CATEGORICAL PERCEPTION IN A CEREBRAL PALSIED POPULATION

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THESIS

ABSTRACT

CATEGORICAL PERCEPTION IN A CEREBRAL
PALSIED POPULATION

By

Janet B. Baldrey

A review of the literature concerning categorical perception and the Motor Theory of Speech Perception has revealed that these concepts have ramifications with respect to the cerebral palsied. The literature is lacking in elaboration on this area. The presence of categorical perceptual patterns in the cerebral palsied population would suggest the applicability of the Motor Theory of Speech Perception to a pathological population.

The purpose of this study was to ascertain the presence of categorical perception in a cerebral palsied population, through the use of identification and discrimination tasks similar to those used in previous studies. The stimuli were rapid and rabid temporally varied at the silent intervocalic segment. The tasks were administered to three groups: a control group and two experimental groups. The two experimental groups were cerebral palsied with good speech and cerebral palsied

with dysarthric speech patterns. The assignment to groups was based on performance on a standard articulation task and the rating of spontaneous speech. There were fifteen subjects in total; five in each group.

The results were computed totals of responses for all stimuli in each group; these were graphed. The displays indicated that all groups perceived categorically. The results were then divided in each group according to what the original word had been. These displays indicated that the groups did perceive categorically but that they perceived differently. The phoneme boundaries were placed at different points along the temporal continuum. The results of the discrimination task indicated that while the subjects perceived categorically in an identification situation, they did not in a discrimination situation.

The Motor Theory of Speech Perception provided the best explanation for the results. Conclusions drawn were that there is not a learning component to speech perception ability and that there was not necessarily a production/perception link for accurate and rapid perception of speech sounds, but it would seem that production abilities did make a difference in the pattern exhibited. The results also indicated that individuals with cerebral palsy do exhibit different perceptual patterns from normal individuals and that cerebral palsied individuals with good speech and those with dysarthric speech exhibit different perceptual patterns from each other.

Directions for further research lie in the areas of delineating these differences more carefully and discovering what factors, i.e., type of speech therapy, could influence this difference.

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INTRODUCTION

In dealing with an individual with a speech and/or language problem, the adequacy of the input channel for speech and language processing must be determined. Although the individual will be audiologically evaluated, normal hearing does not insure an intact language input, perceptual processing channel. The individual must be able to perceive what he hears. To use an analogy, an English speaker may hear French but may not perceive what is being said. From this, speech perception, then, would seem to be synonymous with understanding. In fact, speech perception has been defined in a broad sense as recognition and interpretation of incoming information or as the attaching of meaning to stimuli to which senses respond (McDonald, 1964; Darley, 1964; Travis, 1971). In a more narrow sense, speech perception has been defined as the implied transduction of acoustic energy to neural patterns (Williams, 1972). Because speech production is a motor function, it has been suggested that the stored perceptual patterns referred to may be, in part, at least motor patterns (Liberman, et al., 1967). This approach to the study of speech perception has been most thoroughly developed within the framework of the Motor Theory of Speech Perception. In turn, the Motor Theory has relied heavily on the perceptual pattern phenomenon called categorical perception. The ramifications of this definition and theoretical framework to explain speech perception for a cerebral palsied population are particularly important and far reaching.

Categorical Perception

Identification Tasks

There are single aspects of the acoustic continuum, eg. transitions of the second formant and silent duration, that can signal the difference between phonemes and, therefore, between words. For example, the duration of the silent interval present in stop consonants is sufficient for distinguishing two phonemes (Lisker, 1957; Liberman, et al., 1961); and the second formant transition is a sufficient signal for distinguishing the sounds /b/, /d/, and /g/ (Delattre, et al., 1955; Liberman, et al., 1957). One method of studying this phenomenon is through the use of identification tasks. An identification task is performed in order to determine whether an individual perceives categorically or whether a phoneme is categorically perceived. The listener will be presented with a word and asked to identify it. The listener is given the alternative identification names; for example, he is asked to identify the word as either "rapid" or "rabid." Thus, this is a forced-choice task.

If a phoneme stimulus is systematically varied along one continuum, the sound will be acoustically similar to one phoneme at one end of the continuum and to another phoneme at the other end. For example, using the silent interval duration continuum, the duration can be altered for the intervocalic /p/, shifting the perception from /p/ to /b/ and vice versa. Lisker (1957), using recorded speech words <u>rupee</u> and <u>ruby</u>, found that the perception shifted abruptly from <u>rupee</u> to <u>ruby</u> during an identification task as a result of the length of the silent interval duration. At what point along the temporal continuum the shift occurred was dependent upon what the original word had been. If the stimuli had been produced from <u>rupee</u>, the boundary was between 70 and 80 msec; for those stimuli produced from <u>ruby</u>, the boundary was at about 105 msec. Liberman et al. (1961) used the synthetically produced words <u>rapid</u> and <u>rabid</u> that varied only in the silent interval duration of the intervocalic segment. The phoneme boundaries lay at approximately 70 msec and were "reasonably sharp" (Liberman et al., 1961, p. 183). When the alteration is of the second formant transition, similar boundaries occur. Using an identification task, Liberman et al. (1957) determined that sharp boundaries existed in the perception of /b/, /d/, and /g/ along a continuum where the second formant transition range was 1320 cps to 2980 cps. Although increments in the silent interval duration or the transition remained constant, there was a place along the temporal continuum at which point the alternative stimuli identifications diverged. The listener appears to sort the stimuli into categories. Although, for example, there was no more difference between a word with a 60 msec interval from one with a 70 msec interval and between one with 70 msec and 80 msec, those of 60 msec and 70 msec were perceived as <u>rabid</u> and those of 80 msec as <u>rapid</u>.

<u>Discrimination Tasks</u>

Another aspect of categorical perception is the listener's discriminative abilities. When asked to discriminate those sounds that have categorical identification boundaries, the listener can discriminate no better than he can label the stimuli. That is, discrimination within the phoneme categories has been found to be much poorer than across phoneme boundaries (Liberman et al., 1957). The listener may judge stimuli that are closer on the temporal continuum as different, while stimuli that are farther apart on that same continuum may be judged as the same. Using an example of stimuli with varied silent interval durations, the stimuli with a 50 msec duration will be judged the same as one with 70 msec silent interval duration more often that the 70 msec stimulus will be judged the same as the stimulus with an 80 msec silent interval duration (Liberman et al., 1957; 1961; 1967).

A typical discrimination task would require that the stimuli be presented in ABX traids, with X being identical to either A or B. A and B would be stimuli that were a certain number of steps apart on the continuum. The listener would then have to make a forced choice of whether X was identical to either A or B.

To account for this type of discrimination pattern, the psychological concepts of <u>acquired similarity</u> and <u>acquired distinctiveness</u> have been proposed. Dollard and Miller (1950) have described acquired similarity in this manner: "Attaching the same cue-producing response to two distinctive stimulus objects gives them a certain learned similarity increasing the extent to which instrumental and emotional responses will generalize from one to the other [p. 101]." They have described acquired distinctiveness as follows: "Attaching distinctiveness cue producing responses to similar stimulus objects tends to increase their distinctiveness [p. 101]." The listener, through his long association with the language, has learned to name some of the variations that he hears as /p/ and others as /b/. The place on the temporal continuum of the identification boundaries are determined through a learning process. That is, the discrimination peaks appear at the phoneme boundaries and support an acquired similarity and distinctiveness explanation; these peaks also support that the placement of the boundaries is through a learned process (Liberman et al., 1961; 1967).

The types of discrimination and identification patterns described here are unique because they are found only when phonemes are the stimuli. Also, they are unique because only certain phonemes can be used as stimuli. The aspects of the speech continuum that are varied to produce the categorical perception of the phonemes, i.e., the second formant transitions or silent interval durations, when heard outside of the speech context do not produce the same type of identification and discrimination gradients (Liberman, et al., 1957, 1961). However, categorical perception has only appeared as a perceptual pattern associated with the perception of consonants, particularly the stop consonants.

Motor Theory of Speech Perception

Research into the phenomenon of categorical perception has led to the development of the Motor Theory of Speech Perception that attempts to account for: (1) the rapidity with which a listener can perceive speech; (2) control of the variation of speech sounds that are pr

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produced; and (3) the fact that the identification and discrimination patterns are associated with a limited number of speech sounds. The Motor Theory proposes that "speech is special" and, therefore, is perceived in a special way.

A purely "auditory" processor for speech is inadequate to account for the rapidity and accuracy with which speech sounds are perceived. A listener can process as many as thirty phonemes per second. The temporal resolving power of the ear cannot process thirty discrete acoustic events per second and obtain anything more than an unanalyzable buzz (Liberman, 1970). Consequently, a model of speech perception would have to account for this.

The model would also have to account for the control of the variation of the speech sounds that are produced. The identification ability of listeners demonstrates that this control does occur. The variation associated with speech sound production are of at least two types: allophonic variation and coarticulation.

Each distinct speech sound that we hear and can discriminate from other speech sounds is called a phoneme. Each phoneme is actually a group of sounds, called <u>allophones</u>. The allophones are each different from the other but more similar to members of their phoneme class than to other phonemes. However, categorical perception tasks have demonstrated that this is not always true; some allophones are similar and yet assigned to different phoneme classes. (This seeming contradiction will be explained in the section dealing with the encoder/decoder relationship.)

Allophonic variation is accounted for, at least in part, by reference to the mechanical constraints of the speech mechanism; that is, the movements are never exactly the same for any two productions of the same sound. Allophones are also the result of coarticulation, which is variation in the production of a sound as a result of contextual variation. The articulatory positions of the surrounding phones in a given context affect the production of the phone in question. Therefore, it is not only the characteristics of the phone, per se, but the phonetic context that aides in phonetic discrimination. Liberman et al. (1967) stated: "The same phoneme is most commonly represented in different phonemic environments by sounds that are vastly different. . . . This is a central fact of speech perception [p. 432]." Thus, Ali, Gallagher, Goldstein, and Daniloff (1971) found that listeners could predict the presence of nasal consonants at the end of a CVC syllable and a CVVC syllable, for example /keI/, with better than chance results when the consonants and vowel-consonant transitions had been spliced away from the end. This finding suggested that not only were phones influenced by adjacent sounds but that some information about a phoneme is present in those adjacent phonemes.

The Motor Theory of Speech Perception postulates the concept of the encoding of speech to allow for this parallel transmission of information about more than one phoneme at a time. This parallel transmission in turn could overcome the temporal resolving power of the ear and explain the ability to perceive phonemes more rapidly than other classes of sounds. The model for production of Liberman et al. (1967) may serve as a useful reference for this discussion (Figure 1). Each phoneme is a combination of subphonemic features; each of these features is associated with a specific set of "signals" that are programmed throughout the speech production and perception mechanism. True encoding occurs as a consequence of the interaction of these features' signals. In the model, as the signals for a speech movement move from level to level, the conversions are monotonic. However, at the level of conversion from muscle contraction to vocal tract shape, a very considerable amount of encoding must occur. This would be related to the mechanical and contextual constraints described earlier. Thus, encoding is the merging of past and present instructions to the vocal tract, and the subsequent loss of segmentability of the acoustic signal into discrete phonemes (Liberman et al., 1967). Encoding would not seem to occur below

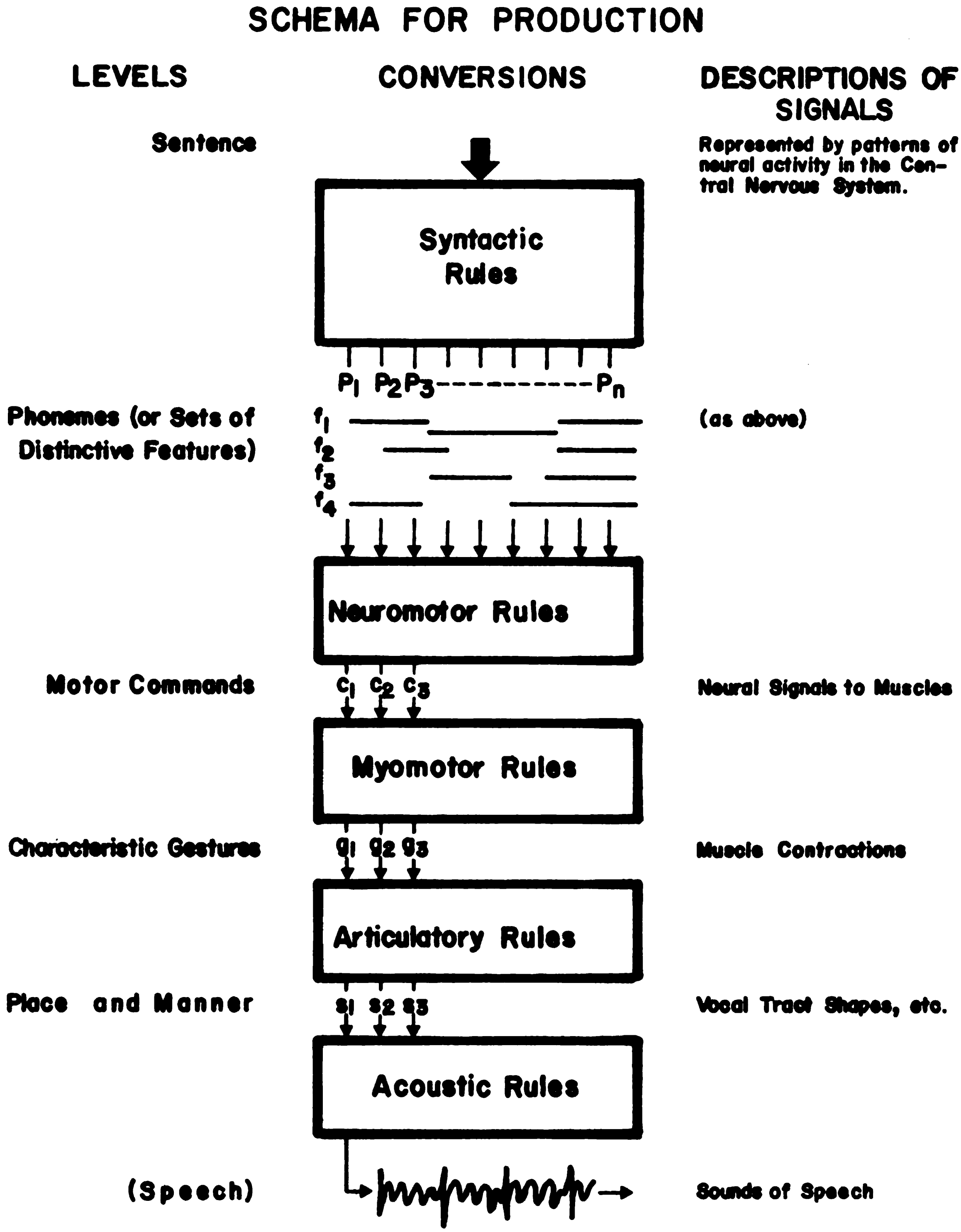

Fig. 1. Schematic representations of assumed stages in speech production (Liberman et al., 1967, p. 445).

the level of conversion from muscle contraction to vocal tract shape because of the monotonic relationship of the shape of the vocal tract to the sound signal. This monotonic relationship is measurable, but above the proposed level of encoding such a relationship is inferred and is more difficult to measure. It is possible, therefore, that some encoding occurs at higher levels in this model.

