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ABSTRACT

Five studies investigated the interaction between language acquisition abilities and environmental factors. Subjects aged 5 to 20 imitated synthetic speech stimuli representing English and novel categories. All except the 5-year olds imitated better than was predicted from studies of categorical perception. The 12-year olds performed optimally. Children were studied who were becoming bilingual. When languages were learned simultaneously, children showed fused systems. Children who had already acquired native languages experienced a "silent" period in the new language during which learning occurred. Accent is discussed in terms of motor-theory and psychological factors. Effects of reduced language input were observed in a hearing child of deaf parents. The language was quantitatively and qualitatively different from normal children's. Absence of signing suggested that language must be directed to the child to permit acquisition. Characteristics of the language model presented to children was investigated by analyzing the speech of adults to a 2-year old child or to an adult. When speaking to the child, adults used shorter, less complex sentences, and more questions. The speech of male and female children could reliably be identified as to sex by judges. Differences in formant patterns suggested that children acquire cultural patterns for marking sex-identification in voice. (Author)

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FINAL REPORT

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DEVELOPMENT OF ORAL LANGUAGE ABILITIES FROM INFANCY TO COLLEGE

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Children were studied who were becoming bilingual. When languages were learned simultaneously, children showed fused systems. Children who had already acquired native languages experienced a "silent" period in the new language during which learning occurred. Accent is discussed in terms of motor-theory and psychological factors.

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The speech of male and female children could reliably be identified as to sex by judges. Differences in formant patterns suggested that children acquire cultural patterns for marking sex-identification in voice.

PREFACE

The author wishes to acknowlege the assistance of a number of students and colleagues. I am grateful to Dr. Arthur Abramson, Dr. Alvin Liberman, and Dr. Harry Cooker for their contributions to the study of the effects of age on the ability to imitate speech sounds. Ms. Rosalind Huntsberry carried out the project on second language acquisition in children. Ms. Marie L. Johnson collected the data on the hearing child of deaf parents. Mr. Robert Brown and Ms. R. A. Salerno were involved in the study of adults' speech to children and adults. Dr. Philip Lieberman and Ms. Donna Erickson were co-investigators on the study of differences between the voice of male and female children.

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INTRODUCTION

The development of language competence seems to follow a very different course from that of other abilities. The young child acquires a remarkably complex linguistic system at a time when his general cognitive ability is quite limited. Indeed, most observers agree that the fundamental structure and sound system are mastered by the age of four (Ervin and Miller, 1963). Another way in which language acquisition is unusual is that, in general, cognitive abilities improve as the child gets older (Piaget, 1955), whereas there is evidence that at least some aspects of language ability decline with age. Lenneberg (1967) has suggested that after a certain critical period, normally ending about puberty, one can never learn to speak a language as a native speaker.

To explain these unique properties of language development, it has frequently been suggested that the child does not "learn" language in the usual sense that one learns history or mathematics (McNeill, 1966; Slobin, 1966; Lenneberg, 1967). Rather, language development emerges through an interaction between exposure to a speaking community and certain special language acquisition predispositions. This type of interaction between a suitable environment and a predisposition to respond is characteristic of the development of many kinds of species-specific behaviors (Lehrman, 1962). For language acquisition, these predispositions probably consist of some general learning processes and some processes specific to language learning.

The predispositions specific to language acquisition may influence behavior in two ways; the one permitting the young child to acquire language and the other limiting the acquisition of new language systems after a certain period. It is these two aspects of language that the present research has investigated. We have looked at a variety of language acquisition situations to study 1) the effect of age on speech imitation abilities, and 2) more general language acquisition processes in the child.

THE EFFECT OF AGE ON THE ABILITY TO IMITATE SPEECH SOUNDS

Lenneberg (1967) has suggested that after a certain critical period, normally ending about puberty, one can never learn a language as a native speaker would. Lenneberg has amassed clinical evidence for this hypothesis from data on aphasia, deafness, and retardation. However, the validity of the hypothesis has never been substantiated by experimental research. The following experiment was designed to observe, in a controlled experimental setting, a particular language skill that may change with age. One example of the child's superiority in language learning seems to be in perfecting the pronunciation, or phonology, of the language or dialect being acquired. Speaking with a "foreign accent" is characteristic of adult acquisition of a language.

Slobin and Sachs (1967) tested English speaking children and adults for their ability to hear the distinctions between various pairs of sounds. In one group, subjects heard Arabic words in which all the sound differences were also phonemic in English. That is, the differences necessary for distinguishing between the two Arabic words are used in English, as in meka versus mega. In the other group, the contrast in sounds was phonemic in Arabic, but not in English. The hypothesis was that the difference in performance between the two test conditions would be greater for adult subjects, since they are more limited by the sound system of English. The adults, as hypothesized, had more difficulty with the pairs that contained distinctions that were not phonemic in English. Fourth grade children, on the other hand, had no more difficulty learning to respond to sounds that were non-phonemic in English than those that were.

In the present experiment, we attempted to investigate the critical period hypothesis further, using stimuli and responses that could be quantitatively measured. This research made use of findings which have emerged from the study of speech perception. Since these findings are basic to an understanding of the study, we will summarize the relevant aspects here.

A particular group of speech sounds, the bilabial stop phonemes, were used in the present experiment as a means of assessing subjects' ability to imitate speech sounds. The property that distinguishes between stop sounds at the same point of articulation (for example, /b/ and /p/) is readily quantified. This property is the time interval between the release of air pressure for the consonant burst and the onset of voicing, and can be measured from spectrographic displays of the sounds. In English, a voiced stop such as /b/ has near simultaneity of stop release and voicing onset, whereas an aspirate stop such as /p/ has a delay before the voicing begins. The relationship between the stop release and voicing onset is referred to as voice onset time (VOT) (Lisker and Abramson, 1964).

As well as quantifiability, there are several other interesting features of the VOT distinction which recommended the use of the stop consonants in this research. 1) The voicing distinction seems

to be used in the sound system of the majority of languages. Therefore the use of these sounds in an experiment taps an important aspect of language. 2) Three types of VOTs are found in speech sounds: voicing lead, simultaneity or near simultaneity, and voicing lag. Lisker and Abramson (1964) measured the VOT values in eleven languages and found the distribution of values to be essentially tri-modal, with peaks at -100, +10, and +75 msec. (By convention, leads are assigned negative values and lags positive.) Most languages use only two of the VOT types. As mentioned, English uses near simultaneity and voicing lag. Spanish uses the simultaneous onset and a voicing lead. Three of the languages studied (Thai, Eastern Armenian, and Korean) use all three onset timing relationships. Therefore, studies using the stop consonants could compare speakers of different language types. 3) The parameters of VOT can be controlled so that sounds from any point on the VOT continuum can be generated on a speech synthesizer (Abramson and Lisker, 1965). Thus in the present experiment we could present to subjects not only the sounds that are typically found in languages, but sounds with VOT values between or beyond the three modal values. 4) Research using synthesized stop phonemes has shown that sounds with VOTs between or beyond the mode of the speaker's language are not well discriminated. Abramson and Lisker (1968) studied adults' perception of synthesized stop sounds with VOT values varying in 10 msec steps from -150 to +150 msec. English and Thai subjects identified each of the synthetic sounds presented to them as the nearest phoneme in their own language. Furthermore, subjects could best discriminate between sounds with VOTs on the boundary of the phoneme category in their languages. That is, the subjects could not hear the 10 msec changes corresponding to changes in the acoustic signal, if it did not signal a change from one phoneme to the next. The effect has been called "categorical perception" (Liberman et al, 1957). Although imitations of the VOT continuum had not been reported in the literature, it was expected that imitations by adults would follow discrimination and therefore also be categorical.

In the present experiment, in order to investigate the hypothesis that there is a decline in certain language abilities with age, we compared children and adults for their ability to imitate synthetic speech sounds representing bilabial stops along the VOT continuum. If the ability to imitate the unfamiliar VOT declined with age, this result would support the hypothesis that the child has special abilities that aid him in learning the phonological system of a language.

METHODS

Five age groups of 6 subjects each were tested individually. The age of each subject was within 3 months of 5, 8, 12, 16 or 20 years. The subjects were monolingual native speakers of English, and were volunteers for the study. The subjects imitated 74 synthetic speech stimuli in a session lasting approximately ½ hour. The stimuli had been synthesized at Haskins Laboratory and recorded in randomized order on tapes. The stimuli consisted of synthesized bilabial stop phonemes which varied in 10 msec steps in voice onset

time from 150 msec voicing lead to 150 msec voicing lag. These stimuli were identical to the stimuli used in the perception experiments of Abramson and Lisker (1968). The sounds were presented to the subject on a Tandberg #1521F tape recorder inside a sound-proofed testing cubicle, and the imitations were recorded with both a regular microphone and throat microphone on a two-track Viking tape recorder.

Wide band spectrograms of the imitations were made on a Kay Sona Graph with an expanded time scale, and these were compared with spectrograms of the synthesized stimuli. Voice onset time (in msec) was measured independently by two assistants to the nearest 5 msec, and a score for each imitation was derived by comparing the VOT of the imitation with the VOT of the synthetic stimulus. Assistants who measured the spectrograms were unaware of the subject's age and of the stimulus being imitated. The imitation scores for the various types of stimuli were analyzed to determine the effect of age on ability to imitate the VOTs in the subjects language, the VOT value used in many other languages, and the VOTs that are not typical of any language.

RESULTS

For each S, the 74 response values were correlated with the corresponding stimulus values to obtain a z-score representing overall degree of accuracy. The mean accuracy scores for the 5 age groups are shown in Table 1.

		mean z-score
age group	5	1.35
	8	2.20
	12	2.44
	16	2.50
	20	2.48

Table 1. Mean accuracy scores (z-scores) for the 5 age groups.

The 5-year olds are the only Ss who differ from the other age groups, with markedly worse overall performance.

In order to compare Ss' responses to different parts of the VOT continuum, the stimuli were divided into 12 categories of about 25 msec each. Figs. 1-5 represent the average response value as a function of the stimulus category for the 5 age groups. In these figures, a dotted line represents the response value that would be obtained if imitations were perfect.

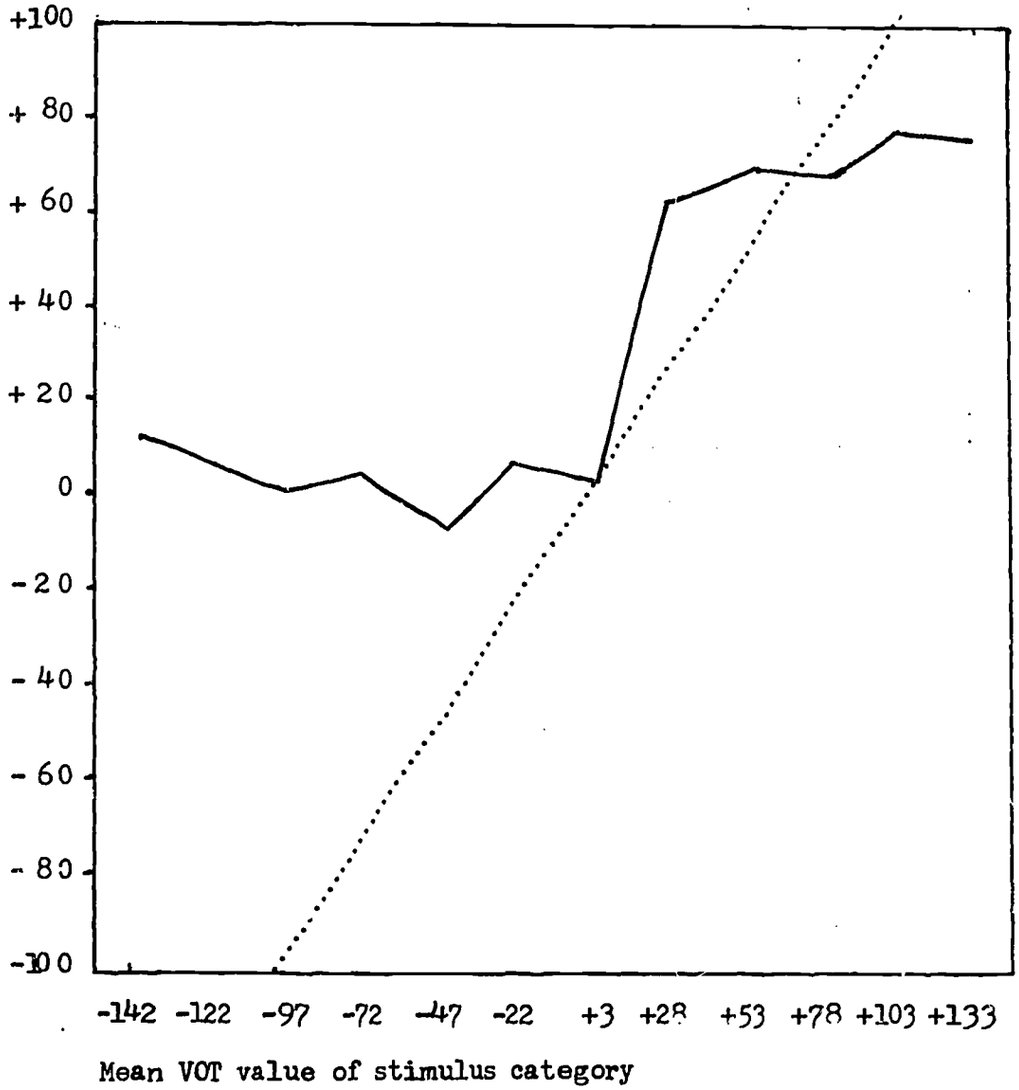

Fig. 1 Histogram of mean VOT value of responses as a function of VOT value of stimulus category, for the 5-year old group.

