ABSTRACT

Acquisition of Theta Roles in Deaf Children with Cochlear Implants

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Deaf children with cochlear implants often display delayed language acquisition. As a result, researchers refer to “hearing age,” the time elapsed since the implantation of hearing aids, in addition to chronological age, the time elapsed since birth. This subpopulation may be a possible new avenue of study for language development. I compared the ability of 7 children enrolled at the Southwestern Hearing School for the Deaf as they determined the subject and object roles in a sentence. Each participant was read a sentence and asked to select the correct corresponding picture. The sentences had varying levels of difficulty depending on the number of possible subjects and objects within the sentences. As expected, older children (measured by hearing age) made fewer errors. All children made more errors as the sentences became more complex. The relatively small sample size precludes strong conclusions, but provides tentative support for separating hearing age from chronological age.

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Dr. Andrew Wisely, Director

DATE: _______________________

ACQUISITION OF THETA ROLES IN DEAF CHILDREN WITH COCHLEAR IMPLANTS

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CHAPTER ONE

Background

We can draw conclusions about the process and stages of language development in general by examining cases of unique linguistic development. Consider, for example, the case of Genie. Genie was discovered at the age of thirteen years and seven months old lacking normal language abilities due to the extremely impoverished and abusive environment she grew up in (Curtiss, Fromkin, Krashen, Rigler & Rigler, 1974). After being removed from that language-impoverished environment and working with various researchers and therapists, Genie developed some language skills. Her lexicon showed steady growth but Genie lagged in the comprehension and production of syntactic and morphological features. The continuing acquisition of lexicon as compared to other language skills could be a result of her general cognitive abilities and not of specific innate language processes. Genie also lacked linguistic features such as movement transformations, question words, demonstratives or other pronouns besides the first person pronouns and she produced short utterances lacking morphological markers (Curtiss et al., p. 540). Ultimately, Genie's language development was not typical and revealed the importance of early exposure to environment with proper linguistic input. Her abilities and order of acquisition of features did not match with typical child language development. Genie's inability to acquire the complex syntax required for sentences longer than about five words and wh-questions provides evidence for the critical period hypothesis of language acquisition.

The critical period hypothesis states that there is a biologically limited period of time for the acquisition for a skill or ability (Guasti, 2002, p. 20). For human language acquisition, the cut-off point appears to be puberty. There is strong evidence for this critical period for the acquisition of language. The above mentioned case of Genie is evidence for the critical period hypothesis because she was pubescent when she was removed from her language deficit environment and exposed to proper language input, but she was still only able to produce and comprehend only limited language. Another example of the importance of environmental exposure during the critical period can be found in the studies on the creation of Nicaraguan Sign Language (NSL) (Senghas & Coppola, 2001, p. 324). In Nicaragua, there was a deficit of government-provided resources or educational opportunities for the deaf population until the later half of the twentieth century. As a result, the majority of deaf individuals lived at home with family and communicated using a 'home-sign' of known gestures. The creation of a school for the deaf brought the previously separated deaf children together. Very quickly, the deaf children took their individual home-signs and developed a common and fully developed language. While this language was shared among the members of the Nicaraguan Deaf community, there was a continuum of differences among individuals' ability to master this sign language. Children who acquired NSL before puberty showed a higher proficiency in its usage than those who acquired NSL after puberty. This continuum of fluency based on age at language exposure is further evidence for language acquisition having a critical period. Both of these cases of unique linguistic development reveal how language acquisition occurs and its limitations. Using this same reasoning, we can draw conclusions about the early stages of language acquisition by studying another linguistically unique subpopulation, deaf children with cochlear implants. In this paper, I have outlined my experiment testing the acquisition of theta roles in a group of deaf children with hearing aids and cochlear implants and developed a timeline for the acquisition of this linguistic feature based on the results of the experiment. Specifically I have attempted to determine when children acquire (1) a single agent of action theta role, (2) agent of action and patient theta roles and (3) the ability to distinguish two possible agents of action into their proper agent of action and patient roles. In addition, I have determined that this experimental design is useful for gathering data on child language acquisition.

Human language learning is dependent on the development of sensory systems, especially the auditory system. While the initial physical development of sensory systems starts early in gestation, the supporting neural components of sensory systems finish developing "in the last 15 to 18 weeks of fetal life (22 to 40 weeks gestational age) and the first 3 to 5 months of neonatal life" (Graven & Browne, 2008, p. 170). Once the sensory systems begin maturing around 8 to 10 weeks before birth, the fetus can begin preparing for language learning. In fact, even before a child is born, the auditory system requires external stimulation for proper development. Therefore, the process of language learning has its roots in the last stages of fetal development when sensory systems are exposed to external stimuli. Language acquisition is influenced by environmental factors as well as by physiological and developmental factors as evidenced in the above-mentioned development of the auditory system.

