International Journal of Pediatric Otorhinolaryngology 79 (2015) 520–526

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

Interaction patterns of mothers of children with different degrees of hearing: Normally hearing children and congenitally hearing-impaired children with a cochlear implant

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ARTICLE INFO

Article history:
Received 8 November 2014
Received in revised form 16 January 2015
Accepted 19 January 2015
Available online 25 January 2015

Keywords:
Cochlear implantation
Child-directed speech
Responsiveness
Mother–child interaction

ABSTRACT

Objectives: This study targets to analyse mother–child interactions in two groups of children with different hearing levels: normally hearing children (NH) and congenitally hearing-impaired children with a cochlear implant (CI). Mothers of hearing-impaired children are shown to use less speech in interactions with their children than mothers of normally hearing children. We aim to investigate whether this observation also holds for mothers of CI children.

Methods: Transcriptions of spontaneous conversations of ten CI children and ten NH children were analysed. We examined whether mothers responded to their children's utterances and whether they repeated or incorporated them in their own follow-up. Conversations were analysed in two consecutive stages, namely a prelexical stage and a lexical one.

Results: Mothers of CI children responded significantly more often to their children's utterances in both the prelexical and lexical stage. They also incorporated their children's utterances more often, however this was only significant in the lexical stage. The type of child utterance was an important trigger for the amount of mothers' responses. All mothers responded significantly more often to lexical utterances in the lexical stage. In the prelexical stage, however, precanonical utterances received the same amount of responses as canonical babbles. Nevertheless, all mothers incorporated canonical babbles more often than precanonical vocalisations in the prelexical stage and lexical utterances more often in the lexical stage.

Conclusions: First, mothers of CI children are more responsive to their children's utterances suggesting that they are aware of their children's hearing status. Second, type of child utterance is an important trigger for both mothers' response level and mothers' type of response in the prelexical and lexical stage.

1. Introduction

The aim of this paper is to analyse mother–child interaction in two groups of children with a different degree of hearing: normally hearing children (henceforth: NH children) and congenitally hearing-impaired children with a cochlear implant (henceforth: CI children). How mothers[1] of CI children interact with their children has scarcely been investigated so far. Because CI children are hearing-impaired, it is possible that the characteristics of the interaction patterns of their mothers will reflect those of mothers with hearing-impaired children who have no CI (henceforth: HI children). However, the CI children studied here are implanted at a young age and have "restored hearing". This could result in similar reaction patterns in mothers of CI children as in mothers of NH children. It is even possible that mothers of CI children respond more frequently to their children's utterances to provide more input since they are aware of their children's relative lack of auditory input. Because frequent and elaborate mother–child interaction has been shown to be quintessential for children's language development [1,2], it is crucial to investigate these interaction patterns in an atypical group such as CI children.

Interaction patterns of mothers of HI children and mothers of NH children show similarities, but also differences. Mothers of HI children use less speech, more gestures, and more attention-getting touches than mothers of normally hearing children [3]. Furthermore, mothers of HI children use significantly more self-repetitions than mothers of age-matched hearing children at 2 and

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[1] We use mother as a generic term for the speech of mothers, fathers, primary caretakers/caregivers and adults. Yet, we are aware that there might be differences in the child-directed speech used by mothers and fathers.

http://dx.doi.org/10.1016/j.ijporl.2015.01.020
0165-5876/

5 years of age [4]. Interestingly, mothers of HI and NH children do not differ significantly in the frequency of initiating conversations and in the frequency of using verbal and nonverbal utterances [5]. Thus, mothers of HI children communicate with their children to the same extent albeit with less speech.

Interactions between normally hearing mother–child dyads have been widely investigated and are shown to be crucial for children's language acquisition [6,7]. Several aspects of parental input are considered to be predictors of children's later language development. For instance, the amount of speech (input) children receive is associated with the size of their receptive and productive vocabularies [8–10]. Children with more talkative mothers understand and acquire words at a faster rate than children of less talkative mothers. Thus, the amount of input plays a crucial role in children's lexical development.

