

A Study on Cochlear-implanted Children's Early First Language Development

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Abstract

This study investigates the cochlear-implanted (CI) children's early language development status. It mainly focuses on two perspectives: 1, whether and how would daily parent-child interaction influence CI children's special belated first language (L1) acquisition; and 2, are there any similarity or differences between the L1 acquisition of CI children and children with normal hearing ability. The study recruited 16 young CI children (aged 3-8 years old), who were born with no hearing ability and received cochlear implantation in January to February 2018. In the beginning of the study, the participants' parents were informed and consented to take several home video clips containing daily parent-child interactions. After 8 months of cochlear implantation, the participants were invited to participate in a language comprehension test. The results of a Pearson correlation coefficient show that, there is a significant positive correlation between the parent-driven efficient communication and participants' test performance, while child-driven efficient communication does. This indicates that proper parenting methods have a significant positive influence on CI children's language development, at least at the early stages. Meanwhile, participants' language test performances showed higher correction rate in noun comprehension, moderate to low correction rate in adjective comprehension, and zero response to verbs. This implies an acquisition order of noun → adjective → verb, which is the same as standard L1 acquisition. However, the mean response time (RT) captured in their language tests is significantly longer than that of normal-hearing children within the same age range.

Keywords: cochlear-implantation, L1 acquisition

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1. Introduction

The process of first language (L1) acquisition is always a mesmerizing field in linguistics. Countless researchers in this field have done in-depth work of L1 acquisition. However, less is known about how L1 is acquired by children with special needs, especially, children with severe hearing impairment by birth. Modern medical technology has developed multiple quite mature advanced methods to enable hearing-impaired patients to hear, among which is realized by manmade cochlea implantation (CI). With the support of society and government funding, infants with hearing impairment can have CI at a very young age. Interestingly, with their hearing ability reconstructed, L1 acquisition still seems to be a big struggle for most, if not all, of these patients. Therefore, this study aims to examine a particular side of this issue: CI children's parent-child interaction and its potential relation with CI children's early lexical development.

2. Background research and literature reviews

2.1 Cochlea implantation and its influences on hearing-impaired children

There are two types of patients with severe hearing-impairment: those who are born with hearing ability but have lost it by accidents and those who are born with impaired hearing system. Based on observation, those who could hear and speak before hearing impairment will return to normal lives right after CI surgery. They can speak and hear like they used to and acclaim that the manmade cochlea almost feel like their own. However, for those who were born without hearing ability, it seems that the situation is far more complicated.

Manmade cochlea is implanted into the human brain to replace the malfunctioning neurons in the impaired cochlea, hence help the brain to receive acoustic information. Therefore, the technology is widely used on newborn children who showed no neuron responses to sounds, hoping that they could hear like normal people do. Clinical hearing ability tests have proved that, after CI surgery, these children can achieve a close to normal level of hearing. The success of regaining hearing ability seems to be the first steps of acquiring their first language. However, these young children all have experienced difficulties in learning their first language.

2.2 Current challenges for hearing-rebuilt children

These hearing-rebuilt children are reported to face multiple challenges in language learning. Firstly, since most of them are very young when receiving cochlea implantation, the physical discomforts that the machine brings are very likely to distract them. In almost all the cases that I have observed, and based on the parents' reports, these children have a tendency to remove the sound receiver attached to the back of their head when the adults were not paying attention.

There are other challenges as well. For these children, since they are not used to sound, they might easily be distracted by any source of acoustic input and could not concentrate on the informational parent-child communications. However, for young children, parent-child communications are the most efficient language developing points. The missing of such interactions will lead to the lack of meaningful language input.

The lack of social support is also a challenge for these children. Since there are few specialized schools or daycare center for these children, they could not enjoy enough amounts of proper social activities, which other children do in kindergartens. It is widely believed that for most children, one of the peaks of L1 development happens at the point when they attend school, where they can learn and practice their language skills. If this is the case, then for hearing-rebuilt children, they might not be able to enjoy such benefit and miss a perfectly productive environment.

2.3 Research Questions

Although there might be many factors that put CI children through extra struggles in their L1 acquisition process, this study will only be focusing on one main issue: will joint-attention/informative parent-child interaction positively influence CI children's early L1 acquisition? To better examine this issue at hand, three related research questions are raised:

1. Is CI children's belated early lexical development order different from that of normal developing children's? If so, what is their acquisition order?
2. What types of parent-child interactions occur among CI children's families? Is there any uniqueness in their parent-child interactions comparing to others?
3. Will a specific type of parent-child interactions influence CI children's early lexical development? If so, what is this type and how does it influence?

