Early Vocal Development in a Normally Hearing Infant and a Young Cochlear Implant Recipient

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Abstract

The developmental progress before expressing the first words is rarely assessed for German-speaking children. For this reason two single-case studies were performed to investigate the early vocal development of a normal hearing female infant and a young female cochlear implant (CI) recipient. Longitudinal data were collected by performing monthly audio- and video-recordings of one-hour mother-child-interactions over one year. Implementation of the Stark Assessment of Early Vocal Development - Revised (SAEVD-R) allowed the classification of children's utterances and the assessment of developmental progress in both children. Results show a decrease of early vocalizations and an increase of adult-like vocalizations for the normal hearing infant as well as for the implanted toddler over the first year. In the first six months of life and respectively of hearing experience the children almost exclusively produced vocalizations assigned to the early developmental levels 1-3 of SAEVD-R. An increase of vocalizations assigned to the more mature levels 4 and 5 of SAEVD-R containing true vowels and consonants was observed in the second half of the first year. Overall the CI recipient showed a slightly faster progress of development than the normal hearing infant with respect to hearing age. Interrater- and intrarater-reliability using the SAEVD-R were satisfying.

1 Introduction

In the first months of language acquisition infants predominantly produce prelinguistic vocalizations. Since the 1970s and 1980s different models have been proposed to capture the developmental progress infants go through before expressing their first words. One of the models characterising the prelinguistic development as temporal overlapping stages is the Stark Assessment of Early Vocal development - Revised (SAEVD-R) [1]. This model goes back to a model which initially was proposed by Rachel E. Stark [2]. In its revised version the model differentiates 23 vocalization types and 5 developmental levels.

Although in literature different hierarchical models about the prelinguistic development have been proposed there is no commonly used tool to assess the progression and time course of prelinguistic development yet. For German-speaking children the early vocal development during the first year of life has rarely been assessed so far. Studies about the early vocal development of young children who receive a cochlear implant are even more scarcely.

The purpose of this study therefore was to investigate the early vocal development of a normal hearing infant and an implanted toddler by implementing the SAEVD-R.

2 Methods

Participants of the two single-case studies were a normal hearing female infant who's developmental progress was measured for her first year of life and a young female cochlear implant recipient who's developmental progress was measured for her first year of hearing experience. Bilateral implantation in this child was performed at the age of 8 months and 3 weeks, onset of both cochlear implant systems was done at the age of 10 months. Thus we differentiate *chronological age* which starts with birth for both children and *hearing age* which is defined to start with birth for the normal hearing child and to start with date of onset of the cochlear implant systems in the case of the implanted child.

Data collection for both children included monthly recordings of unrestricted mother-child interactions which were 50-60 minutes in duration each. Audio and video data were collected using a digital camcorder and a high performance microphone stated in maximum distance of 3 meters to the interaction situation. Data afterwards were digitized and saved on DVDs. For each of the monthly sessions 100 utterances were selected before further analysis was performed.

Data analysis was done adopting the vocalization types and developmental levels of the SAEVD-R. After performing a pre-training with the participating judges, utterances of both children were fully classified by two independent observers and to an amount of 50% for a second time. In order to avoid influences of observer's expectations about the developmental progress judges were blind to the age of the infant while coding the data. The 23 prelinguistic vocalization types and the 5 developmental levels suggested in the SAEVD-R are shown in Tabel 1.

Implementation of the SAEVD-R for a German normal hearing infant and a young German cochlear implant recipient was done in this study for the first time.

3 Results

Data analysis was done on a total of 1200 utterances for the normal hearing infant and on a total of 1300 utterances for the implanted child. Results are presented by always refering to the hearing age of both children, i.e. by comparing the chronological age of the normal hearing infant and the hearing age of the implanted toddler. Results of both children are shown in Figure 1 and 2 by presenting the absolut numbers of occurence of the 23 vocalization types for each session. Additionally four intervalls of frequency of occurence were found by calculating quartiles. They were defined as never/ very rarely, infrequently, sometimes and frequently and are presented using different levels of grey.

In the first six months both children almost exclusively produce vocalizations which can be assigned to the levels *Reflexive* (level 1), *Control of Phonation* (level 2) and *Expansion* (level 3).