However, not only the amount of input is important, also the variation in child-directed speech has an influence on children's later language development. For instance, both maternal lexical richness, i.e. the use of different word types and word tokens, and syntactic complexity (as measured by mean length of utterance) have a positive effect on the lexical development of two-year-olds [9]. Morphological complexity as well as lexical diversity of mothers' language positively influence the morphological complexity of the children's speech [11]. Thus, variation in child-directed speech is reflected in children's own speech.

In addition to the amount of input and the variation in the input, also interactional factors, such as contingent replies, i.e. immediate reactions to children's utterances, have a positive influence on children's language development. For instance, the amount of contingent replies has been shown to be beneficial for the age at which children produce their first words [2]. Furthermore, children of more responsive mothers achieve the 50-word stage earlier and engage in combinatorial speech, i.e. combining words into sentences such as "mommy ball", at a younger age than children of less responsive mothers [2]. Thus, there seems to be a clear relationship between the contingency of responses and children's language development.

Taken together, several characteristics of maternal input, such as the amount of speech, variation in speech and contingency of replies have beneficial effects on children's later language development. But no research has ever systematically investigated whether mothers of CI children respond to their children's utterances in a comparable way as mothers of NH children. It is possible that mothers of CI children are more responsive in order to provide them with more fruitful input.

In this paper, we will analyse how mothers interact with their children in two consecutive developmental stages: the prelexical stage immediately preceding the lexical stage during which the children's first words are acquired. In the first two years of life, children move from precanonical utterances over canonical babbling to conventional words [12,13]. Precanonical vocalisations are utterances that appear in different forms such as a repetition of a single vowel, e.g./a a/or a combination of consonants without a vowel/ps/. These vocalisations have no adult target word [14,15]. Around the age of 7 to 10 months children achieve an important milestone in speech development when they start to produce canonical babbling [15,16]. Just like precanonical vocalisations, canonical babbles have no adult target, but they differ from the precanonical ones in sound and form: utterances such as/bababa/ not only sound like adult words, they also consist of adult-like syllables, such as a consonant-vowel sequence [12,13,15]. Around the age of 12 months, children start to produce identifiable lexical items or words [16–18], though they express these words with a lot of variation [19]. A child may for instance produce the word *ball* as/bɑbɑ/,/bɑ/or/bɑl/, but these instances of the word *ball* are recognised as the word *ball* by their mothers.

In the transition from the prelexical to the lexical stage, children continue to produce prelexical vocalisations, but the balance between prelexical and lexical utterances twists [20]. With age the number of prelexical utterances decreases and the number of lexical utterances increases [20,21]. Around the age of 20 months, NH children start producing significantly more lexical than prelexical utterances, though prelexical vocalisations remain present [20]. In the first two years of life, the balance in children's utterances thus changes from more "primitive" (prelexical) to more "mature" (lexical) productions.

As children's productions change over time from predominantly prelexical to lexical, their mothers' responses evolve as well [22,23]. Mothers tend to respond to their children's most "mature" vocalisations: when babbles enter the children's repertoire, mothers predominantly respond to those more "mature" utterances. When children start producing lexical utterances, mothers predominantly respond to them and incorporate (part of) them far more often than the more "primitive" vocalisations [24]. Do mothers of CI children have the same dynamics when interacting with their children? Or are mothers of CI children 'happy' with every utterance, regardless of the maturity, and more responsive to all types of child utterances? Are incorporations of their children's previous utterances equally present in mothers of CI and NH children?

Briefly, the current study investigates the following two research questions: (1) is there a difference in mother–child interaction depending on the child's hearing status?; and (2) are mothers influenced by the type of child utterance in both quantitative and qualitative aspects of their responses? We will answer these questions in two linguistic stages, i.e. a prelexical and early lexical stage.

2. Method

2.1. Participants

The data analysed in the present paper are part of the CCLC (CLiPS Child Language Corpus), which contains transcribed video- and audio-recordings of 40 normally hearing and 10 congenitally HI children with a cochlear implant. All recordings were made in the children's homes and consisted of spontaneous interactions between the children and their primary caretakers. The video-recordings lasted between 50 and 120 minutes. Of each recording a sample of 20 minutes in which the child was most vocally active was transcribed using the CHAT transcription conventions [25]. All parents were normally hearing, Dutch-speaking, and of middle-to-high socioeconomic background. At the moment of the recording parents had signed a statement of informed consent, but were not aware of the aim of the present study. This study received approval from the ethical committee.