3. Method

3.1 Participants

The target participants were 16 young children, between 3 and 8 years of age, who was diagnosed with severe hearing loss at birth and received cochlear implantation (CI) in early 2018. All participants come from the same region in Guangdong Province, China, and their caretakers (parents, grandparents, etc.) speak the same dialect as well as standard Mandarin Chinese. They have no exposure to sound of any kinds before CI surgery, nor received any forms of education in sign languages.

3.2 Pre-test preparation

Before receiving CI surgeries, potential participants and their parents attended a briefing section of the research. Parents who signed the consent forms were informed to take several home videos, with the minimal length of 15 minutes each, containing daily parent-child activities. Videos were submitted once a month or a 8-month period. These videos are meant to capture the natural parent-child interaction patterns of each participant, therefore no specific instructions were given to the parents regarding to the content of these videos. In addition, since this research did not aim to test any particular parental methodology or theory of language acquisition, no instruction or advice on how to communicate with the participants after CI surgeries was provided to the parents. In other words, all videos collected from the participants' parents would contain only parent-child interactions occurred in a natural, non-intervened setting.

3.3 Materials

The participants will take a set of language development tests after 6 months of acquiring hearing ability. There already exist a number of various tests to monitor the development of the CI patients' hearing ability, but there are only few tests that are devoted to their language development.

In order to create such a set of language development tests, I have read some literatures on L1 acquisition, specifically of Chinese speaking children. Among the studies that I have read, I found Ho's (2007) work on early L1 acquisition and children's cognition development enlightening. In her work, she marked certain behaviors and abilities as milestones of language comprehension and production development and specified children's age of each milestone's occurrences. For example, a child would recognize the calling of his/her name by the age of 1 year and 6 months old, and should be able to recognize familiar household items by the age of 2. Since Ho's (2007) work only adapts to children with normal hearing ability, the "year of age" she used does not only refer to the child's birth age; it could also refer to the child's hearing age, in other words, the time span of exposure to child's L1. Considering this point, I created a set of language development tests for my participants based on Ho's (2007) framework.

There are 2 sections in my language comprehension tests. Section 1 only tests the participants' vocabulary size in familiar items. According to the interviews with the parents, the target participants did not have much social life due to their physical condition before the CI surgery. Most of them spent time with their caretaker (sometimes grandparents, or nannies) at home all day long. This information indicates that the participants should be very familiar with household items even without knowing their names. In Ho's (2007) study, children at age 2 should reach a status in which they have no difficulty in acknowledging familiar items by their names. Considering that the target participants are 3- to 6- year-olds with a hearing-age of only 8 months, on one hand, their cognitive development should allow them to recognize each item, on the other hand, their young hearing age might not be sufficient enough to map the nouns they have just acquired to the familiar items. Level I tests are designed in order to find out if this conflict actually exists.

Section 1: Comprehending familiar nouns	
<p>Task 1: Identifying familiar items</p> <p>Contents:</p> <p>Target words:</p> <p>杯子 碗 苹果 衣服 鞋子 小狗 小鸟 猫咪 太阳 月亮 cup bowl apple shirt shoe dog bird cat sun moon</p> <p>Question formats:</p> <p>1. 哪个是[target word]? Which is [target word]?</p> <p>2. [target word]在哪里?</p>	<p>Task 2: Identifying body parts</p> <p>Contents:</p> <p>Target words:</p> <p>手 脚 头 鼻子 嘴巴 眼睛 耳朵 头发 脖子 身体 hand foot head nose mouth eye ear hair neck body</p> <p>Question formats:</p> <p>1. 指一下他的[target word]. Point to his/hear [target word].</p>

<p>Where is [target word]?</p> <p>3. 指一下[target word]. Point to [target word].</p>	<p>2. 他的[target word]在哪里? Where is his/her [target word]?</p> <p>3. 哪里是他的[target word]? Where is his/her [target word]?</p>
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Fig.1 Sample content of language development test (Section 1)