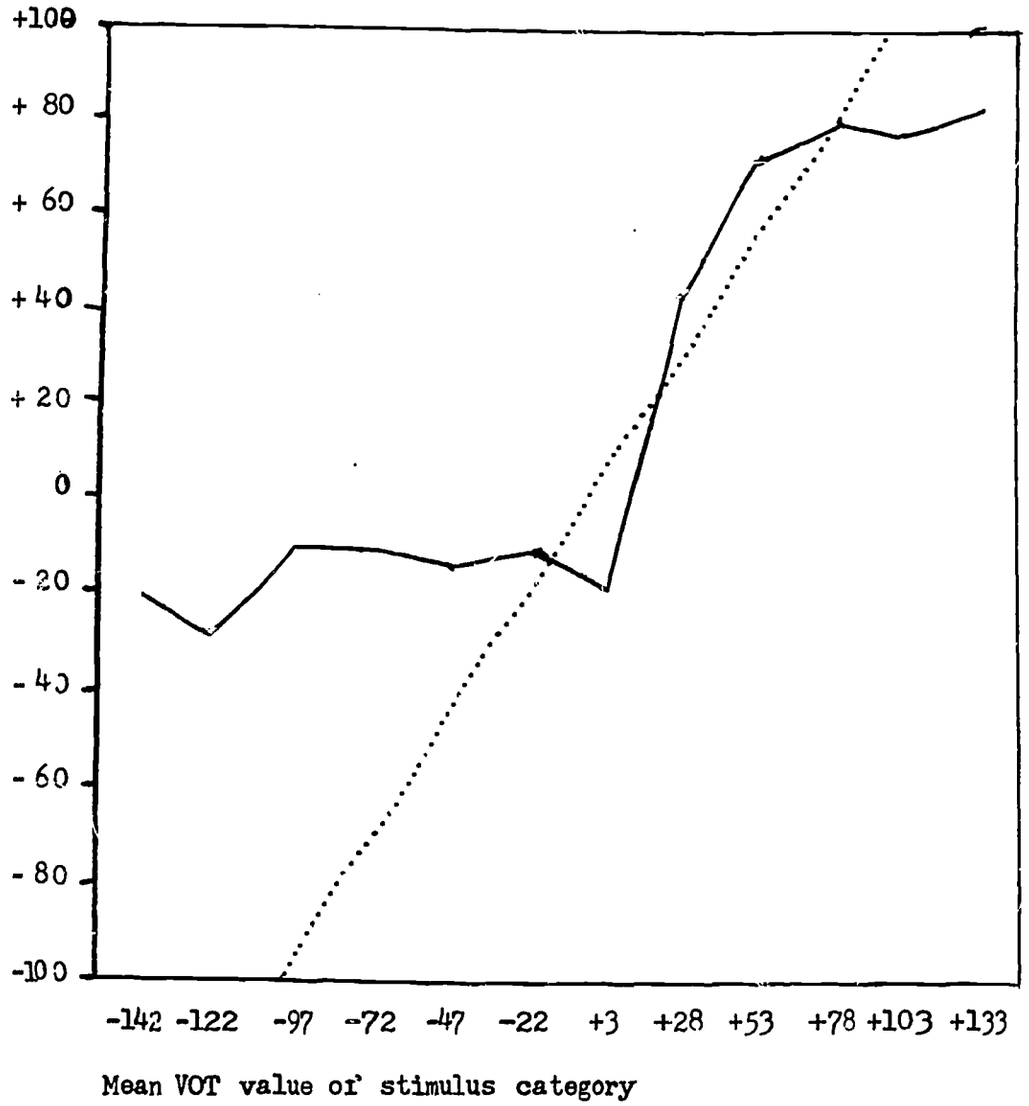

Fig. 2 Histogram of mean VOT value of responses as a function of VOT value of stimulus category, for the 8-year old group.

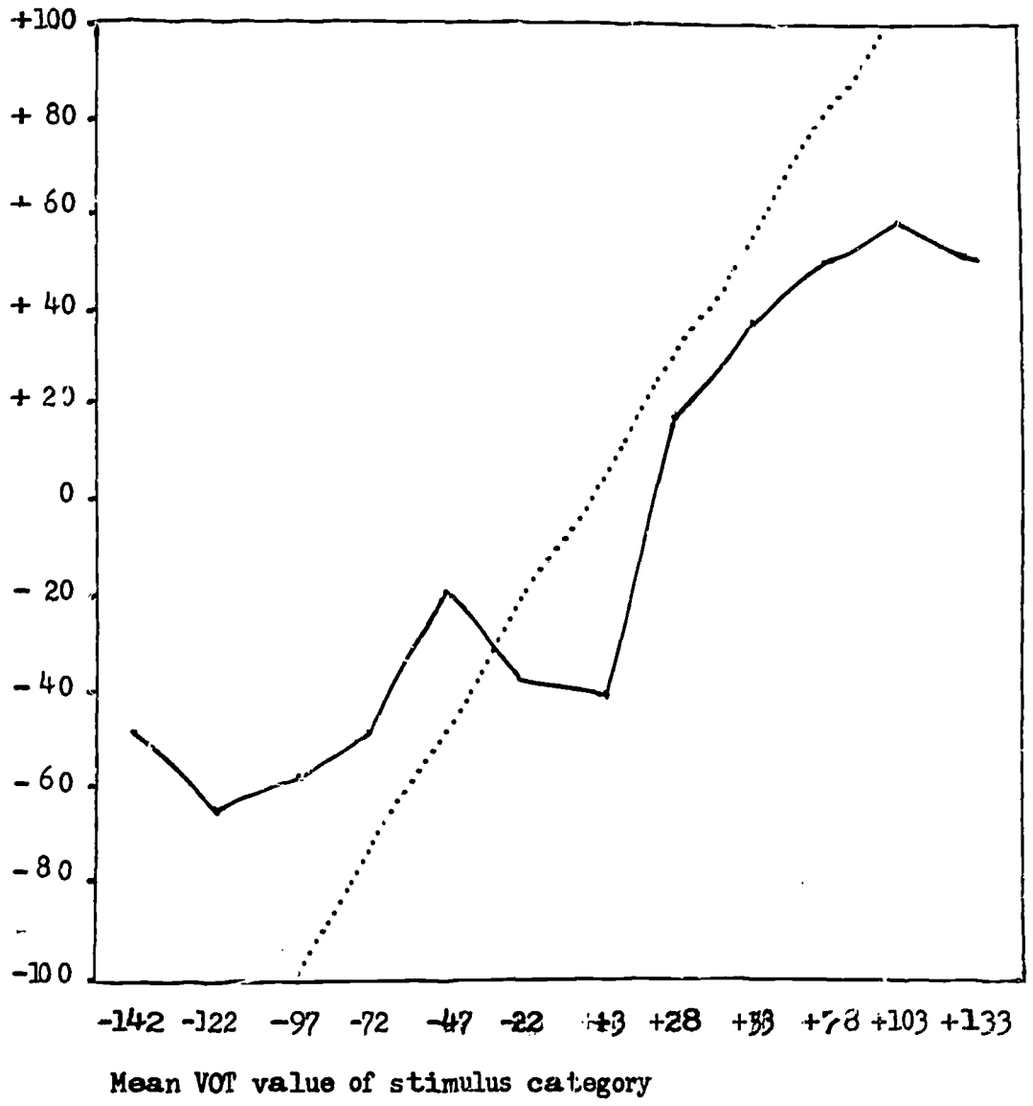

Fig. 3 Histogram of mean VOT value of responses as a function of VOT value of stimulus category, for the 12-year old group.

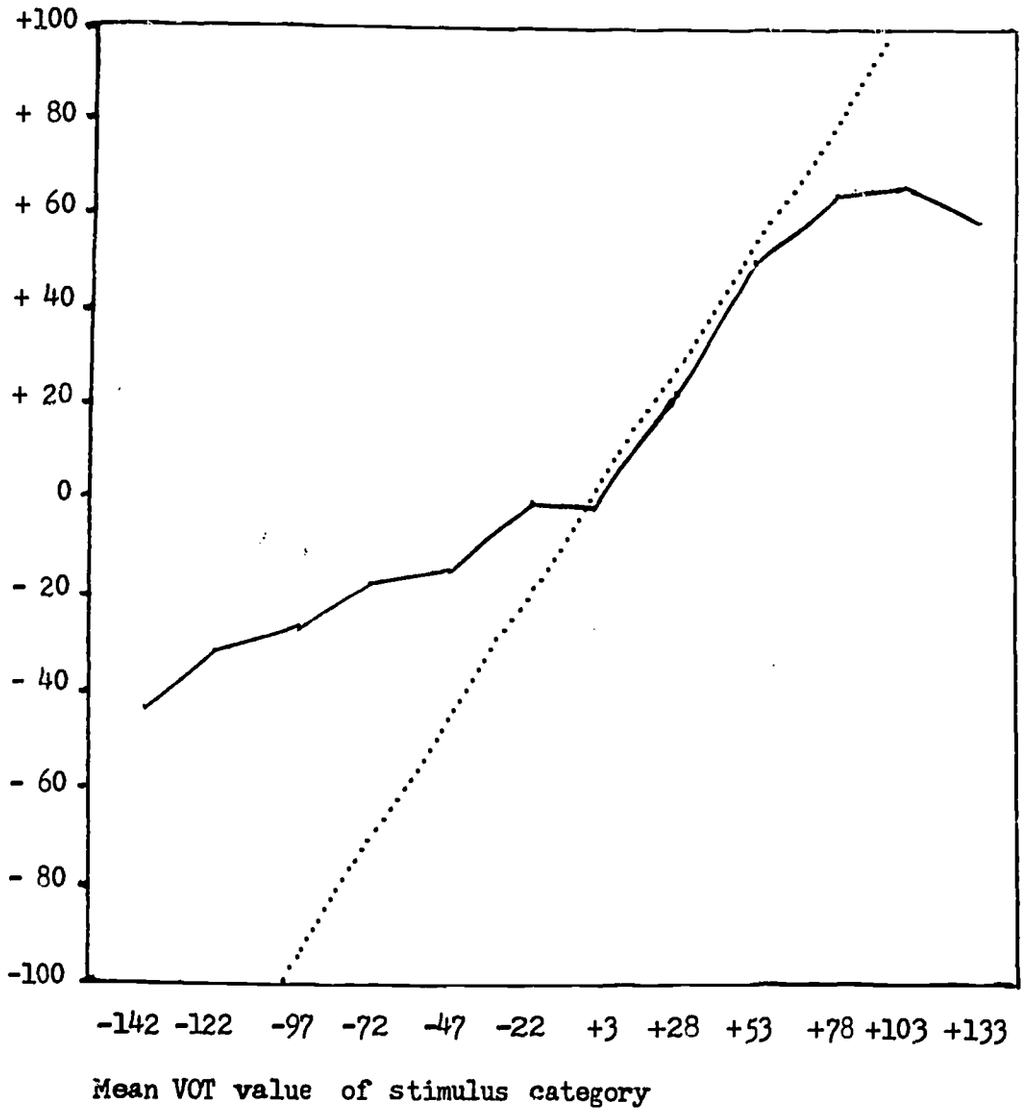

Fig.4 Histogram of mean VOT value of responses as a function of VOT value of stimulus category, for the 16-year old group.

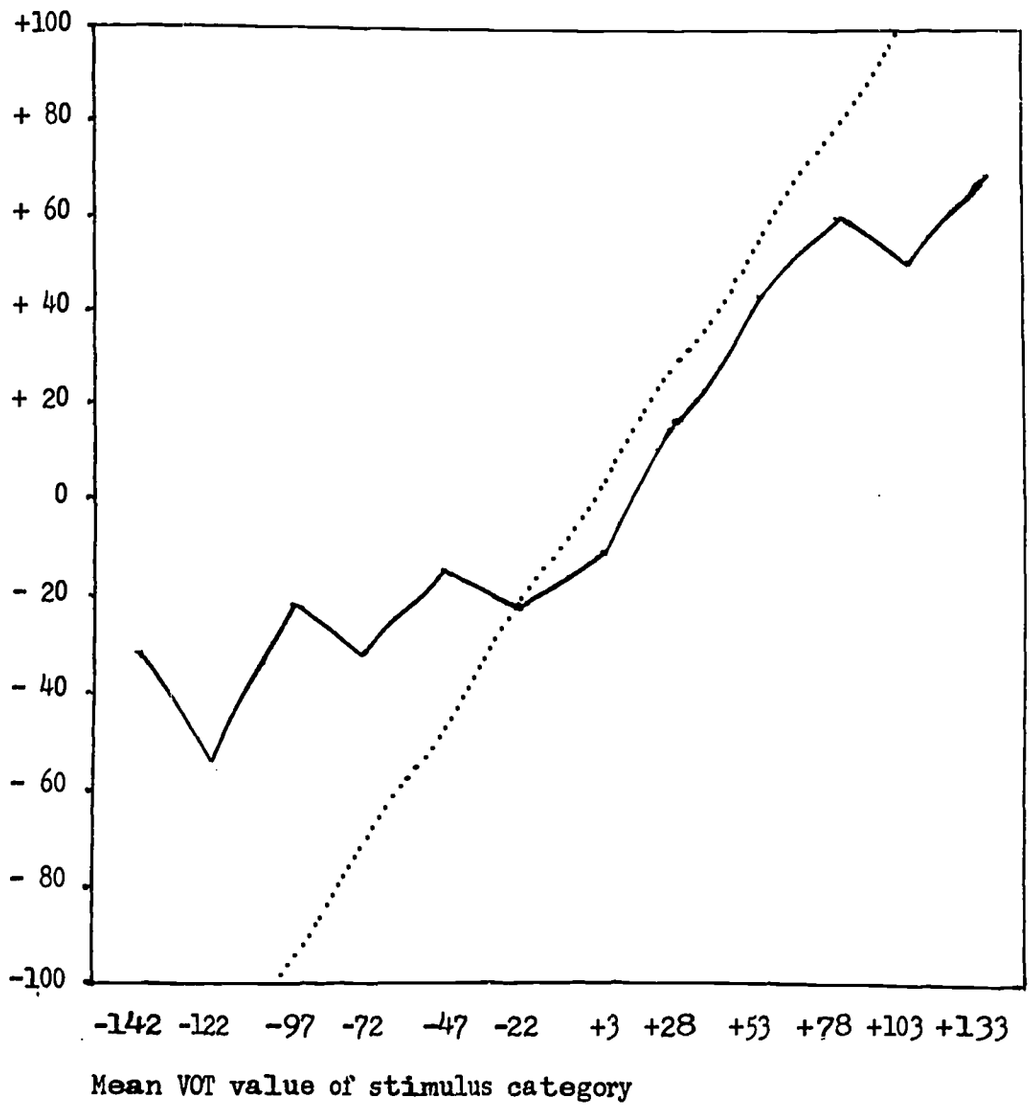

Fig. 5 Histogram of mean VOT value of responses as a function of VOT value of stimulus category, for the 20-year old group.