The encoding of phonemes by the speaker necessitates that the listener be able to extract the correct information from this coded signal; that is, he must be able to decode what he hears.

In perceiving or decoding speech the listener must have some reference that is consistent or invariant in the sound to allow for accurate perception and identification. It has already been explained that the acoustic signal has no such invariance as a result of the encoding process. The invariance necessary for accurate decoding must be present prior to the encoding, above the level of vocal tract shape. It is unlikely that such invariance occurs at the muscle contractions level for: "If muscles contract in accordance with the signals sent to them, then this conversion is essentially trivial (Liberman et al., 1967)."

Perhaps the neuromotor signals provide the necessary invariance for the decoder. Through electromyographic recordings of the muscles of the speech mechanism it has been demonstrated that enough invariance is present to fulfill the expectation that the motor commands are sufficient to be used by the decoder in the perceptual process (Liberman, et al., 1967). This concept, however, necessitates a close association between speech production and speech perception. Shankweiler and Studdert-Kennedy (1967) were of the opinion that the most practical system for decoding would be as part of the encoding system, both with appropriate linkages to the sensory and motor components of the speech production centers. They stated " . . . it would be unparsimonious to assume that the speaker/listener employs two entirely separate processes of equal status, one for encoding language and the other for de-coding [p. 452]." Consequently, one hears the same /d/ because perception is mediated by the neuromotor correlates of gestures that, in essence, are the same. The /d/ gesture, or some important characteristic of that gesture, may be the same in any two cases (Liberman, et al., 1967).

The idea of mediating neural correlates of articulatory gestures is the basis of the explanation of the differences in the perception of speech sounds. Earlier it was noted that only certain phonemes were categorically perceived. Only the phonemes that are encoded are categorically perceived. The listener after long experience associates the phonemes with the appropriate articulations;

over time these articulations, or the neuromotor patterns of these articulations, become part of the perceiving process. When significant acoustic cues that occupy different positions along a single continuum are produced by essentially discontinuous articulations, i.e., /p/ and /b/, the perception becomes discontinuous, or categorical. When acoustic cues are produced by movements that vary continuously from one articulatory position to another, e.g., the vowels, perception tends to change continuously with no apparent perceptual categories (Liberman, et al., 1967).

The association of the production and perception of speech leads to the hypothesis that the placement of the phoneme boundaries and the discrimination of encoded speech sounds was a learned ability mediated by the neuromotor correlates of articulatory production (Liberman et al., 1961; 1967). This is supported by the concepts of acquired similarity and acquired distinctiveness. Through experience with the production of speech, the listener begins to categorize the speech sounds. Some of the allophones are very similar acoustically, and the listener must learn where to place the phoneme boundary to perceive them accurately. Those within the category acquire similarity; those across the boundary acquire distinctiveness. This explains why two similar allophones are perceived as different phonemes. The concept of learning playing a part in speech perception is further supported by evidence from discrimination tasks. The discrimination of encoded speech sounds is largely controlled by the phoneme labels available (Liberman, 1961). Further, the position that perception is mediated via stored neuromotor patterns suggests that speech, in some way, is a special phenomenon associated with specific characteristics of man's neurological system.

The "speech is special" tenet is supported by differences between the perception of speech and nonspeech stimuli. The nonencoded speech sounds, vowels, and nonlinguistic stimuli, tones and so on, are perceived in a continuous manner. There is also another difference between encoded sounds and nonencoded sounds with respect to place of perception. Through dichotic listening tasks it has been shown that speech stimuli are more readily perceived by the right ear, which dominates the auditory tract to the left hemisphere (Kimura, 1961). The left hemisphere has been found to be pre-potent for speech at a very early age (Kimura, 1967). Studies have been conducted that not only demonstrate a stronger right ear advantage for speech sounds but a stronger right ear advantage for phonemes that are highly encoded (Day and Vigorito, 1973; Cutter, 1973). Nonlinguistic stimuli, e.g., melodies, have been shown to be more readily perceived in the right hemisphere (Broadbent and Gregory, 1964; Bryden, 1963). These data would support the proposed close association of the language and speech production centers with the speech perception centers and, concommitantly, a close association of the encoding and decoding of speech,

Consequently, it has been suggested that the perception of speech is special. It is carried out by a special processor, and it has a strong learning component.

Criticisms of the Motor Theory

The presence of stored motor patterns for categorical perception for certain speech sounds has been challenged by Lane (1965). In researching the categorical perception of nonspeech stimuli, he has obtained identification boundaries and discrimination peaks at these boundaries. He used stimuli that were produced by inverting the spectrograms of speech stimuli and then playing these through a Pattern Playback device to convert the picture to sound. In this way, Lane obtained stimuli that varied as the speech sounds varied but were nonlinguistic in nature. Similar stimuli were used by Liberman et al. (1961), but no phoneme boundaries or discrimination peaks were obtained in that experiment. Beare (1963) and Ekman (1963; in Lane, 1965) obtained labelling gradients comparable to those of the stop consonants with stimuli of spectral colors. The discrimination of the colors was the most acute at the boundaries between color classes, just as discrimination is most acute at the boundaries between phoneme classes. These data would appear to cast doubt on the premise that categorical perception is peculiar to phonemes and, therefore, that speech has a special processor.

The premise that there is a learning component to speech perception is challenged by data from experiments of infant perception. The left hemisphere is pre-potent for speech and language at an early age (Kimura, 1967). Some would go so far as to say that this specialization is present at birth (Molfere, 1973). If this is the case, a certain undefinable amount of speech and language ability is innately determined. For example, it has been found that infants of one and four months of age can categorically perceive stop consonants (Eimas, et al., 1971). The placement of the phoneme boundaries would appear to be one of the innate characteristics of speech, at least to some extent. These results would not support a special process for speech perception that depended on the use of learned articulatory patterns.

This information could cast serious doubt on the Motor Theory of Speech Perception. The criticism that nonlinguistic stimuli are categorically perceived has been responded to by Studdert-Kennedy et al. (1970). Obtaining the same results for nonencoded stimuli as for encoded stimuli for labelling functions is possible. The important factor in these experiments is the degree to which the stimuli are categorically perceived. Any set of stimuli, if spaced widely enough along a sound continuum, can produce labelling functions that are categorical. For the encoded speech sounds, the space necessary for this type of function is very small. In examining the labelling gradients, the sharp decline in alternate identifications produces a valley on the function; a valley also appears to either side of the discrimination peaks. These valleys are as important as the peaks; they depict the lack of alternate identifications or the chance discriminations. These valleys are missing in the Lane (1965) study. The absence of the valleys indicate inefficient sorting of within category stimuli.

There is no rebuttal for the fact that there is categorical perception in the infant. Presence of phoneme boundaries at birth does not preclude a special processor; it does not preclude a close association of production to perception. It does indicate that the learning component of speech perception may not be critical. However, a learning component could still be active; learning could serve as a means to refine the Perceptual speech and accuracy of speech perception.

Categorical Perception and the Cerebral Palsied

If transduction of acoustic energy to neural patterns, learned or innately given, is a component of speech perception, an individual with brain damage could have difficulty perceiving speech. Cerebral palsy is defined according to Westlake and Rutherford (1961) as " . . . a group of disturbances of motor function which occurs as a result of involvement of the cortical and subcortical motor control areas [p. 1]." The proposed close association of the production patterns of speech sounds with the perception of speech would suggest certain important ramifications for the cerebral palsied population. Speech is a motor function, resulting from neuromotor programming activity; and the cerebral palsied individual, by definition of the disorder, suffers from motor dysfunction. In fact, one of the problems frequently associated with cerebral palsy is disordered speech. These problems can be caused by a wide range of lesions at various levels of integration of the neurological tracts. They can be symbolization difficulties, muscular involvement, or motor programming problems. Referring to Figure 1, it is obvious that cerebral palsy can disrupt production of speech at any level. If the Motor Theory is valid and if the disruption occurs at the level of the conversion of muscle contraction to vocal tract shape, then the disruption in production should in fact result in a disruption in perception. Those speech problems due to muscular involvement of dysarthrias would cause the individual to have production problems, with absent or distorted production patterns for the speech sounds; this would be especially true if there is a learning component to speech perception. Ability of the cerebral palsied to perceive categorically would bear directly on a Motor Theory of Speech Perception. This in turn could bear directly on the approach of the intervention program used with the cerebral palsied in speech therapy.

McNeilage, Rootes, and Chase (1967) conducted a study of a seventeen-year-old female with severe impairment of somesthetic perception and motor control. On articulation, or production tasks, she performed poorly. In an attempt to assess her categorical perception ability several different types of stimuli were used in identification and discrimination tasks. She was asked to identify and discriminate voiced stop consonants in syllables and front vowels. The identification task only was administered for voiced and voiceless stop consonant initial position, voiceless stop consonant in initial cluster, and voiced/voiceless stop consonant in intervocalic position. She achieved the same degree of unanimity of identification for only the rupee/ruby as did the subjects, who were normal college students, in a previous experiment using the same stimuli. However, McNeilage et al. concluded "no tendency for the overall trend of the patient's perceptual judgments to be influenced by her productive disabilities [p. 464]."

The presence of a categorical perception pattern in the identification and discrimination of an individual with a neurological disorder lends support to the critics of the Motor Theory of Speech Perception. The data from the McNeilage et al. (1967) study support a nonlearning based theory of speech perception. The data also could support an approach to speech perception where speech is not considered to be special. The presence of categorical perception in a brain damaged population could suggest that the Motor Theory of Speech Perception is wrong; that the neuromotor correlates are unnecessary for speech perception. Or, this perceptual pattern in a braindamaged population could suggest a modified Motor Theory of Speech Perception; one where the system is innately tuned to develop speech and language, both for perception and production, and the production of the phonemes does not aid in perception, thereby eliminating the learning component. That is, the female subject used in the McNeilage et al. (1967) study may or may not have the propensity to develop the neural patterns for production innately given, and she may or may not use them for perception of phonemes. The presence of the categorical perceptual pattern in a neurologically impaired individual does indicate that she is perceiving as a normal individual, whatever the process may be.

Categorical perception tasks could help determine whether the cerebral palsied population are perceiving as the nonbrain damaged population does. This information could raise the question of the effect of different perception on speech and language and the effect of speech and language on perception. The ability of a cerebral palsied person to perceive normally would benefit speech and language pathologists working with these individuals. Also, this information could provide valuable information to investigators of speech perception. That is, if the Motor Theory of Speech Perception is valid, then persons who exhibit neuromotor problems, such as cerebral palsy, should also exhibit difficulty in performing certain speech-specific perceptual tasks.

Statement of the Problem

From a review of the literature, there would appear to be a need for a study that would explore the speech perception of the cerebral palsied population with respect to the phenomenon called categorical perception. This is because (1) this population has a high probability of speech perceptual difficulties due to brain damage, and (2) information about categorical perception in pathological populations may help clarify the issues concerning the Motor Theory of Speech Perception.

Specifically this study seeks to answer these questions:

1. Does the cerebral palsied individual exhibit a categorical perception pattern, as measured by identification and discrimination tasks using the words rapid and rabid and varying the intervocalic silent interval duration?

2. If so, how does this pattern compare with non-brain damaged individuals?

3. Are there any differences between the perceptual patterns of cerebral palsied individuals with good speech and those with dysarthric speech?

4. How do judges rate the intelligibility of cerebral palsied speakers, and does this correlate in any way with severity of involvement?

CHAPTER II

EXPERIMENTAL PROCEDURES

This study used fifteen subjects divided into three groups. Each subject listened to a set of tests designed to demonstrate his ability to perceive categorically.

Subjects

The subjects of this study were fifteen adult volunteers, all of whom exhibited normal hearing (+20dB) in at least one ear at the frequencies of 250, 500, 1000, 2000, 4000, and 8000 Hz. All had normal intelligence as measured by completion of at least a high school education. They were divided into three groups of five each: a control group and two experimental groups. The control group was comprised of normal young adults. The experimental groups were comprised of subjects who were diagnosed as cerebral palsied, having sustained brain damage pre- or peri-natally. Each subject was asked to read the Sentence Articulation Test Section of <u>The Fisher-Logemann Test of Articulation Competence</u> and to speak extemporaneously for three minutes. Three trained judges rated the subject on over-all intelligibility, articulatory errors, and the presence of dysarthric speech patterns.

More specifically, the composition of the groups was as follows:

Group I: Control. This group consisted of three females and two males. The age range was from 21 years 9 months to 28 years 3 months with a mean age of 24 years 2 months. Each subject was free from a history of neurological impairment and speech and language impairment.

Group II: Cerebral Palsied/Good Speech. This group was comprised of one male and four females. The age range was 20 years 4 months to 47 years 5 months with a mean age of 29 years 5 months. Each subject was rated by all three judges as being free of articulation errors and dysarthric behavior, and all received a high positive overall intelligibility rating of 1 (see Table 1). All subjects except one were able to mark their own score sheets. The one subject who required assistance was visually impaired; the examiner marked as the subject responded verbally. This group consisted of four subjects diagnosed as spastic and one as athetoid.