An organism's physiological and developmental processes are controlled by genetic mechanisms. Language acquisition is therefore also dependent not only on having the necessary environmental input but also on having the correct functional genes. Evidence for one particular gene necessary for proper language abilities can be found by studying the FOXP2 gene. The multigenerational family KE, which contains both members who do and do not have this heterozygous missense mutation, has been the focus of the study of this importance of this gene on language capacity (MacDermot, Bonora, Sykes, Coupe, Lai, Vernes, Vargha-Khadem, McKenzie, Smith, Monaco & Fisher, 2005, p. 1075). The mutation causes difficulties in making the sequential movements for articulation of speech, and grammatical processing. The FOXP2 gene is only one of many genes necessary for proper language abilities. Nonetheless, the impairments seen in the KE family demonstrates the importance of genetic influences in language development.

While language acquisition requires sufficient environmental input for language learning to take place, humans show remarkable adaptability in adjusting to uncommon or delayed sources of input (Guasti, 2002, p. 16). An example of the flexibility of language acquisition can be is found in the development of sign language. While the typical child learns to produce a vocal language in response to auditory input, a deaf child exposed to a visual sign language will produce a gestural language. Importantly, the developmental sequence seen in children acquiring sign language mirrors that of hearing children acquiring spoken language, such as the production of variegated and canonical manual babbling (Guasti, 2002, p. 50). The production of sign language by deaf individuals also supports the assumption that language is a universal human ability and is not dependent on the capacity to hear or speak.

The currently influential theory of language acquisition is Chomsky's Universal Grammar (UG; Guasti, 2002, p. 17). Chomsky posits that every neurotypical child is born with an innate 'Language Acquisition Device,' which has preprogrammed language settings that are set with exposure to the language spoken in the environment around the child. This theory explains how children are able to learn any language to which they are exposed, and why the general sequence of language development is the same for all languages. This theory also takes into account the influence of both genetics and environment on the development of language. One of the predictions of UG is that language development tends to occur in the same developmental pattern from simple structures to more complex ones both between languages and among individuals learning the same language. Therefore, deaf children with cochlear implants should be following the same developmental schedule as the rest of the population, but at a delayed age, contingent on the timing of their implant surgery.

A neurotypical infant with normal physical abilities will begin the language acquisition process when first exposed to language, which for the majority of infants is at birth (or even slightly before). Exceptions to this include infants who have cognitive or language impairments that disrupt normal language acquisition processes. Therefore, the investigation of the earliest stages of language development typically involves neonates. But experiments involving infants must take into account their physical and cognitive limitations. One limitation is that the physical mechanisms used in language production are not in the proper anatomical locations for speech in infants for the first four months of life. The larynx must descend, and the throat and vocal tract must elongate before speech is anatomically possible (Guasti, 2002, p. 47-48). The expressive language developmental timeline is set due to these physical limitations and thus speech samples are not a viable option for testing. Studies of receptive language abilities are possible, but constrained. In addition to the physical limitations, cognitive limitations of infants, such as limited attention span, and a lack of ability to follow directions, should be taken into account. As a result, most research on early acquisition of language focuses on receptive rather than expressive language abilities. The information on early language acquisition is incomplete due to these experimental limitations.

The difficulty in gathering data on early language acquisition is especially relevant for syntax. A typical child will begin producing single word utterances around one year of age and two word utterances several months later. Therefore, expressive data containing syntax will only be available after at least two years of syntax acquisition have already past.

Previous research has studied young infants regarding the acquisition of prosody and the ability to differentiate languages and used procedures such as the high-amplitude sucking procedure (HAS) (Mehler, Jusczyk, Lambertz, Halsted, Bertoncini and Amiel-Tison, 1988). In this task, infants suck on a pacifier that contains a pressure sensor linked to a computer. After establishing a baseline-sucking rate, the infants are presented with a stimulus played over a loud speaker. The rate at which the stimulus, consisting of a novel phoneme, is played is based on the sucking rate of the infant. If infants find the phoneme to be of interest, they will suck at a higher rate, resulting in a continual playing of the novel phoneme. Over time as the infants becomes habituated to that phoneme, the sucking rate decreases. Once the sucking rate has declined to a predefined habituation point, experimental trials with new stimuli or control trials with the same stimuli can be added. This task is designed to test a specific aspect of language, the ability to differentiate phonemes, while taking into account the abilities of the infants participating in the study. HAS is a useful experimental paradigm for testing the ability of infants to differentiate phonemes, prosody patterns or other auditory elements of language, but is limited in what other aspects of language it can test, such as the abstract organization of parts of speech in syntax.

The present study examines the subpopulation of deaf children with cochlear implants to better understand early language acquisition. One advantage of this approach is fewer physical and cognitive constraints. Deaf children with cochlear implants begin to receive auditory information when their implants are switched on for the first time, which is at a later age than when a typical child begins to receive auditory input. In such individuals, speech pathologists distinguish between chronological age and hearing age. Chronological age is what is typically meant when an individual's age is based upon date of birth. Hearing age is the specialized term that refers to the amount of time an individual has had access to auditory input. For deaf children with cochlear implants this would be when the implant is activated. For the majority of the hearing population, these two values are the same: infants begin receiving auditory input on the day of birth. However, these two values can be separated a year or two or more for deaf children with cochlear implants. Given that these children are older, they are more developed cognitively and physically, and can complete more demanding tasks than HAS.

