyer, 1991; Pillsbury, Grose, & Hall, 1991).

Third, OM during infancy may interfere with certain prelinguistic skills that are critical to the normal development of linguistic abilities at later ages. This hypothesis has not yet been tested. Although very few studies have examined the emergence of early language abilities during the second year of life in these children (Friel-Patti & Finizto, 1990; Wallace et al., 1988), no studies have systematically measured the impact of OM on prelinguistic skills.

Recent research indicates that there are dramatic changes in speech perception abilities during the prelinguistic period, as the infant moves from language-general to language-specific processing of speech during the first year of life (Jusczyk, 1992; Kulh, 1992; Werker & Pegg, 1992). During this same period the infant moves through a predictable series of stages to gain considerable skill in the production of speech sounds (Oller, 1980; Roug, Landberg, & Lundberg, 1989; Stark, 1980). It has been demonstrated that the auditory environment has an important impact on the normal development of babbling. Briefly, the acoustic and phonetic characteristics of babble vary with a child's linguistic environment and hearing status (de Boysson-Bardies et al., 1992; de Boysson-Bardies, Halle, Sagart, & Durand, 1989; Kent, Osberger, Netsell, & Hustedde, 1987; Stoel-Gammon & Otomo, 1986). Of particular interest are studies that reveal significant delays in the age of onset for canonical babble among deaf infants (Eilers & Oller, 1994; Oller & Eilers, 1988).

The importance of examining babbling development in the context of early onset OM is further highlighted by the finding that delays in the development of prelinguistic speech are associated with specific expressive language delay (Stoel-Gammon, 1989; Whitehurst, Smith, Fischel, Arnold, & Lonigan, 1991). Two recent case studies suggest a relationship between early onset OM, babbling, and early language development. Donahue (1993) reported a diary study of a child who demonstrated delays in both phonological and expressive language skills, secondary to chronic otitis media during the first year of life. Although this child produced her first words at the early age of nine months, her word productions for the next seven months were based on the prosodic, rather than the segmental, features of words (specifically, her expressive words tended to have unique prosodic patterns but variable segmental characteristics). Consequently, her expressive vocabulary size was limited until the age of 17 months, when she abandoned the "tone language" strategy and subsequently increased her expressive vocabulary from 20 to 120 words within a two-month period. Another case study documented phonetic inventories for a boy who underwent bilateral tympanoplasty tube insertion before 11 months of age for treatment of chronic OM (Robb, Psak, & Pang-Ching, 1993). Assessments conducted at monthly intervals revealed that his phonetic repertoire was age-appropriate at 11 months in comparison with published norms. Over time, his phonetic repertoire became increasingly restricted so that by 14 months of age only [m] and [h] were observed. The number of different consonants used gradually returned to normal during the next five months. They also reported that his consonant-to-vowel ratio was consistently lower than expected throughout the course of the study.

The purpose of the present study was to examine the effect of OM on prelinguistic speech development in children aged 6 through 12 months of age. This study improves on the case studies described above by using a larger sample of children and systematic assessment techniques applied at regular intervals in a longitudinal design.

Method

Subjects

Eighteen infants were referred by community health nurses or family physicians at or before the age of six months. Nine of the infants were reported to have had no known ear infections before referral (although many of them experienced ear infections at a later age), while the remaining infants had received antibiotic treatment for at least one ear infection at or before the age of six months. These two groups of children will be referred to as the "late onset" and "early onset" groups respectively. The late onset group consisted of five boys and four girls while the early onset group consisted of six boys and three girls.

All of the infants had unremarkable birth, developmental, and family histories at time of referral, with the following exceptions: one child in the late onset group was born five weeks premature[1]; another child in this group has a father who stutters; a third child in this group was successfully treated for "hip click" prior to six months of age; several children in the early onset group have siblings with positive otitis media (OM) histories and one of these siblings was referred for a speech-language assessment due to parental concerns, but was found to be functioning within the normal range; another child in this group has a cousin who was diagnosed with pervasive developmental disorder during the course of the study.