Group III: Cerebral Palsied/Dysarthric Speech. This group was comprised of one male and four females. The age range was 22 years to 45 years 4 months with a mean age of 41 years. Each subject was rated by all three judges as having at least three articulatory errors and exhibiting some behavior descriptive of dysarthric speech patterns. All sounds on the articulation task could be counted as errors. The range of number of errors for these subjects was 11 to 130; the mean number of errors was 43.6. The subjects received varied overall intelligibility ratings. (See Table 1.) All subjects were able to mark their own score sheets.

TABLE 1. Scales for rating experimental subjects

Functional	Therapeutic	Speech Intelligibility
1-no practical limitation of activity	1-no bracing or apparatus	1-always intelligible
2-slight limitation	2-minimal bracing or apparatus	2-almost always intelligible
3-moderate limitation	3-bracing & apparatus	3-usually intelligible
4-great limitation	4-institutionalized	4-usually unintelligible
5-no useful activity		5-almost always unintelligible
		6-always unintelligible

Rating Scales

Three listeners, all Master's level students at Michigan State University's Department of Audiology and Speech Sciences, listened to recorded samples of the experimental subjects' speech. They scored each subject on the presence of articulatory errors, dysarthric speech patterns, and overall intelligibility. The experimenter rated the experimental subjects on two separate scales similar to those of Denhoff and Robinault (1960). One of these dealt with functional ability, as defined by what the individual could do without assistance (mechanical or human). The other scale can be described as therapeutic, defined here as the amount of bracing or apparatus used by the individual. These three scales are described in Table 1.

Experimental Stimuli

Stimuli Preparation

In order to determine whether categorical perception existed, identification and discrimination tasks were employed. These tasks consisted of words whose silent intervocalic segments were temporally modified. The words *rapid* and *rabid* were spoken by a trained adult male speaker in a sound-proofed recording suite using an Electro-Voice 635A Dynamic Omni-directional microphone. The words were recorded on a full-track tape deck (Ampex 601, Model 652) at 7 1/2 ips. These words were then dubbed from the original recording to a second tape, using a full-track Ampex Model AG 600 and Ampex 601 tape recorders. These second generation recordings were used for generating the experimental stimuli.

The stimulus items for the experimental tasks were prepared by a mechanical cut and splice technique as described by Lisker (1957). Using a tape editor, the silent intervocalic interval was aurally determined for each word. The silent interval was cut from each word and a segment of blank leader tape was spliced between the segments preceding and following the silent interval. To insure that only the silent interval had been cut away and that the spliced segment was of the desired duration, a spectrogram (Kay-Sonograph) was made of each stimulus item. These were compared with spectrograms of the original words. The silent intervals were measured and found to be accurate to within ±4 msec. Twenty-four stimuli with silent intervals ranging from 40 msec to 150 msec in 10 msec steps were made from the words _rapid_ and _rabid_. There were twelve stimuli per word.

Experimental Tape Preparation

Two tasks were administered to each subject. One task required an identification or labelling response; the other was a discrimination task where the subject was asked to make a same/different judgment. Both tests were prepared by dubbing the prepared stimuli from an Ampex 601 Model 652 recorder to an Ampex Model AG 500 tape deck, half-track, using both tracks simultaneously.

Test I was the Identification Task. It consisted of three presentations of each of the 24 stimuli, for a total of 72 trials. The subject heard the number of the trial, a 2-second pause, and then the test stimulus. The subject was given 10 seconds in which to respond. All trials were on one tape. The length of time to administer this task was approximately 15 to 20 minutes. Randomization was achieved by selecting a number from a set of 72 numbers where each number from 1 to 24 was represented three times.

Test II was the Discrimination Task, designed according to a paired comparisons AX paradigm. It consisted of pairing all stimuli prepared from one word with all other stimuli prepared from that word, that is, all stimuli prepared from the original word rapid were paired with all other stimuli prepared from the word rapid. The same was true for all stimuli prepared from the original word rabid. Stimuli prepared from different words were not paired, for example, one from rapid to to one from rabid, in order to eliminate potential perceptual cuing by a difference other than silent interval duration.

Test II consisted of 78 pairs for each set of stimuli, resulting in a total of 156 trials. Each trial consisted of the trial number, a 2-second pause, test stimulus A, a 3-second pause, test stimulus B, and a 10-second pause for responding. The pair presentations and the ordering of the stimuli within each pair were randomized.

This experimental task was presented in two parts: Part A consisted of trials 1-78 and Part B consisted of trials 79-156. Each part required approximately 20 to 25 minutes to administer. (See Appendix A.)

Thus three experimental tapes were constructed. One consisted of the stimuli to be used for the identification task. Two tapes were constructed for the discrimination task, parts A and B. With three tapes, there were six possible presentation orders. The presentation order for each subject was determined on a random basis. The order of presentation was kept constant between experimental and control groups; see Table 2.

TABLE 2. Order of test presentations

Subject Number	Test Order
1	test I; test IIA; test IIB
2	test I; test IIB; test IIA
3	test IIA; test IIB; test I
4	test IIB; test IIA; test I
5	test IIA; test I; test IIB

Testing Procedures

The examiner screened each subject's hearing prior to administering the articulation or listening tasks. A portable Beltone audiometer was used in a sound-treated room using standard audiometric procedures. The examiner then asked each subject to read the sentences on The Fisher-Logemann Test of Articulation Competence.[1] After this, the subject was asked to talk about his job, school, or something of interest to him for approximately three minutes. This was all recorded on a Sony portable tape recorder, Model TC-106A.

The examiner then asked for pertinent information from all subjects such as birthdate and for information from the experimental subjects such as type of diagnosis and time of onset of cerebral palsy.

The examiner then went into the control booth. The instructions were printed on a test booklet in front of each subject. Inside each test booklet were response sheets associated with each of the experimental tasks. The instructions were read by the examiner through a loud speaker located in the sound-treated listening room. The directions for the Test I: Identification Task were as follows:

Test I: You will be listening to single words. You are being asked to decide if this word is "rapid" or "rabid." For each word you will first hear the number of the trial, then the word. Then mark on the answer sheet which word you think it is. Please listen carefully. If you want more time on any word, or want to stop the tape, let the examiner know. Thank-you.

The directions for the Test II: Discrimination Task were as follows:

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[1]It was necessary to use the picture portion of this measure with the visually impaired subject.

Test II: You will be listening to pairs of words. Some will be the same word and some will be different words. You are being asked to decide if the pair is the same or different. If you decide they are the same, mark SAME on your answer sheet; if you decide they are different, mark DIFFERENT. Please listen carefully. If you want more time on any pair, or want to stop the tape, let the examiner know. Thank-you.

After the directions were read, the subject was advised which answer sheets to turn to.

Both tests were presented at 72 dB SPL through a single loud speaker in a sound-treated room. The subject sat facing the speaker at a distance of five feet. The test tapes were played on a tape recorder of a Maico Audiometer (Model MA-24). The experimenter monitored the subjects both visually and auditorily from the control room.

Calibration

Prior to testing, all equipment was calibrated. After eight of the 15 subjects had been tested, the equipment was again calibrated. At the end of the testing procedure, the equipment was checked for consistency of calibration.

The calibration procedure was as follows: a Brüel-Kjaer sound level meter, type 1613, with a 4145 condenser microphone was fixed to a tripod at the same height as the head of a person sitting in a chair and placed five feet from the speaker. White noise was generated at 70 dB HTL and presented through the speaker. Using the A scale on the sound level meter, the reading was 72 dB SPL.

The tape recorder was calibrated by playing a tape of a 1000 Hz tone at 70 dB HTL through the loud speaker and attenuating the speech gain to peak at 0 dB VU.

CHAPTER III

RESULTS AND DISCUSSION

Identification Task

The total judgments for each silent interval duration were computed (see Appendix B). The results of the identification task are shown in Figures 2a to 2c. The results of the identification task indicate that the cerebral palsied population does perceive categorically. Phoneme boundaries are evident for each of the three separate groups. Because the task was a forced choice between two alternatives, the graph lines are mirror images of one another. From these graphs it is obvious that the boundaries are not as clear cut as in previous experiments. Previous experiments (Liberman et al., 1957, 1961) were concerned with the concept of categorical perception and not with the formulation of normative data. Therefore, in previous studies subjects were eliminated because they failed to label consistently and/or failed to exhibit perceptual boundaries. None of the subjects in the present study were selected on the basis of ability to label consistently or were given any training in this type of task. This could be the

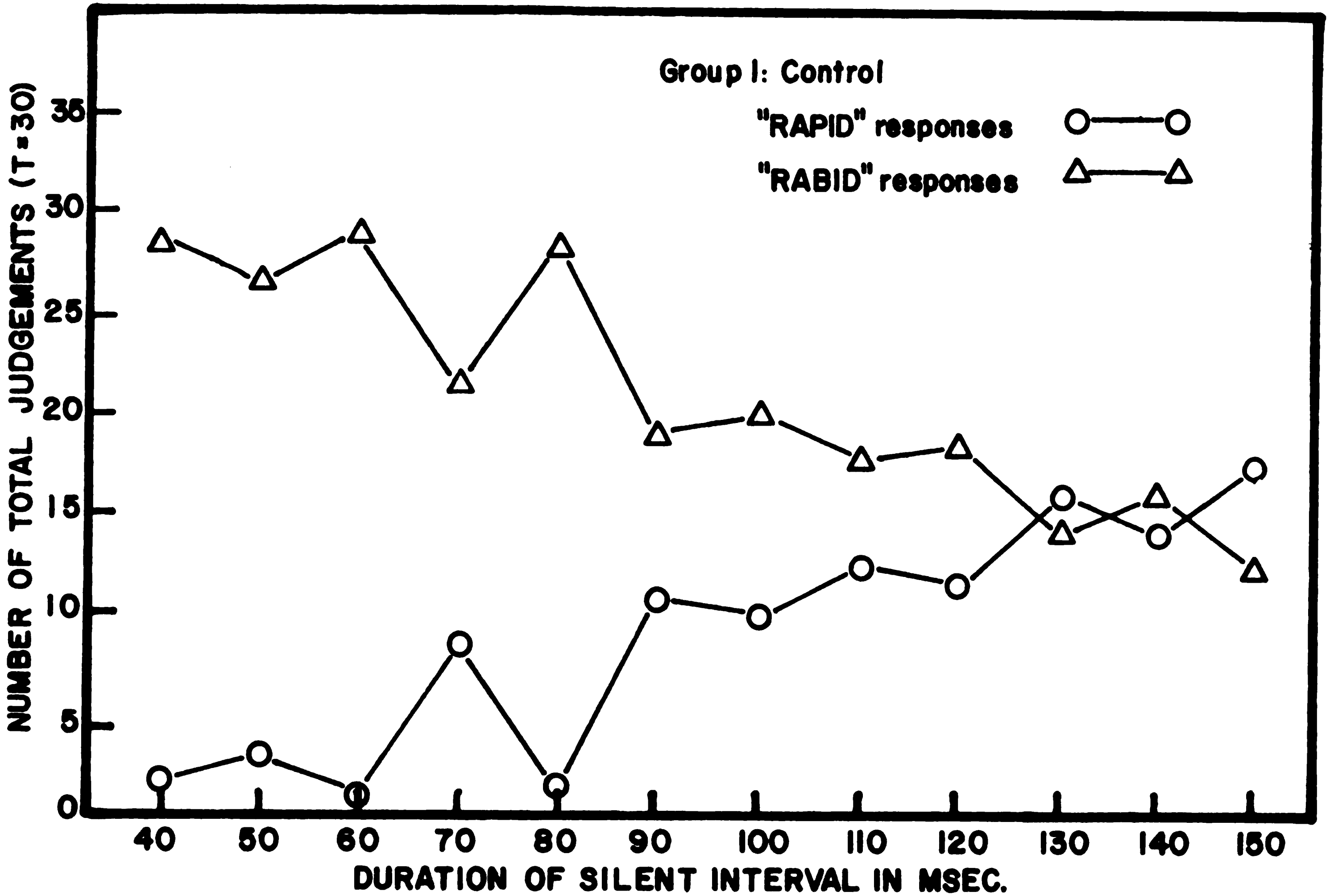

Fig. 2a. Identification task function for Group I: Control for Intervocalic /p/ and /b/. Each point shows relative frequency of /p/ and /b/ identifications.