Completely categorical responses would yield a bimodal response pattern, with responses to all stimuli below about 20 msec being an English /b/ (about 0 msec), and responses to all stimuli above about 20 msec being an English /p/ (about 50 msec). Fig. 1, showing the responses of the 5-year old group, is close to an ideal picture of categorical responses. However, inspection of the other figures reveals that the 12-, 16-, and 20-year olds imitated the stimuli better than would be expected if all Ss were imitating categorically. These Ss, as a group, showed some degree of success in matching their responses to the stimuli they had heard.

Grouped data can be misleading with respect to the categorality of an individual's responses. Therefore, each S's responses were plotted as a function of the corresponding stimulus values. Two correlation coefficients were obtained: 1) for positive stimuli and responses to positive stimuli, and 2) for negative stimuli and responses to negative stimuli. For each S, a frequency distribution of response values was also made. On the basis of the response patterns revealed in these data, Ss were assigned to one of three categories: 1) Categorical responses (responses bimodal, with modes in the range of the English /b/ and /p/, or in the range of the prevoiced /b/ and English /p/), 2) Intermediate responses (not bimodal in the English pattern, but correlations not high), and 3) Non-categorical responses (not bimodal in the English pattern, and correlations between responses and stimuli were high). The number of Ss in each of these categories is shown in Table 2. By this analysis, the 12- and 16-year old Ss are unusual, with no 12-year olds and only 1 16-year old showing clearly categorical responses.

	Categorical responses	Intermediate responses	Non-categorical responses
5	4	2	0
8	4	1	1
12	0	3	3
16	1	2	3
20	3	2	1

Table 2. Number of Ss in each age group classified as categorical, intermediate, or non-categorical in responses.

The stimulus categories that were of special interest in this study are those in which the VOT value for the prevoiced /b/, the English /b/, and the English /p/ typically fall. These are categories 2, 7, and 9, respectively. Table 3 shows the average difference

between the stimulus values and response values for these three categories, for the five age groups. A zero difference score would represent perfect imitation, and the higher the score, the greater the average error. From these values, a score representing the ability to imitate non-English sounds as compared with English sounds was derived by taking the ratio of the average error on the English phonemes categories to the average error on the non-English prevoiced /b/ category. Thus, this imitation ability acore is the ratio of the category 7 and category 9 scores to the category 2 score. This ratio is shown is in last cloumn of Table 3. A higher ratio represent less distinction between the ability to imitate English sounds and the ability to imitate non-English sounds.

	Category 2	Category 7	Category 9	Ratio of English score to non-English score
5	1.95	.45	.48	.24
8	1.47	.47	.46	.32
12	1.10	.80	.42	.56
16	1.56	.34	.38	.23
20	1.44	.56	.34	.31

Table 3. Difference scores (amount of error) for three stimulus categories, and the ratio of category 7 and category 9 to category 2 , for the five age groups.

For the prevoiced /b/ category, the 12-year olds are more accurate than the other groups. Their ratio representing ability to imitate the non-English sounds is also higher. For the other 4 groups, the imitations of English speech sounds is substantially different from (better than) the imitations of the foreign speech sound.

To determine whether improvement in imitations occurred over the 74 test trials, a score for each S was obtained for the differences between stimuli and responses for the first 20 and last 20 trials. Of the 30 Ss, 24 improved from the first trials to the last. Table 4 shows the mean difference (error) score for each age group for these trials. The 8-year olds and the 20-year olds improved significantly ($t = 2.51$ and $t = 2.93$, respectively, $p<.05$ for both groups). The maximum difference between first and last trials was found for the 12-year olds. All of the groups benefitted, to some degree, from the practice gained over the 74 test trials, in spite of the fact that no feedback was available as to the accuracy of their imitations.

	First 20 trials	Last 20 trials	Difference	T-test for difference
5	.98	.78	.20	2.40
8	.88	.76	.12	2.51
12	.99	.73	.26	2.22
16	.85	.71	.14	1.92
20	.85	.68	.17	2.93

Table 4. Mean difference between stimulus and response for the first 20 trials as compared with the last 20 trials, for each age group.

DISCUSSION

The present study was designed to investigate the hypothesis that children have special abilities to acquire new phonological categories, and that these abilities diminish as the child approaches puberty. We will first discuss the youngest age group studied, the 5-year olds. The results do not support the hypothesis that young children are better than adults at imitating synthetic, bilabial speech sounds along the VOT continuum, or that they are relatively better than adults at imitating the non-English (prevoiced /b/) sound. In fact, the youngest age group, the 5-year olds, had the poorest accuracy of imitation overall and also the poorest accuracy of imitating the prevoiced /b/ stimuli. Though the 5-year olds improved over the 74 test trials, they remained the least accurate imitators when only the last 20 responses are scored. Four out of the 6 children in this group were classified as giving clearly categorical responses, and the grouped data shown in Fig. 1 presents an almost ideal picture of categorical responding. The 5-year olds, then, perform very poorly on this task with respect to abilities to imitate novel speech sounds. Whatever their actual ability may be for acquiring new speech sounds and phonological systems, the ability is not so general that it is reflected in the present task.

The present results show that the 5-year olds had acquired the phonological categories used in English to distinguish between /b/ and /p/. They change from /b/ to /p/ responses at just the point that would be expected from the adult identification and discrimination results (Abramson and Lisker, 1968). With the methodology used in the present study, we can draw no conclusions about the children's ability to perceive the VOT differences that do not signal a difference between /b/ and /p/ in English. Either they do not hear the other differences in the stimuli, or if they do, they have inadequate control of their production to match the non-phonemic VOT values.

If children are able to acquire new languages and accents, why did this study not find the 5-year olds imitating the prevoiced /b/ category better than they did? There are many possible reasons. Perhaps the young Ss did not understand the instructions. Perhaps the task was so far removed from the normal language acquisition situation that the mechanisms for acquiring new speech sounds were not engaged. For example, the sounds were not presented in a language context. There was very little external motivation in this task. No reinforcement was given, and no feedback as to the accuracy of the imitation. Older Ss may have been sufficiently motivated by the instructions which urged them to imitate as well as possible. The 5-year olds may need some better reason to want their speech to sound like the sounds they hear. Hanlon (1971) showed that young children were more likely to change certain characteristics of their own speech to match a character's voice if that character played the "nurturant" role in a puppet show. Also, it is well known that children who are exposed to more than one language often "choose" one language to speak, and refuse to speak the other even though they may comprehend it.

One interesting aspect of the young children's performance in this experiment was not readily quantifiable. That is that the children seemed to imitate certain "voice quality" characteristics of the computer synthesized speech. It is possible that some Ss imitated what they were attempting to imitate very well, but that they had focused on a cue that was not the relevant one in the experiment.

Part of our lack of understanding of the language acquisition process is clearly our lack of understanding of the variables that are involved in starting and controlling the sound acquisition process. Finding young children to be more language bound than the "critical period" hypothesis predicts is not without precedent. In pilot studies carried out for the Slobin and Sachs (1967) experiment, it was found that 2nd graders were worse than 4th graders, 6th graders and adults in several language learning and discrimination tasks. Yeni-Komshian, Zubin and Afendras (1968) studied a 5-year old and a 20-year old who were attempting, over a course of many trials, to learn the Arabic voiceless fricatives /x/ and /ḥ/. They found no support for the hypothesis that the child would show better language learning skills.

Looking at the other groups, most surprising is the relative lack of categorical responding in the older Ss. Although there had been no reports of imitations of the VOT continuum by adults in the literature, it was expected that their imitations would follow their perception, and therefore be categorical. As can be seen from the grouped data presented in Figs. 3-5, from the analysis of individual Ss presented in Table 2, and from the learning data presented in Table 4, the 12-, 16-, and 20- year old Ss do not simply respond with the English /b/ and /p/ to every stimulus.

Another recent study has shown that completely categorical perception is not found with all methodologies. Port and Yeni-Komshian (1968) tested two groups of Ss for their perception of stimuli along the VOT continuum by having the Ss place the stimuli along a graphic rating scale. The control group's responses indicated that they

perceived categorically. The experimental group was trained by listening to an ordered set the the stimuli one time. Some of the trained Ss changed their mode of perception, and became more sensitive to the real acoustical differences among the stimuli, therefore scaling the stimuli in a more linear fashion. Other trained Ss remained categorical in their perception. Port and Yeni-Komshian argue that certain Ss can shift out of the categorical mode, and that their free-response task enabled those Ss to demonstrate their perceptual abilities. The technique used in the present study - imitation- also shows that Ss can perform better than one would predict from the earlier perception data. A few Ss perform very well, as indicated by high correlations between stimulus and response values. It would be interesting to study such Ss to attempt to determine what is involved in their abilities to perceive and imitate the acoustical properties of the stimuli.

The 12-year old Ss were different from the other age groups in several ways. No S in that group responded in a clearly categorical manner. The 12-year olds imitated the prevoiced /b/ category better than the other Ss, but their imitations of the English categories were not better. They showed the largest improvement in imitation scores over the 74 trials. This pattern of results may indicate that the 12-year olds were better than the other groups at imitating non-English speech sounds. If 12-year olds can be considered still within the "critical period" discussed by Lenneberg (1967), these data could be taken as some support for the hypothesis. Perhaps the abilities of the 5- and 8-year olds were masked by the artifical experimental task, whereas the 12-year olds retained their language acquisition abilities and were able to understand the instructions, were internally motivated to imitate well, and had better "test taking" skills. Whatever the explanation for the outstanding performance of the 12-year old group, the result is interesting since adults perform better than children of this age on most psychological tasks.

In summary, the present experiment found some support for the critical period hypothesis, with 12-year old Ss imitating non-English speech sound more accurately than did older Ss. However, the two younger age groups tested (5-year olds and 8-year olds) did not perform as well as the 12-year olds. The 12-year olds may combine language acquisition abilities that older Ss have lost with abilities to perform well in an experimental situation that the younger Ss have not yet acquired, thus performing at an optimal level on this kind of task.

SECOND LANGUAGE ACQUISITION IN CHILDHOOD

It is commonly believed that children can learn a second language easily. Lenneberg (1967) speaks of a "critical period" during which other languages can be acquired through the special language acquisition functions. After this period, ending about puberty, a second language may be learned, but with more effort and with less chance of ultimate fluency.

On the other hand, Smith & Braine (in press) suggest that the language acquisition process is the same for children and adults, but that several factors make direct comparisons difficult. First, the criteria for success are vastly different for the child as compared with the adult. A child is described as fluent when he can communicate at the appropriate level for his age. This level probably is far below the adult's in terms of vocabulary and sentence complexity. The adult must communicate with other adults about complex matters, and his deficits show up more readily. Secondly, it is difficult to hold constant such factors as motivation to learn and exposure to the second language across different age groups.

To support their view, Smith & Braine report census data (Bachi, 1956) of language use in immigrants to Israel as a function of age at time of immigration and length of time since immigration. The study showed a drop in use of the new language for those who immigrated after thirty, whereas the "critical period" argument of Lenneberg (1967) should predict that the drop point would come around puberty.

In an experimental study of teaching Russian commands to different age groups (8-, 10-and 14-year olds and college students), Asher and Price (1967) found that the oldest group performed far better than the children. Though these results are contrary to the critical period hypothesis, such a study might have masked the language acquisition abilities of the younger subjects because of the special skills involved in the experimental situation.

Though there are many speculations, there has been little detailed study of the child learning a second language in a natural setting. We have begun such a project, studying children who already have acquired some of their first language, and are now being exposed to a second. The research described here was carried out preliminary to a detailed longitudinal study now underway of English acquisition in two children (a 3-year old Chinese-speaking girl and an 8-year old Japanese-speaking boy).

We were interested in variations in reactions to the second language task and used a case study technique to gather data from a number of children. Though this research does not include comparisons with adults learning a second language and thus, cannot answer the "critical period" question directly, we feel more understanding of second language acquisition patterns in children is a necessary prerequisite for an attack on that question.

METHODS

Fourteen children between the ages of three months and thirteen years were studied. One of these was the investigator's daughter, who is a native speaker of English, but had spent two years in Japan. The other

thirteen were children of parents who previously resided in countries outside the United States, but were now associated with the University of Connecticut.

Interviews were held in English with the children, and tapes were made of their spontaneous conversation and reading. The parents were asked to evaluate the children's performance in both their native language and English, and to give additional information about the language environment. Language environment were classified as compound or coordinate according to criteria described by Lambert, Havelka and Crosby (1958). A "compound" bilingual is one who learns both languages in a single environment; a "coordinate" bilingual is one who learns two languages in separate contexts, so that the two languages rarely come into contact with one another. The language acquisition pattern of these fourteen children was also compared with a diary study of bilingual development, Leopold's (1939) study of his daughter, Hildegarde.