The CI children were recorded monthly from the moment their device was activated up to 30 months after implantation. All children were implanted below the age of 20 months. More detailed information about the CI children is provided in Table 1: the children's hearing loss with and without hearing aids (HA) and with CI are provided, as well as their age at implantation and at activation. The cause of deafness was in six cases genetic of which five were mutations in the connexine-26 gene. In the other four cases the cause of deafness is unknown.

From the CCLC database, the transcriptions of 10 NH children and their parents were randomly selected. *Kind & Gezin* (the Flemish infant welfare centre) checked the children's hearing approximately three weeks after birth as part of a nation wide neonatal screening program. These mother–child dyads were also followed monthly, starting when the child was between 6 months and up to 24 months. These children are monolingual

Table 1
Individual child characteristics of the CI group.

Subject	Hearing loss (in dB)	Age HA (y;mm.dd)	Hearing loss with HA (dB)	Age implantation CI	Age activation CI	Uni- or bilateral	Hearing loss with CI (dB)
S1	117	0;4.0	107	0;5.5	0;6.4	Bilateral (1;4)	43
S2	120	0;1.4	120	0;6.21	0;7.20	Unilateral	30
S3	120	0;1.21	107	0;8.23	0;9.20	Unilateral	43
S4	103	0;5.8	63	0;8.21	0;9.21	Unilateral	32
S5	115	0;1.18	113	0;10.0	0;11.20	Unilateral	33
S6	91↓117 ↓ progressive hearing loss	0;3.6	45↓115	1;1.7	1;2.4	Unilateral	43
S7	120	0;9.3	120	1;1.15	1;2.27	Unilateral	47
S8	93	0;4.24	47	1;4.27	1;5.27	Unilateral	35
S9	113	0;10.0	117	1;6.5	1;7.9	Unilateral	42
S10	112	0;2;0	58	1;7.14	1;9.4	Unilateral	52

Dutch-speaking and free of patent cognitive, health or hearing problems.

2.2. Child utterances

The children's vocal productions were divided into two main types of utterances: prelexical utterances and lexical ones, i.e. conventional words.

All prelexical utterances of the children were first coded using an adapted version of the annotation scheme proposed by Koopmans-van Beinum and Van der Stelt [14]. For the analyses of the prelexical stage, we further differentiated between precanonical and canonical vocalisations. We consider the following as precanonical vocalisations: (1) interrupted or uninterrupted phonations such as [a a a] or [a]; (2) single or repeated articulations without phonation, such as [p p]; and (3) combinations of phonations with one articulation, e.g. [ata]. Canonical babbles are vocalisations with two or more articulations with interrupted or uninterrupted phonation, such as [tatata] or [dadada].

Utterances were considered as lexical when they met the criteria proposed by Vihman and McCune [19]. This procedure includes different criteria that are based on (1) the context; (2) the phonological shape of the vocalisation; and (3) the relation to other vocalisations. In our dataset, a vocalisation is considered as a word when the mother identifies it as one, the utterance matches (a part of) the adult target word, and the child uses it in a particular referential context, for instance, a child says *baba* every time (s)he sees or plays with a ball.

Each lexical child utterance was phonetically and orthographically transcribed using CHILDES' CHAT conventions [25]. The children's cumulative vocabulary count was derived from the transcriptions. Compiling a cumulative vocabulary is a standard procedure in developmental psycholinguistics [7]. The procedure is as follows: a list of the word forms a child produces is compiled for each individual recording session in a longitudinal study. Thus, starting from the chronologically first session, a list of the word forms produced by the child is accumulated. The number of different word forms in the first session is the first cumulative number of vocabulary items. Consecutively, the list of word forms of the second session is compared to the first one, and the number of new word forms produced are added to the cumulative vocabulary count. This procedure is iterative.