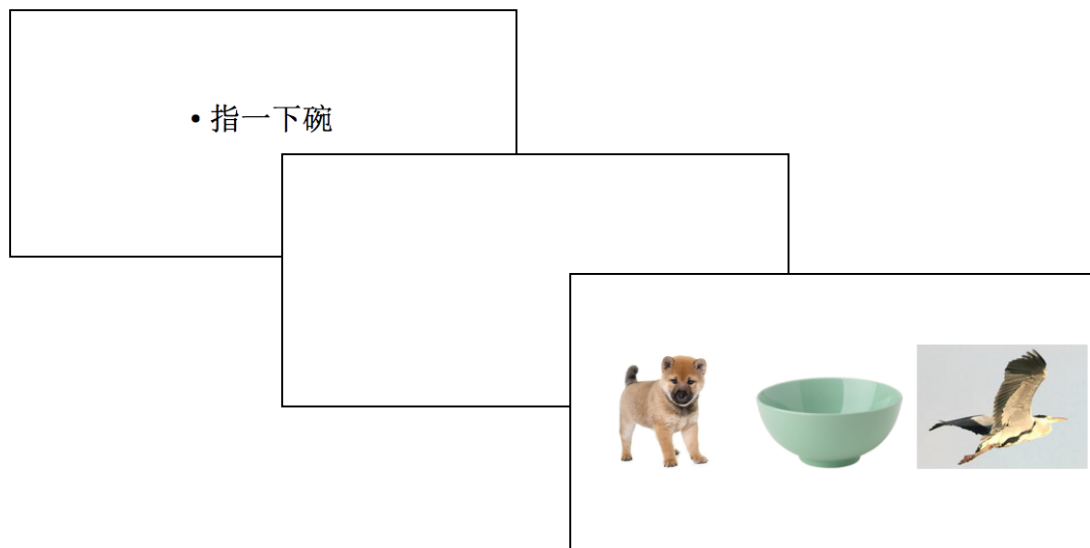
Procedure:

At the beginning of each test item, a question containing the target word will show up on the screen. The mother/caretaker will read out the question loud and clear. Then after 500 ms, the participant will be provided a picture containing several items (including the target item and some distractors). The participant is expected to point out the target items upon hearing the questions. If the participant showed no response, the mother/caretaker could repeat the question up to three times. The tests will be programed and run by E-prime, and the test results (the correctness and response time of each test item) will be collected. One sample item from the actual test is shown as below:

Step 1: sentence containing target word for the parent/caretaker to read out.

Step 2: blank screen lasts for 500 ms.

Step 3: three items containing the target item appear on the screen. The participant should point to the item according to what they have heard.



Section 2 test will be focusing on the recognition of basic physical concepts. According to Ho (2007), the acquisition of this specific ability starts at around 2 years of age and will reach adult-like level at around 4 years of age. More complicated and conceptual nouns and even adjectival phrases are included in understanding these physical concepts, therefore I put the test of these more complex lexical items in a more advanced difficulty level comparing to Section 1 test.

Section 2: Comprehending physical concepts

Target concepts:

Task 1: opposite physical concepts

大/小 ; 干净/脏 ; 高/矮

big/small; clean/dirty; tall/short

Task 2: basic physical concepts

Colors (红 red, 黄 yellow, 蓝 blue, 绿 green, 黑 black, 白 white)

Quantity (多 many, 少 few)

Question formats:

1. 哪个是[target word]的?

Which is [target word]?

2. 哪个比较[target word]?

Which is more [target word]? (Comparative formation)

Fig.2 Sample content of language development test (Section 2)

The procedure of this section resembles that of the previous section.

3.4 Data collection

Video data coding scheme

The purpose of collecting pre-test videotapes is to obtain data of the parent-child interaction patterns. More specifically, as I have mentioned in the previous section, I will be targeting actions that behave like meaningful communication. In Tomasello and Todd's (1983) work on lexical development, they have developed a systematic coding scheme for parent-child joint attention from a behaviorism point of view. Although their work focused mainly on very young infants (15- to 21-month olds) with unimpaired hearing ability, their coding scheme did not contain much information from verbal language. Therefore, I adapted the main structure of their coding scheme and rewrote one as the coding method for this research:

1. Child initiated the interaction and parent actually followed and focused on the same object for a minimum of 3 seconds (child-driven communication);
2. Parent initiated the interaction and child actually followed and focused on the same object for a minimum of 3 seconds (parent-driven communication);
3. Child looked at parent for confirmation (child was aware of their mutual focus on the same object).