Comparing the amount of the different vocalization types the chronologically younger normal hearing infant produces reflexive vocalizations like Vegetative Sounds (VEG) and Quasi-Resonant Nuclei (Q, Q2) with higher frequencies than the implanted child. Vocalizations of level 1 are produced from the beginning and stay 'frequently' until months 8 and 9 in the normal hearing infant whereas the implanted child doesn't produce *Vegetative Sounds* and *Quasi-Resonant Nuclei* to amounts which are 'frequently' after month 4.

Table 1: The SAEVD-R. Developmental levels (column 1), suggested ages of occurrence (column 2), and codes as well as short explanations of the vocalization types of the SAEVD-R (column 3).

Level	Age	Vocalization type
1.Reflexive	0-2 months	**VEG:** Vegetative Sounds **CR:** Crying, fussing **Q:** Quasi-Resonant Nuclei **Q2:** Two or more Qs
2.Control of Phonation	1-4 months	**F:** Fully-Resonant Nuclei **F2:** Two or more Fs **CV-1:** Closant-Vocant Combination, isolated Closants and Consonants **CV-2:** Two Closant-Vocant Combinations, two or more Closants **CH:** Chuckle, laughter
3.Expansion	3-8 months	**V:** Isolated Vowel **V2:** Two or more Vowels **VG:** Vowel Glide **IN:** Ingressive Sound **SQ:** Squeal **MB:** Marginal Babbling
4.Basic Canonical Syllables	5-10 months	**CV:** Consonant-Vowel Syllable **CB:** Canonical Babbling **WH:** Whispered Production **CV-C:** Consonant-Vowel Syllable followed by an isolated Consonant **CVCV:** Disyllables
5.Advanced Forms	9-18 months	**CMPX:** Complex Syllable **JN:** Jargon **DIP:** Diphthong

Frequencies of vocalizations assigned to level 2 are similar in both children, although the implanted toddler produces vocalizations of level 2 more often and more consistent. Another difference between the children is that the normal hearing infant predominantly produces Fully-Resonant Nuclei which are vowel-like vocalizations (F, F2) and the implanted child produces vowel-like vocalizations (F, F2) as well as Closants which are consonant-like vocalizations and Closant-Vocant Combinations (CV-1, CV-2). Anyway for both children vocalization types of level 2 remain 'frequently' from the beginning and stay the dominant form throughout the whole first year.

Analysing the amount of vocalizations of level 3 like Vowels (V, V2), Vowel Glides (VG), Ingressive Sounds (IN), Squeals (SQ) and Marginal Babbling (MB) the chronological older implanted toddler produces such vocalization types much earlier than the normal hearing infant. For the normal hearing child vocalizations of level 3 firstly emerge in months 2. Frequency and variety of those vocalizations then gradually increase and reach absolut amounts which were assessed to be 'sometimes' in months 6-12. In contrast the implanted toddler begins to produce vocalizations assigned to level 3 from the beginning in month 0. Different vocalization types with exception of Ingressive Sounds (IN) then were observed 'infrequently' but with a high variety in months 3-6 before frequency of Vowels (V), Vowel Glides (VG) and Marginal Babbling (MB) increases to amounts assessed to be 'sometimes' or even 'frequently'.

In the second half of the year vocalizations assigned to the levels *Basic Canonical Syllables* (level 4) and *Advanced Forms* (level 5) increase in both of the children.

The results show that the normal hearing infant gradually begins to produce Consonant-Vowel-Syllables (CV), Canonical Babbling (CB), Disyllables (CVCV) and Complex Syllables (CMPX) in month 7. Anyway those vocalization types stay 'very rarely' until months 11 and 12 in which they were observed 'sometimes'. The implanted child in contrast shows a more rapid increase of vocalizations consisting of true consonants and vowels. Vocalizations from level 4 especially single Consonant-Vowel Syllables (CV) are produced with obvious amounts assessed to be 'sometimes' beginning in months 8. Complex Syllables (CMPX) as well as Diphthongs (DIP) were 'sometimes' observed only in the months 9-11. Vocalizations like Whispered Productions (WH) and Consonant-Vowel Syllable followed by an isolated Consonant (CV-C) weren't observed in both children throughout the whole first year.

Overall our results indicate that the implanted child´s development starts with more mature vocalizations and progresses a little faster than the development of the normal hearing child.

Interrater- and intrarater-reliability using the SAEVD-R after a theoretical and practical pre-training were examined as acceptable to good.