[1]This child was assessed close to the chronologial ages of 6, 9, 12, 15, and 18 months. His REEL standard scores were determined in reference to his adjusted age of 17 months, however. This child was not excluded because Eilers, Oller, Levine, Basinger, Lynch, and Urbano (1993) reported that premature birth does not result in delayed onset of the canonical babble stage.

All of the infants lived in two-parent homes with at least one employed parent. All parents were native speakers of English. The mean number of years of education for the mothers was 15.11 and 13.77 for the late and early onset groups respectively. The mean number of years of education for the fathers was 14.9 and 14 for the late and early onset groups respectively. The range across groups was 12 to 16 years of education for the mothers and 10 to 20 years of education for the fathers. These differences in years of education between groups were not found to be statistically significant $t(1,16) = 1.81$, $p = .09$, for mothers; $t(1,16) = .61$, $p = .55$, for fathers.

Procedure

All the children visited the audiology department at the Alberta Children's Hospital for approximately one hour at the ages 6, 9, and 12 months. All assessments were conducted within two weeks of the birth date, except for three instances where the assessment occurred three weeks after the birth date (these exceptions occurred for children in the early onset group, two at six months and one at 12 months of age). In most cases, hearing and impedance measures were obtained first and then a taped speech sample was obtained from the infant immediately thereafter. Occasionally the speech sample was obtained on a separate day, within one week following the audiology assessment. The speech samples were recorded in an Eckoustic double-walled sound chamber, using a Sony Walkman Professional tape recorder and a Crown PZM-6D microphone. The mother was instructed to interact with her child in the usual manner. The mother and child were provided with the same set of quiet toys during each assessment (e.g., soft blocks, cloth books, pop beads, stuffed toys, a ball, and puppets). No effort was made to restrict the child's movements during recording sessions; rather the microphone was moved when necessary so that it was within one to two feet of the child, preferably positioned with the child facing the microphone (the pressure zone microphone used was capable of capturing almost all speech produced within the sound chamber, even when whispered). The recording session was continued until the child produced 60 utterances, which generally took between 10 and 30 minutes.

The auditory sensitivity and middle-ear impedance measures were conducted by a paediatric audiologist (see Table 1 for a summary of the assessment procedures). Parents attended all well-baby and immunisation clinics and visited the family doctor whenever the baby seemed ill, hearing/middle-ear problems were suspected, or a prescribed course of antibiotics was complete. The infant's middle-ear status was checked by the physician at all of these visits. Combined with scheduled visits to the audiology department

Table 1. Description of Assessment Procedures Used When the Infants were 6, 9, and 12 Months Old

Assessment	Procedure
Pure-Tone Average	Visual reinforcement audiometry was used to determined the infant's threshold for responses to warble tones presented in the sound field. The average threshold for the frequencies .5, 1, and 2 kHz was calculated.
Speech Reception Threshold	Visual reinforcement audiometry was used to determine the infant's threshold for live-voice speech stimuli presented in the sound-field.
Tympanometry	A flat tympanogram (i.e., type B) or, peak pressure below -100 decaPascals combined with an absent ipsilateral acoustic reflex at 1 kHz indicated abnormal middle ear function.
Infraphonological Analysis	Fifty utterances were selected from each tape and then classified according to the coding scheme described in Table 2. The frequency of occurrence for each of the 5 different utterance types was then expressed as a proportion of the total sample.
Canonical Babble Ratio	The total number of canonical syllables divided by the total number of utterances (i.e., 50). Note that a multisyllabic canonical utterance may contain both canonical and noncanonical syllables.

for the purposes of this study, the infants' ears were examined at approximately one- to two-month intervals. The investigators kept a record of the number of times antibiotics were prescribed for treatment of OM (each prescription typically lasting 10 to 14 days).

The speech and language assessments and analysis of the speech samples were completed by a speech-language pathologist. The specific measures and procedures that were used are described in detail in Rvachew, Slawinski, Williams, & Green (1995). A short summary of the speech sample analysis procedure is shown in Table 1. Fifty consecutive utterances were selected from each tape-recorded speech sample. An 'utterance' was defined as follows: infant-produced speech that was bounded by one second of silence, an audible inspiration, or adult speech; perceived to have a "unifying pitch contour"; produced and recorded with sufficient loudness for coding; and, not so obscured by adult speech or other noise as to prevent accurate coding. These utterances comprised both babble and occasional words, but no effort was made to distinguish meaningful and nonmeaningful utterances for any of the analyses. Nonspeech sounds such as crying, laughing, burping, grunting, etc. were excluded.