All transcriptions in which the child's cumulative vocabulary did not exceed 250 word forms were analysed. When a child eventually did not reach the 250-word limit at the end of the recordings, all transcription sessions were analysed.

2.3. Maternal reactions

All maternal verbal utterances were transcribed phonetically and orthographically. When a mother took her turn in the conversation, this was coded as a "reaction". When a mother did not respond to her child's utterance within two seconds, this was coded as "no reaction", since the mother did not take her turn in the conversation.

When a mother responded clearly to a child utterance within two seconds, but the response was incomprehensible, this response was considered as a "reaction". However, these types of reactions were only coded on the general reaction vs. no reaction level because it was impossible to further classify them.

The second level in our coding scheme takes into account whether the mother incorporates the child's vocal production or not. We distinguished between reproductive and non-reproductive reactions. Maternal reactions that incorporated the child's previous utterance in some way were coded as reproductive.

(1) *CHI: auto *car*
*MOT: dat is een auto he *that's a car isn't it*

In example (1) the mother (*MOT) replies to her child's (*CHI) *car* utterance by confirming that what she sees is indeed a car.

A non-reproductive reaction does not incorporate or reproduce the child's previous utterance as in example (2).

(2) *CHI: die *that*
*MOT: de brandweerauto *the fire truck*

The mother replies to the child's utterance *that* by providing him the name of the object, though not repeating the child's own utterance. This constitutes a move-on in the conversation, but no incorporation.

2.4. Reliability

Intra-rater reliability was assessed by the first author of the present paper for 92.38% of the data after approximately 3 months. The reliability for reaction vs. no reaction reached a correlation coefficient of 0.99 ($p < 0.001$). The correlation coefficient for reproductive vs. non-reproductive was also 0.99 ($p < 0.001$).

2.5. Statistical analyses

Our dataset exhibits a three-level hierarchy: individual utterances (the lowest level) are nested within observation sessions at consecutive ages (second level), which in turn are nested within individual children/mothers (the highest level). Because multi-level modelling (MLM) takes this sampling hierarchy into account, it is used to analyse our data statistically [26–28]. Several studies about language acquisition have used this statistical method for analysing

their data [7,16,29–31]. The R software [32] was used for our analyses.

MLM takes two different parts of variance into account: a random part in which the variance between children and ages is accounted for and a fixed part with the fixed effects (independent variables). Two separate analyses for our two dependent variables were performed: (1) reaction vs. no reaction to the child's utterance; and (2) reproductive vs. non-reproductive. Both dependent variables are binomial. In R, binomial variables are automatically turned into logits in the analyses.

Several independent variables or fixed effects are represented in our models: (1) the type of child utterance (prelexical vs. lexical), (2) the children's hearing status (NH vs. CI), and (3) also a developmental measure. Since mothers respond rather to children's linguistic level than to their chronological age [4,5,33,34], analyses were made based on children's "linguistic" age. The third independent variable was intrinsically related to their vocal productions.

Analyses were divided into a prelexical and a lexical stage. For the prelexical stage, true canonical babbling ratio (tCBR) was taken as the developmental measure (or dependent variable). True canonical babbling ratio is the proportion of canonical CV syllables such as/ba/over the total number of syllables in children's vocal production [35,36]. The measure is called true CBR because the consonants in the CV sequences are restricted to so-called true supraglottal consonants: stops, fricatives, nasals and liquids, thus excluding for instance glides [35]. For the prelexical stage, the monthly data of each child were analysed from the first recording until word onset. Thus, the starting point for the 10 NH children was at 6 months of age (the first recording), and from that point onwards for each participating child each subsequent month was analysed until word onset. The starting point for the CI children constituted the month during which their device was activated and from that point onwards each subsequent month was analysed until word onset. For the lexical stage, all monthly data starting from word onset until the children reached a cumulative vocabulary of 250 word forms were analysed.

The mean number of transcriptions analysed per child for the prelexical stage is 7 (range = 3–13; median = 7) for the mothers of the CI children and 11 for the mothers of the NH children (range = 8–15; median = 10). For the lexical stage a mean of 10 transcriptions (range = 3–13; median = 11) in the CI group and 12 (range = 8–14; median = 12) in the NH group were analysed per child.