The first two criteria are complementary to each other, meaning that a meaningful communication occurrence will either fall in the first or the second pattern. However, the third one can happen to both child- and parent-driven interactions. As for the "3-second" standard mentioned in the first two criteria, in Tomasello and Todd's (1983) study, they have explained that any focus that is shorter than 3 seconds can be proved to be meaningless. Considering the third criterion can happen to both parent- and child-driven communications, there are actually 4 types of communication patterns that will be recorded in the coding of the videos:

Type A: Child-driven communication
 Type A*: Child driven communication w/ child confirmation
 Type B: Parent-driven communication
 Type B*: Parent-driven communication w/ child confirmation

Video coding procedures

Each video was clipped to 15-min length containing only target content (parents' camera setting time etc. was removed). The 4 types of communication patterns were identified from the videos and the numbers of their occurrences in each video as recorded. After handling one participant's all videos throughout the 8-month period, the average numbers of occurrences of the 4 types of communication was noted as their communication pattern. Specifically, Type A and B communication patterns were recorded by times of their occurrences. Type A* and B* (communication /w child confirmation) was noted as ratios. For example, if, on average, a participant has 10 occurrences of Type A communication, which contains 3 occurrences of child confirmation, and 20 occurrences of Type B communication, which contains 10 occurrences of child confirmation, then this participant's communication pattern gathered from his (imagined) videos would be displayed in Fig. 3:

Participant No.	Type A Count	Type A* Ratio	Type B Count	Type B Ratio
Imagined	10	0.30	20	0.50

Fig. 3 Language development test data collection

The language development test was compiled and run by E-prime, which would automatically capture participants' detailed responses, including item options and response times (RTs), to each test item. After participant had finished the test, results would be computed by DataAid and exported to the research computer.

4. Results and analysis

4.1 Parent-child communication patterns

Following the coding scheme adapted from Tomasello and Todd (1983), two main types of communication patterns (child-driven and parent-driven), each with two variations (with or without child confirmation), were picked out from multiple home activity videos collected from the participants. For convenience reasons, I have marked the two communication types and its variations as:

Type A: Child-driven communication
 Type A*: Child-driven communication with child confirmation
 Type B: Parent-driven communication
 Type B*: Parent-driven communication with child confirmation

The average counts of these communication occurrences within a 15-min long parent-child interaction and its child confirmation ratio is listed in Fig. 4.

Participant No.	Type Counts	A Type Ratio	A* Type Counts	B Type Ratio	B*
1	22.30	0.373	9.00	0.222	
2	21.00	0.684	16.75	0.508	
3	13.33	0.425	16.00	0.133	
4	6.67	0.500	29.00	0.471	
5	10.00	0.500	26.00	0.654	
6	3.00	0.667	8.00	0.750	
7	15.00	0.533	19.00	0.158	
8	15.33	0.044	18.67	0.089	
9	6.00	0.667	8.00	0.125	
10	23.00	0.551	22.33	0.448	
11	10.70	0.500	23.00	0.232	
12	13.00	0.308	7.00	0.00	
13	3.67	0.545	17.67	0.623	
14	13.00	0.692	11.00	0.364	
15	6.50	0.385	9.50	0.263	
16	16.00	0.323	18.70	0.214	

Fig. 4 detailed joint-attention patterns

From the form we can see that, among the 16 participants, more preferred parent-driven communication compared to child-driven communication. A generalization of participants' communication type preference is presented in Fig.5.

	Child-driven	Parent-driven	No-preference
Participant Counts	3	6	7

Fig. 5

Fig. 4 also reflects the situation of child confirmation ratio happening in both child- and parent-driven communications. On average, 48.1% of child-driven communications contain the action of child confirmation, which occurs in 32.8% of parent-driven communication. The following chart depicts the individual differences of child-confirmation ratios in both types of communication.