The 50 utterances were digitised using the Computerized Speech Research Environment (Avaaz Innovations Inc.). Acoustic and perceptual criteria were then used to classify each utterance as belonging to one of a number of different infraphonological categories. These utterance types were defined by Oller (1986) and are described briefly in Table 2. Many utterances combined multiple infraphonological categories; for example, an utterance might contain three

Table 2. Infraphonological Classification of Utterance Types

Utterance Type	Definition
quasiresonant nucleous (QRN)	syllabic nasal or nasalized vowel with little energy over 1200 Hz
fully resonant nucleous (FRN)	vowel-like utterance produced with normal resonance and phonation
marginal babble (MB)	consonant combined with a FRN but does not meet the criteria for a CB utterance
canonical babble (CB)	consonant and a FRN joined by smoothly changing formant transitions (25-120 ms duration)
other	primarily squeals, growls, yells, and raspberries

Note. Definitions condensed and adapted from Oller (1986).

syllables coded as marginal babble and one coded as canonical babble. The utterance would be coded in accordance with the highest category observed. The canonical babble ratio was then determined for the complete sample by dividing the total number of canonical syllables by the total number of utterances (i.e., 50).[2]

Reliability

Five samples (i.e., 250 utterances) were recorded by a speech-language pathologist who was trained by the first author to perform the infraphonological analysis. Point-by-point agreement between the first author and the reliability coder was calculated at two levels: there was 86% agreement between judges when each utterance was classified using the categories shown in Table 2; agreement was 86% when counting the number of canonical syllables contained with canonical babble utterances.

[2]The canonical babble was defined by Oller and Eilers (1988) as the number of canonical syllables divided by the number of utterances; we have used this same definition in this article so that the results can be compared with this early work. The canonical babble ratio has been redefined as the ratio of canonical syllables to the total number of syllables in the sample (e.g., Oller et al., 1994).

Results

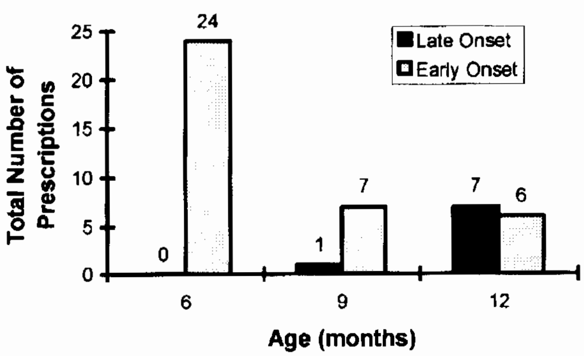
Statistical Analysis

All statistical analyses involved 2 x 3 mixed analyses of variance (ANOVA), with otitis media history as the between-subjects factor with two levels (late and early onset) and age as the within-subjects factor with three levels (6, 9, and 12 months). Planned comparisons were accomplished using *t*-tests to compare mean scores for the late and early onset groups at each age level. The outcome of these tests was assessed with alpha set at .05.

Audiological Assessment

The age of onset of OM varied from one to six months for the early onset group. Three children in the late onset group experienced no identified episodes of OM during the course of the study. The remaining children in the late onset group were treated for one or more episodes of OM between 9 and 12 months of age. Figure 1 shows the total number of prescriptions for antibiotics to treat OM for each group for three age intervals. At six months the number of prescriptions was counted for the six-month period since birth. At 9 and 12 months the number of prescriptions was counted for the three-month period since the last audiometric assessment. The mean number of prescriptions for antibiotics to treat OM during the period birth through 12 months of age was .89 and 4.11 for the late and early onset groups, respectively. The data show that the early onset group experienced earlier onset and a significantly greater number of prescriptions for treatment of OM in comparison with the late onset group, $F(1,16) = 17.076$, $p = .001$. There was also a significant effect of age, $F(2,32) = 4.05$, $p = .026$, and a significant age-by-group interaction, $F(2,32) = 10.055$, $p = .0006$. Specifically, infants in the early onset group were treated for OM significantly more often prior to six months of age and between six and nine months of age, $t(8) = -4.82$, $p = .0007$, at six months; $t(8) = -1.95$, $p = .04$, at nine months. However, the number of prescriptions for treatment of OM was not significantly different for early onset and late onset infants for the 9 through 12 month period, $t(8) = .26$, $p = .4$.