CHAPTER TWO

Experiment

Methods

Participants

I tested 8 students from the Southwestern Hearing for the Deaf in Coppell, Texas. Parental permission was obtained as a signed consent form before testing began. Only seven of those participants produced usable responses, (the youngest participant did not finish the majority of the items.) The participants ranged in age from 5 years 4 months to 2 years 7 months old; however, seven of the participants were between the ages of 5 years 4 months and 4 years 2 months. Five of the participants were female and three participants were male. The amount of time the participants had implants ranged from 4 years 8 months to less than 2 months. The hearing loss in the participants ranged from mild to profound, with the exception of one participant with no hearing loss. The participant without hearing loss is part of a fraternal twin set and was used in a comparison with the deaf twin. One participant had been diagnosed with apraxia. Table 1 lists the characteristics of the participants.

Table 1.
Participant Ages and Hearing Loss

Participant	Sex	Chronological age	Hearing Age	Hearing Loss
1	Female	5 years 1 month	2 years 6 months	Right: Profound Left: Moderate/Severe
2	Female	5 years 1 month	2 years 6 months	Right: Profound Left: Profound
3	Female	4 years 5 months	4 years 2 months	Right: Mild/Moderate Left: Mild/Moderate
4	Male	4 years 10 months	4 years 7 months	Right: Moderate/Severe Left: Profound
5	Male	4 years 2 months	3 years 2 months	Right: Moderate Left: Severe
6	Female	4 years 2 months	4 years 2 months	No hearing loss
7	Female	5 years 4 months	4 years 8 months	Right: Moderate/Severe Left: Moderate/Severe

Note: Participants 5 and 6 are fraternal twins. Participant 3 has apraxia.

Research Design

The experimental procedure used in this study is based on Hirsh-Pasek and Golinkoff's Intermodal Preferential Looking Paradigm. In this procedure, a statement is played over speakers into the room the participant is in. Also within this room are two television screens, each playing a different image with one of the screens showing images depicting what is being played over the speakers. Children will visually fixate more quickly on and spend more time looking at the screen that shows the image matching the statement being played over the speaker than the other screen. One change made to the Hirsh-Pasek and Golinkoff design for this experiment is the picture selection by participants pointing instead of by visual fixation (McDaniel et al., 1996, p. 108).

Pointing is a more active and definite response than looking. The participants had differing levels of expressive language abilities, and using a picture-pointing task compensated for these differences. The picture-pointing task is one the participants were already familiar with due to speech therapy. The use of a previously known task reduced the errors the participants might make due to unfamiliarity or uncertainty about what they should be doing.

The actors in a sentence are called arguments and within a sentence each argument has a thematic role. These thematic roles or theta roles serve to describe the function of the argument in the sentence, including grammatical function (Guasti, 2002, p. 82-83). Children assign grammatical function to arguments through a process called semantic bootstrapping. Semantic bootstrapping involves matching a sentence with events occurring in reality to create a semantic representation of the sentence that corresponds to real world events. The child then uses this semantic understanding of events to determine the grammatical function of each theta role in the sentence. The agent of action theta role, which has the grammatical function of subject, and the patient theta role, which has the grammatical function of object, are both tested in this study (Guasti, 2002, p. 94).

I tested the comprehension of agent of action and patient theta roles. Items tested differed in their levels of complexity; the less complex test items should produce fewer errors than the more complex test items. Likewise, the more linguistically developed participants should complete more items correctly, particularly the more difficult test items. Ideally, the construction of this developmental timeline would reveal the sequence of complex theta role acquisition.

The inclusion of the puppet in the experiment was on the advice of linguistics professor Dr. Lydia Grebenyova. Framing the task as helping the puppet is more engaging for young participants than simply having a series of questions to answer. The satisfaction of aiding the puppet and the puppet's thanks also serve as a reward for the participants.

Materials

Eighteen test items were used in this experiment. The test items were split into three groups depending on the difficulty of determining the theta roles of each sentence. Each test item had three accompanying pictures. The first group of test item sentences contained a single agent of action theta role and is listed in Table 2. This first group of test items determined if the participants were capable of matching the subject of the sentence to the pictures; the same subjects and similar pictures were used in later test items.

Table 2.
First Group of Sentences – Identify Subject

1. This is a cat.
2. The dog is brown.
3. The girl is smiling.
4. This is a boy.
5. The baby is sleeping.
6. This is a mom.

The second group of test items was more complex, and included both an animate argument and an inanimate argument that is acted upon; these test items are listed in Table 3. This second group of test items, in addition to testing understanding of both agent of action and patient theta roles, determined whether the participant understood the verbs used in both this group and the next group.

Table 3.
Second Group of Sentences – Understanding of Theta Roles and Verbs

7. The cat is sitting on the chair.
8. The dog is holding the ball.
9. The girl is touching the flower.
10. The boy is licking the lollypop.
11. The baby is hugging the blankey.
12. The mom is holding the book.