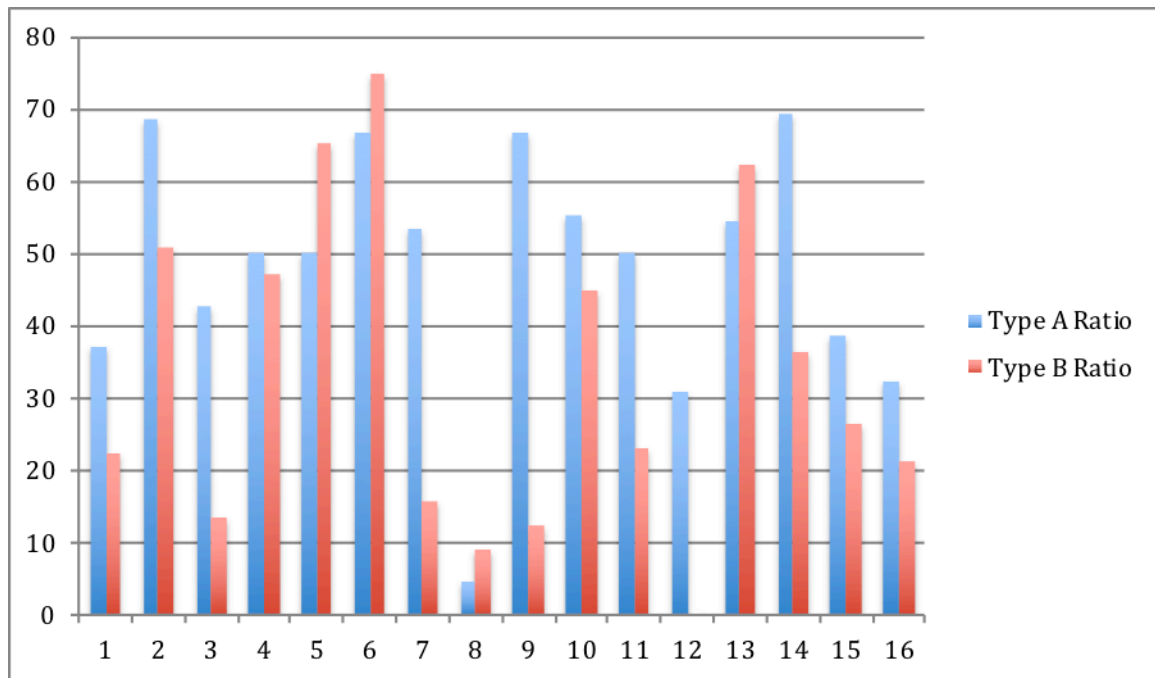


Fig. 6 Individual differences of child-confirmation ratios in joint-attention

More than half of the participants have an obviously higher tendency to confirm with their caretakers when they initiated the communication. Only a small portion of the participants confirm with their caretakers more when their caretaker initiated the communication.

4.2 Language development test performances

The language development test was conducted 6 months after all participants have their CI turned out and functioned properly. The test was divided into two major sections: noun acquisition (S1) test and adjective/adjectival phrase acquisition (S2). The detailed performances of each participant are listed below:

Participant No.	S1 Correction Rate	S1 Mean RT/ms	S2 Correction Rate	S2 Mean RT/ms
1	0.811	8866.46	0.610	7538.42
2	0.890	6028.68	0.790	6956.95
3	0.300	13094.8	0.230	15686.64
4	0.650	8476.15	0.570	7411.97
5	0.200	18589.70	0.730	7039.36
6	0.800	7509.40	0.790	10936.97
7	0.400	7121.05	0.430	8804.44
8	0.650	6053.15	0.375	7781.08
9	0.700	8713.45	0.367	13069.02
10	0.850	4785.70	0.552	6852.62
11	1.000	2919.00	0.584	4399.56
12	0.200	8880.50	N/A	N/A
13	0.850	14799.75	0.352	11467.33
14	0.700	8963.75	0.470	10252.81

15	0.200	31395.00	N/A	N/A
16	0.900	6073.2	0.403	10824.05

Fig. 7 Detailed test performances

All participants have completed the noun acquisition (S1) test, and expressed certain knowledge of nouns regarding to familiar household items. As for the adjective acquisition (S2) test, 2 of the 16 participants failed to complete the test.

The test results show that participants did not reach the same level of comprehension when hearing noun phrases and adjectival phrases. The average correction rate of S1 and S2 tests (see Fig. 8) reflects that participants have a slightly higher correction rate in S1 test than that in S2 test.

	S1 Correction Rate	S1 mean RT/ms	S2 Correction Rate	S2 mean RT/ms
Participants' Average	0.631	10141.86	0.518	9215.80

Fig. 8 Participants' general test performances

Interestingly, although participants expressed a better grasp of noun phrases than adjectival phrases, the data show that they spent less time responding to adjectival phrases than noun phrases. On average, participants needed around 9 seconds to respond to an adjectival phrase. But when hearing a noun/noun phrase, they needed one more second to respond.