Figure 1. The total number of antibiotic prescriptions for treatment of otitis media for the late onset group and for the early onset group as a function of age.



The results of the tympanometric assessments were interpreted using the criteria suggested by Silman and Silverman (1991). These criteria are summarised in Table 1. The number of abnormal middle ears observed for the late onset group was zero, three, and three for the 6-, 9-, and 12-month assessments, respectively. The number of abnormal middle ears observed for the early onset group at these assessments was six, four, and 3. Each child was assigned a score of zero, one, or two, indicating the number of normal ears per child at each assessment. When submitted to a 2 x 3 mixed analysis of variance, no between-group differences in middle-ear status were found, $F(1,16) = 1.33$, $p = .27$.

The mean pure-tone average and speech-detection thresholds are shown in Table 3 for both groups at each of the ages 6, 9, and 12 months. Although the pure-tone average thresholds were slightly lower for the late onset group when compared to the early onset group, these differences were not statistically significant, $F(1,16) = 1.063$, $p = .32$, when submitted to a 2 x 3 mixed analysis of variance. A main effect of age was observed, however, $F(2,32) = 20.32$, $p = .0001$. The results for the speech detection thresholds were similar, with a main effect for age revealed, $F(2,32) = 12.66$, $p = .0002$, but no significant effect of OM history $F(1,16) = 1.25$, $p = .27$.

Table 3. Results of Audiometric Assessment by Group and Age

Type of Threshold	Age of Infant in Months		
	6	9	12
late onset group			
pure tone average	31.1(13.6)	21.9(6.2)	15.4(5.4)
speech reception	18.9(6.0)	9.4(1.7)	9.4(6.3)
early onset group			
pure tone average	34.6(13.9)	23.7(7.1)	20.9(7.5)
speech reception	21.1(11.7)	12.2(6.2)	11.1(8.2)

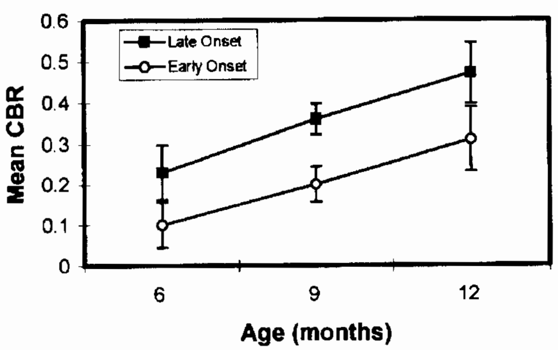
Note. Cell values reflect mean thresholds by group and by age, expressed in decibels (dB HL). The standard deviations are shown in parentheses. The pure tone average is the average threshold in response to .5, 1, and 2 kHz warbled tones; speech reception threshold is the lowest level of speech stimulation to elicit reliable head-turn responses from the infant.

Speech Sample Analysis

As described above, each utterance in a sample was coded according to the categories shown in Table 2. In addition, the number of canonical syllables contained in any utterance coded as CB was counted (note that any utterance containing at least one canonical syllable was coded as a CB utterance, and thus multisyllable canonical utterances might contain both canonical and noncanonical syllables). This analysis yielded two outcomes for each sample: (a) a frequency count for each of the five utterance types, and (b) a canonical babble ratio. These two measures are related in that the canonical babble ratio will increase with both the number and length of canonical utterances contained in the sample.

Figure 2 shows the mean canonical babble ratio for both groups at all three age levels. Both groups show a similar rate of increase in the canonical babble ratio with age, but the late onset group achieves a consistently higher mean score in comparison with the early onset group. The mean and standard deviation of the canonical babble ratios

Figure 2. Mean canonical babble ratio for the late onset group (closed squares) and for the early onset group (open circles) as a function of age.