The third group of test items was the most complex tested and contained two possible animate arguments that could fill the agent of action theta of the sentence. These are listed in Table 4. This third group of test items tested the participants' discernment of the correct agent of action and patient theta roles that determines which argument is the subject of the sentence and which is the object.

Table 4.
Third Group of Sentences – Determining Subject and Object of the Sentence

13. The cat is sitting on the dog.
14. The dog is licking the cat.
15. The girl is touching the boy.
16. The boy is holding the girl.
17. The baby is hugging the mom.
18. The mom is holding the baby.

Three test pictures accompanied each test item (see Appendix C). For the first group of test items, one of the three pictures was the correct subject mentioned in the test items while the other two pictures were subjects from the other test items. In the second group of pictures, one of the three pictures showed the correct relation of the animate subject to the inanimate object. The two other pictures showed an incorrect relationship between the subject and object and the subject by itself. The pictures corresponding to the third group of test items contained either the subjects in the correct subject-object relationship described in the test sentence, a reversed subject-object relationship to the test item or the two subjects not interacting. Each set of three pictures corresponding to a test item was mounted on colored cardstock and randomly assigned a letter, 'A,' 'B,' or 'C,' to indicate the participant's response during the experiment.

Procedure

The testing took place at a wooden child-sized table and two chairs borrowed from one of the classrooms of the Southwestern Hearing School for the Deaf, which is located in the fellowship/dining area of Metrocrest Community Church building. A child-sized table and chairs were set up in a corner with testing material resting on another chair off to the side. The participants were pulled out of the classroom in the context of playing a game with the experimenter.

The test items were framed in the experiment as helping a blue Muppet-style puppet dubbed 'Sally' borrowed from the collection of Coppell Independent School District kindergarten teacher Cindi Carlton (see Appendix A). A participant response sheet and pen were used to record responses to the test items (see Appendix B).

I recorded the participant's gender, first initial and the testing order. The participants were seated at the table and the experimental task was framed as helping the puppet 'Sally' determine what picture the experimenter was describing in the following speech:

> "Hello, this is my friend Sally and she needs help. Will you help her? Sally doesn't know what picture I'm talking about. Will you point to the right picture so Sally knows what I'm talking about?"

Three pictures were placed on the tabletop facing the participant before the experimenter read out the test item. The participant then indicated which picture they believed to be correct by pointing, touching or handing the picture to the experimenter. Given the ages, limited attention spans and hearing difficulties of the participants, the test items and directions were repeated as often as needed. After the participant indicated a picture selection, the picture letter on the back was recorded. The procedure was then repeated for all remaining test items. After completion of all of the test items, the experimenter (through the puppet) thanked the participant and escorted them back to class. The school's director provided background information such as date of birth, date of implant, extent of hearing loss and other factors that could impact language abilities.

Results

Responses were gathered from seven of the eight children, who have been assigned numbers for the purposes of discussion. While the youngest child was tested, no usable responses were produced. All of children responded to all of the test items with the exception of the one child with apraxia (participant 3) who responded to 17 out of 18 test items. The responses are listed below in Table 5 with the incorrect responses bolded and the number of incorrect responses per participant and group listed.

For the first group of test items (sentences 1 to 6), 44 out of 48 responses were correct with 2 errors occurring on sentence 3, 1 error on sentence 4 and 1 error on sentence 6. All of the errors in this group of test items came from the same two participants, 1 and 2. The second group of test items (sentences 7 to 12), 41 out of 48 responses were correct with 1 error in sentence 8, 2 errors in sentence 9, 1 error in sentence 10, 1 error in sentence 11 and 2 errors in sentence 12. All seven errors came from participants 1, 2 and 3 with participant 1 making 1 error and participants 2 and 3 both making 3 errors.

On the third group of test items (sentences 13 to 18), 27 out of 48 responses were correct with 3 errors in sentence 13, 4 errors in sentence 14, 2 errors in sentence 15, 5 errors in sentence 16, 4 errors in sentence 17 and 2 errors in sentence 18. All participants but participant 7 made errors in this group of test items; participant 1 made 3 errors, participant 2 made 5 errors, participant 3 made 5 errors, participant 4 made 2 errors, participant 5 made 3 errors and participant 6 made 3 errors.

Table 5.
Participant Responses to Test Items

	1	2	3	4	5	6	7	Incorrect Responses	Incorrect Responses per Group
1	C	C	C	C	C	C	C	0	4/48
2	B	B	B	B	B	B	B	0	
3	**C**	B	**C**	B	B	B	B	2	
4	**B**	C	C	C	C	C	C	1	
5	C	C	C	C	C	C	C	0	
6	A	A	**B**	A	A	A	A	1	
7	B	B	B	B	B	B	B	0	7/48
8	**C**	A	A	A	A	A	A	1	
9	C	**A**	**B**	C	C	C	C	2	
10	A	A	**C**	A	A	A	A	1	
11	C	**B**	C	C	C	C	C	1	
12	A	**C**	**B**	A	A	A	A	2	
13	A	**C**	**B**	**B**	A	A	A	3	20/47
14	**B**	A	**C**	A	**B**	**B**	A	4	
15	B	**A**	**C**	B	B	B	B	2	
16	**B**	**A**	**NR**	**B**	**B**	**A**	C	5	
17	**B**	**B**	**B**	A	A	**B**	A	4	
18	C	**B**	C	C	**A**	C	C	2	
Total Errors	6	8	10	2	3	3	0	32	

Note: All incorrect responses are bolded.