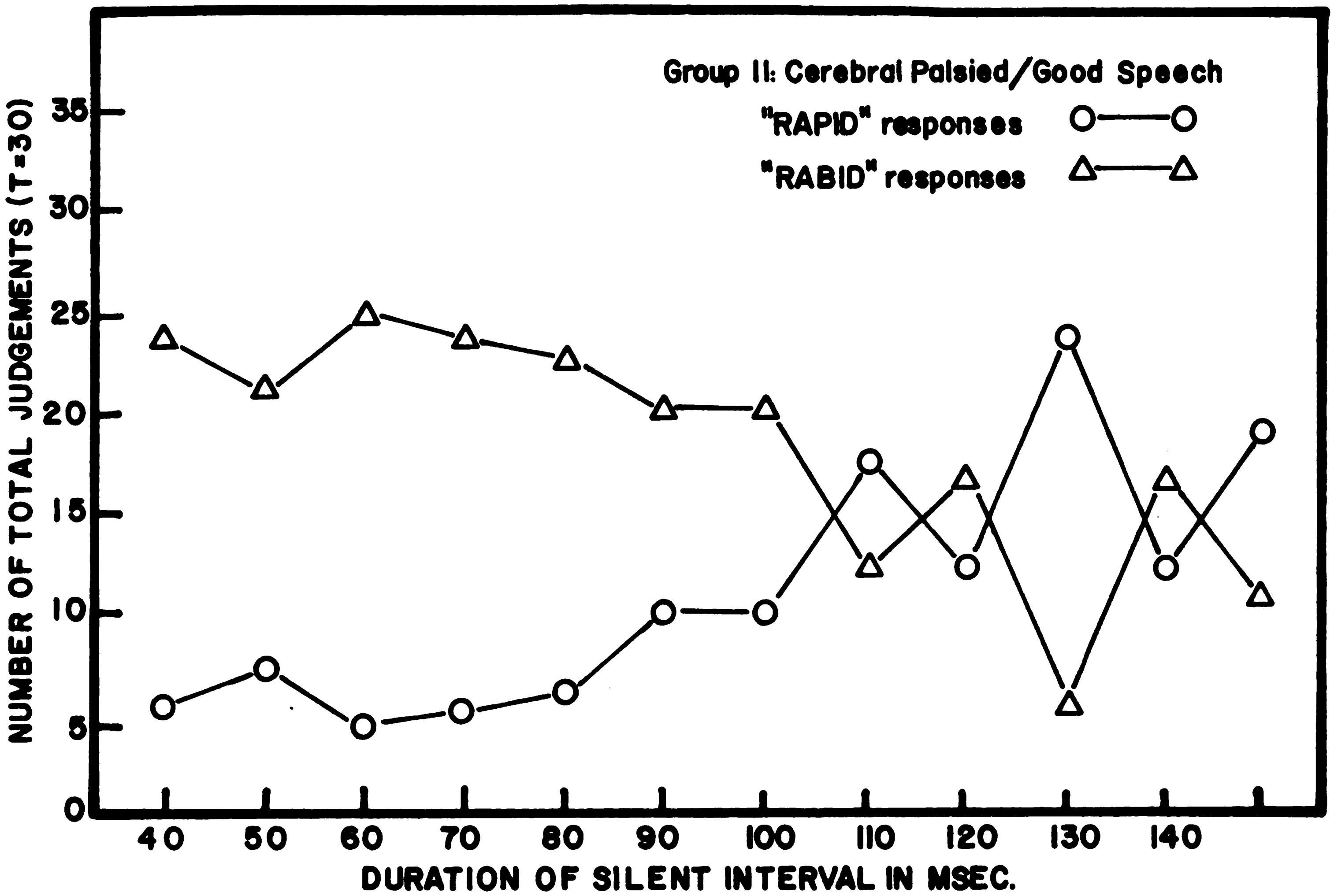

Fig. 2b. Identification task function for Group II: Cerebral Palsied/Good Speech for Intervocalic /p/ and /b/. Each point shows frequency of /p/ and /b/ identifications.

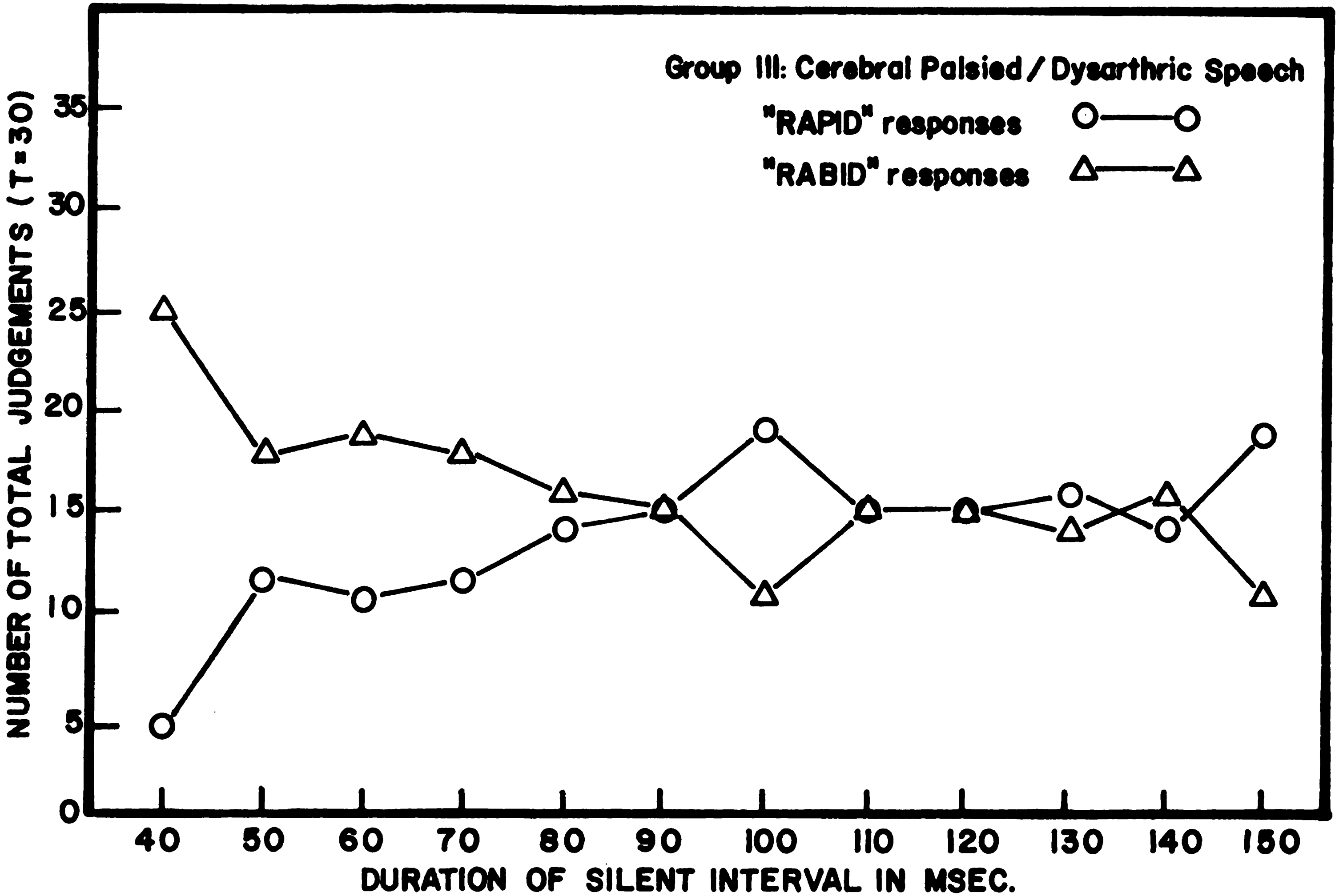

Fig. 2c. Identification task function for Group III: Cerebral Palsied/ Dysarthric Speech for Intervocalic /p/ and /b/. Each point shows frequency of /p/ and /b/ identifications.

reason for the more variable boundaries. However, there are also differences between the groups in phoneme boundary placement. For Group I (Fig. 2a) the boundary is most distinct, occurring at approximately 130 msec, for the durations used. As the variability in the groups increased, the type of configuration became more confusing. Although there still appeared to be phoneme boundaries, rather than one or two cross-overs, there is a wide range along the continuum of what appears to be "random" identification (Figs. 2b and 2c).

Group II data showed cross-overs in the same region on the continuum as Group I. The cross-over points for this group were associated with shorter silent interval durations, the first appearing between 100 msec and 110 msec. For Group III the cross-over points on the continuum were at 90 msec and continue through the same silent interval durations as for Groups I and II.

Liberman et al. (1961) found, for synthetic speech, that 70 msec was the phoneme boundary between the perception of /p/ and /b/. Lisker (1957), who used recorded live speech, also determined that between 70-80 msec was the boundary for some stimuli, but that approximately 105 msec served as the boundary for other stimuli. These cross-over points in the present study were all higher than those previously found, especially for Group I, which was the group most comparable to these other studies. This difference could be related to the stimuli. It could also, and this seems more likely, be due to the nonpreselection of the subjects.

To determine whether the boundaries for the three groups converged, the data were collapsed over temporal intervals. That is, the total judgments for two steps along the continuum (i.e., 40 msec and 50 msec) were computed and then graphed together; and subsequently results for three steps along the continuum were handled similarly. These data are shown in Figures 3a to 3c. For each graph, the section on the right is the plotting of two stimuli simultaneously; on the left is the plotting of three stimuli simultaneously. A clearer picture was gained of the subjects phoneme boundary placement. Groups I and II placed the phoneme boundary similarly. Group III varied from the other two groups in placement. The phoneme boundaries appeared to be closer together than when the stimuli were plotted as individual points. The points at which the data crossed over for each grouping of stimuli are listed in Table 3.

TABLE 3. Cross-over points for data from the Identification Task for temporally collapsed data, in msec.

Group	2 Stimuli	3 Stimuli
Group I	130-140	120-130
Group II	110-120	120-130
Group III	90-100	90-100

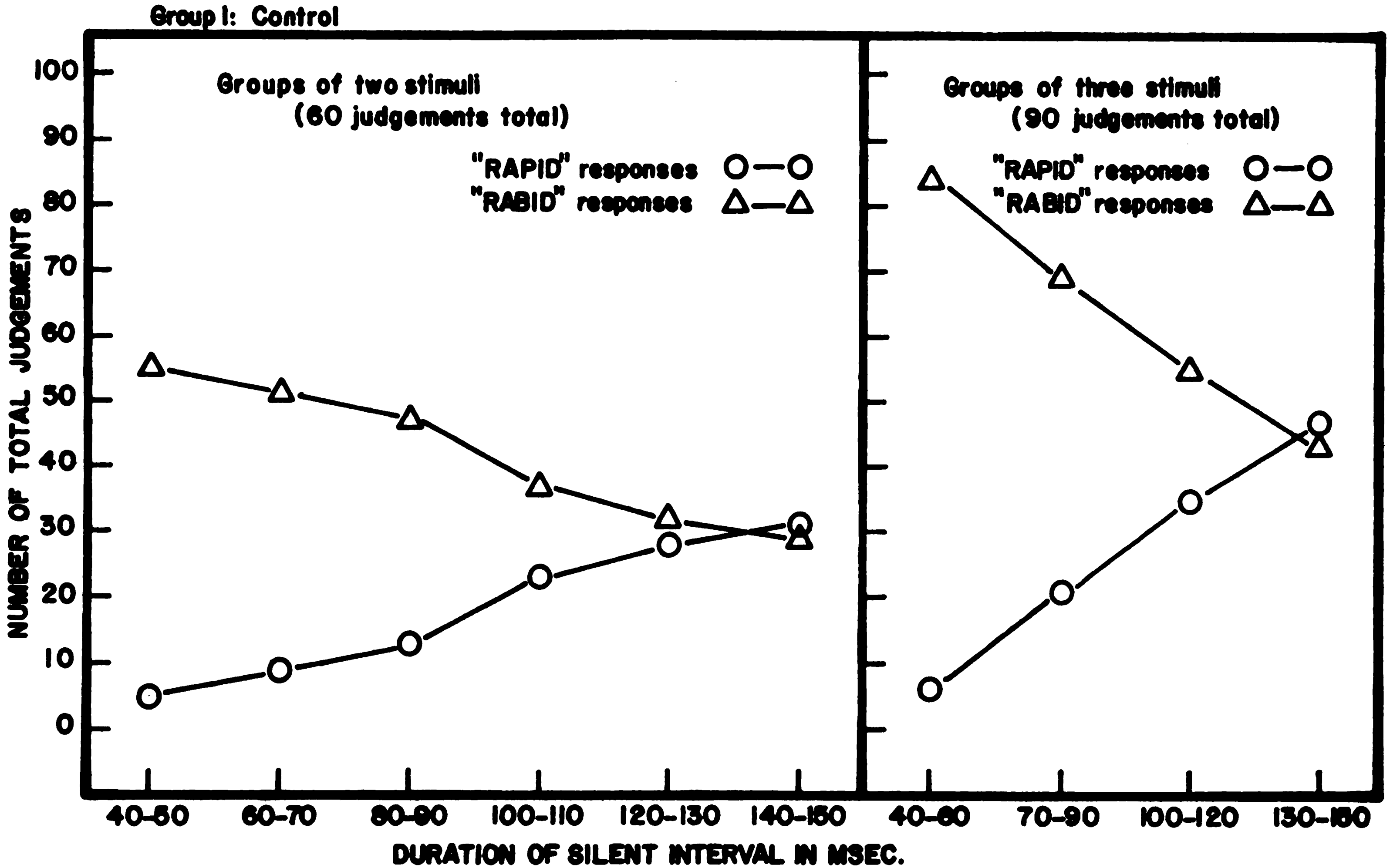

Fig. 3a. Identification task function for Group I: Control for Intervocalic /p/ and /b/, for combined data in groups of 2 and 3 for frequency of /p/ and /b/ identifications.