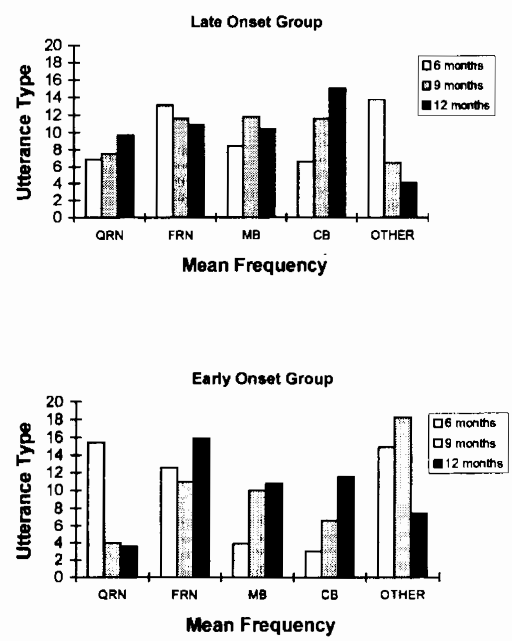


obtained by the late onset group infants were as follows: at six months M = .23, sd = .20; at nine months M = .35, sd = .11; at 12 months M = .47, sd = .22. The mean and standard deviation of the canonical babble ratios obtained by the early onset group infants were as follows: at six months M = .10, sd = .14; at nine months M = .20, sd = .12; at 12 months M = .31, sd = .10. Statistical analysis revealed significant main effects of both age, $F(2,32) = 8.16$, $p = .0017$, and OM history, $F(1,16)=16.59$, $p = .0012$. Between group differences in canonical babble ratio were found to be significantly different at ages nine months, $t(16) = 2.36$, $p = .016$, and 12 months, $t(16) = 2.04$, $p = .029$, but not at six months, $t(16) = 1.58$, $p = .067$.

Previous research with normally developing and profoundly hearing impaired infants shows that all normally developing children attain the canonical babbling stage between the ages of 6 and 11 months, usually by seven months of age, when this stage is operationalized by a canonical babble ratio of .2 or higher (Eilers & Oller, 1994; Oller & Eilers, 1988). For the late onset group, this level of canonical babbling was demonstrated by four infants at age six months, eight infants at nine months, and all nine infants at 12 months. For the early onset group, the canonical babble stage was indicated for one infant at six months, four infants at nine months, and all nine infants at 12 months. In addition, three infants in the early onset group showed remarkable fluctuations in their canonical babble ratio over time. For example, one infant's score fell from .44 at six months to .12 at nine months, rising only to .24 at 12 months. Another infant in this group obtained scores of .1, .42, and .24 at the three observation intervals. A similar downward shift in the canonical babble ratio was observed for one child in the late onset group after he began to experience recurring middle-ear effusion at the age of nine months.

Figure 3 shows the profile of frequency of occurrence of each of the five utterance types by group and by age. The upper panel of this figure represents the mean frequency of each utterance type produced by the late onset group while

Figure 3. Profile of mean frequency of occurrence of five different utterance types as a function of age. The utterance types shown are QRN (quasiresonant nucleous), FRN (fully resonant nucleous), MB (marginal babble), CB (canonical babble), and other (raspberries, squeals, growls, etc.). The upper panel shows the mean frequency of these utterance types for the late onset group while the lower panel shows these same data for the early onset group.



the lower panel represents these frequencies for the early onset group. The late onset group produced a higher proportion of canonical utterances at all ages, although both groups produced CB utterances with increasing frequency as they grew older. Also notable, the early onset group produced a higher frequency of other type utterances at all ages in comparison with the late onset group.

Discussion

This study demonstrates that the canonical babble ratio is sensitive to individual variation in age of onset of otitis media (OM) during the first year of life. This finding suggests that infraphonological analysis of infant speech samples may provide a means to investigate many unanswered questions about the relationship between early OM and later language development. For example, it is still not clear whether age of onset has an effect on outcomes that is independent of amount of time with middle-ear effusion. Measurement of the canonical babble ratio coupled with more frequent assessment of middle ear status in a larger sample of infants may allow us to differentiate these variables.