In general, accuracy on these tasks was associated with hearing age: those with greater hearing ages made fewer errors. Participant 7 has had her implants for 4 years 8 months, the longest of any of the participants, and made no errors on any of the test items. As the hearing age decreased, the number of errors increased for all of the participants with the exception of participant 3, who has apraxia, a possible confounding variable (see Figure 3). Even the hearing fraternal twin falls into this pattern of increasing hearing age and decreasing errors. This pattern of decreasing errors was not found with increasing chronological age, indicating that chronological age does not affect the accuracy of responses (see Figure 4).

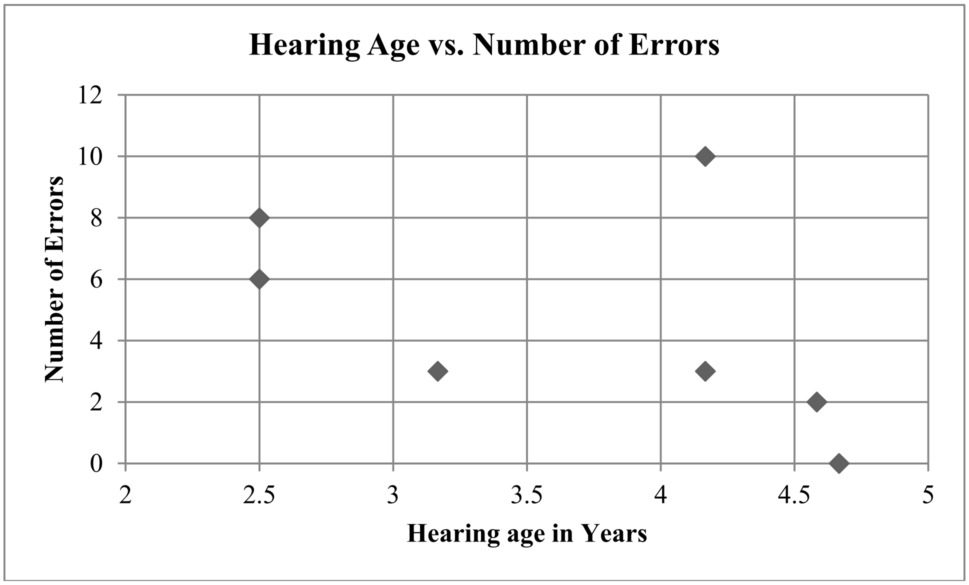


Figure 3.
Hearing Age vs. Number of Errors

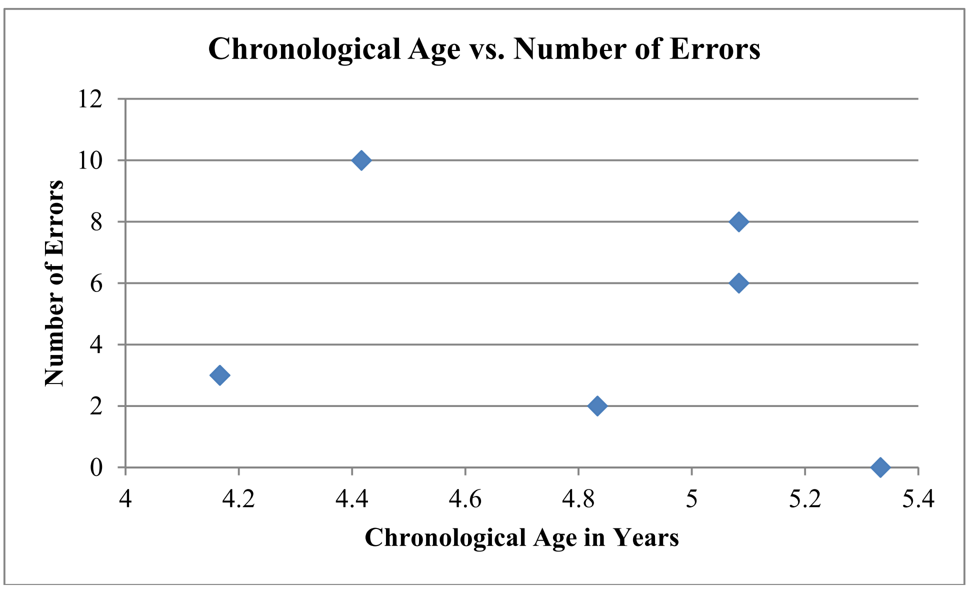


Figure 4.
Chronological Age vs. Number of Errors

Participants 5 and 6 are a fraternal twin set: participant 5 has moderate hearing loss in the right ear and severe hearing loss in the left and participant 6 has no hearing loss. Despite a year different in their hearing ages, the twins have identical error rates and similar patterns of errors. Both twins correctly responded to all of the sentences in the first two groups, revealing their acquisition of subject identification and the correct assignment of agent of action and patient theta roles between an animate subject and inanimate object. However, both struggled with determining the agent of action and patient theta role between two animate actors in test items 14 and 16.