4.3 Possible correlations between parent-child communication pattern and their language development test performances

In order to find out whether there exist any possible correlations between participants' parent-child communication pattern and their early language development, the Pearson correlation test was used. The results are listed below.

		w/ Correction Rate			w/ Mean RT/ms		
		R-value	R²	P-value	R-value	R²	P-value
Counts of Occurrences		0.2079	0.0432	0.438	-0.3223	0.1039	0.224
Ratio of Child-confirmations		0.4079	0.1664	0.1168	0.0249	0.0006	0.927

* indicates a significant correlation at $p < .05$

** indicates a strongly significant correlation at $p < .05$

Fig. 9 Type A Communication and its Correlation w/ Participants' Performances

The results of a Pearson correlation test reflect that, there is no significant correlation found between Type A communication (child-driven) and participants' performances in language development test in general.

		w/ Correction Rate			w/ Mean RT/ms		
		R-value	R²	P-value	R-value	R²	P-value
Counts of Occurrences		0.2349	0.0552	0.3812	0.3918	0.1535	0.1334

Ratio of Child- confirmations	0.5086*	0.2587*	0.0442*	0.1876	0.0352	0.4866
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* indicates a significant correlation at $p < .05$

** indicates a strongly significant correlation at $p < .05$

Fig. 10 Type B Communication and its Correlation w/ Participants' Performances

A Pearson correlation run for Type B communication (parent-driven) and test performance shows that, general Type B communication has a none-significant positive correlation with participants' test performance. However, Type B communication with child-confirmation shows a significant correlation with the correction rate of the language development test. The R-value for this pair is 0.5086, which is a strong positive correlation. This entails that, when there are more parent-driven communications with child-confirmation in participants' daily activities, the participants would reach a higher score in the early language development test.

In light of the significant correlation found between parent-driven communication with child confirmation and general language test performance, a second Pearson correlation test was run to find out exactly which section of the language test was the key influence. The results are listed below.

	w/ Correction Rate			w/ Mean RT/ms		
	R-value	R ²	P-value	R-value	R ²	P-value
Noun (S1)	0.26	0.0676	0.3308	0.125	0.0156	0.6446
Adjective (S2)	0.6638*	0.4406*	0.0096*	-0.1651	0.0273	0.5730

* indicates a significant correlation at $p < .05$

** indicates a strongly significant correlation at $p < .05$

Fig. 11 Type B Communication (w/ child-confirmation) and its Correlation w/ Participants' Performances in Noun and Adjective Acquisition

Surprisingly, an R-value of 0.26 reflects that there is almost no correlation found between Type B communication with child-confirmation and early noun acquisition. However, this specific type of communication has a significant correlation with adjective/adjectival phrase acquisition, with an R-value of 0.6638.

5. Discussion

5.1 CI children's belated L1 development

The research process and results are a display of the participants' first 8 months of late L1 acquisition. The communication details collected from their home videos show their natural language learning process and their language test performances reflects the results of this early L1 acquisition stage. Some noticeable phenomena are found among the research data.

The first phenomenon spotted is that participants' L1 acquisition order, although a belated one, seem to synchronize with that of normal-hearing children's. Although there might not be a universal timetable for language learning across languages (Caselli et al., 1995), piles of evidence shown that young normal developing children start off their lexical development with nouns. Markman (1989) proposed the "whole object constraint" of infants' early lexical development: young children tend to

assume that a new word will refer to a whole object, but not the subparts or actions/states of that object. In light of this constraint, normal developing children will acquire nouns faster than any other lexical items. Macnamara (1986) also pointed out that nouns, especially names of concrete and accessible items, are acquired sooner than other lexical items. He proposed that before exposed to the nouns, the idea or concept of a familiar object has been created when the child has first set eye on it. Upon hearing the noun and established the mapping between the noun and the object, the child would acquire the noun and its meaning successfully. Other lexical items, such as verbs and adjectives, are reported acquired later due to several reasons. One possibility is that verbs and adjectives do not directly point to any object of interest. Therefore in early language acquisition, children tend to ignore that part of speech, rather focus on the nouns. This possibility accords with Markman's (1989) "whole object constraint". Another possibility is that, the grammatical complexity of these lexical items might have caused its late acquisition (Gentner, 1982). O'Grady (1987) provided some related arguments. He pointed out that verbs and adjectives are often used as predicates, while nouns are often used as arguments. Predicates are secondary to arguments, since they are descriptions of the key arguments' actions or states. In other words, if a child is able to use or understand a predicate, he/she must have a solid entity as the argument in his/her mind (O'Grady, 1987). If this were true, than logically speaking, verbs and adjectives would be acquired later than nouns.