3. Results

First, we will discuss the quantitative aspect of our analyses, i.e. whether there is a reaction or not. These analyses will be discussed for the main research topics, namely do mothers of children with a different hearing status respond more or less frequently to their children's different types of child utterance? Second, the qualitative aspect of our results will be discussed, do mothers of children with a different hearing status respond more or less with a reproductive response to their children's different types of child utterance?

A total of 29,385 utterances in the prelexical stage (4475 canonical babbles and 24,910 precanonical vocalisations) and 47,095 in the lexical stage (26,620 prelexical utterances and 20,475 lexical utterances) were analysed. In the prelexical stage there were 9,980 utterances in the CI group (median = 763 utterances, range = 189–2736 utterances) and 19,405 in the NH group (median = 1975 utterances, range = 1345–2648 utterances). In the lexical stage there were 20,544 utterances in the CI group (median = 2095 utterances, range = 615–3321 utterances) and 26,551 in the NH group (median = 2643 utterances, range = 1690–3665 utterances).

The statistical analyses using multi-level models will be reported as follows: the best fitting model will only be reported, including the parameter estimated and standard errors, in addition the *z*-scores and the corresponding assessment of statistical significance are reported. The corresponding tables can be found in Appendix A. In the section reporting the results, only the p-values will be referred to.

3.1. Reaction vs. no reaction

3.1.1. Hearing status and linguistic age

Mothers of CI children are more responsive to their children's utterances than mothers of NH children in both the prelexical ($p < 0.001$) and lexical stage ($p < 0.001$). The relevant multi-level analyses can be found in Tables A1 and A2 in Appendix A. True CBR was no main effect in the prelexical stage ($p = 0.629$), meaning that mothers are not becoming more responsive when their children's prelexical utterances are becoming more "mature" (i.e. contain more canonical babbles). Cumulative vocabulary, however, did reach marginal significance in the lexical stage ($p = 0.085$), indicating that the more words children acquire, the more responsive mothers become.

3.1.2. Type of child utterance

Children's type of utterance was no trigger for mothers' response level in the prelexical stage. Mothers did not respond more frequently to children's canonical babbles than to their precanonical vocalisations ($p = 0.396$). However, an interaction effect between hearing status and type of child utterance was found ($p = 0.022$). Posthoc analyses (Tukey HSD) revealed that mothers of CI children respond significantly more to canonical babbles ($p < 0.001$) and to precanonical vocalisations ($p = 0.001$) than mothers of NH children. Fig. 1 shows that mothers of CI children are more responsive to both types of utterances.

All mothers responded significantly more frequently to lexical than to prelexical utterances ($p < 0.001$). They thus notice the difference in maturity level and respond more frequently to the children's highest level, i.e. lexical utterances.

Furthermore, an interaction effect between hearing status and type of child utterance was found ($p = 0.019$). Post hoc tests (Tukey HSD) revealed that mothers of CI children responded significantly more frequently to children's prelexical ($p < 0.001$) and lexical

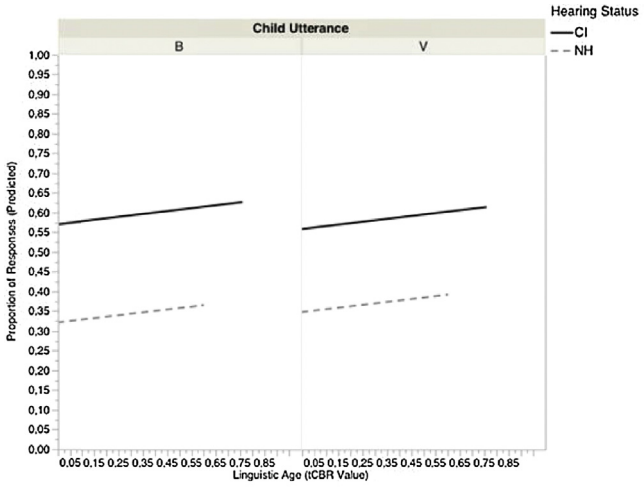

Fig. 1. Amount of responses (expressed in predicted proportions) by hearing status and type of child utterance (B = canonical babble, V = precanonical vocalisation) in the prelexical stage.

utterances ($p < 0.001$) than mothers of NH children. Fig. 2 shows that mothers of CI children indeed are more responsive to both prelexical and lexical utterances than mothers of NH children.