RESULTS AND CONCLUSIONS

Description of each child

1. Joan, 4 yrs. 6 mos. English/Japanese. The investigator's child spent two years in Japan, from ages two and a half to four and a half. She thus learned Japanese in a co-ordinate environment. Once in Japan, her contact with English speakers was confined almost entirely to the home situation. Her first words in Japanese were "itai" (it hurts) and "dame" (stop it, that's bad.) At the end of the two years, performance in Japanese was more refined than was her English, although she was probably slightly below that of the normal Japanese child her own age.

2. Kathy, 9 hrs. Hungarian/English. Upon her arrival in the U.S. Kathy had entered Storrs Grammar School three months previous to the interview. She had had no previous exposure to English. She had acquired a vocabulary estimated to about 200 words. She had just begun to put together some short sentences. Her comprehension consisted chiefly of simple commands, though it may be presumed that she also understood some utterances common to her classroom situation. Her /r/ sound was the only noticable accent. It was reported that her exposure to English was considerable--about eighty per cent of her time was spent with English speaking persons. Kathy's attitude was extremely enthusiastic. Her parents reported that she wanted to go to school even if she was sick. She was able to begin reading sentences after three or four weeks in school, but her speech had not yet progressed beyond isolated words. Kathy's mother spoke no English. Her father, a fluent speaker, tried to help her with school work and short sentence constructions, but ordinarily English was not spoken in the home. First words learned were reported as "stop," "walk" and "don't walk" (streetcorner signs.)

3. Tinku, 2 yrs. Punjabi/English. Also newly arrived in this country. Described as able to put four to five words together in Punjabi. In three months time he picked up only a few words in English. His exposure to English was from playmates in the neighborhood, and he tried to speak English to the other children, even though he knew only words, and speech fragments. When other children said something he did not comprehend, he always said "No--no." His vocabulary in English was estimated at 25-50 words plus a few phrases such as "I don't know" and "Come on."

4. Peggy, 23 mos. Chinese/English. Born in the U.S., though both of her parents came from Formosa. Her contact with English had been through one or two neighborhood playmates. She was already putting together strings of as many as five to seven words in Chinese, but her mother noticed that she used English words interchangeably with Chinese. Her only negative form was the use of the English "no", which she used in her spoken Chinese: "no sui-cha" (no shopping)--this type of negative was volitional, to demonstrate something she didn't want. Instead of the Chinese "buiya", she preferred "uh-uh" or "I don't want to."

5. Mariapas, 3 yrs., 9 mos. Spanish/English. The youngest of four children from Chile. The family had spent two years in this country and lived in compound linguistic environment. English was spoken outside the home, of course, but also when guests came to the house. In addition, the children now preferred to speak English to each other at home rather than their native Spanish. The mother estimated that the children spoke about 50% English and 50% Spanish. Mariapas, however, was estimated to speak 30% English, 30% Spanish and 40% her own inventions. Mariapas understood both English and Spanish, but (like Hildegarde, age two to two and a half) her speech contained a mixture of both languages, and differentiation had not yet taken place. Unlike other children in the study, Mariapas' play experience and contact with other children was mostly at home. Neighbor children came to play, but not on a regular basis. Her brother reported that she tried to answer in English when it was spoken, and often invented words that she thought sounded like English to use in her replies. Her spoken English did not have a characteristic American accent, though her mother indicated that her accent on Spanish productions was normal. Mariapas was still speaking in short sentences and phrases. Her linguistic development, in general, resembled that of Hildegarde at a much younger age. Family members said she was "lazy" in speaking, since she could make herself understood well enough at her level of development. Because of the compound environment, all family members understood both her Spanish and English productions and could fill in the rest from context and constant contact with Mariapas. So far, Mariapas had not found it necessary to communicate extensively with monolingual persons from either the English or Spanish environment.

6. Maria Loreto, 7 yrs., 6 mos. Spanish/German/English. Older sister of Mariapas. She had attended kindergarten in a German school in Chile and had learned a little German before coming to the U.S. At the time of the interview she was a balanced bi-lingual. She rated her abilities in English as best in comprehension, followed by speaking and writing, with reading being the most difficult. She spoke English without any trace of accent. She sounded like any normal seven year old American child in casual conversation. Though most of her English exposure had been at school, she used English in the neighborhood, watched television and often spoke English with her brothers and sisters. For a period of six months after arriving in the States and beginning school, Maria Loreto did not speak a single word in English. She began reading in English before she began speaking. Once she began to talk, she spoke in full-blown sentences, using appropriate grammatical structures. Her mother reported questioning her about why she never talked at school, and the

child had replied, "I'm listening, Momie. When I know how to talk, I'll talk."

7. Paul, 12 yrs. Spanish/English. Brother of Mariapas and Maria Loreto. The only child in this family with exposure to English before coming to the U.S. Paul attended primary school through the fifth year in Chile, and attended an English class from the first year on. His bi-lingual status was balanced, and his use of English forms and idoms was impressive. On certain words, it was possible to detect a slight difference in pronunciation of the vowel /a/. This might be the only trace of Spanish influence which could be detected in his speech. He remarked that he noticed he was beginning to forget some words in Spanish; a signal that more exposure to English might result in English dominance. He felt that he had the "same personality" in both languages and that there was little problem in adjusting to life in this country. He rated comprehension as his highest ability in English, saying that reading and speaking gave him no difficulties, but that he felt they were intrinsically more difficult skills.

8. Maria, 13 yrs. Spanish/German/English. Eldest child of the Chilean family. She had attended a German school in Chile, along with Maria Loreto. Having studied German for six years, she spoke it very well at the time she arrived in the U.S. Her mother rated her vocabulary as more developed in Spanish than in English but noted that she gets "A in school in English," as well as other subjects. At the time of this interview she was spending a great deal of time listening to the radio and watching television when she was not at school. Maria's mother said that Maria had also gone through a period of silence at school. Maria's mother said that it lasted for one or two months, considerably shorter than that of Maria Loreto. Unlike the other children in the family, Maria was very anxious to return to her friends in Chile, and is reticent to participate fully in social life with her American friends.

9. Sareta, 5 yrs. Hindi/English. Hindi speaking parents. Sareta spoke English at school and with her playmates. Communication with her younger sister was also via English. Sareta and her sister were both born since their parents departure from India, so that there has been a long period of English exposure. Even though their parents speak Hindi to each other, Sareta understood Hindi, but had begun to prefer English. She could be classified as English dominant. She exhibited no accent. She expressed herself well in English. Neighbors reported that the mother often spoke in English to her children, a fact that probably classifies the family as compound rather than co-ordinate

10. Veneta, 23 months. Hindi/English. Younger sister of Sareta. Pre-bilingual, has only recently begun putting two words together. Most of her vocabulary items are Hindi, but she mixes English words, and comprehends simple statements in English by Sareta.

11. Karine, 7. Chinese/English. In her third year of school (2nd grade) in this country. Her parents reported that she learned English at school. In the beginning she was extremely shy, and in fact, went a whole year before saying even a word to her teacher. It was only a couple of months, however, before she began trying to speak English

with her schoolmates. In spite of this breakthrough, she was not confident at school, and was often tearful, until once when she received all A's on a report card. From this point on, Karine took on the new culture wholeheartedly, and her parents quietly complained that she had become so Americanized that she was developing neither the humility nor modesty they would hope for. Karine's expressive English seemed advanced, even for an American child of her age. Her mother is a writer, and Karine demonstrated her own talents for the interviewer by reading some of the short stories she had written and illustrated. Karine's mother had begun teaching her to read in Chinese, and since Chinese was spoken at home with her parents, Karine may probably be considered a balanced bi-lingual.

12. **Karwina**, 5 yrs., 6 mos. Chinese/English. Karine's younger sister. Though she spoke English and Chinese about the same amount of time as her older sister, Karwina now demonstrated a preference for English. The two children communicated to each other in English. Karwina was just beginning to speak when the family moved to Connecticut. Karwina first learned Chinese, and played mostly at home. It was after Karine had already established a place for herself in the neighborhood that Karwina joined her sister and then proceeded to learn English. An observer from International House reported that Karwina always clung to her mother in public, and that she was almost three and a half years old when she finally began to play with other children at social gatherings. Even at this time it was observed that Karwina seldom talked herself. Parents reported that the first words of both children were "bad words" such as "Cut it out", "you brat", and "Stop it."

13. Kathy, 6 yrs. Korean/English. Came to the University of Connecticut from Korea in 1969. Kathy attended kingergarten and spoke clearly and confidently in English. She was aware that her development in English was ahead of her mother's. Though her mother spoke to her in Korean, Kathy preferred to answer her mother in English, in the presence of the interviewer. Her mother stated that when Kathy began school the previous fall, she was not confident in English. Kathy's accomplishments, like many of the other children, had come with entry into school. Kathy did not establish playmates outside the house for about six months after their arrival in this country. Her mother said that she would sometimes go out to play and after looking around, she would return home. After this period she began learning single words, names of people and objects and her mother felt that fluency was attained around nine months to a year later (this would be some months after school had begun.) Kathy reportedly practiced her English on her brother, who began picking up English from her, piece by piece.

14. Bobby, 3 yrs., 6 mos. Korean/English. Brother of Kathy. Understood both English and Korean, but spoke only in English. His English was a remarkable imitation of his sister's style, detailed and deliberate. Bobby used isolated words and short phrases from Korean in his speech, his mother said, but interference in English was negligible. He used no Korean forms in the presence of the interviewer. Bobby did not utter a word in any language, however, until he was three years old. His mother remarked that rather than ask for something he wanted or needed, he retained a kind of stubbornness and

would learn to answer his own needs. An example of this was that at two, he went to the refrigerator and poured his own glass of milk. Bobby's expressive English reflected a rapid acquisition of rules. He asked many questions, used "he" for "she" and left off final "s" forms on some expressions. These kinds of language features are common in English speaking children Bobby's age. His communication skill was excellent. What seemed remarkable in his case was that only a few months ago he had been silent, and that almost his entire language acquisition up to this point had been taken from the model provided by his sister. (Bobby was enrolled in a nursery school, but only attended three hours a week.)

Generalizations

Table 1 summarizes the data for the fourteen children. Generalizations, of course, must be speculative since they are based on a small sample. Furthermore, we find peculiarities of development which may reflect differences in personality as well as differences in language environment. For example, it was reported that Maria Loreto did not speak any English for six months after arrival here, though when she started to speak she could say full sentences.

In all cases where beginning language environmental input consisted of more than one language (Hildegarde, Peggy, Mariapas) expressive language consisted of words appearing in both language systems. This suggests that in the early stages, language input remains undifferentiated. The child does not appear to comprehend that his input consists of a split presentation, so he makes no conscious distinctions. In addition, the child's productive syntactic structure differs from his comprehensive structure in that while he can understand the meaning of two given words for the same referant, (Hildegarde's bilingual competition) or the use of two different forms (Peggy, negative) the child focuses on one symbol or one form to convey his intended meaning. This suggests a productive limitation which, although it does not interfere with his language receptivity (comprehension) can be said to affect his knowledge of the language which allows him to produce meaningful utterances. We have, as of yet, no samples of children just beginning to learn languages in a co-ordinate environment, where context would separate the languages by separating the experience. Peggy's language learning most closely approximates this possibility, but it must be admitted that her parents have given her some assistance and encouragement in vocabulary and phrases in English. It might be hypothesized, however, that despite separate environments, fusion of linguistic input might be expected at early stages of language development. If this were the case, early expressive language might be viewed as a semantically based symbol system which appropriates any comprehended form (and many of these apprehensions might be limited by cognitive maturation) which would help convey the intentions of the speaker.

Another point made clear by looking at the speech of bilingual children is that the language that dominates the experience becomes the dominant language of the individual over time. Language development by Joan, Hildegarde and Paul suggests that while growth of vo-

cabulary and forms in one language is occuring, the language not in constant use either remains at the same level of development, grows only very slowly, or may even deteriorate, particularly in expressive capabilities. Comprehension abilities do not appear to be seriously affected, unless a language falls into disuse for a number of years. Since children's dominant language can fluctuate according to environmental input, and environmental pressures, bilingual language learning offers support for the idea of the importance of environmental experience in language development.

The role of imitations and expansions as a central element in the learning process is brought into question by the language learning experiences of Maria Loreto and Bobby. Both children produce syntactically well-developed speech, yet both children went through extended periods of silence, after which their language seemed to emerge, almost in full bloom. These children may somehow have gone through the trial and error process of rule acquisitions internally, imitating mentally even though they refused to speak in social situations. The role of these periods of silence which occurred in almost every bilingual's language change, demands more attention and closer study. What mental "switching" processes were at work during Hildegarde's week of silence after her return from Germany? Does silence allow particular learning mechanisms to function more effectively? For instance, during silence, comprehension capabilities, which appear to make the foundation for language growth, can be concentrated on without the added complications and overload of productive speech. Is there a period in normal child language development (for instance the period of one word utterances?) during which a similar kind of growth is occurring?

We have seen, also, in the compound versus co-ordinate distinction, that the language learning process may be quite different according to these circumstances. Although it is recognized that any bilingual must develop two syntactic systems (and this appeared to be precisely the problem of Mariapas), compound bilinguals like Mariapas, Paul and Hildegarde (before age five) may demonstrate more fused semantic systems than do co-ordinate bilingual children. An interesting question might be whether or not certain cognitive capacities, developed by a co-ordinate, would necessarily be reflected in his other language. Would a four year old Russian-English bilingual develop the "if-then" constructions in both languages at the same time, or would this construction have to be touched off experientially in the second language for it to come into productive use in his rule system? Certain personality "splits" can often be noted in bilinguals--how and to what extent is language involved in, and a mental reflection of, the "split presentation"?