The results of this study have shown similar order. Three sets of tests were originally prepared for the participants, noun, adjective and verbs. However, none of the participants could complete any item in the verb test, therefore the results contained only the noun an adjective tests. As seen from the last section, participants' average correction rates are 63.13% in noun test, and only 45.34% in adjective test. Participants' performances are obvious better in noun test than in adjective test, indicating that they have acquired more nouns than adjectives. The failure of the verb test indicates that, at this point, none of the participants have acquired any verbs yet. Unquestionably, participants have shown an acquisition order of noun-adjective-verb.

The second noticeable phenomenon spotted from the research is that, CI children's RTs are significantly longer than that of normal developing children. Before participants attend the language test, the adjective test was run as a pilot test in a kindergarten. 20 young (age 3- to 4-yo) normal developing children participated as volunteers (consented by their legal guardians). The result comparison is listed below:

	Mean Correction Rate	Mean Response Time (ms)
Normal Children	0.9043	3600.84
CI Children	0.4534	9215.80

Fig. 12 Comparison between Normal Children and CI Children regarding the Adjective Comprehension Test

As expected, the mean correction rate of normal developing children is above 90%. The results also show that for each test item, normal developing participants would only need slightly over 3 seconds to respond. However, CI participants would need over 9 seconds for each item, which is 3 times longer than that of normal hearing children. Although I have not found any criteria on regular RTs for comprehending an adjective/adjectival phrase, this huge difference between CI participants and normal developing volunteers put forward a crucial question: what could have caused it?

One hypothesis is that, CI children might need extra time in capturing and identifying the sounds of human language. In a regular case, a human fetus would have developed a complete hearing system at around 32 weeks of its mother's pregnancy. At 38 weeks of pregnancy, the fetus would be able to distinguish familiar and unfamiliar sound patterns, especially of human languages, preferably the mother's voice (DeCasper, 1986). This is because the damp environment of the uterus screened out most of the high pitch (>100Hz) noises, and lower pitch sounds such as human language can be delivered successfully. Shortly after the baby is born, it could sort out the different patterns of sounds and pick out human language from a pile of other noises, thanks to the pre-birth "practices". This early development would not require any real language experience after birth, and is likely to be activated automatically at birth (Kuhl, 1993). CI children, on the other hand, were born deaf, therefore did not receive any of these sound stimuli as a fetus. As observed during the research process, when participants' manmade cochlea machine was turned on for the first time, all participants showed different degrees of fear and unsettlement. Their first encounter of sounds was in a more complex and noisy environment comparing to a mother's uterus, which means that they are on their own to figure out which sound clip is a sentence, and which sound clip is only a puppy's bark. By the time of participating the language test, CI participants have only experienced sounds for 8 months. It is highly possible that they have not yet developed an intuition when hearing human language. In other words, their long RTs in the test reflect an acoustic problem, not a language processing one. If they are given more time to expose to and experience natural human language, the RT difference mentioned above will fade away eventually.

Another possibility is more intuitive and straightforward: CI children's lack of familiarization with the lexical items push them to pause and think more before they respond. Undeniably the participants have only been exposed to language for 8 months when they took the test. Even if they subjectively start to "learn" their first language from day one, they still have way less time to master their language skills comparing to the volunteer group. Hesitating upon new knowledge would not poster any problem in competence.

To figure out which of the above possibilities is closer to the truth, further studies will need to be done.

5.2 Communication pattern's potential influence on CI children's L1

Many studies have provided evidence of how early parent-child interactions could influence infants' early lexical development. Young children have a "mapping system" to learn about not only language, but also new things they encounter in life. When seeing a new item, they would associate this item to a concept created in their own mind. If an adult happen to provide a referential description, for example the item's name, during this mapping process, the child is likely to absorb that knowledge and acquire this noun naturally (Macnamara, 1986; Prasada, 2014; Trueswell et al., 2016, etc.). Trueswell et al. (2016) have found out that, a timely referent to the object would help boost child's early lexical development. If the adult provide linguistic information when the child was not paying attention to the same object at the same time, then the information provided by the adult is highly likely to be uninformative.