The nature of the variables that mediate between OM and language development is also unclear. For example, this and other studies suggest that OM-related hearing loss is not a significant factor. However, there may be disruptions to other aspects of auditory ability that could potentially interfere with language development. Longitudinal assessment of babbling combined with assessments of sound localisation, speech discrimination in noise, and auditory attending skills would be valuable. Investigations of babbling may also help us to examine other potential variables such as the illness experience and mother-infant interactions.

The body of literature relating to OM suggests that while many children with OM histories recover to attain normal levels of language functioning by school age, other children demonstrate persistent problems with language and academic outcomes. Canonical babble analysis may provide a means to predict which children will have ongoing problems with language development, secondary to chronic OM during the first year of life. Assessment of babbling ability could be useful in the search for, and evaluation of, early interventions directed at mitigating any disruptions to prelinguistic auditory and speech skills that may occur as a consequence of early, chronic middle-ear disease.

In this study, children with early onset OM demonstrated consistently lower canonical babbling ratios over a six-month period in relation to children with later onset OM. All children had attained the canonical babble stage by 12 months of age however, and it is not clear that the observed differences in canonical babble ratio will prove to be functionally significant. These children will be followed until the age of 18 months in order to examine the relationship between babbling and early language abilities. As noted earlier, some studies suggest that a low frequency of consonant babble is associated with specific expressive language delay. Whitehurst et al. (1991) analysed the phonetic characteristics of babble produced by two-year-old children with specific expressive language delay, and then used this information to predict individual differences in the children's language abilities five months later. They reported that the "single strongest correlate of language outcome was the proportion of consonantal to vowel babble" (p.1121). Furthermore, Stoel-Gammon (1989) observed that two infants who displayed atypical patterns of prelinguistic speech development later demonstrated delayed phonological and language abilities at age 24 months.

There have not yet been any systematic investigations of the relationship between prelinguistic speech production skills and later phonological development. Studies of the links between OM and phonological delay are also relatively rare. When considered, between-group differences with respect to phonological abilities are consistently found for groups that vary in OM history (Chalmers et al., 1989; Menyuk, 1986; Roberts et al., 1988;). Several authors have attempted to find a consistent pattern of phonological error associated with OM history, but so far no reliable relationships have emerged (Shriberg & Smith, 1983). Paden, Matthies, and Novak (1989) found a certain pattern of phonological error could predict recovery from phonological delay among a group of children who received pressure equalisation tubes subsequent to recurrent OM. Persistently delayed phonological skills were associated with early onset and late recovery from OM as well as inaccurate production of velars, liquids, and word final obstruents (Paden, Mathies, & Novak, 1989). More recently, Paul, Lynn, & Lohr-Flanders (1993) found that children with histories of both OM and expressive language delay tended to show less improvement in phonological skills during the preschool period in comparison with late-talking children who had negative OM histories.

In summary, this study found that infants who experienced OM before six months of age demonstrated lower canonical babble ratios between 6 and 12 months of age, when compared with children who experienced OM at later ages. This finding suggests that further studies involving longitudinal assessment of the canonical babble ratio may provide valuable information about the relationship between OM and prelinguistic speech development, and about the relationship between prelinguistic speech development and later language abilities.

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References

Avaaz Innovations Inc. (1994). *Computerized Speech Research Environment.* London, Ontario.

Boysson-Bardies, B. de, Halle, P., Sagart, L., & Durand, C. (1989). A crosslinguistic investigation of vowel formants in babbling. *Journal of Child Language, 16,* 1-17.

Boysson-Bardies, B. de, Vihman, M.M., Roug-Hellichius, L. Durand, C., Landberg, I., & Arao, F. (1992). Material evidence of infant selection from target language: A cross-linguistic phonetic study. In C.A. Ferguson, L.Menn, & C. Stoel-Gammon (Eds.), *Phonological development: Models, research, implications* (pp. 369-392). Timonium, MD: York Press.