A remaining question is that of accent. How does learning of a second language by a child take place without accent carryovers? The earliest speech of Hildegarde contained German, English and mixed sounds. Yet she spoke English without accent and later, German. Recent study of auditory feedback mechanisms suggests that information which helps us discriminate between various sounds we hear in language is not simply the acoustic information carried by the sound production. Feedback carried from the sensorimotor system reflecting the movements necessary for producing a "p" sound, for instance, is part of the information used by individuals in order to distinguish a "p" from a "b" sound. If this is the case, patterns of hearing and identifying sounds would be formed while learning a native language. These patterns might then be used in the processing of a new sound pattern from another language. A person learning a new language would thus make the sound he thinks he hears in the new language, but information he gets about the sound is incomplete because he hears the sound partly as something he already produces. He may be unable to distinguish between his production of the sound, and that of the speakers around him, except as he is informed of incorrect pronunciations. People moving from one area of the country to another often retain their accents. After some years in the new environment they no longer perceive their speech as different from the speech of those around them.

However, we may be able to account for the accent carryover from one language to another, and the absence of this carryover in children, in psychological terms. In the case of Hildegarde, her peer group during her stay in Germany, spoke what Leopold called a "mechanical" German, and she picked up this speech style. Conformity with the peers during these early childhood years is a cherished objective. This type of "over-imitation" was also seen in the case of Joan, who assumed body gestures of her Japanese playmates. One such movement was a "pidgeon-toed" walk. This walk had not been noted in early physical development and it disappeared after her return to the United States. The father of one bilingual child interviewed reported that his little girl was very talented in mathematics, and was always the first one in the class to understand, until she perceived that this separated her from her group. Her desire to be one of the group was so strong that she feigned errors on her arithmetic papers so that she would not be singled out for achievement. All children interviewed who were school-age shared this type of sensitivity about their status as "foreigners," and there seemed to be no end to energy given towards mitigating this position. Strangely, the situation seems the reverse for the adult, who has already internalized his culture, and formed his identity within a certain cultural context. The expression of the self is, of course, "self-expression". Maintaining an accent, in this regard, could very well be associated with maintaining a sense of separateness, so he can remember "who he is". Whereas the identity of a child is fused with social reality and determined by it, the adult may need to preserve something which separates him from the environment of the new language and its procedures and requirements. Language is, perhaps, a chief mode. Actors are persons skilled in the business of imitating accents and personality characteristics. Their business is to "assume" the identity of various types of people. It is understood that in the theatre, roles are only pretending. In real experience, taking on a new language and a new personal identity carries with it not only the fears of failing to create a new and different personal and cultural identity, but the threat of losing the established one. These pressures could be as powerful for the adult as are pressures to conform for children.

Table 1. Summary of data from children interviewed.

BILINGUAL CHILDREN

Name	Age	Native Country	Linguistic Environment	Degree of Bilingualism	Accent	Interference
Hildegarde		U.S.	Compound (early)	Balanced at 6 yrs.	No	Yes
Joan		U.S.	Co-ordinate	Japanese dominant at 4.7 yrs.	No	No
Kathy	9	Hungary	Co-ordinate	Pre bilingual, 200 words, after 3 mos. in U.S.	rolls /r/	Yes
Tinku	2	India	Co-ordinate	Pre-bilingual, 25 50 words, after 3 mos. in U.S.	—	—
Peggy	23 mos.	Formosa	Co-ordinate	Pre-bilingual, uses 5-7 word utterances in Chinese	—	Yes
Paul	12	Chile	Compound (Eng. in school)	Balanced, after 2 yrs in U.S.	/a/ sound	No
Mariapas	3.9	Chile	Compound	30% Eng., 30% Spanish 40% invented	?	Yes*
Maria Loreto	7.6	Chile	Co-ordinate	Balanced, after 2 yrs. in U.S.	No	No
Maria	13	Chile	Co-ordinate	Balanced, after 2 yrs. in U.S.	?	No

*Sample of Mariapas spontaneous speech:

Jo (I) can't ne can't, Jo can do esso,
You want here, I want to go to bed, Loreto,
go to the basto (grass) and see a dog, —
much of her speech is incomprehensible to outsiders

BILINGUAL CHILDREN cont.

Name	Age	Native Country	Linguistic Environment	Degree of Bilingualism	Accent	Interference
Bobby	3.6	Korea	Co-ordinate	English dominant, after 2 yrs. in U.S.	No	No
Kathy	6	Korea	Co-ordinate	English dominant, after 2 yrs. in U.S.	No	No
Veneta	23 mos.	India	Compound (probably)	Pre-bilingual	---	---
Sareta	5	India	Compound (probably) recently	English dominant after 2 yrs. in U.S.	No*	No
Karin	7	Formosa	Co-ordinate	Balanced, after 3 years Mother teaches her Chinese	No	No
Karwina	5.6	Formosa	Co-ordinate	English dominant after 3 years in U.S.	No	No

*Sareta uses a th/s substitution in spoken English

LANGUAGE DEVELOPMENT IN A HEARING CHILD OF DEAF PARENTS

Lenneberg (1967) reported that he had observed several hearing children of deaf parents, and he concluded that "language onset is never delayed by this dramatically abnormal environment, even though the quality of vocalization of the preschool children tends to be different; children very soon become 'bilingual' in the sense that they use normal voice and speech for hearing adults and abnormal voice and 'deafisms' for their parents" (p. 137). If this conclusion is correct, the special language acquisition ability must be remarkably resistant to disturbance by deficiencies in the input. We were interested in studying the effect of reduced language input in a hearing child of deaf parents, and if language development was delayed, the effect of an intervention program at age three years, nine months.

METHODS

John, a hearing child of deaf parents, was seen in seven sessions over a period of four weeks.* At the time of first interview he was 3 years, 9 months. Samples of his spontaneous speech in sessions with the investigator were recorded. During these sessions, the investigator talked with John, but did not attempt any structured language stimulation. John's language and motor abilities were assessed at the first session and at the last. The assessments were based on observation, analysis of the tape recorded samples, Peabody Picture Vocabulary Test for comprehension of single words, Templin-Darley Screening Test of Articulation, the ITPA Subtest of Auditory Sequencing, and developmental items from Gesell and Binet.

John's mean length of utterance (MLU) for each session was computed, using Brown's (1970) criteria, so that language samples could be compared with those of a normally developing hearing child of hearing parents. The language samples for such a child, Nomi, had been collected and transcribed earlier. Six samples from John and Nomi were matched on MLU.

John's mother was interviewed, mostly through writing but with some speech, regarding the parental background, John's previous history, and John's current abilities. The teacher at John's preschool was also interviewed.

RESULTS AND DISCUSSION

Background information. John's mother was congenitally deaf as a result of maternal rubella. His father acquired deafness at age two or three, reportedly from pneumonia. Both parents had very limited oral speech. The mother attended the Maine School for the Deaf and the father attended the Mississippi School for the Deaf. The father was employed as an assembly worker. There was a younger sibling, 16 months,

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* The data were collected by Marie L. Johnson and reported in Johnson (1971).

who also had essentially normal hearing. The mother and father communicated with each other in manual sign language, but the children seemed not to attend to the signing (according to the mother). The mother expressed a negative attitude toward sign, and did not expect her children to use it. The parents reported using speech, primarily single word utterances, in communicating with the children, although they did use some pantomime gestures such as hand clasping for "go wash your hands." Generally, interaction between the mother and child was nonverbal. John sometimes spoke to his mother, and made no attempt to use sign or gestures. There were no hearing relatives or friends to provide verbal stimulation for the children. John played infrequently with neighborhood children. He watched television occasionally.

According to his mother, John babbled for a while at about six months, but she did not observe any other speech until about two years, six months. He then started saying a few single word utterances. The mother said that she tried to get John to say words for things, but he wouldn't imitate her utterances. The words he picked were primarily from TV commercials, such as "Kool Aid."

John's hearing was tested at the onset of the project. There was a slight conductive deficit in the right ear because of a cold. The hearing in his left ear was normal. There was no unusual medical history reported.

At three years, John had started attending a preschool, but he was terminated by the preschool personnel after a few months because of his lack of language and the suspicion that he was severely retarded. At 3 years, 8 months he was entered in a program for handicapped children. There were nine other children in the class which met for two hours five times a week. The teacher had no special knowledge of language development or ways to encourage language acquisition, and the class was oriented toward group activities rather than individual contact. The teacher considered John a very quiet child, who did not speak spontaneously and responded with one word to questions, but understood simple commands and responded well to the class routine.

Results of Pre- and Post-Tests. Fig. 1 shows the language assessment profile for the first and last sessions, a little over one month apart. John showed improvement on all abilities assessed over the period in which he was seen by the investigator. These improvements may be due in part to the individual language stimulation and models she provided for him.

One striking characteristic of John's speech initially was its "flatness" or lack of affect. He spoke very softly in a monotone. By the end of the one month period, these characteristics had improved.

Comparison of Language Samples with Another Child's. When John's samples were matched to another child's on the basis of mean length of utterance, it was apparent that John's language was not qualitatively like that of a younger child. The Appendix contains a sample from

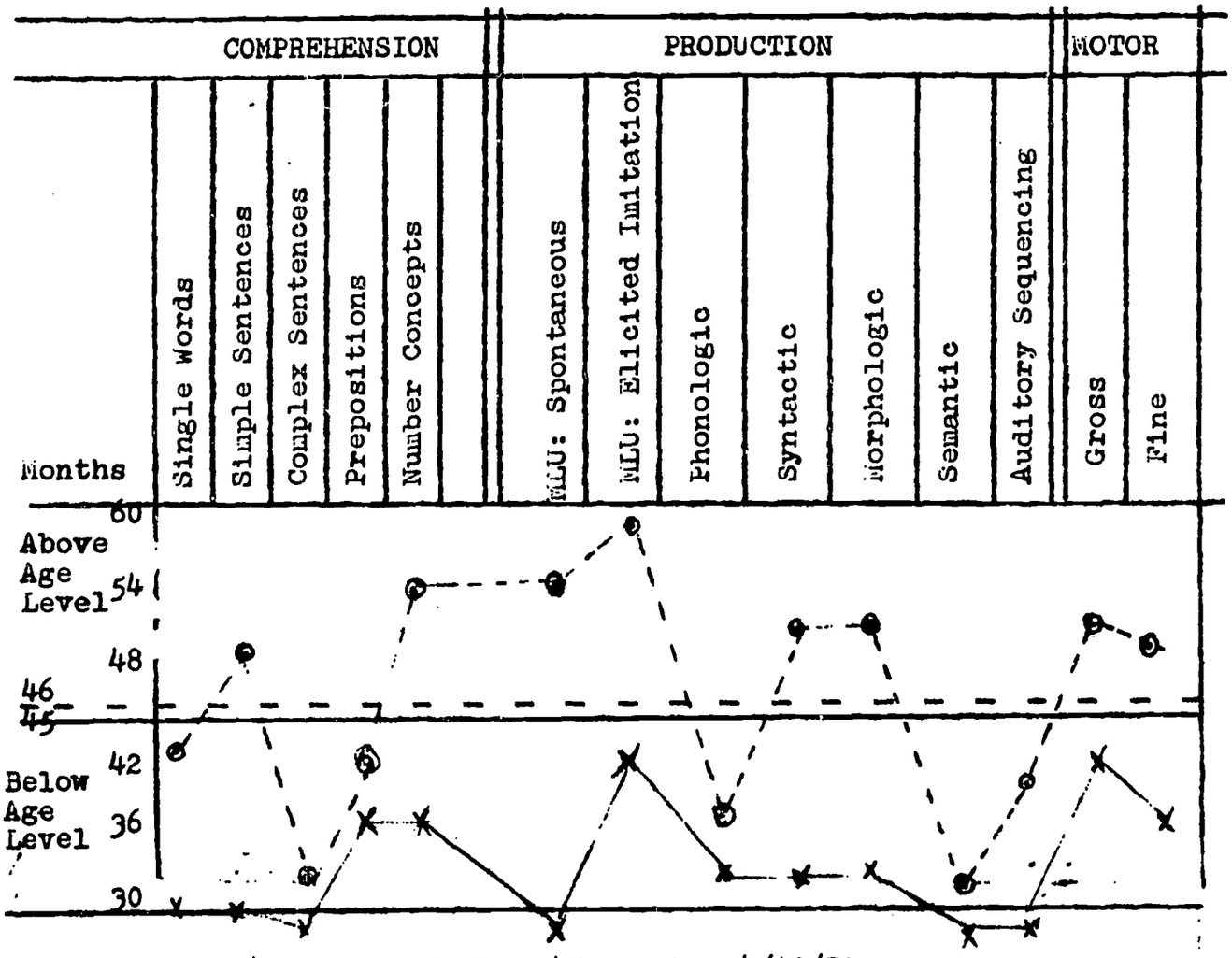
LANGUAGE ASSESSMENT PROFILE

Date: 4/13/71 - 5/18/71 Name: John

D.O.B.: 7/6/67 C.A.: 3 years 9 months - 3:10

Investigator: Marie L. Johnson, Speech, Hearing and Language Clinician

ABILITIES ASSESSED



COMMENTS: X_____ At C.A. 45 months, 4/13/71

●_ _ _ _ At C.A. 46 months, 5/18/71

This assessment based on observation; transcription of tape recorded samples; Peabody Picture Vocabulary Test for comprehension of single words; Templin-Darley Screening Test of Articulation; ITPA Subtest of Auditory Sequencing; Developmental Items from Gesell and Binet.

Fig. 1 Language Assessment Profile for John, showing pre- and post-stimulation results.

John at MLU 2.88, age 3:9; from Nomi at MLU 2.88, age 2:2 ; and Nomi at MLU 3.19, age 3:9.