These studies on normal developing children's early lexical development have established the importance of meaningful parent-child interaction in L1 acquisition.

Such parent-child interactions occur among CI children and their parents as well. Based on participants' home videos, an average of 28.64 occurrences of such meaningful interaction are found in every 15-min of parent-child playtime. Roughly 43.33% of these interactions were initiated by the participants, the rest were initiated by their parents. The study has also found that, some participants tend to initiate more of such interactions, while others tend to wait for their parents initiate any communication. In order to find out whether such interaction tendencies would influence participants' lexical development, a Pearson correlation coefficient test was run. The results show that, a significant correlation exists between parent-initiated interactions with child confirmation and participants' adjective test performance. The R-value of 0.5086 indicates positive correlation. In other words, if the parent is more initiative and the child is more likely to check with his/her parents' reactions during their parent-child interactions, the child is more likely to achieve higher performance in the adjective test.

Although the research only recruited 16 participants, which indicates that the Pearson correlation coefficient test result is less reliable, it still entails the importance of a parent's role in CI children's lexical development. Joint attention has a special role in early lexical development, not only of normal developing children, but also of children with special needs. Many studies in autism children's early L1 acquisition have found out that joint attention has a strong positive correlation with their early language development (Loveland and Landry 1986; Mundy et al. 1994, etc.). However, in the specific case of autism children, Luyster et al.'s (2008) research has shown that the initiation of joint attention does not play a role in L1 acquisition. The important booster is the child's response to the joint attention (Luyster et al., 2008). Like autism children, CI children have special needs and demands extra care in L1 acquisition. However, unlike the results from the autism studies, our current study has revealed that for CI children, the initiation of joint attention is as important as response to joint attention. One way to interpret this finding is that, since our participants have less experience with sounds, a parent's informative verbal input together with visual instructions can help them focus on an utterance as well as map the object to that utterance. Also, as observed from the home videos, parents tend to repeat a sentence/phrase when their children look back to them during their interactions. If the child did not respond (making confirmation) to his/her parent during joint attention, he/she might not capture the acoustic signal in the first time. Interestingly, child-initiated interactions with child confirmation did not show any correlation with their test performance. After reexamined the home videos, I have found that child-initiated interactions involve less language input from the parent. When a child focuses on an object and tries to capture his/her parent's attention with it, often the parents tend not to call out the item's name or say anything about the object, but to utter something less relevant to the object such as "good job". But when the parent initiates an interaction, he/she tends to be in a "teaching" mode, and will always speak out something about the object as his/her child focuses on the object. In other words, coincidentally or not, child-initiated joint attentions spotted in this study involve less timely linguistic input, which makes them less informative than the parent-initiated ones. To conclude, a parent's effort in making child-parent

interactions informative and child's prompt response in joint-attention play a positive role in CI children's early lexical development.

6. General Conclusion and Limitations

The findings of this study have answered the main research questions. Firstly, by assessing participants' language comprehension, we do find out that CI children's early L1 acquisition roughly goes through a similar chronological development pattern found among most normal developing children. At 8 months of hearing-age, they could comprehend most familiar objects' names (nouns) presented in the test. As for adjectives and adjectival phrases, participants also show certain degree of comprehension, which indicates they acquire these lexical items later than nouns. A trial test containing more linguistically complex structures, such as verb phrase, was also presented to the participants. However, the failure of responding to these test items was universal across all participants. The only logical explanation is that participants have not yet acquired the meanings and uses of verbs at all. This acquisition pattern anchors with Markman's (1989) "Whole Object Constraint", which refers to children's early lexical acquisition have a tendency of arguments over predicates.

Secondly, by studying the participants' home videos, we can see that parent-child interactions within CI children's families are typical among all families as well. Joint-attentions between parent and child are spotted frequently, and the ratio of informative interactions is not as low as expected. However, I do notice that in child-initiated joint attentions, informative verbal instructions from the adult are rare. This will cause the deduction of meaningful language input to the participants. On the other hand, informative joint-attention proves to influence participants' early lexical development, especially in predicate acquisition.

Although the proposed research questions are answered, there are still many limitations. A crucial one is that the data pool of this study is very small. Difficulty of recruiting qualified participants has caused the results of this study are not at all universal. All results will only serve as an indicator of these 16 participants' language development status, but not all CI children. Besides, many other problems regarding CI children's L1 acquisition are found, therefore further study in this field is needed.

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