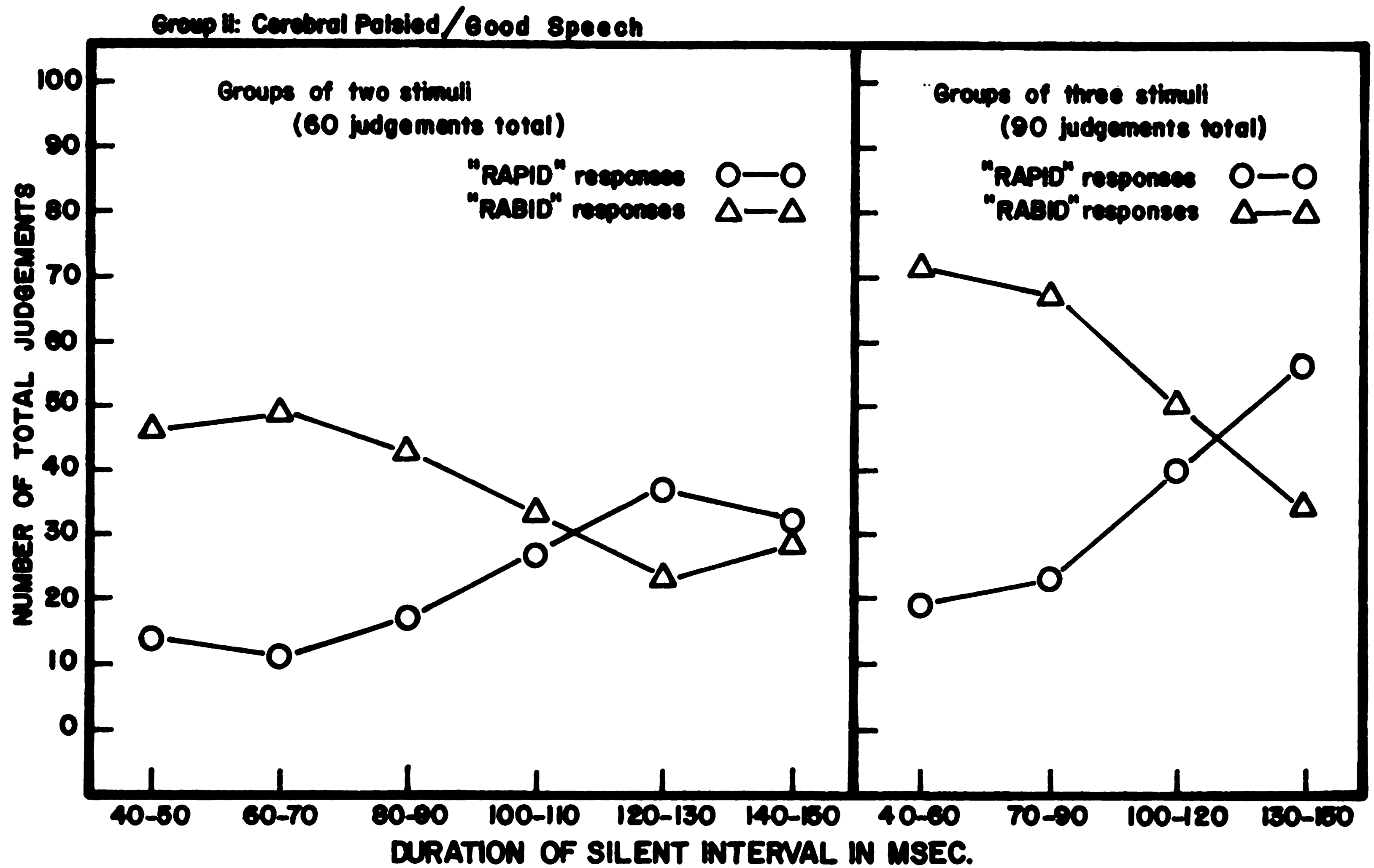

Fig. 3b. Identification task function for Group II: Cerebral Palsied/Good Speech for Intervocalic /p/ and /b/, for combined data in groups of 2 and 3 for frequency of /p/ and /b/ identifications.

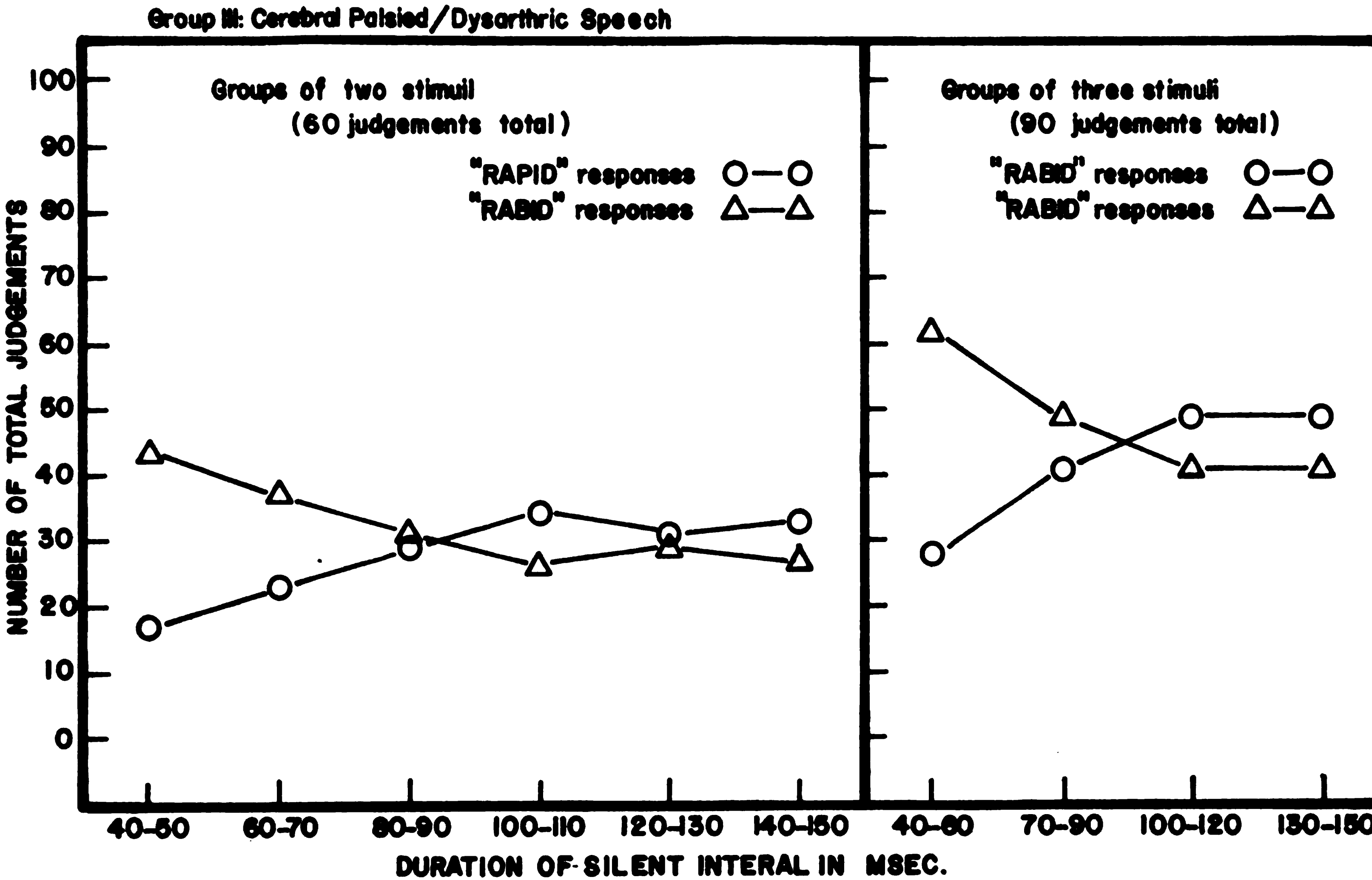

Fig. 3c. Identification task function for Group III: Cerebral Palsied/ Dysarthric Speech, for Intervocalic /p/ and /b/, for combined data in groups of 2 and 3 for frequency of /p/ and /b/ identifications.

There was still a decelerating trend, toward shorter durations, from Group I to Group II to Group III. However, when the data were plotted in groups of three, Groups I and II converge. That is, the phoneme boundaries of these two groups were closer than for Group II and Group III.

Lisker (1957), using the words _rupee_ and _ruby_, found the range of closure durations for /p/ 90-140 msec with an average of 120 msec, and that for /b/, the range was 65-90 msec with an average of 75 msec. If the stimuli used had been made from the word _rupee_, judgments were divided between 70 and 80 msec. If the stimuli had been produced from _ruby_, the boundary line was at 105 msec. Therefore, a 30 msec closure duration difference can be expected for identification gradients made from different words. In the present study the words were _rapid_ and _rabid_. To determine whether a boundary shift as described by Lisker (1957) was present, the data were separated on the basis of what the original word had been. These data were then computed in groups of two and three points along the temporal continuum. Graphs were made for the data from each word; there were two graphs per word, one for the groups of two stimuli and one for the groups of three stimuli. These are shown in Figures 4a to 4c. The boundaries for those stimuli made from _rabid_ are not different from Group I to Group II to Group III. So,

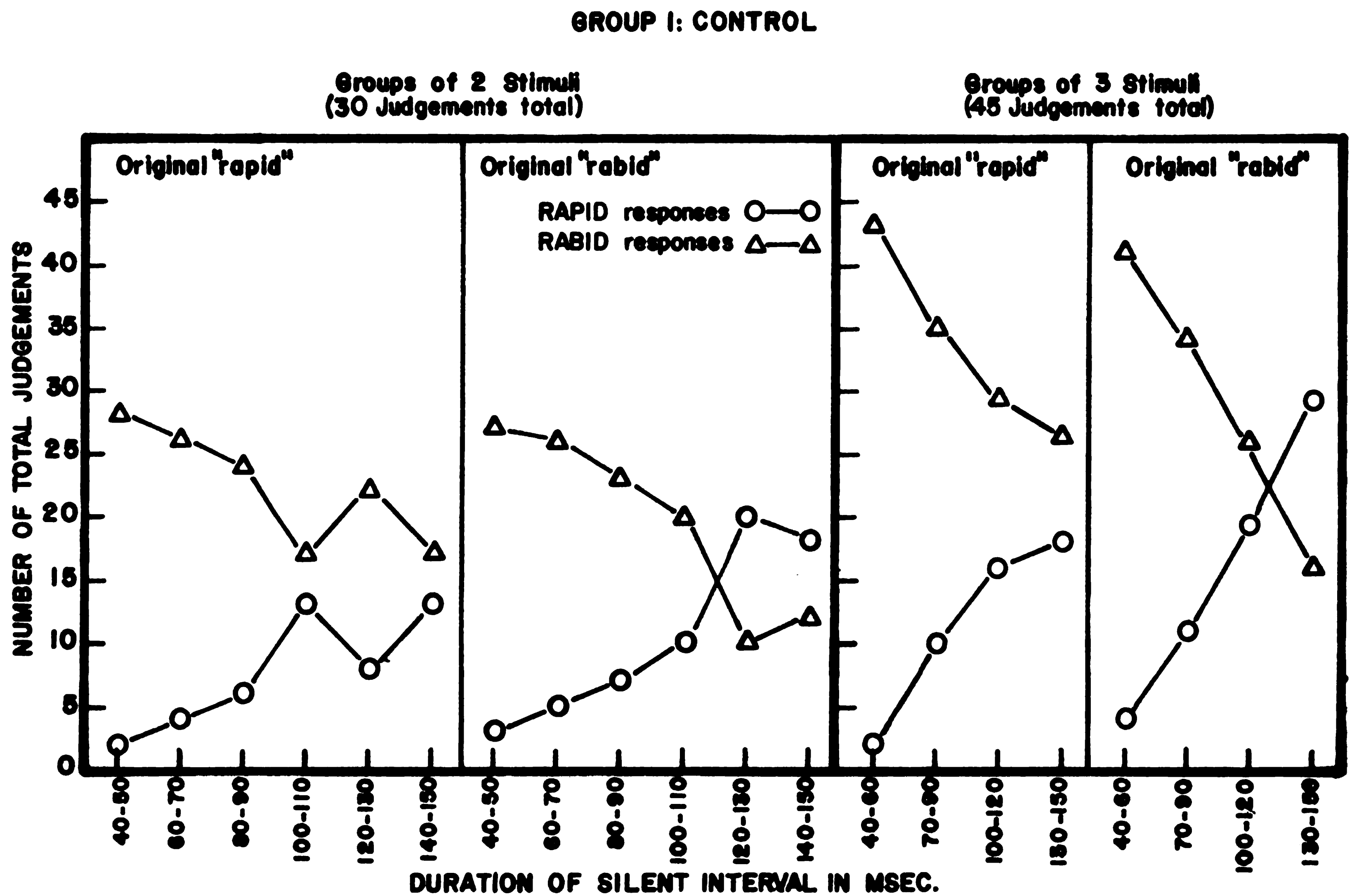

Fig. 4a. Identification task function for Group I: Control. Separated functions by: original word for stimulus production and by groupings 2 and 3 stimuli.

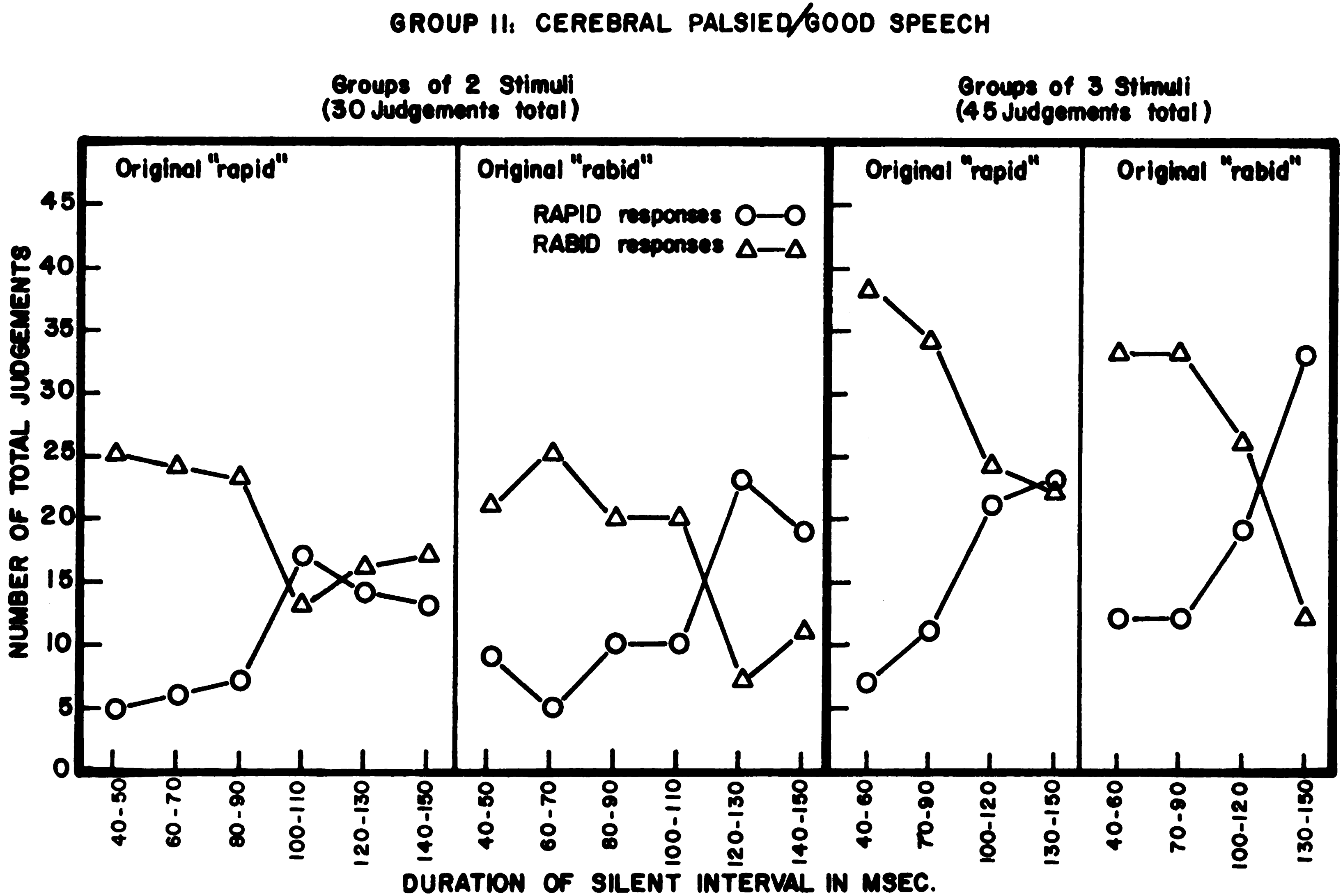

Fig. 4b. Identification task function for Group II: Cerebral Palsied/Good Speech. Separated by: original words for stimulus production and by groupings of 2 and 3 stimuli.