John shows some linguistic behavior characteristic of a child with his mean utterance length. For example, he does not use many inflectional endings (that chair for "that's a chair"; car fall for "the car fell." He frequently forms negatives by placing the negative word external to the main sentence (no go in house; no have one). He sometimes forms questions without reversing the subject and verb or auxiliary verb (where plane is? why you came off?) or by simply changing the intonation contour on the declarative word order (eat supper?; boy push the girl?) He frequently uses the objective case for a pronoun subject (me play in that; them crash).

In spite of these similarities, the majority of John's utterances have characteristics unlike that of the typical child at that mean utterance length, and certainly unlike the typical child of his chronological age.

John often seemed to be trying to express rather complex ideas with limited formal language skills. In one instance, the investigator asked "Do you like to play ball?" John replied My mommy my house uh play ball. The meaning of this unusual utterance seemed to be "I play ball at my house with my mommy." The investigator's interpretations "You play ball with mommy?" and "At home?" were answered by Yeah, at home play ball.

In another case John was looking at a picture of two houses, and said: house, two house, not one house, that two house. Similarly he said of a picture of a house with windows: not window two window. Although John did not have the conventional inflectional marking for plural in his language system, he was clearly aware of plurality and seeking a way to express it.

The following are other examples of the disparity between his language and thought:

That car it go truck ("that car crashed into the truck.")
What's that been have? (What did that one have?")
Thats a thing goes that go in the house ("that's a thing that goes in the house.")
That a what goes that? ("what does that do?" or "where does that go?")
That go at up the sky? (Does that go up in the sky?")
My home my big horse ("I have a big horse at home.")

It seems likely that John's cognitive development was far ahead of his language development. In a normal environment, as a child acquires new ideas he also acquires the language to express these ideas (e.g., see Cromer, 1968 for a description of the acquisition of the English tense system). In John's case, his environment did not provide the language models, and we hypothesize that he was trying to express concepts rather typical for a child of his chronological age with an extremely limited linguistic system.

Furthermore, although John was reported by his mother as not signing, it is possible that he had some ability to understand sign. Some of the unusual constructions in his language may have been due to interference from the system used in sign. For example, it has been reported that sign uses a freer word order and a great dependence on context for clarification of semantic relations (Slobin, personal communication). Some of John's utterances had these characteristics; for example:

Fall that back and That fall back ("that falls back.")
I want that make ("I want to make that.")
Where the wheels plane? ("Where are the plane's wheels?")
Where is it plane? ("Where is the plane?")
In that class is David ("David is in that class.")
This one open it ("open this one")
Can't open it this ("I can't open this.")
Wheres it another one ("Where's another one?")
Dump that out airplane ("Dump out that airplane."
No miss the bus not (No, we didn't miss the bus.")

In the English speaking children that have been studied, it is unusual to find word order that does not reflect standard English order, especially with regard to the subject-verb-object order. Some children exhibit reversals in the two-word stage (Bowerman, 1970) but by the time sentences of several words in length are used, the order of the words used in a sentence is typically that found in adult language. Of course, we must be cautious in our generalizations about the normal language development pattern since so few children have been studied.

The report that John and his younger brother did not sign is interesting. It is generally thought that children of deaf parents become bilingual in sign and speech. Perhaps these children would eventually, or perhaps their knowledge of sign was much greater than was believed by their mother. In any case, the absence of signing in the children may have reflected a negative attitude toward sign on the part of the parents. When an observer was present, the mother did not sign to John or his younger brother, but did sign to her husband. The mother may have felt, when she knew her child could hear, that he should not learn sign language. This would reflect a common attitude toward sign that prevails among educators of those with hearing handicaps--that sign should be withheld so the child will be motivated to use his residual hearing and learn speech as much as possible.

We have tended to assume in the past that the child simply "picks up" the language he is exposed to, and that no special modification of the input is necessary for the child to abstract the language patterns. John's case argues against that view in two respects. First, with regard to sign, although we cannot come to any definite conclusions about his knowledge of the system, it seems safe to assume that he didn't have the competence that would be expected of a deaf child of his age. Perhaps, as mentioned above, this was a reflection of his

parent's negative attitude. The negative attitude could have influenced his learning in that it caused his mother not to sign to him, not to interact with him in sign the way a deaf mother typically would with a deaf child. Perhaps exposure to the signing between his mother and father was insufficient for learning the system of sign.

Similarly, John had been exposed to speech, but typically not speech directed to him individually, as a hearing mother would while interacting with her child. Perhaps exposure to TV, playmates, adults speaking to one another, and a relatively group-oriented nursery school did not provide John with the type of input necessary for learning the system of English. Though he had some vocabulary and structure at the first session, the improvement over the four weeks may be a reflection of the individual, personal type of language stimulation he received.

In conclusion, our study of one hearing child of deaf parents leads us to an opinion contrary to Lenneberg's. In this case, the lack of appropriate exposure to language had a quantitative and qualitative effect on the child's language development. Since the child had heard TV and speaking people frequently, we suggest that such non-personal exposure to language was not sufficient for him to abstract the underlying structure of the language.

APPENDIX

Sample from John at age 3:9, Mean Length of Utterance 2.88.

John	Investigator
what that?	
	I don't know. What is that?
plane?	
	Yes, those are airplanes.
oh.	
plane. plane uh car?	
	There're the cars again.
plane. what there plane.	
	You want to play with the planes?
yep.	
open that.	
can't open it this.	
	You can't open it?
can't do this.	
this one open it.	
	You did open it?
look at all the plane.	
can open that plane?	
where the wheels plane?	
take it off.	
off.	
that wheels.	
this not take off plane.	
	That plane has wheels.
this is how uh plane.	
where is it plane?	
	Huh?
where plane is?	
	Where are the wheels?
not wheels.	
right there wheels.	
	Yes, that one has wheels.
that go at up the sky?	
	Yes, it goes up in the sky.
That?	
	Where?
that the back?	
	Those are the wings.
wings?	
where there back?	
	One wing, two wings.
that enough two wing.	
	Right, and that's the tail.
tail. that tail.	
that?	
	That's part of the tail.
suh part of tail.	
	Right.
it go down?	

there crash it.
airplane go.

Uh-huh

it go up the skies.

Show me how the airplane goes.

not go. uh oh. not broke that.

Show me how it goes up in the sky.

Wow. And what kind of noise does it make when it goes?

no. go back. see that see.
airplane don't go up.
odf. can't go. can't go.

That one can't go?

can't go. me nother one.
where's nother one?

Like that? I don't know if there's another one like that. Let's see. Yes, here's one like that.

uh can't go.

No wheels.

this way. down. (scream)

That's going backwards.

that go backward.

Right, that's the way it goes.

that backward this way.

Yes, right. That's the way it goes.

uh can't go. go.
uh can't fall on that.
it get broken.

It didn't break.

yeah uh go crash.
that crash. that kite.

Like a kite. Yes, a kite goes like that.

not a car. get broken.
go get another one car.
yeah. it broken that fun.

You had a crash between the airplane and the car.

that car it go truck.

It crashed the truck.

crash on the truck.

Yeah.

it fall that back.

Fall the back?

yeah.

The truck fall the back?

yeah. gotta fix this all.

Did you fix it?

yep. nother truck.

Another truck?

what 'n that back?

That's for pulling something.

where is it another one?
ah not broken. can't fall out.
dump that out airplane.
take this off. take it off.
go back make this circle.
uh go fix these.
what's that been have?

What?

what is that four?

What is that for?

that four.

Let's see.

that four.

Four, or is that a three?

that a three?

It's a three. That's a three.

that four.

That's four.

that's a four.

Yes, that's a four. What's that one?

that on.

Let's see.

on.

Three.

three.

That's a three.

wha that fall down.

Yes. Let's see if they all have numbers on them. Yes, look at that. What's that number? Look. What number is that?

number.

What number?

that number.

Number four.

number four.

That's a number four.

crash em by back.

Look at that one.

that?

That says five.

five?

Five. 1, 2, 3, 4, 5.

Sample from Nomi at age 2:2, Mean Length of Utterance 2.88.

Nomi	Investigator
	Are you looking for Georgie? He's right up there.
way up there.	
Georgie sit here.	
Baby, sit here. Baby, sit here.	
	Do they want something to eat?
yogurt. yogurt. yogurt.	
	Georgie wants to eat yougurt?
Georgie eat yogurt.	
	Does Georgie like yogurt?
oh Georgie's tired.	
	Does Baby like spaghettios?
spaghettios.	
	Did Baby finish all her spaghettios?
Baby has spaghettios.	
	Baby has spaghettios, yea. Did Baby finish all her spaghettios? Are the spaghettios all gone?
all gone.	
do you wnat some more? o.k.	
wha you want?	
dinner? o.k.	
	Nomi, can you say "What does Baby want?"
what's Baby want?	
	What's Baby want?
what's Baby want?	
	What's Baby want?
I'm dancing.	
	Say, "What does she want?"
Wha she want?	
	What do you want, Nomi?
What do you want?	
	No, what do <u>you</u> want, honey?
I like the cake. the cake.	
	Do you like spaghettios?
get up. I want get up here.	
	Hard to walk on there, isn't it?
I want get up here.	
what do you want?	
what do you want?	
sit up. sit up.	
Baby sit up. Baby sit up.	
Baby sit up. Baby sit up.	
	She is having trouble sitting up.
sitting up.	
	What does Agra have on?
Agra has on.	
	What does Agra have on?
black.	

	Right. What does Baby have on?
what's Baby have on?	
	What does Baby have on?
what's Baby have on?	
	What do you think? What do you think she has on?
belly button.	
	Belly button.
belly button.	
	Does he have naything on? Does Baby have anything on?
Baby has belly button. belly button. sit there.	
	Does the Baby have no clothes on?
no clothes on.	
	He has no clothes on.
get clothes.	
	Does the Baby have shoes on?
Baby has shoes on. o.k.	
	What are you going to do for the Baby?
what's in there?	
	That shampoo. Are you going to shampoo Baby?
what's in there?	
	Shampoo. I think you have enough shampoo left. Are you going to wash Baby's hair?
Baby hair. Baby, I'm brushing Baby	
	Georgie's hair is king of a mess. What can you do with Georgie's hair?
sit up, Georgie. sit up, Georgie. sit up, Georgie. what's in there?	
	Shampoo.
sit up. sit up. bend over. bend over. I spank Georgie. I spank Georgie.	
	What did Georgie do?
I spank him.	
	What did Georgie do to get a spanking?
Georgie come here. Georgie come here.	
	Was Georgie bad?
Georgie's bad.	
	Did Georgie cry?
Georgie cry.	
	When he got a spanking.
yep. yep.	
	Did Nomi hold him then? Hold him and make him feel better?
feel better. feel better. I spank Agra. A spank Agra. lay down. feel better. I spank Baby. I spank Baby.	

what's in there?

Nothing.

nothing.

Are you shampooing Mommy?

yep. I spank mommy.

Was Mommy bad?

mommy bad. hugging mommy.

Oh, Mommy feels better.

lie down. I spank Georgie.
you naughty boy. you naughty
boy. spank you. spank you.
I told you. I told you.

You told Agra. What did you tell Agra?

lie down.

Lie down and be good?

be good.

Go to sleep?

sleep. Agra. look it.

Agra's all wrapped up.

wrapped up.
go lie down here.
look at the flower.
petal. that's right.
this is petal. petal.
and it's green. pink.
brown. don't want that.
o.k. I find flowers.
finding Georgie's flower.
finding Georgie's flower.
finding Georgie's flower.
I broke it. I broke it.
look at that. I find petal.
look at that. look at that.

Oh, look at all the flowers Nomi found.

look at that. look at that.

Oh, did you take all the petals off the flowers?

yep. Daddy?

Daddy had to go out for a few minutes.

where's Daddy?

He had to go out for a few minutes. He had to go over to the lab.

broken.

Broke the flower.

yep. what's Mommy doing?

Nothing.

o.k. what's that?
what's that? what's that?
look at that. another one.
and another one. throw it in
the garbage. put in garbage.
I put it in the garbage.

You put it in the garbage.

Sample from Nomi at age 3:9, Mean Length of Utterance 3.19.

Nomi	Investigator
my truck is getting some more dirt. where is the beads?	
	The beads? I don't know. Where did you? I saw it over there a little while ago. Did you find it?
pick it up. put it in the truck.	
	Did you find it?
nooo.	
	Come over and sit at the table to play, honey. I can get you some more toys. If you come up here you can use this as a road.
don't do that. I want to get more. what is this?	
	What do you think?
that?	
	What do you think that is?
a puzzle.	
	No, what's that thing you've got in your other hand?
I want to play with it.	
	O.K.
corner. where's the corner	
	Corner?
yeah. how about this corner. what is this part of? the zebra? the zebra's leg. and this part of the zebra? what? this is. what is this?	
	You didn't look at it, did you? We'll have to wait until it's all made, honey. What do these look like over here?
I don't know. feet! and this. feet look like a face.	
	They look like a face?
yeah, a face. what's this? that's not giraffe. that's a zebra.	
	Right.
push that.	
	Is this harder than most of your puzzles at home? What kind of a place is it where lots of animals live? What's it called?
a zoo.	
	Yep. Did we go to the zoo ever?
yes.	
	What did we see?
I don't know.	
	You don't remember?
no.	
	That was a long time ago, wasn't it?

I don't know.
is that...? no. is that?

Did we have fun?

that doesn't go there.
is that go. yeah. hey.
puzzles sure does.

Nomi, do you ever look at the pictures when you're doing puzzles? Or just the shape?

this is elephant.
this is a elephant.

Where?

this is a horse.
is this a horse?
is this a horse?

Could you say some sentences while you're doing this?

turn this all over.

Would you say some things after me while you're doing that?

no. after.