3.2. Incorporation: Reproductive vs. non-reproductive reaction

In this part of the results, we will discuss whether there are differences the two groups of mothers concerning incorporations. Do mothers of CI children incorporate their children's utterances more often than mothers of NH children?

3.2.1. Hearing status and linguistic age

In the prelexical stage, mothers of CI and NH children are highly similar in their responses: no main effect of hearing status ($p = 0.635$) was found (see Tables A3 and A4 in Appendix A for the details of the multi-level analyses). Mothers of CI and NH children thus incorporate their children's utterances to a similar extent in this stage. Notwithstanding the fact that hearing status was no main effect in the prelexical stage, it does reach significance in the lexical stage: mothers of CI children respond with more reproductive responses than mothers of NH children ($p < 0.001$).

In both stages, the number of reproductive responses decreases. This is indicated by a negative effect of true CBR in the prelexical stage ($p < 0.001$). A negative main effect of cumulative vocabulary ($p < 0.001$) indicates that the more words a child learns, the fewer mothers tend to incorporate their children's utterances.

3.2.2. Type of child utterance

Mothers responded more often with a reproductive response to canonical babbles than to precanonical vocalisations in the prelexical stage ($p < 0.001$). Furthermore, an interaction effect between true CBR and type of child utterance ($p < 0.001$) was found, indicating that the negative main effect of true CBR is less marked for the precanonical vocalisations. Whereas the amount of responses to canonical babbles decreases over time, the amount of responses to precanonical vocalisations remains more or less stable, as shown in Fig. 3.

In the lexical stage, word-like (lexical) utterances are significantly more often incorporated than prelexical utterances ($p < 0.001$). An interaction effect between type of child utterance and hearing status ($p < 0.001$) was found. Posthoc analyses (Tukey HSD) reveal that mothers of CI children incorporate prelexical utterances significantly more often than mothers of NH children ($p < 0.01$). No significant differences were found in the amount of incorporations of lexical utterances in the lexical phase ($p > 0.05$). Finally, an interaction between cumulative vocabulary and lexical utterances ($p < 0.001$) indicated that the negative effect of cumulative vocabulary is less present for the lexical utterances.

As Fig. 4 shows, mothers of CI children incorporate more of their children's prelexical utterances whereas there is no difference in incorporation of lexical material. It is also clear that lexical utterances are incorporated far more often than prelexical ones.

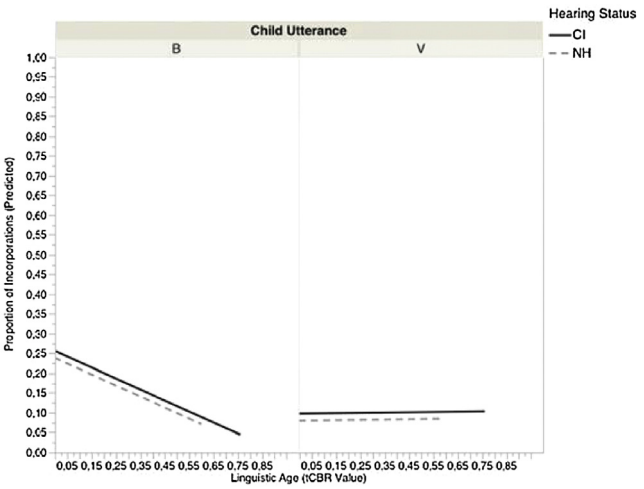

Fig. 3. Amount of incorporations (expressed in predicted proportions) by hearing status and type of child utterance (B = canonical babble, V = precanonical vocalisation) in the prelexical stage.

4. Discussion

In the current study, the interaction patterns of mothers with NH and CI children in two consecutive linguistic stages were investigated. Quantitative and qualitative aspects of these interactions were analysed.