Brandes, P.J., & Ehinger, D.M. (1981). The effects of early middle ear pathology on auditory perception and and academic achievement. *Journal of Speech and Hearing Disorders, 46,* 301-307.

Chalmers, D., Stewart, I., Silva, P., & Mulvena, A. (1989). *Otitis media with effusion in children - The Dunedin study.* Oxford: MacKeith Press.

Clarkson, R.L., Eimas, P.D., & Marean, G.C. (1989). Speech perception in children with histories of recurrent otitis media. *Journal of the Acoustical Society of America, 85,* 926-933.

Donahue, M.L. (1993). Early phonological and lexical development and otitis media: A diary study. *Journal of Child Language, 20,* 489-501.

Eilers, R.E., & Oller, D.K. (1994). Infant vocalizations and the early diagnosis of severe hearing impairment. *Journal of Pediatrics, 124,* 199-203.

Eilers, R.E., Oller, D.K., Levine, S., Basinger, D. Lynch, M.P., & Urbano, R. (1993). The role of prematurity and socioeconomic status in the onset of canonical babbling in infants. *Infant Behavior and Development, 16,* 297-315.

Feagans, L., Sanyal, M. Henderson, F., Collier, A., & Appelbaum, M. (1987). Relationship of middle ear disease in early childhood to later narrative and attention skills. *Journal of Pediatric Psychology, 12,* 581-595.

Friel-Patti, S., & Finitzo, T. (1990). Language learning in a prospective study of otits media with effusion in the first two years of life. *Journal of Speech and Hearing Research, 33,* 188-194.

Gravel, J.S., & Wallace, I.F. (1992). Listening and language at 4 years of age: Effects of early otitis media. *Journal of Speech and Hearing Research, 35,* 588-595.

Grievink, E.H., Peters, S.A.F., Bon, W.H.J. van, & Schilder, A.G.M. (1993). The effects of early bilateral otitis media with effusion on language ability: A prospective cohort study. *Journal of Speech and Hearing Research, 36,* 1004-1012.

Gunnarson, A.D., & Finitzo, T. (1991). Conductive hearing loss during infancy: Effects on later auditory brain stem electrophysiology. *Journal of Speech and Hearing Research, 34,* 1207-1215.

Jusczyk, P.W. (1992). Developing phonological categories from the speech signal. In C.A. Ferguson, L.Menn, & C. Stoel-Gammon (Eds.), *Phonological development: Models, research, implications* (pp. 17-65). Timonium, MD: York Press.

Kaplan, G.J., Fleshman, J.K., Bender, T.R., Baum, C., & Clark, P.S. (1973). Long-term effects of otitis media: A ten-year cohort study of Alaskan Eskimo children. *Pediatrics, 52,* 577-585.

Klein, J.O., Chase, C., Teele, D.W., Menyuk, P., & Rosner, B.A. (1988). Otitis media and the development of speech, language, and cognitive abilities at seven years of age. In D.J. Lim (Ed.), *Recent advances in otitis media* (pp. 396-397). Toronto: B.C. Decker.

Kent, R.D., Osberger, M.J., Netsell, R., & Hustedde, C.G. (1987). Phonetic development in identical twins differing in auditory function. *Journal of Speech and Hearing Disorders, 52,* 64-75.

Marchant, C.D., Shurin, P.A., Turczyk, V.A., Wasikowski, D.E., Tutihasi, M.A., & Kinney, S.E. (1984). Course and outcome of otitis media in early infancy: A prospective study. *Journal of Pediatrics, 104,* 826-831.

Menyuk, P. (1986). Predicting speech and language problems with persistent otitis media. In J.F. Kavanaugh (Ed.), *Otitis media and child development* (pp. 83-96). Parkton, MD: York Press.

Moore, D.R., Hutchings, M.E., & Meyer, S.E. (1991). Binaural masking level differences in children with a history of otitis media. *Audiology, 30,* 91-101.

Oller, D.K. (1980). The emergence of the sounds of speech in infancy. In G.H. Yeni-Komshian, J.F. Kavanaugh, & C.A. Ferguson (Eds.), *Child phonology* (Vol. 1, pp. 93-112). New York: Academic Press.