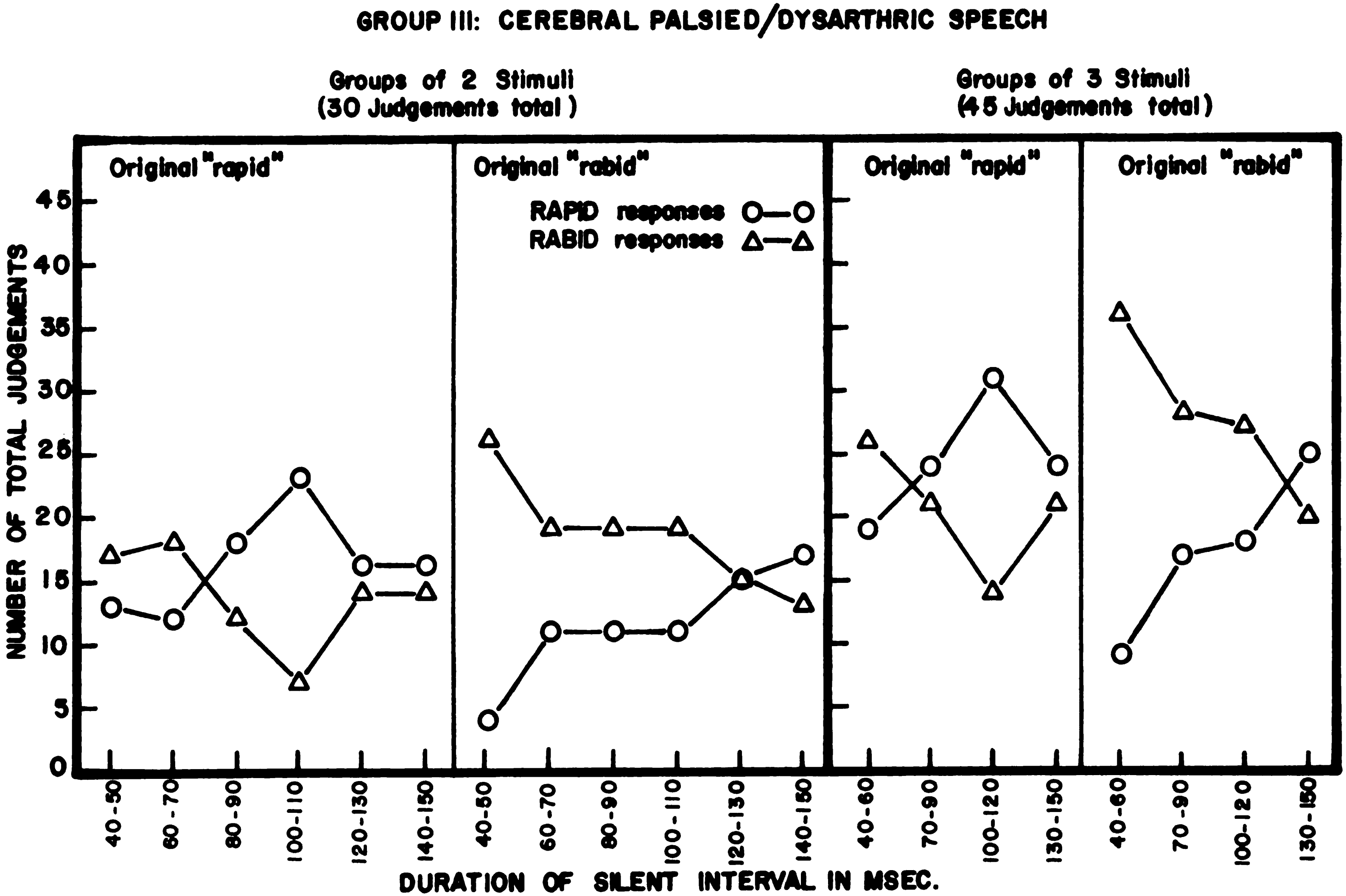

Fig. 4c. Identification task function for Group III: Cerebral Palsied/Dysarthric Speech. Separated by: original words for stimulus production and by groupings of 2 and 3 stimuli.

consequently these boundaries can be said to be the same. For those stimuli made from rapid, the downward trend was still apparent. Group I showed no cross-over points for these stimuli. Group II had cross-overs at 90 msec to 100 msec, 110 msec to 120 msec for groups of two stimuli; for groups of three stimuli, the cross-over was between 120 msec and 130 msec. Group III data for groups of three stimuli placed the phoneme boundary between 60 msec and 70 msec; for groups of two, the phoneme boundary was between 70 msec and 80 msec. Only the data for Group III showed the 30 msec difference found by Lisker (1957), a difference which he attributed to other cues. He did not elaborate on what these other cues might have been.

The perceptual patterns do show a difference among the groups. Whereas each group appeared to perceive categorically, the categories are quite different, indicating some difference in perception. Because the two cerebral palsied groups differed from the control group, it would seem that a part of the difference could be due to the presence of cerebral palsy, and more specifically to the motor dysfunction associated with cerebral palsy. This contention is supported by the fact that the two cerebral palsied groups differed from each other whereby the more severe group was less apt to show categorical perception. However, the more severely involved subjects, with respect to speech involvement, in Group III, were not less apt to demonstrate categorical perception patterns than other subjects in Group III.

Although there is categorical perception in all three groups, a Motor Theory of Speech Perception can help to explain the differences. These results could also weaken the Motor Theory of Speech Perception. Because Group III did categorically perceive, neuromotor patterns are not necessary; and this nullifies the connection of production and perception. However, if the Motor Theory of Speech Perception is used as a base, it provides an explanation for the difference among the groups. Cerebral palsy is the result of brain damage and is a motor dysfunction. Even if the speech is not disordered, as in Group II, it is possible for there to have been some rearranging of the neuromotor patterns necessary for speech perception. This does not mean that the individual would have a perceptual disability, but it could mean a perceptual difference. Group II's perceptual pattern was different from Group I.

By assuming that the brain damage could disorder the stored neuromotor correlates for perception, it must also be assumed that these correlates are innately given, as suggested by previous research (Eimas, 1971). The present study does support this contention, because of the fact that Group III did categorically perceive. These subjects have not had long experience with the speech sounds which Liberman et al. (1957, 1961) stated were necessary for categorical perception. Further, they were able to place phoneme boundaries, while experiencing minimal motor speech history. This lack of experience could weaken the link between production/ perception.

However, Group III did perceive more differently from Group I than did Group II. Consequently, there could be some advantage to be gained in speech perception when the listener is able to produce the speech sounds. However, this is not necessary for accurate and rapid perception. It could make a difference in degree of accuracy or rapidity of perception, however.

Motor Theory does provide the basis for an explanation of these data. These data also can tell us something about Motor Theory. First, as stated above, the data support the contention that the system is innately tuned to speech + language production and perception; secondly, there is possibly some advantage to be gained by being able to produce the speech sounds; and third, the data provide implications about the level at which the encoding occurs. Because of the difference between Group I and Group II, it seems likely that some encoding occurs above the level of the conversion of muscle contractions to vocal tract shape. This would be because Group II, which has no difficulty at that level, does have a different perceptual pattern from Group I. The likely place for this additional encoding to occur would be at the level of the neural correlates, the presumed invariants necessary for the decoder to operate. The data from electromyographic studies strongly support the invariance of the motor commands (Liberman et al., 1967). Liberman et al. (1967), however, state that only further investigation can determine if any significant restructuring or encoding occurs at the higher levels of production. The differences between Groups I and II indicate the possibility of some degree of restructuring may occur at this higher level. In this case, the correlates could be different, not enough to affect the speech of the individual, but only enough to affect the encoding that takes place at this level. The difference in encoding between the Group I and Group II could be accounted for on the basis of this contention. For Group III there would be a difference of the encoding at the level proposed by Liberman et al. (1967) and at the higher level proposed here. This would explain the greater difference between Group I and Group III than between Group I and Group II.

The groups do not differ in even steps along the temporal continuum. The difference between Group III and Group II is greater than the difference between Group II and Group I. This would indicate that the greatest amount of encoding occurred at the level of conversion from muscle contraction to vocal tract shape. This is because the greatest difference in perceptual pattern occurred in the group that had difficulties at that level; the disturbance of the encoding at that level caused more difference; therefore, more encoding must occur there.

Discrimination Task

Predicted Discrimination Peaks

Liberman et al. (1967) stated that the points of maximal and minimal differential sensitivity should be displaced along the continuum to correspond with the phoneme boundaries. It should then be possible to predict these points given the phoneme boundaries. Liberman et al. (1957) devised a test to predict the entire discrimination function for phonemes. The discrimination peaks were located at the phoneme boundaries. In the present study, the ABX triad was not used, so the predictive test of discrimination function was not applied. However, since the previous discrimination peaks have fallen at the phoneme boundaries, it can be predicted that the discrimination peaks of the present study should fall at the phoneme boundaries. The data from the separate sets of stimuli grouped into two's and three's, as presented in Figs. 4a to 4c, were the data used to predict the discrimination peaks. The predicted discrimination peaks are listed in Table 4.

TABLE 4. Predicted discrimination peaks from data obtained by collapsing the judgments into groups of two and three; these were also separated by original word.

Group	Rapid		Rabid	
	Sets of 2	Sets of 3	Sets of 2	Sets of 3
Group I	none	none	110-120	120-130
Group II	90-110 110-120	120-130	110-120	120-130
Group III	70-80	60-70	110-120 120-130	120-130

Obtained Discrimination Functions

The actual discrimination functions should provide information about the learning component proposed by Motor Theory. From the Identification Task there appeared to be an advantage to being able to actually produce the phonemes and to benefit from the learning that took place in the development of speech production.

In order to further delineate the assumption of the Motor Theory, the discrimination functions were plotted by comparing each stimulus in a set with the stimulus next to it (Appendix C) in what is referred to as a "one-step" comparison. These data appear in

Figure 5. The discrimination is below chance within the categories, many fewer than 50% of the judgments were "different." There are peaks at some of the phoneme boundaries as predicted from the identification task. The peak for Group II, taken as the highest point, is between 120 msec and 130 msec. However, the peak for Group III occurred much further along the continuum than predicted, being at 90-100 msec point rather than at the predicted 60-70 msec point. For each set of data, one for each original word, there is no correlation between the predicted and obtained peaks. There also are none of the valleys that are important within the categories to indicate the efficient sorting of within-the-category stimuli. The discriminations were predominately of the "same" judgment. The stimuli would, therefore, seem to exhibit acquired similarity, because of the fact that such diverse cues all produced the same response in so many listeners.

These data indicate that the labelling of speech sounds and the discrimination of the speech sounds are not related, as had been proposed (Liberman et al., 1957; 1961; 1967). Further, the learning component of speech perception is not supported by these findings. These data would support one of Lane's (1965) objections to categorical perception tasks. That is, if the subject is allowed to label a stimulus as anything he wishes, the

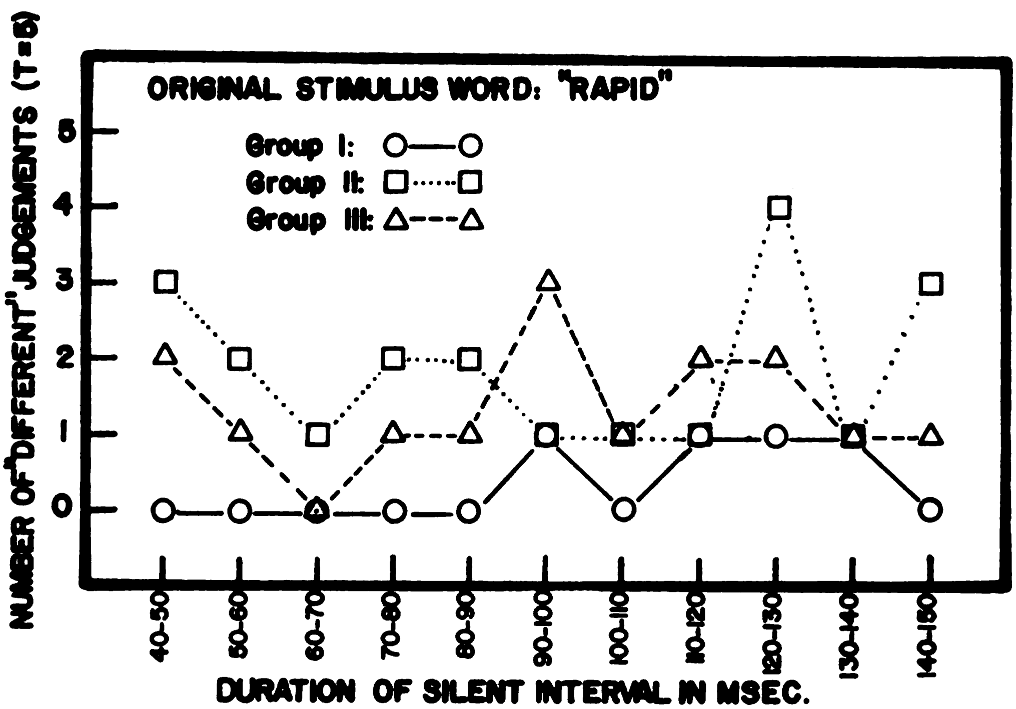

Fig. 5a. Discrimination task function displayed by a one-step comparison using results from stimuli produced from original word "rapid."