A first important finding is that mothers of CI children respond more frequently to their children's utterances in the prelexical as well as in the lexical stage. This is in contrast with earlier findings about mothers of hearing-impaired children [3]. This suggests that mothers of CI children try to compensate for their children's relative lack of input, or simply for the fact that they underwent

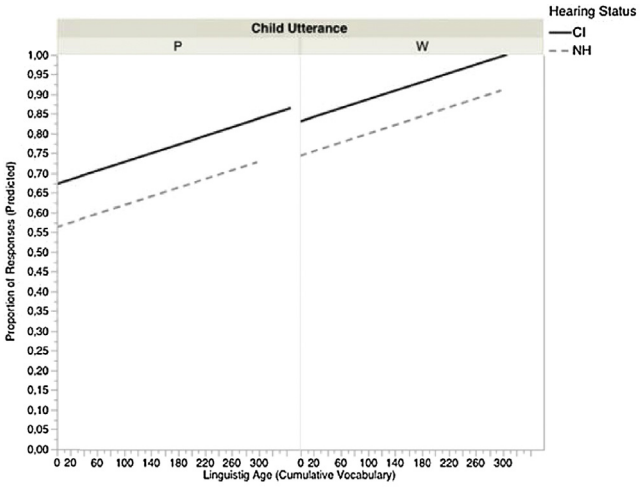

Fig. 2. Amount of responses (expressed in predicted proportions) by hearing status and type of child utterance (W = word-like/lexical items and P = prelexical utterances) in the lexical stage.

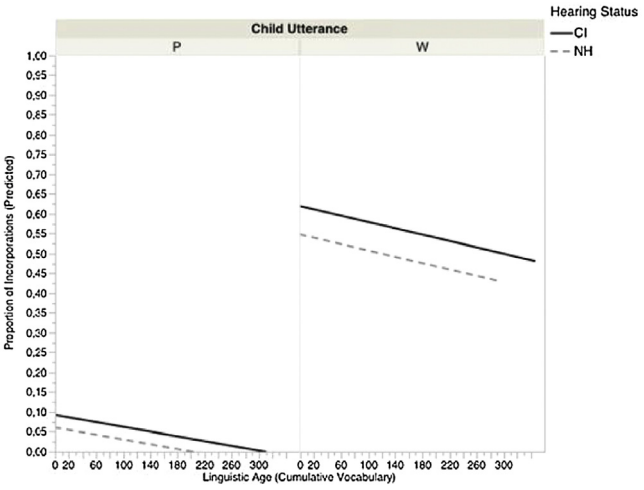

Fig. 4. Amount of incorporations (expressed in predicted proportions) by hearing status and type of child utterance (W = word-like/lexical items and P = prelexical utterances) in the lexical stage.

surgery in the first months of life, by providing their children (un)consciously extra linguistic input.

Children's utterances develop from precanonical utterances over canonical babbling to conventional words [12,13]. In other words, in the time bracket under investigation, children's utterances develop from less to more "mature". Mothers have been shown to be aware of these changes: they are more attentive to their children's most mature utterances [22–24]. Our results partially confirm these findings. In the lexical stage, lexical utterances received significantly more responses than prelexical ones. However, there was no main effect of vocalisation type in the prelexical stage. Thus, in general, mothers do not respond more frequently to canonical babbles than to precanonical vocalisations. Possibly later canonical babbles are already interpreted (and coded) as lexical items. Nevertheless, this result contradicts the finding of Otomo [24] who did find a quantitative difference between canonical babbling and precanonical vocalisations. Methodological matters might explain these distinct findings. Whereas we investigated the reaction patterns of 20 mother–child dyads (10 NH and 10 CI), Otomo [24] only analysed three Japanese mother–child dyads. Also the timespan under investigation is different. Otomo [24] only analysed four recordings in the period when the children were between 1;0 and 1;8/1;9 whereas our dataset contains monthly video-recordings from 6 up to 24 months of age for the NH children and 1 up to 30 months post activation for the CI children. Because our dataset contains more data, and more data lead to more reliable estimates, our conclusions are arguably more valid.