Oller, D.K. (1986). Metaphonology and infant vocalizations. In B. Lindblom & R. Zetterstrom (Eds.), *Precursors of early speech* (pp. 21-36). New York: Stockton Press.

Oller, D.K., & Eilers, R.E. (1988). The role of audition in infant babbling. *Child Development, 59,* 441-449.

Oller, D.K., Eilers, R.E., Steffens, M.L., Lynch, M.P., & Urbano, R. (1994). Speech-like vocalizations in infancy: An evaluation of potential risk factors. *Journal of Child Language, 21,* 33-58.

Paden, E.P., Matthies, M.L., & Novak, M.A. (1989). Recovery from OME-related phonologic delay following tube placement. *Journal of Speech and Hearing Disorders, 54,* 94-100.

Paul, R., Lynn, T.F., & Lohr-Flanders, M. (1993). History of middle ear involvement and speech/language development in late talkers. *Journal of Speech and Hearing Research, 36,* 1055-1062.

Pillsbury, H.C., Grose, J.H., & Hall, J.W. (1991). Otitis media with effusion in children. *Archives of Otolaryngology, 117,* 718-723.

Robb, M.P., Psak, J.L., & Pang-Ching, G.K. (1993). Chronic otitis media and early speech development: a case study. *International Journal of Pediatric Otorhinolaryngology, 26,* 117-127.

Roberts, J.E., Burchinal, M.R., Koch, M.A., Footo, M.M., & Henderson, F.W. (1988). Otitis media in early childhood and its relationship to later phonological development. *Journal of Speech and Hearing Disorders, 53,* 424-432.

Roug, L., Landberg, I., & Lundberg, L.-J. (1989). Phonetic development in early infancy: A study of four Swedish children during the first eighteen months of life. *Journal of Child Language, 16,* 19-40.

Rvachew, S., Slawinski, E.B., Williams, M., & Green, C.L. (1995). Comparison of perceptual and acoustic analyses of two infants' phonetic ability. *Journal of Speech-Language Pathology and Audiology, 19,* 77-88.

Shriberg, L.D., & Smith, A.J. (1983). Phonological correlates of middle-ear involvement in speech-delayed children: A methodological note. *Journal of Speech and Hearing Research, 26,* 293-297.

Silman, S., & Silverman, C.A. (1991). *Auditory diagnosis: principles and applications.* San Diego, CA: Academic Press.

Stark, R. (1980). Stages of speech development in the first year of life. In G.H. Yeni-Komshian, J.F. Kavanaugh, & C.A. Ferguson (Eds.), *Child phonology* (Vol. 1, pp. 73-92). New York: Academic Press.

Stoel-Gammon, C. (1989). Prespeech and early speech development of two late talkers. *First Language, 9,* 207-224.

Stoel-Gammon, C., & Otomo, K. (1986). Babbling development of hearing-impaired and normally hearing subjects. *Journal of Speech and Hearing Disorders, 51, 33-41.*

Teele, D.W., Klein, J.O., Rosner, B.A., & the Greater Boston Otitis Media Study Group (1984). Otitis media with effusion during the first three years of life and development of speech and language. *Pediatrics, 74,* 282-287.

Wallace, I.R., Gravel, J.S., McCarton, C.M., Stapells, D.R., Bernstein, R.S., & Ruben, R.J. (1988). Otitis media, auditory sensitivity, and language outcomes at one year. *Laryngoscope, 98,* 64-70.

Welsh, L.W., Welsh, J.J., & Healy, M.P. (1983). Effect of sound deprivation on central hearing. *Laryngoscope, 93,* 1569-1575.

Werker, J.F., & Pegg, J.E. (1992). Infant speech perception and phonological acquisition. In C.A. Ferguson, L. Menn, & C. Stoel-Gammon (Eds.), *Phonological development: Models, research, implications (pp. 285-312).* Timonium, MD: York Press.

Whitehurst, G.J., Smith, M., Fischel, J.E., Arnold, D.S., & Lonigan, C.J. (1991). The continuity of babble and speech in children with specific expressive language delay. *Journal of Speech and Hearing Research, 34,* 1121-1129.