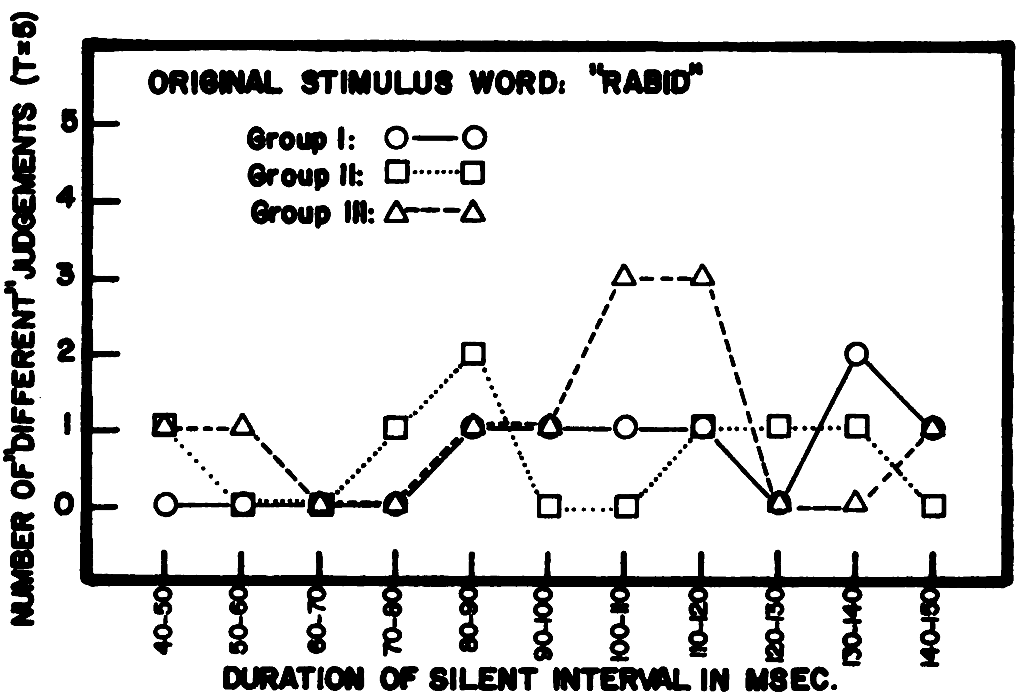

Fig. 5b. Discrimination task function displayed by a one-step comparison using results from stimuli produced from original word "rabid."

perception is not going to be categorical. In the present study, the subject had to label either rapid or rabid. Although the discrimination task was also forced choice, the subject was making a judgment on similarity or difference to only one word. Without another reference (i.e., the two words of an ABX paradigm) the subject did not easily sort the stimuli into two categories. The listener had difficulty on the basis of silent interval duration alone in discriminating these stimuli. It would seem from this study that more than one subphonemic feature must differ for the listener to easily sort out the phonemes.

The three groups performed comparably on this task. Although the three groups identified in a categorical mode, they did not discriminate in a categorical mode. Thus, the results of the present investigation would tend to weaken the arguments for the learning component of speech perception, the production/perception link, and the idea of labelling and discrimination being closely associated.

Ratings of the Speech of the Cerebral Palsied

The mean ratings of the judges for overall speaker intelligibility and number of articulation errors, and the ratings of the examiner of functional capacity and therapeutic appliances, can be found in Table 5.

TABLE 5. Ratings of the Overall Intelligibility of the two Experimental Groups; ratings of their functional capacity and of their need for therapeutic appliances; and mean number of errors on articulation test.

Group	Functional	Therapeutic	Speech Intelligibility	No. of Errors
Group II				
1	4	3	1	0
2	2	2	1	0
3	4	3	1	0
4	1	1	1	0
5	-2	-2	-1	0
	M 2.6	M 2.2	M 1	0
Group III				
1	4	3	2	11
2	4	3	2	12
3	3	3	1	11
4	4	3	5	130
5	-1	-1	-4	54
	M 3.2	M 2.6	M 2.8	

The mean ratings for the Group II functional and therapeutic ratings are somewhat higher than for Group III. However, inspection of the individual ratings for each group's subjects show low variability between the groups. The difference between the two groups in the mean ratings for overall speech intelligibility was significant. This would support the conclusions that the differences between groups are related to something that is related to the difference in speech ability. However, it must be kept in mind that the experimenter was the one to rate the subjects on functional ability and the therapeutic scale, whereas three judges rated the overall speech intelligibility. This could be a biasing factor.

Conclusions

Conclusions that have been drawn from the results of the study can be summarized as follows:

1. There is not a learning component to speech perception ability.
2. There is not necessarily a production/perception link for accurate and rapid perception of speech sounds.
3. Individuals with cerebral palsy do exhibit different perceptual patterns from normal individuals.
4. Cerebral palsied individuals with good speech and those with dysarthric speech exhibit different perceptual patterns from each other.
5. It would seem that production abilities did make a difference in the pattern exhibited.

Implications for Further Research

From the results of this study some directions for further research can be recommended. A weak point in this study was the preparation of the stimuli; the manual cut and splice technique is not as accurate as synthetic speech. Replicating this study using synthetic speech would give a more precise picture of the perceptual differences among groups.

In an attempt to define the benefit gained from production ability, a study involving children and adults with cerebral palsy would give information on this topic. Also, the type of previous speech therapy the subjects had received could play a part in their ability to perceive categorically.

CHAPTER IV

SUMMARY

The phenomenon of categorical perception was studied with a cerebral palsied population. The implication that the results could have for a Motor Theory of Speech Perception and the explanations this theory could provide for the results were also considered.

Fifteen adult subjects were evenly divided into three groups: control, cerebral palsied/good speech, and cerebral palsied/dysarthric speech. All subjects were of normal intelligence and had hearing. The cerebral palsied groups were comparable except for their speech production abilities. Each subject responded to identification and discrimination tasks.

The results indicated categorical identification for all groups. Discrimination results were similar for all of these groups, but they were not related to the predictions associated with categorical perception studies and Motor Theory. The results indicated that production abilities were not necessary for accurate perception but that the ability to produce the speech sounds made a difference in the perceptual pattern of these listeners. Those listeners who could not produce the phonemes exhibited greater variability. There was a difference between the two cerebral palsied groups and the control group. This was indicative of a component of perception that was altered by the cerebral palsied involvement. It was hypothesized that this indicated encoding takes place at a higher level than that proposed by a Motor Theory of Speech Perception.

APPENDICES

APPENDIX A

TASK TRIAL COMPOSITION

APPENDIX A

Identification Task-Trial Composition

Trial #	Stimulus	Trial #	Stimulus
1	rabid-110	37	rabid-40
2	rapid-40	38	rabid-50
3	rapid-60	39	rapid-110
4	rapid-100	40	rapid-90
5	rapid-50	41	rabid-130
6	rabid-40	42	rabid-150
7	rapid-110	43	rabid-70
8	rabid-140	44	rabid-80
9	rapid-140	45	rapid-80
10	rabid-120	46	rapid-120
11	rapid-90	47	rabid-120
12	rabid-130	48	rapid-70
13	rapid-130	49	rapid-100
14	rabid-70	50	rabid-110
15	rapid-80	51	rapid-50
16	rapid-150	52	rabid-50
17	rabid-90	53	rapid-70
18	rabid-80	54	rapid-130
19	rabid-50	55	rapid-40
20	rapid-70	56	rabid-140
21	rabid-60	57	rapid-120
22	rabid-150	58	rabid-90
23	rapid-120	59	rapid-90
24	rabid-100	60	rabid-130
25	rapid-130	61	rabid-40
26	rapid-40	62	rabid-70
27	rapid-140	63	rapid-140
28	rabid-90	64	rabid-150
29	rabid-140	65	rabid-100
30	rapid-50	66	rapid-110
31	rabid-50	67	rapid-150
32	rabid-110	68	rapid-80
33	rapid-100	69	rabid-120
34	rapid-150	70	rapid-60
35	rabid-100	71	rabid-80
36	rapid-60	72	rabid-60

Task Trial Composition

Discrimination Task-Trial Composition

Trial #	Word	Interval	Trial #	Word	Interval
1	rapid	20-130	46	rabid	150-130
2	rabid	90-90	47	rabid	110-40
3	rabid	150-110	48	rapid	60-70
4	rapid	40-70	49	rapid	40-50
5	rapid	40-60	50	rabid	90-150
6	rapid	90-110	51	rabid	70-140
7	rabid	80-80	52	rapid	120-100
8	rabid	140-50	53	rapid	130-150
9	rabid	60-70	54	rapid	110-150
10	rapid	150-80	55	rapid	110-70
11	rapid	100-40	56	rabid	100-40
12	rabid	100-50	57	rabid	40-90
13	rapid	40-90	58	rabid	100-140
14	rabid	140-60	59	rapid	150-100
15	rapid	80-70	60	rapid	90-90
16	rabid	110-70	61	rabid	140-140
17	rapid	110-110	62	rapid	70-50
18	rapid	110-40	63	rabid	50-110
19	rapid	150-140	64	rabid	40-120
20	rabid	150-40	65	rabid	150-50
21	rabid	120-90	66	rabid	60-40
22	rapid	120-60	67	rapid	150-60
23	rabid	130-40	68	rapid	110-100
24	rabid	120-60	69	rapid	100-140
25	rapid	90-100	70	rabid	130-130
26	rapid	100-50	71	rabid	70-70
27	rapid	140-110	72	rapid	40-150
28	rapid	40-40	73	rapid	80-120
29	rabid	150-150	74	rapid	130-50
30	rabid	70-130	75	rapid	50-50
31	rapid	120-50	76	rabid	60-50
32	rabid	120-70	77	rabid	50-130
33	rapid	40-80	78	rapid	150-90
34	rabid	90-70	79	rapid	130-100
35	rabid	140-120	80	rabid	140-130
36	rapid	140-50	81	rabid	50-120
37	rapid	130-80	82	rapid	70-50
38	rabid	120-100	83	rabid	110-100
39	rabid	130-90	84	rabid	120-120
40	rabid	80-40	85	rabid	130-120
41	rapid	90-140	86	rapid	100-100
42	rapid	150-50	87	rapid	130-60
43	rapid	100-70	88	rapid	60-60
44	rabid	110-110	89	rapid	150-120
45	rapid	130-140	90	rapid	140-70

Discrimination Task-Trial Composition (cont'd.)

Trial #	Word	Interval
91	rapid	70-130
92	rabid	120-110
93	rabid	150-80
94	rabid	60-100
95	rabid	100-130
96	rapid	140-120
97	rapid	140-140
98	rapid	80-100
99	rapid	90-70
100	rabid	90-110
101	rabid	80-90
102	rabid	140-110
103	rapid	120-130
104	rapid	120-120
105	rapid	140-80
106	rapid	130-90
107	rabid	130-80
108	rabid	60-150
109	rabid	80-50
110	rabid	60-80
111	rapid	110-120
112	rapid	90-50
113	rapid	80-50
114	rapid	40-140
115	rabid	50-40
116	rabid	70-40
117	rabid	150-120
118	rabid	100-150
119	rapid	40-120
120	rapid	60-110
121	rapid	80-60
122	rapid	70-70
123	rabid	110-130
124	rapid	80-80
125	rapid	100-60
126	rapid	60-90
127	rapid	110-50
128	rabid	60-60
129	rabid	50-70
130	rabid	140-40
131	rabid	150-150
132	rabid	50-90
133	rabid	100-120
134	rabid	100-90
135	rabid	120-120
136	rapid	70-120
137	rabid	70-80
138	rabid	60-110
139	rabid	90-60
140	rabid	140-90
141	rapid	80-110
142	rabid	60-130
143	rabid	70-100
144	rabid	100-80
145	rabid	40-40
146	rabid	50-50
147	rapid	130-40
148	rapid	60-140
149	rabid	80-110
150	rabid	140-150
151	rapid	90-120
152	rapid	130-130
153	rapid	80-90
154	rapid	60-50
155	rabid	70-150
156	rabid	140-80

APPENDIX B

IDENTIFICATION TASK DATA FOR INDIVIDUAL SUBJECTS

Identification Task Data for Individual Subjects

APPENDIX B

Stimuli Produced From "Rapid"

Group	Judgment	Silent Interval Duration (msec)											
		40	50	60	70	80	90	100	110	120	130	140	150
Control													
1	P	0	0	0	0	0	0	1	0	0	0	1	1
	B	3	3	3	3	3	3	2	3	3	3	2	2
2	P	0	0	0	2	2	1	2	3	1	2	2	1
	B	3	3	3	1	1	2	1	0	2	1	1	2
3	P	0	0	0	0	0	0	0	0	0	0	0	0
	B	3	3	3	3	3	3	3	3	3	3	3	3
4	P	0	0	0	1	0	3	3	3	2	3	3	3
	B	3	3	3	2	3	0	0	0	1	0	0	0
5	P	1	1	0	1	0	0	1	0	0	0	0	2
	B	2	2	3	2	3	3	2	3	3	3	3	1
Cerebral Palsied/Good Speech													
1	P	0	0	0	0	0	0	2	0	2	2	0	2
	B	3	3	3	3	3	3	1	3	1	1	3	1
2	P	1	0	0	0	0	0	0	1	0	1	2	1
	B	2	3	3	3	3	3	3	2	3	2	1	2
3	P	0	1	0	0	1	1	1	2	0	3	0	0
	B	3	2	3	3	2	2	2	1	3	0	3	3
4	P	1	0	0	2	2	1	2	1	0	2	0	3
	B	2	3	3	1	1	2	1	2	3	1	3	0
5	P	0	2	2	2	1	1	2	3	2	2	2	3
	B	3	1	1	1	2	2	1	0	1	1	1	0
Cerebral Palsied/Dysarthric Speech													
1	P	0	2	2	2	2	3	3	3	1	2	2	2
	B	3	1	1	1	1	0	0	0	2	1	1	1
2	P	1	1	0	0	1	1	1	2	2	2	0	2
	B	2	2	3	3	2	2	2	1	1	1	3	1
3	P	0	2	0	1	1	1	3	1	2	1	0	2
	B	3	1	3	2	2	2	0	2	1	2	3	1
4	P	1	1	1	0	2	1	3	1	1	0	2	2
	B	2	2	2	3	1	2	0	2	2	3	1	1
5	P	2	3	3	3	3	3	3	3	2	3	2	2
	B	1	0	0	0	0	0	0	0	1	0	1	1