Concerning the qualitative aspect, all mothers remarked the difference in maturity. Canonical babbles were significantly more often incorporated than precanonical vocalisations. Similarly, a main effect of type of vocalisation was found in the lexical stage: mothers incorporate lexical items far more often than prelexical vocalisations. This is in line with the findings of Otomo [24].

Concerning the qualitative aspect of the interactions, another difference between the NH and CI children was found. Mothers of CI children incorporate their children's utterances more frequently, but this was only significant in the lexical stage. Several explanations are conceivable for this finding. First, the utterances of CI children may be less clearly articulated and hence require more reproduction from the mothers in order to be sure that they understood their child. Second, the utterances of CI children may contain more speech errors, making the mothers more alert to correct them. CI children have been shown to make more phonological errors than their NH peers [37]. Mothers of CI children therefore may use more reproductive replies in their feedback than NH mothers [38,39]. Third, mothers of CI children follow their children's language development more closely, which makes them more attentive to their children's utterances and resulting in more frequent incorporations. Fourth, mothers of CI children are attributing meaning to the CI children's prelexical utterances by incorporating them in some way.

Furthermore, the effect of cumulative vocabulary shows that mothers are incorporating their children's utterances less over time. This means that the exact phrasing of the child's utterance becomes less the focus of attention and the flow of the conversations becomes more prominent. Mothers are using move-ons instead of incorporations. Further research could investigate this: is there a difference in move-ons between mothers of NH and CI children? And a related question to be investigated: do mothers of CI children incorporate their children's utterances for a longer period whereas mothers of NH children respond with more topic continuing move-ons?

In summary, this investigation has revealed that CI mothers respond more frequently to their children's utterances in both the prelexical and lexical stage. They also incorporate their children's utterances more often, but only significantly more frequently in the lexical stage. All mothers are aware of their children's utterance level and respond more frequently to lexical than to prelexical utterances.

Acknowledgements

The present research was supported by grant G009511N of the Fund for Scientific Research—Flanders (FWO) to Steven Gillis.

Appendix A. Statistical models

Tables A1–A4.

Table A1
Prelexical stage—reaction vs. no reaction.

Variable	Estimate (logits)	Std. error	*z*-Value	*p*-Value
Intercept	0.523	0.30	1.746	0.081
tCBR	−0.004	0.008	−0.483	0.629
Hearing [NH]	−1.139	0.262	−4.353	<0.001
Utterance type[V]	−0.057	0.067	−0.848	0.396
Utterance type[V] × hearing[NH]	0.185	0.081	2.292	0.022

Table A2
Lexical stage—reaction vs. no reaction.

Variable	Estimate (logits)	Std. error	*z*-Value	*p*-Value
Intercept	0.797	0.150	5.306	<0.001
Cumulative vocabulary	0.002	0.001	1.723	0.085
Hearing [NH]	−0.504	0.124	−4.064	<0.001
Utterance type [W]	1.046	0.047	22.118	<0.001
Utterance type [W] × hearing [NH]	−0.137	0.058	−2.350	0.019

Table A3
Prelexical stage—incorporation vs. no incorporation.

Variable	Estimate (logits)	Std. error	*z*-Value	*p*-Value
Intercept	−1.05	0.233	−4.501	<0.001
tCBR	−0.023	0.006	−3.984	<0.001
Hearing [NH]	−0.094	0.197	−0.475	0.635
Utterance type [V]	−1.25	0.188	6.655	<0.001
Utterance type [V] × tCBR	0.021	0.006	3.600	<0.001

Table A4
Lexical stage—incorporation vs. no incorporation.

Variable	Estimate (logits)	Std. error	*z*-Value	*p*-Value
Intercept	−2.311	0.119	−19.48	<0.001
Cumulative Vocabulary	−0.006	0.001	−5.32	<0.001
Hearing [NH]	−0.531	0.145	−3.66	<0.001
Utterance type [W]	2.799	0.074	37.78	<0.001
Utterance type [W] × hearing [NH]	0.297	0.086	3.44	<0.001
Cumulative vocabulary × utterance type [W]	0.004	0.0009	4.19	<0.001

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