In the first group of test sentences, the 4 errors that occurred all involved choosing the incorrect human, such as selecting 'boy' instead of 'girl' or 'girl' instead of 'mom.' The pictures were drawn to show obvious indicators of gender: hair length, type of clothing and color of clothing; so it is unclear why participants 1 and 3 made errors on test items 3 and 4. The error made on test item 6 is more understandable since both 'mom' and 'girl' are female. While participants 1 and 3 did not answer correctly all of the test items, their performance on the other test items indicates a solid understanding of the agent of action theta role. The lack of errors from the other participants indicates that they have mastered identifying the subject theta role in the sentence.

In the second group of test sentences, participants 1, 2 and 3 made all 7 errors. For test item 8, participant 1 selected the picture with the dog and the ball instead of the dog holding the ball, which indicates that the participant is aware the presence of both objects in the sentence but not the relationship between them. 5 of the 7 errors in this group of test items were the selection of the picture that had both of the objects in the sentence but without the correct interaction between them. 4 of the participants made no errors in this group of test items, which indicates that these participants have an understanding of both the agent of action and patient theta roles and how they interact in a situation with an animate actor as the subject of the sentence and an inanimate object of the sentence. Participant 1 made only one error in this group of sentences which likely means she has a solid understanding of agent of action and patient theta roles. Participant 2 and 3 each made errors on half of the test items in this group of sentences meaning that they are possibly still acquiring this use of theta roles.

The greatest number of errors was made in the third group of test items. 14 out of the 20 incorrect responses involved the selection of the picture with the theta roles of the agent of action and patient reversed. This indicates that the participants making these errors are aware that both objects in the sentences fill a theta role but they are unable to determine the correct relationship between them.

While the sample size is limited, enough data was gathered to begin building a basic timeline of acquisition for theta roles. Given the small sample size, 'mastery' of a level of theta role acquisition is taken to be no errors at that level of testing. When generating the timeline, the data from participants 3 and 6 were left out because participant 3 had a confounding apraxia diagnosis and participant 6 does not have any hearing loss. Both the acquisition of a single argument in an agent of action theta role and the acquisition of an animate and inanimate argument in agent of action and patient theta roles are acquired between 2 years, 6 months and 3 years, 2 months. The acquisition of a single argument in the agent of action theta role has almost half the number of errors as the acquisition of an animate and inanimate argument in agent of action and patient theta roles, which indicates that the acquisition of a single argument in the agent of action theta role occurs sometime before the acquisition of an animate and inanimate argument in agent of action and patient theta roles. Therefore, the theta roles needed to comprehend the first 12 test items in this experiment are acquired by 3 year, 2 months of age. The acquisition of the ability to distinguish two possible agents of action into their proper agent of action and patient roles occurs some time around 4 years, 7 months and 4 years, 8 months.

Discussion

As expected, the performance on test items declined and the number of errors increased as the test items became more complex, which can then be used to produce a rough timeline of acquisition of theta roles. Hearing age was a better predictor than chronological age for the number of errors made during the experiment and was therefore used in the construction of the timeline for theta role acquisition.

This experimental design produced viable data and can be used as a new technique for probing the earliest stages of language acquisition. The field of neurolinguistics is lacking in experimental designs for testing early syntax development. If I had more time and access to a greater number of subjects then I would like to expand the sample size and establish a firm timeline for the acquisition of different aspects of theta roles. I would also like to expand the use of this new technique to probe other aspects of syntax development such as when various principles and parameters are set.

There is a general timeline for the critical period of language acquisition that stretches from prenatal exposure to puberty. Case studies like Genie and the development of NSL have established the general closing for the critical period for language acquisition. Observational studies are also used to determine what and roughly when children acquire certain syntactical features of a language. However, these observational studies are limited by their design to rely upon the participant to produce the structure of interest naturally within conversation. While certain situations can be set up to elicit desired features, this still does not yield a large amount of usable data. In addition, observational studies do not determine if the child comprehends a structure or is merely correctly repeating something heard in the surrounding language environment. Instead of relying on the serendipity of spontaneously produced structures, my experimental design tests the comprehension of theta roles by forcing the participant to make a decision involving the understanding of the overall sentence.

The experiment could be improved by gathering a more complete medical history and related information from the parents. More information could be used to determine possible interfering factors such as possible language acquisition before implantation in the participants with less severe hearing loss. In addition, it would be important to confirm the source of hearing disorder for each participant to ensure that it is congenital and not acquired after the language acquisition process has begun. More detailed information about the home language environment would also be needed to rule out any possible interference from second language acquisition. For example, despite speaking English to their children, the fraternal twins' parent's first language was not English and could be a possible source of second language interference from twins.