After you finish? No, that's going to take a long time. That's a pretty complicated puzzle.

would you help me?

Yeah, I will if you'd like me to.

SOME CHARACTERISTICS OF ADULTS' SPEECH TO CHILDREN

It is clear from the past decade of research on child language development that children do not learn language by memorizing sentences or merely imitating adult speech. The child has the ability to discover the patterns of the language from the spoken utterances he hears. An attempt to explain the nature of this ability has been a focus of developmental psycholinguistic research. Many researchers have emphasized the difficulty of the child's discovery task and the abstractness of the linguistic rules the child must discover. Concentration on these aspects of the problem has led some theorists to conclude that the child has a rich innate knowledge of language universals. The interest in "innate properties" and "universals" has sometimes been accompanied by a relative lack of interest in the characteristics of the language input the child receives. McNeill (1966), for example, claimed that the major role of the parent's utterances was to provide data so that the child could test his hypotheses about language, hypotheses that were already sharply constrained by the child's knowledge of language universals. McNeill thought that the speech of adults to children was a "random, haphazard sample, in no way contrived to instruct a child on grammar" (p. 173). Bever, Fodor, and Weksel (1965) argued against Braine's theory of contextual generalization, which they felt depended in part on the primacy of the active declarative sentence form in the child's linguistic environment. They claimed that "there is little evidence that adults engage in a careful limitation of their linguistic output when conversing with children" (p. 470). Although they stated that "the character of the verbal environment plays a major role in language acquisition," they seem to limit that role to the obvious domains of "which language, vocabulary, style, and accent the child learns" (p. 471).

Recently, a few investigators have challenged the view that the input is random and not designed to help the child in abstracting the patterns of the language. They have examined the nature of the linguistic input the child receives to learn whether it is different from the spoken language in general, and if so, whether the differences could aid the child in discovering the underlying structure of his language. Brown, Cazden and Bellugi (1967) reported that the mothers in their sample used less complex linguistic forms more frequently to their children, and that the pattern of frequency distribution of linguistic forms was quite similar across the three mothers studied. Drach (1969) analyzed the speech of a mother to her 26 mo. old child as compared with her speech to two adult women, finding that the topics spoken of were very different to child and adult. A number of differences in the form of the speech were found. For example, when speaking to the child, the mother used shorter sentences, spoke slower, and restricted the variability of sentence types and lexical items. Sentences to the child were less complex grammatically, particularly with regard to subordinate clauses.

In the present study, we have compared the speech of adults when

speaking to an adult or a child. We have examined some of the same variables that were reported in Drach's study. However, in this study, 1) several adult speakers were studied, 2) the child and adult listeners were not known to the adult speakers, 3) the topic of conversation was kept constant for the two listening situations, 4) the listener did not reply, and 5) the speech sessions were vidoetaped. The study was designed to investigate the characteristics that are present in the speech of adults to children, and to discover whether there are characteristics present that might help the child in discovering the structure of the language.

METHODS

Five adults served as Ss, three female and two male. One of the males was a graduate student and the other an undergraduate. Two of the females were undergraduates and the other female a guidance counselor. The youngest was twenty and the oldest was thirty. None had children, but all reported at least some contact with young children.

In order to obtain the most natural speech possible in the experimental setting, the Ss were not informed of the true nature of the study. Each S was acquainted with E prior to the experiment, and was asked if he or she would help E conduct an experiment designed to study how children and adults pay attention to stories. The S was told that he would tell a story to an adult and to a child to elicit their attention, and that that attention was the focus of the study. The videotape equipment further enhanced Ss' belief that aspects of the listeners' behavior was being studied.

The study was conducted in a large therapy room in the University of Connecticut Speech Center, with an observation room on the other side of a one-way mirror. In the therapy room, two chairs were arranged approximately three feet from the mirror, side by side, and facing the mirror. (A highchair was used for the child.) Sound was transmitted through a microphone in the ceiling above the chairs. During the session, S was alone in the room with the listener. In the observation room, Sony videotape equipment was set up to tape two minutes of each interaction with a listener. The tape was begun as S entered the room and stopped after two minutes had elapsed.

The speech task was to tell a story based on a picture provided to S before he or she entered the therapy room. The picture was taken from a child's coloring book, and showed a woman opening a door and finding several dogs on her doorstep. Each S was given as much time as he or she wished to study the picture before being requested to begin. The S was told to say whatever he or she wanted, but that continuous speech was necessary.

For each S, the story was told first to a child. The child listener was a 22 mo. old girl whose vocabulary consisted of about 30 words. The Ss were told these facts, and also told that the child's comprehension was greater than her active vocabulary indicated. After performing the speech task to the child, S repeated

the task with an adult female as listener.

RESULTS AND DISCUSSION

The taped samples of adults' speech were analyzed for rate of speech, number of sentences, use of past tense, and type of sentence. Rate of speech was measured by counting the total number of words in the first minute of the speech sample. To measure use of the past tense, each occurrence of any past tense form of a verb during the two minute sample was counted. The type-of-sentence analysis was based on the following definitions: 1) An interrogative is a sentence using a wh-word, subject-auxiliary verb reversal, and/or rising intonation at the end of the sentence. 2) Simple declaratives are subject-verb-object sentences with one main idea, including sentences with verbs understood, but excluding exclamations with no predication implied. 3) Complex declaratives are subject-verb-object sentences with more than one predicate (eg., with an embedded phrase).

The results are summarized in Table 1. Mean differences were analyzed statistically with the a-test for one sample with more than one condition (equivalent to the t-test fro matched pairs). Significant differences between speech to child and adult were found in rate of speech, use of interrogatives, number of sentences spoken, and use of complex sentences.

These results indicate that adults speaking to young children spoke significantly slower, used more sentences per time unit, and used a much greater percentage of interrogatives and a smaller percentage of complex sentences when speaking to the child, but did not differ in the use of past tense and simple declaratives. The differences noted are probably no the only differences which exist in the data. Subjectively, basic pitch seemed to be higher to the child, repetition to the child seemed to be more frequent, and a more varied intonation contour seemed to be used to the shild. A preliminary analysis of the number and type of concepts expresses suggested that more complex concepts and a greater number of concepts per time unit was spoken to the adult.

The differences found indicated the use of a simpler form of speech to a child, in general. Perhaps adults change their speech to match their expectations of the listener's abilities to comprehend. However, there are two differences for which such an explanation seems unable to account. The subjectively observed raise in pitch to the child would not appear to aid understanding of the message. Perhaps the adult attempts to establish rapport by imitating the higher pitched voice of the child, or perhaps it is used as a signal to attract the child's attention. Also, the increase in percentage of interrogatives to the child is interesting. It might be interpreted as an attempt to gain feedback as to whether the sppech is comprehended, but Ss seemed not to expect or await answers to the apparent questions.

The raise in pitch and the greater use of interrogatives may be related. The majority of interrogatives were classes as such because of the rising intonation at the end of the sentence. Without this

Table 1

Means for adult speakers with child and adult listaners for several linguistic variables in a 2 min speech sample.

	Words per minute	Number of past tenses	Number of sentences	Number of interrogatives	Number of simple declaratives	Number of complex ddeclaratives
Child listener	132.0	8.8	53.8**	49.6**	41.2	9.2
Adult listener	169.6*	16.4	24.4	6.4	30.8	62.8**

* Significantly greater, $p < .05$

**Significantly greater, $p < .01$

intonation pattern, they would have been classified as simple declaratives because of their word order. If the rising intonation is signalling something other than "answer this question," then the sentences are really a type of declarative. Rising sentential intonation may be a special kind of pitch change, and both high pitch and intonational variety may be devices to hold the child's attention, signal emphasis, mark boundaries, or otherwise aid the child in comprehension. Should this be the case, the difference in percentage of declaratives spoken to the child as compared to the adult would be significantly different. The hypothesis regarding the interrogatives could be tested by observing speech to children in a language which signals interrogation without using rising intonation. If such a study revealed the same use to rising intonation at the end of sentences, it could be suggested that it also might signal something other than interrogation in our own language.

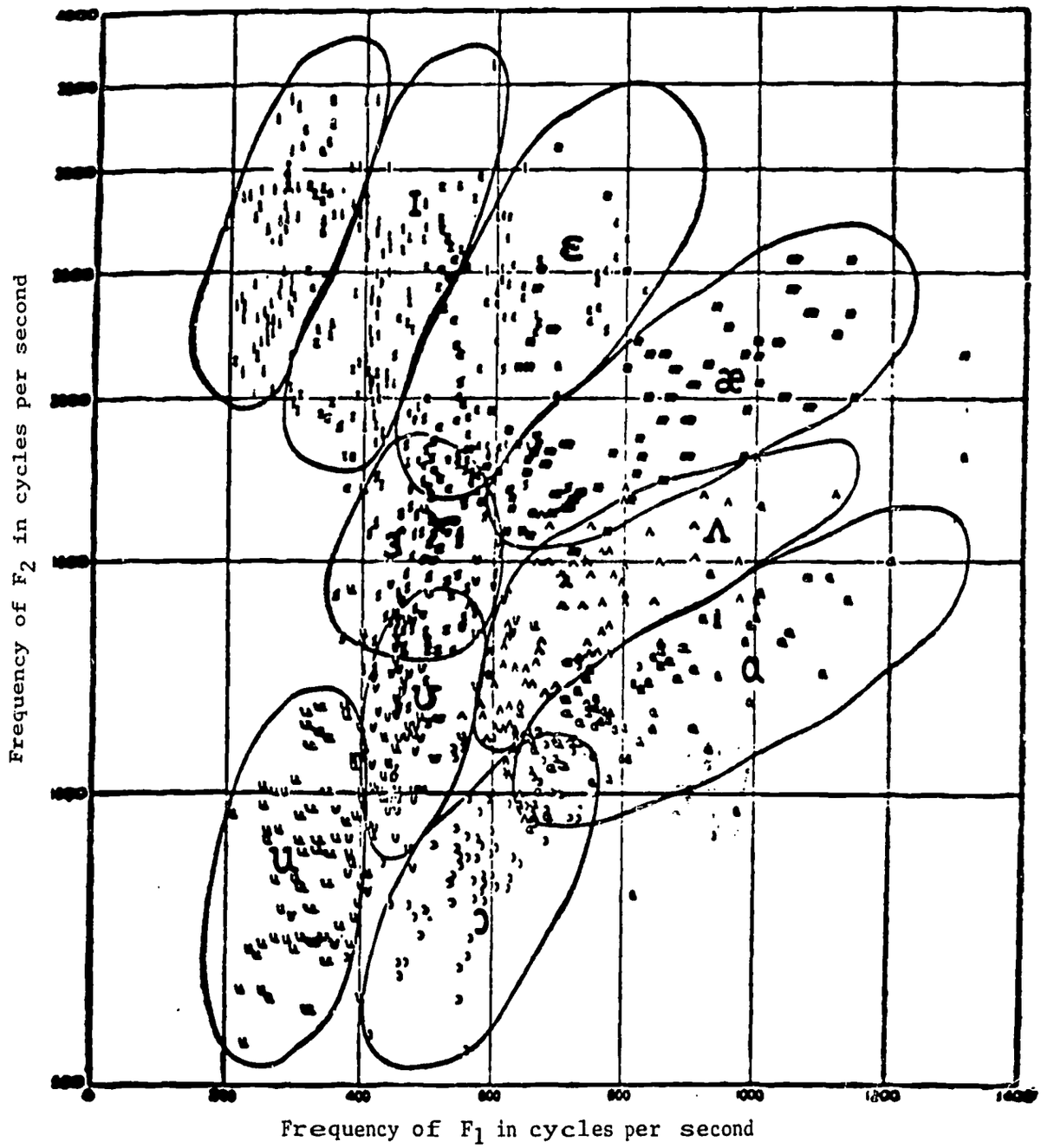
ANATOMICAL AND CULTURAL DETERMINANTS OF MALE AND FEMALE SPEECH

It is usually possible to differentiate the speech of normal, adult male and female speakers of English. It is not clear whether the factors that enable listeners to categorize a voice as either female or male are wholly dependent on anatomical differences between the male and female speech producing equipment, or whether learned, culturally prescribed factors also play a part in defining the norms for male and female voice quality.

Culturally determined differences in men's and women's speech certainly exist in some languages. For example, Haas (1964) has reported sex-determined styles in the American Indian language of Koasati. In Thai, according to Haas, the differences are quite evident since the language requires different sets of lexical items for men and women. In English we also see some stylistic differences in vocabulary though they are not very large. The focus of this study is, however, not on these rather evident lexical aspects of sexual differentiation but on basic phonetic factors.

When adult male and female voices are phonetically differentiated the most obvious factor is pitch, or fundamental frequency of phonation The lower fundamental frequencies of the male are a consequence of secondary sexual dimorphism that occurs at puberty (Negus, 1949; Kirchner, 1970). The larynx of the male is enlarged and the vocal cords become longer and thicker. Although pitch is the most obvious perceptual factor recent studies have demonstrated that it is possible to differentiate adult male and female speakers of English with no information about fundamental frequency (e.g. Schwartz, 1968; Schwartz and Rine, 1968). In all likelihood, the relevant cue for these discriminations is the pattern of formant frequencies, or resonances of the supralaryngeal vocal tract. It is quite reasonable that the sex of speaker should be identifiable from the formants. Secondary sexual dimorphism causes males, on the average, to have larger supralaryngeal vocal tracts than females, leading to a pattern of lower formant frequencies. In Fig. 1 we have reproduced the data obtained by Peterson and Barney (1952) for the vowel formants of a sample of 76 adult males, adult females and children who were all speakers of General American English. Each phonetic symbol represents a token of a vowel for an individual speaker. The frequency of the second formant is plotted with respect to the vertical axis while the first formant is plotted with respect to the horizontal axis. Note that there is no single data point for a particular vowel; there are instead regions defined by these loops.