		0	1	2	3	4	5	6	7	8	9	10	11	12
Level 1	**VEG**		25	22	19	30	9	20	27	15	6	4	6	4
	CR							3		2	5	14		
	Q		25	32	38	26	23	29	21	39	34	11	20	10
	Q2		21	24	13	8	3	4		5	1	6	1	3
Level 2	**F**		20	25	10	7	17	28	7	32	20	21	14	14
	F2		19	19	6	10	30	20	11	4	19	22	10	12
	CV-1		16	5	13	17	12	7	19	5	4	15	12	14
	CV-2		2		6	11	6	8	8		3	3	4	4
	CH							1						
Level 3	**V**								3	2	8	2	7	6
	V2								1		1	2	2	2
	VG						2	1		7	2	1	3	1
	IN				2	2			1		2	1		
	SQ						2	1	9	9		1	2	
	MB			1	5		3	8	4	1	2	6	7	7
Level 4	**CV**								2	2	1	1	13	6
	CB									1		4	8	4
	WH													
	CV-C													
	CVCV								1			1	2	10
Level 5	**CMPX**									3		1	8	13
	JN												2	2
	DIP													
Never/ very rarely 0-2		Infrequently 3-6				Sometimes 7-14				Frequently ≥ 15				

Figure 1: Vocalizations of the normal hearing child. Absolute occurrence of the 23 types of vocalization separated with respect to the 5 developmental levels (rows) and with respect to the first 12 months of live (columns).

		0	1	2	3	4	5	6	7	8	9	10	11	12
Level 1	**VEG**	20		27	3	4	2	13	6	1	3	2	6	4
	CR						1		1					
	Q	10	19	43	16	18	10	8	4	5	9	13	5	9
	Q2	2	13	13	1	2	1	3	1	2	2	1	3	4
Level 2	**F**	24	24	19	21	28	41	26	21	9	18	19	26	19
	F2	12	18	2	8	17	20	27	10	7	7	8	4	8
	CV-1	22	23	8	23	22	9	22	23	14	16	16	20	16
	CV-2	15	9	1	9	7	6	7	13	19	15	4	6	7
	CH				15	2							2	
Level 3	**V**		1		5	2	2		9	3	17	13	15	26
	V2				1	1		1		1		1	1	1
	VG	2			2	4	4	3	9	6	3	8	5	2
	IN													
	SQ				1	2					1		1	
	MB	3	8		1	1	4	1	10	13	2	4	2	2
Level 4	**CV**	1				2			3	12	8	11	9	9
	CB									3		1	3	5
	WH													
	CV-C													
	CVCV									4	1	3	1	5
Level 5	**CMPX**					1			3	4	6	5	10	2
	JN													
	DIP											6		1
Never/ very rarely 0-2		Infrequently 3-5				Sometimes 6-13				Frequently ≥ 14				

Figure 2: Vocalizations of the implanted child. Absolute occurrence of the 23 types of vocalization separated for the 5 developmental levels (rows), and shown for the recording before onset of the cochlear implant systems (0) and shown for the recordings done during the first 12 months of hearing experience (columns).

4 Conclusion

Two single-case studies were performed to assess the prelinguistic development before learning of first words and before the vocabulary spurt.

The SAEVD-R which was implemented and used for German-speaking children for the first time in this study was proved here to be a helpful tool in documenting and evaluating the early vocal development for normal hearing children as well as for early cochlear implant recipients. Using this hierarchical scale the performed study of children's prelinguistic vocalizations was sensitive and reliable.

Comparing the results with respect to the chronological age of the normal hearing child and with respect to the hearing age of the young cochlear implant recipient the prelinguistic developments of both children show similar but slightly different progressions and time courses. The normal hearing child of this study predominantly produces vocalizations of level 1 and 2 in the first half year of its life, then gradually starts to produce more mature vocalizations of level 3, and finally begins to show true vowels and consonants (level 4 and 5) at the end of the first year of life. This developmental progress of the normal hearing infant is with few exceptions comparable to the results given in other studies [1]. In contrast the implanted child in our study begins the prelinguistic development with more mature vocalizations and shows a slightly faster progress of development than the normal hearing infant. This faster developmental progress was also observed for other implanted children. Progression and time course of the implanted child of our study is similar to the progression and time course of another early implanted child [3] which was also assessed using the SAEVD-R. The more advanced cognitive and sensorimotor competence at the beginning of hearing after implantation and onset of cochlear implant systems and thus at the beginning of auditory controlled vocal development in the case of the implanted child in comparison to the normal hearing child may explain these developmental differences.

References

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