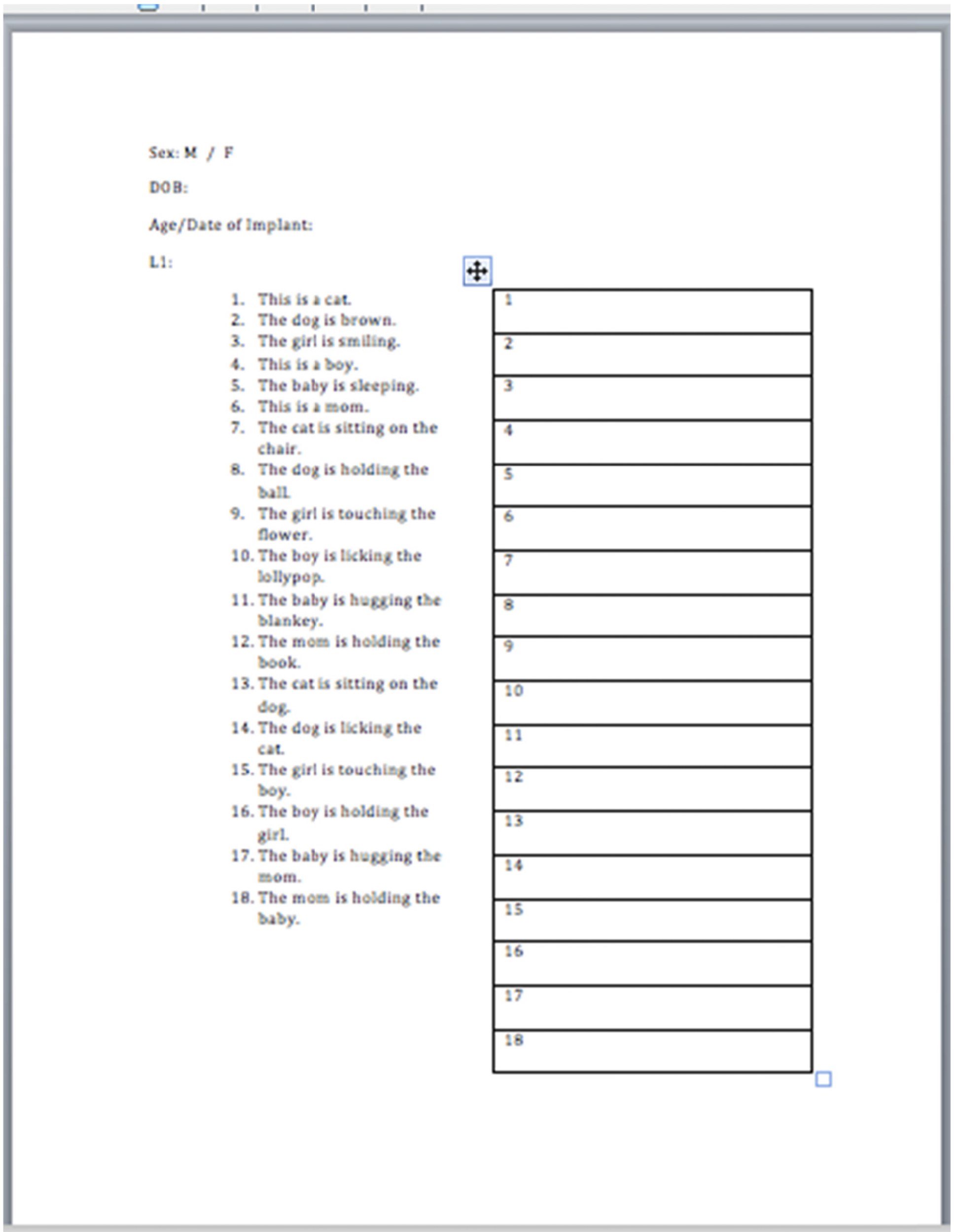
The sample size for this experiment was small, with usable data from only 7 participants. Increasing the sample size would reduce errors and build a more complete and comprehensive timeline for acquisition of theta roles. Another difficulty was determining how to conclude when acquisition has occurred: is it when a structure is produced correctly 50% of the time, or 75% or 100%? Given the small sample size, I set the requirement for considering the acquisition of a feature to be complete at 100% when constructing the timeline.

APPENDICES

APPENDIX A

Figure 1. Blue Muppet-like puppet used in experiment.

APPENDIX B



Sex: M / F

DOB:

Age/Date of Implant:

L1:

1. This is a cat.
2. The dog is brown.
3. The girl is smiling.
4. This is a boy.
5. The baby is sleeping.
6. This is a mom.
7. The cat is sitting on the chair.
8. The dog is holding the ball.
9. The girl is touching the flower.
10. The boy is licking the lollypop.
11. The baby is hugging the blankey.
12. The mom is holding the book.
13. The cat is sitting on the dog.
14. The dog is licking the cat.
15. The girl is touching the boy.
16. The boy is holding the girl.
17. The baby is hugging the mom.
18. The mom is holding the baby.

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Figure 2. Participant Response Sheet.