There are, however, some rather puzzling aspects to the actual acoustic disparities that exist between adult male and female speakers. Mattingly (1966) in a re-analysis of the Peterson and Barney data, showed that the acoustic differences are greater than one would expect if the sole determining factor were simply the average anatomical difference that exists between adult men and women. It is possible that adult men and women modify their articulation of the same phonetic elements to produce acoustic signals



Note: Closed loops inclose 90 percent of the data points in each vowel category.

Fig. 1. Formant frequencies of American-English vowels for a sample of 76 adult men, adult women and children (Peterson and Barney, 1952)

that correspond to the male-female archetypes. In other words, men tend to talk as though they were bigger, and women as though they were smaller, than they actually may be. Since these effects of acculturation would have to be acquired in childhood it becomes reasonable to test Mattingly's hypothesis by examining the speech production of children, to see whether they, in fact, acquire male-female speech distinctions.

Anatomical studies have demonstrated that the larynx of a pre-adolescent boy or girl is likely to be the same size given the same weight and height (Kirchner, 1970). Therefore, one would expect preadolescent children to have essentially the same fundamental frequencies regardless of sex. There is no difference in mandible length between boys and girls before puberty (Walker and Kowalski, 1971; Hunter and Garn, 1971). Since mandible length accounts for half of the supralaryngeal tract length, we can reasonably assume that prepubertal boys and girls of the same height and weight have the same supralaryngeal vocal tract size. Therefore, one would not expect the formant frequencies of boys and girls to differ. If they do differ, the difference may reflect acculturation to the male and female sex roles. Our present study had two purposes. First, to see whether boys and girls have acquired voice characteristics before puberty that allow their voices to be identified as to sex, and second, to see whether differences in formant frequencies play a role in this differentiation.

METHODS

Short samples of speech were recorded for 26 children who ranged in age from 4 to 14 years. There were 14 boys and 12 girls in this group. Each child repeated a short sentence "I thought I saw a big blue meanie outside," read a passage from a children's book and repeated the sustained vowels /a/, /i/, and /u/. The children were all recorded at home using a Sony TC800 recorder and Sony microphone which had a flat frequency response to 8 kHz. The children were all from middle-class backgrounds and had all lived in the Storrs, Connecticut area for at least four years, with the exception of one child who had recently arrived from Kansas and two who had spent a year in England during the previous academic year. All were monolineal except for one child who was from a bilingual Korean-English background. These children exhibited no unusual behavior with regard to our acoustic analysis.

A tape was constructed consisting of the 26 imitations of the sentence in a random order. Eighty-three adult judges listened to this tape and attempted to identify each voice as a boy or a girl.

A sound spectrograph was used to make normal wide and narrow bandwidth spectrograms and quantized wide bandwidth spectrograms of all sustained vowels. Formant frequencies and fundamental frequencies were determined from these spectrograms.

RESULTS AND DISCUSSION

Analysis of the sex identification data indicated that the answer to our first question - can judges distinguish the sex of children from their voices? - was an unqualified yes. The adult judges reliably and validly, identified the sex of the children from

their voices ($t=51.13$, $df=82$, $p<.001$). 81% of the guesses were correct. Twelve of the fourteen boys' voices were identified as boys, and 9 of the 12 girls were identified as girls. Two girls were overwhelmingly misidentified as boys.

To answer the second question--are differences in formant characteristics involved in this identification?--we analyzed the frequency measurements of the isolated vowels, /a/, /i/, and /u/. Nine pairs of boys' and girls' voices were formed from our original sample of 26 by matching on height and weight. The mean height for the nine boys and girls was 52", and the mean weight 62 lbs. The average age of the girls was older than the boys by four months. For these pairs, we did not include any child over 12 years. This matching of children in pairs was to insure against voice differences that were merely a reflection of a difference in anatomical structure.

If no sex-difference exists for the vowels, one would predict the same fundamental frequency and the same formant frequencies for the boys and girls. This pattern was not obtained.

Table 1 shows the average fundamental frequency for the boys and the girls on the left. On the right is the average formant frequency values for F_1 and F_2 of /a/, /i/, and /u/. For the 9 pairs analyzed, the average fundamental frequency was higher for the boys than for the girls ($t=2.54$, $df=8$, $p<.05$). It would be most unlikely that the judges used this cue, higher fundamental for the boys, in accurately identifying the sex of the child.

Taking the obtained formant frequency values for all the vowels together, the boys yield lower values than the girls, though not significantly ($t=1.92$, 53 df, $p<.06$). There are a number of reasons to eliminate the vowel /a/ from our consideration at this point. For example, it is the least identifiable of the vowels (Peterson and Barney, 1952) and quite subject to dialect variation. We will return to a discussion of /a/ separately below.

The formant values for the vowels /i/ and /u/ were significantly lower for the boys than for the girls ($t=2.33$, 35 df, $p.<.05$). This pattern of lower formants for the males is the same pattern we find in adult speakers. The judges' success in identification may have been based, in part, on this difference in the formant patterns between the boys and girls.

In the nine pairs of children we have been discussing there were many children who were well-identified, but also a few who were inconsistently identified, or misidentified as to sex. Let us now look at the characteristics that lead to accurate or poor identification within one sex. From the original 26 children, we again formed pairs matched on height to eliminate gross differences in anatomical structure and development. These pairs consisted of three of the best-identified children and three of the worst-identified children, for each sex. Table 2 shows the fundamental and formants for the best and worst boys and girls. For the boys, we find a similar pattern to that which we saw when comparing boys and girls. The most boy-like voices have higher fundamentals but lower formants. The correlation over-all between lowness of formants and probability of identifying a boy's voice as a boy is significant ($t=.67$, 13 df, $p<.01$).

TABLE 1

MEAN FUNDAMENTAL AND FORMANT FREQUENCIES FOR NINE PAIRS OF BOYS AND GIRLS, MATCHED ON HEIGHT AND WEIGHT

		/a/		/i/		/u/	
	F0	F1	F2	F1	F2	F1	F2
Girls	249	968	1568	321	3247	420	1173
Boys	274	932	1611	302	3136	352	975

TABLE 2

MEAN FUNDAMENTAL AND FORMANT FREQUENCIES FOR THE THREE BEST AND THREE LEAST IDENTIFIED VOICES, FOR EACH SEX, MATCHED ON HEIGHT

		/a/		/i/		/u/	
	F0	F1	F2	F1	F2	F1	F2
Boys:best identified	270	944	1370	315	3278	315	982
Boys:least identified	248	926	1574	352	3352	444	1111
Girls:best identified	234	982	1593	333	3370	426	1222
Girls:least identified	260	963	1611	296	2944	426	1148

For the girls, the pattern is the mirror-image. The most girl-like voices have lower fundamentals and higher formants. However, there were some girls with relatively low formants who were still judged accurately, and the correlation between highness of formants and probability of identifying a girl's voice as a girl was not significant ($t=.50$, 10 df, $p<.05$). Perhaps some other characteristics indicated that these were feminine voices to the judges. We will return to this topic in a moment.

The girls who were least identifiable as girls include two who were overwhelmingly identified as boys (by 81% and 86% of our sample, respectively). These two girls were not the tallest or heaviest in our sample. They had formant patterns close to the boys' average. A neighbor who knew nothing of the aims of the experiment or the results, was asked to describe these girls. In one case, the girl was sketched as "athletic, strong, and competitive," and in the other as "a tomboy, very sports-minded, a real tough kid but well liked." Of course, these data are merely suggestive, but we feel further investigation of the relationship between personality and acquisition of like-sex characteristics would be worthwhile.

To summarize the experimental results: Judges could reliably and validly identify the sex of children from their voices. Boys on the average had higher fundamentals but lower formants than girls. The most boy-like voices and the least girl-like voices also showed this same pattern. There are several possibilities we can suggest to explain these results.

First, perhaps past claims about equality in skeletal structure, and thus articulatory structure, are not correct. If the boys, and the girls identified as boys, had larger vocal tracts, the lower formants would result from this anatomical difference. Two aspects of our data argue against this view, but not strongly enough at this point to be conclusive. First, in the case of the vowel /a/, the boys showed a higher F_2 than did the girls matched on height (with a mean of 1611 for boys and 1568 for girls). Though this difference is not statistically significant, it is different in direction from the difference found for all other formants. This apparent inconsistency in the data may be explainable if we consider the formant pattern for /a/. To make the vowel /a/, both F_1 and F_2 are pulled from the neutral schwa-like position to a more intermediate value, a higher F_1 and F_2. The more /a/ is closer to the ideal, the more F_1 and F_2 converge. However, if some boys are attempting to lower their formants, and especially F_1, they would be able to keep F_1 low by pronouncing /a/ somewhat more centrally, with a lower F_1 and higher F_2. If the boys' articulatory mechanism were simply larger than that of the matched girls, we would expect both F_1 and F_2 to be lower. The data suggest, furthermore, that it is the younger boys who tend to lower the F_1 of /a/. Whereas formants are expected to become lower as height increases, for the boys F_1 of /a/ increases actually, though not significantly, with age ($r=+.15$ 13 df). For all other formants measured in this study, the expected negative correlation between value of formant and height was found. These values are shown in Table 3.

TABLE 3

CORRELATIONS OF HEIGHT AND FORMANT FREQUENCIES FOR 14 BOYS AND 11 GIRLS

	/a/		/i/		/u/	
	F1	F2	F1	F2	F1	F2
BOYS	+.15	-.27	-.38	-.74**	-.29	+.04
GIRLS	-.36	-.63*	-.64*	-.25	-.56	-.57

*Significant at P<.05

**Significant at P<.01

Inspection of Table 3 also reveals that the girls' formant values are following their increase in height more closely than the boys' values, with the exception of F_2 of /i/.

If there is no average difference in articulatory mechanism size, the differences we have observed could arise from differential use of the anatomy. There could, for example, be hormonal control over certain aspects of the motor output. Or, the children could be learning culturally determined patterns that are viewed as appropriate for each sex. Within the limit of his anatomy, a speaker could change the formant pattern by pronouncing vowels with phonetic variations, or by changing the configuration of the lips. Rounding the lips will lengthen the vocal tract, and lower the formants. Spreading the lips will shorten the vocal tract, and raise the formants. The characteristic way some women have of talking and smiling at the same time would have just this effect.

We do not want to claim that the formant pattern we have reported completely accounts for the judges' ability to identify the sex of the child speaker. In fact, we would argue that only a part of the accuracy depends on that cue. The judges in our study listened to a sentence, not an isolated vowel, and perhaps other features of voice quality, the intonation pattern, pronunciation, and so on, contributed to accuracy more than did the characteristics of the vowels that we have examined. As mentioned earlier, some girls with rather low formants were not confused with boys. In general it seemed to us, subjectively, that boys had a more forceful, definite rhythm than the girls. These impressions merit more investigation.

In spontaneous speech, in fact, we would certainly expect other characteristics of sentence production to differ. Though research in this area has not been extensive, a few examples will illustrate some phenomena in English that may be involved in the differentiation of male and female speakers.

We can see an obvious difference in vocabulary items--men tend to use swear words, while women use "nice" euphemistic phrases such as "goodness gracious," etc. There may well be more subtle vocabulary differences in men's and women's speech in American English. Ruth Brend (1971) has noted different intonation patterns. Certain patterns, such as the "surprise" pattern (Oh, that's awful!) or the "cheerful" pattern (Are you coming? or Goodbye) are used predominantly, if not solely, by women. It has been claimed that, in general, women seem to have more extremes of high and low intonation than do men.

In addition to intonation differentiation we may also see phonological distinctions in men's and women's speech. Fischer (1958) found that lisping tends to be associated with female speech, and that in certain New England dialects boys tend to use in for the present participle ending, while girls tend to use ing. For example: fishin' as compared with fishing.

Some aspects of the sex-determined speech style can be used by a speaker of the other sex if the situation is appropriate. Haas (1964) found that in Koasati, the speech of women differed in certain respects from that of men, and yet the women would use the male forms when teaching a young boy the language, or a male would use the female forms when reporting dialogue in a story. Within our culture, we can see variations in speech style when adults speak to babies (Drach, 1969; Brown, Salerno and Sachs, 1972). Some aspects of this speech style may be an exaggeration of features that distinguish feminine from masculine speech, such as higher perceived pitch and variability in intonation. The situations in which people use this speech style have a feature in common--they are what J.P. Scott (1958) has called care-giving, or "epimeletic," situations. Courting couples sometimes speak a type of "baby-talk" and some people use it when talking to pets. The care-giving role in our culture is considered most appropriate for females, but both women and men typically are embarrassed about using baby-talk, or claim they don't use it. The negative attitude toward this speech style is not universal, however. Ferguson (1956) reports that in Arabic, both men and women use a conventionalized baby-talk to babies, although it is considered more appropriate for women.

We know little at this time about listener's evaluation of speakers and messages as influenced by the speaker's voice and speech characteristics. Typically, in our culture, having an "effeminate" voice is a problem for a man. With the amount of overlap in physical structure that exists between men and women, perhaps some men learn, among other things, to lower their formants in order to sound more masculine. We expect that having a voice perceived as "low pitched" is not a severe handicap for a woman, although an aggressive, "masculine" speech style may be. The absence of this agressive style, however, may cause listeners to regard the feminine speaker as "lacking in authority," placing the woman who wants to be both womanly and assertive in a difficult position. It would be interesting, for example, to observe the development of girls, like the two mentioned in this study, whose speech is perceived as masculine. Will these girls retain this speech style, or modify it as the acculturation forces become greater in their teens?

The research described today suggests that the pattern of formants in male and female children may not be determined totally by their anatomical structure, and that these patterns are one of the cues that tell us whether a voice is male or female.

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