APPENDIX C

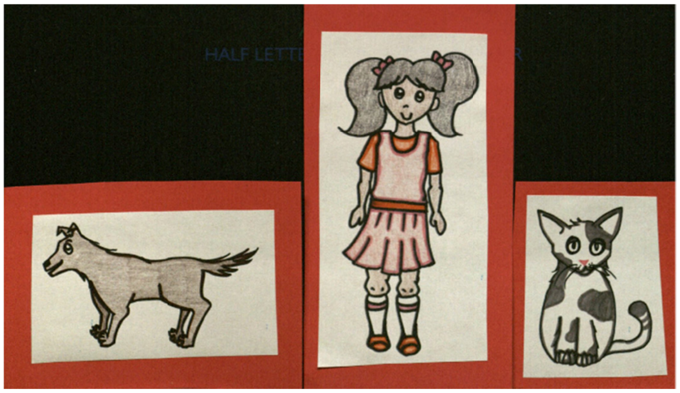

Figure 3. Pictures corresponding to test idem 1: ‘This is a cat’

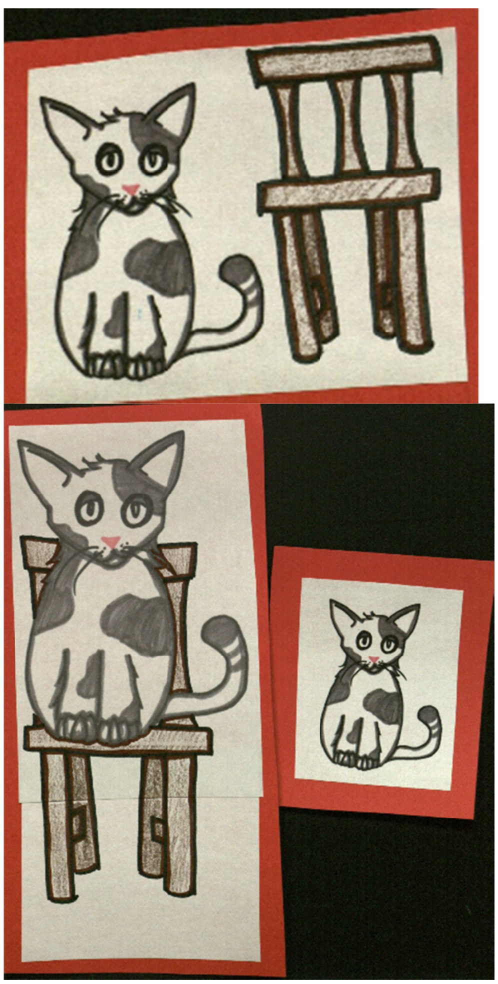

Figure 4. Pictures corresponding to test idem 7: ‘The cat is sitting on the chair.’

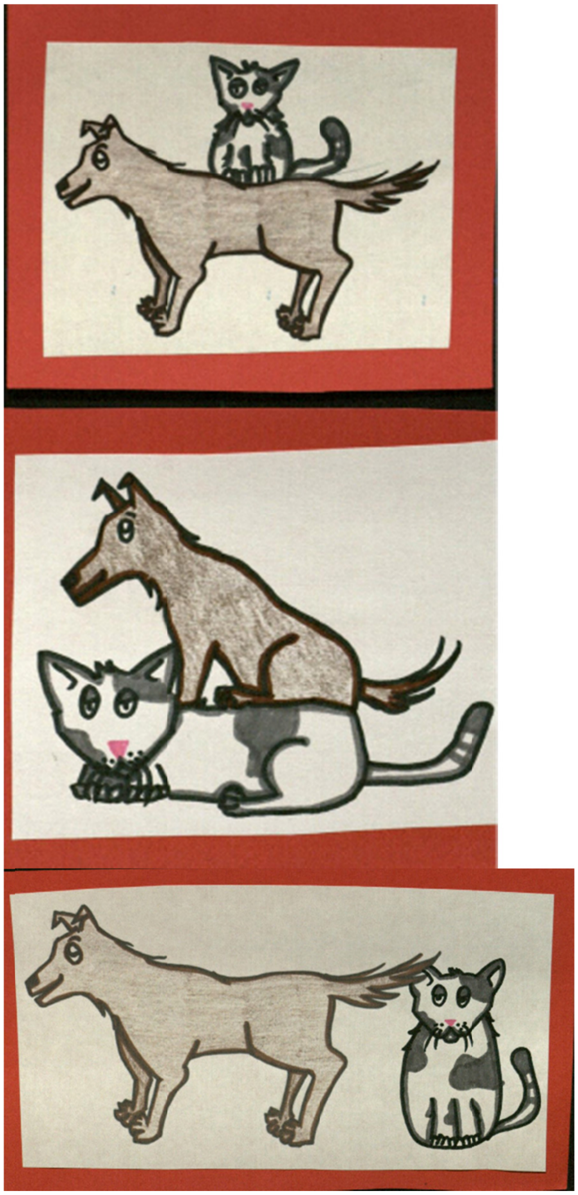

Figure 5. Pictures corresponding to test idem 13: ‘The cat is sitting on the dog.’

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