Identification Task Data for Individual Subjects

Stimuli Produced From "Rabid"

Group	Judgment	Silent Interval Duration (msec)											
		40	50	60	70	80	90	100	110	120	130	140	150
Control													
1	P	0	0	0	2	0	3	1	1	2	2	2	2
	B	3	3	3	1	3	0	2	2	1	1	1	1
2	P	0	0	0	0	0	2	0	3	2	3	2	3
	B	3	3	3	3	3	1	3	0	1	0	1	0
3	P	0	0	0	0	0	0	1	1	2	2	1	3
	B	3	3	3	3	3	3	2	2	1	1	2	0
4	P	0	0	0	0	0	0	0	2	1	2	3	2
	B	3	3	3	3	3	3	3	1	2	1	0	1
5	P	1	2	1	2	0	2	2	0	2	2	0	1
	B	2	1	2	1	3	1	1	3	1	1	3	2
Cerebral Palsied/Good Speech													
1	P	0	0	0	0	0	1	0	2	3	3	3	2
	B	3	3	3	3	3	2	3	1	0	0	0	1
2	P	1	2	1	0	1	1	2	2	3	3	2	1
	B	2	1	2	3	2	2	1	1	0	0	1	2
3	P	2	0	1	0	0	0	0	0	0	3	0	1
	B	1	3	2	3	3	3	3	3	3	0	3	2
4	P	1	2	1	2	2	2	1	2	2	2	1	3
	B	2	1	2	1	1	1	2	1	1	1	2	0
5	P	0	1	0	0	0	3	0	1	1	3	3	3
	B	3	2	3	3	3	0	3	2	2	0	0	0
Cerebral Palsied/Dysarthric Speech													
1	P	0	0	1	2	1	1	0	1	2	2	2	2
	B	3	3	2	1	2	2	3	2	1	1	1	1
2	P	0	0	0	1	1	3	2	2	2	2	3	2
	B	3	3	3	2	2	0	1	1	1	1	0	1
3	P	1	3	1	2	2	2	2	1	2	3	2	2
	B	2	0	2	1	1	1	1	2	1	0	1	1
4	P	0	0	2	0	1	0	1	1	1	1	1	2
	B	3	3	1	3	2	3	2	2	2	2	2	1
5	P	0	0	1	1	0	0	1	0	0	0	0	1
	B	3	3	2	2	3	3	2	3	3	3	3	2

APPENDIX C

DISCRIMINATION TASK DATA FOR INDIVIDUAL SUBJECTS

Discrimination Task Data for Individual Subjects

APPENDIX C

Stimulus Pair (in msec)	Judgment	Group and Subject Number Control					C.P./Good Speech					C.P./Dysarthric				
(from "rapid"		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
40-40	S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	D															
40-50	S	1	1	1	1	1		1		1			1	1	1	
	D						1		1		1	1				1
40-60	S	1	1	1	1				1	1	1		1	1	1	1
	D					1	1	1				1				
40-70	S	1	1	1	1	1	1	1	1	1			1	1	1	1
	D										1	1				
40-80	S	1	1	1	1	1	1	1	1	1			1	1		1
	D										1	1			1	
40-90	S	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	D										1					
40-100	S	1		1		1		1	1	1	1		1	1		
	D		1		1		1					1			1	1
40-110	S			1			1			1	1			1	1	1
	D	1	1		1	1		1	1			1	1			
40-120	S	1		1	1	1		1			1		1	1	1	
	D		1				1		1	1		1				1
40-130	S			1		1					1		1	1	1	
	D	1	1		1		1	1	1	1		1				1
40-140	S	1		1		1		1				1	1	1	1	
	D		1		1		1		1	1	1					1
40-150	S	1	1	1		1	1			1		1	1	1	1	
	D				1			1	1		1					1
50-50	S	1		1		1		1	1	1		1	1	1	1	
	D		1		1		1				1					1
50-60	S	1	1	1	1	1		1	1	1		1	1	1	1	
	D						1				1					1

Discrimination Task Data for Individual Subjects (cont'd.)

Stimulus Pair (in msec) (from "rapid")	Judgment	Group and Subject Number Control 1	2	3	4	5	C.P./Good Speech 1	2	3	4	5	C.P./Dysarthric 1	2	3	4	5
50-70	S	1	1	1	1	1		1	1	1	1	1	1	1	1	
	D						1									1
50-80	S	1	1	1	1	1	1	1		1		1	1	1	1	
	D								1		1					1
50-90	S			1	1	1	1	1	1	1	1	1	1	1	1	
	D	1	1													1
50-100	S	1	1	1		1	1		1	1			1	1	1	1
	D				1			1			1	1				
50-110	S	1	1	1	1	1	1		1			1	1	1	1	
	D							1		1	1					1
50-120	S		1	1	1	1	1		1	1			1	1		1
	D	1						1			1	1			1	
50-130	S	1	1	1	1	1		1			1				1	
	D						1		1	1		1	1	1		1
50-140	S	1	1	1	1	1	1		1	1	1	1	1	1	1	1
	D							1								
50-150	S	1	1	1		1	1	1	1	1	1				1	
	D				1							1	1	1		1
60-60	S	1	1	1	1	1	1	1		1	1	1	1	1	1	1
	D								1							
60-70	S	1	1	1	1	1	1		1	1	1	1	1	1	1	1
	D							1								
60-80	S	1	1	1	1	1	1				1		1	1	1	
	D							1	1	1		1				1
60-90	S	1		1		1	1	1	1			1	1	1	1	1
	D		1		1					1	1					
60-100	S	1		1		1		1	1		1	1	1	1		1
	D		1		1		1			1					1	
60-110	S		1	1		1		1	1				1	1		
	D	1			1		1			1	1	1			1	1

Discrimination Task Data for Individual Subjects (cont'd.)

Stimulus Pair (in msec) (from "rapid")	Judgment	Group and Subject Number Control					C.P./Good Speech					C.P./Dysarthric				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
60-120	S		1	1	1	1			1	1			1	1	1	1
	D	1					1	1			1	1				
60-130	S			1		1									1	
	D	1	1		1		1	1	1	1	1	1	1	1		1
60-140	S	1	1	1	1	1			1				1	1	1	
	D						1	1		1	1	1				1
60-150	S	1		1		1				1			1			1
	D		1		1		1	1	1		1	1		1	1	
70-70	S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	D															1
70-80	S	1	1	1	1	1	1		1		1		1	1	1	1
	D							1		1		1				
70-90	S	1		1		1		1		1		1	1	1	1	
	D		1		1		1		1		1					1
70-100	S	1		1		1	1			1	1					1
	D		1		1			1	1			1	1	1	1	
70-110	S	1		1		1		1		1		1		1	1	1
	D		1		1		1		1		1		1			
70-120	S		1	1	1	1		1					1	1	1	
	D	1					1		1	1	1	1				1
70-130	S	1	1	1	1	1		1		1	1		1	1	1	
	D						1		1			1				1
70-140	S	1		1		1								1	1	1
	D		1		1		1	1	1	1	1	1	1			
70-150	S	1		1		1	1		1		1	1	1	1		1
	D		1		1			1		1					1	
80-80	S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	D															1
80-90	S	1	1	1	1	1	1		1	1		1	1	1		1
	D							1			1				1	

Discrimination Task Data for Individual Subjects (cont'd.)

Stimulus Pair (in msec) (from "rapid")	Judgment	Group and Subject Number Control 1	2	3	4	5	C.P./Good Speech 1	2	3	4	5	C.P./Dysarthric 1	2	3	4	5
80-100	S	1		1				1		1	1			1		
	D		1		1	1	1		1			1	1		1	1
80-110	S	1	1	1		1		1	1	1			1	1		
	D				1		1				1	1			1	1
80-120	S	1	1	1	1	1	1	1		1	1		1			
	D								1			1		1	1	1
80-130	S	1	1	1		1	1	1	1		1	1	1	1	1	
	D				1					1						1
80-140	S		1	1		1		1				1		1		
	D	1			1		1		1	1	1		1		1	1
80-150	S		1	1		1	1		1		1			1	1	
	D	1			1			1		1		1	1			1
90-90	S	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	D										1					
90-100	S	1	1	1		1	1	1	1		1			1		1
	D				1					1		1	1		1	
90-110	S	1	1	1		1		1	1		1	1	1	1		1
	D				1		1			1					1	
90-120	S	1		1		1	1	1	1			1	1	1		1
	D		1		1					1	1				1	
90-130	S	1	1	1		1	1			1				1	1	
	D				1			1	1		1	1	1			1
90-140	S	1	1	1	1	1		1		1		1	1	1	1	1
	D						1		1		1					
90-150	S	1		1		1			1	1			1	1	1	1
	D		1		1		1	1			1	1				
100-100	S	1	1	1	1	1		1	1	1	1	1	1	1	1	1
	D						1									
100-110	S	1	1	1	1	1	1	1	1		1		1	1	1	1
	D									1		1				

Discrimination Task Data for Individual Subjects (cont'd.)

Stimulus Pair (in msec) (from "rapid")	Judgment	Group and Subject Number Control					C.P./Good Speech					C.P./Dysarthric				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
100-120	S	1	1	1	1	1	1	1		1	1	1	1			
	D								1					1	1	1
100-130	S	1	1	1	1	1		1		1	1	1	1	1	1	1
	D						1		1							
100-140	S	1		1		1	1		1	1			1	1	1	
	D		1		1			1			1	1				1
100-150	S	1	1	1		1	1		1	1	1	1	1	1		1
	D				1			1							1	
110-110	S	1	1	1	1	1	1	1	1	1		1	1	1		1
	D										1				1	
110-120	S	1	1	1		1	1	1	1	1			1	1	1	
	D				1						1	1				1
110-130	S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	D															
110-140	S	1		1		1		1	1			1	1	1		1
	D		1		1		1			1	1				1	
110-150	S	1		1	1		1	1	1	1	1	1	1	1	1	1
	D		1			1										
120-120	S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	D															
120-130	S	1		1	1	1		1				1	1	1		
	D		1				1		1	1	1				1	1
120-140	S		1	1	1	1	1	1	1	1	1	1	1	1	1	
	D	1														1
120-150	S	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	D										1					
130-130	S	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	D										1					
130-140	S		1	1	1	1	1	1	1	1			1	1	1	1
	D	1									1	1				

Discrimination Task Data for Individual Subjects (cont'd.)

Stimulus Pair (in msec)	Judgment	Group and Subject Number: Control 1	2	3	4	5	C.P./Good Speech 1	2	3	4	5	C.P./Dysarthric 1	2	3	4	5
(from "rapid")																
130-150	S	1	1	1	1	1	1		1	1	1	1	1	1	1	
	D							1								1
140-140	S	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	D										1					
140-150	S	1	1	1	1	1	1			1		1	1	1		1
	D							1	1		1				1	
150-150	S	1	1	1		1		1	1	1	1	1	1	1	1	1
	D				1		1									
(from "rabid")																
40-40	S	1	1	1	1	1		1	1	1	1	1	1	1	1	1
	D						1									
40-50	S	1	1	1	1	1	1	1		1	1	1		1	1	1
	D								1				1			
40-60	S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	D															1
40-70	S	1	1	1	1	1	1	1	1	1	1	1		1	1	1
	D												1			
40-80	S		1	1	1	1	1	1	1	1	1	1		1	1	1
	D	1											1			
40-90	S	1	1	1	1	1		1	1			1		1	1	1
	D						1			1	1		1			
40-100	S			1	1	1	1	1	1	1	1		1	1	1	
	D	1	1									1				1
40-110	S			1		1	1	1	1	1			1	1	1	1
	D	1	1		1						1	1				
40-120	S			1				1	1		1	1			1	1
	D	1	1		1	1	1			1			1	1		
40-130	S			1	1				1		1	1		1	1	
	D	1	1			1	1	1		1			1			1

Discrimination Task Data for Individual Subjects (cont'd.)

Stimulus Pair (in msec) (from "rabid")	Judgment	Group and Subject Number Control 1	2	3	4	5	C.P./Good Speech 1	2	3	4	5	C.P./Dysarthric 1	2	3	4	5
40-140	S			1		1		1	1			1		1	1	1
	D	1	1		1		1			1	1		1			
40-150	S			1	1	1		1			1			1		1
	D	1	1				1		1	1		1	1		1	
50-50	S	1	1	1	1	1	1	1	1			1	1		1	1
	D									1	1			1		
50-60	S	1	1	1	1	1	1	1	1	1	1	1		1	1	1
	D												1			
50-70	S	1	1	1	1	1			1	1	1	1		1	1	1
	D						1	1					1			
50-80	S	1	1	1	1	1	1	1	1	1	1	1	1	1		1
	D														1	
50-90	S		1	1	1	1		1	1	1	1	1	1	1		1
	D	1					1								1	
50-100	S	1	1	1	1	1	1	1	1		1	1		1	1	1
	D									1			1			
50-110	S		1	1		1		1	1	1	1	1		1	1	1
	D	1			1		1						1			
50-120	S			1		1		1	1	1	1	1		1		
	D	1	1		1		1						1		1	1
50-130	S			1		1			1		1			1	1	1
	D	1	1		1		1	1		1		1	1			
50-140	S			1					1	1					1	1
	D	1	1		1	1	1	1			1	1	1	1		
50-150	S			1		1					1			1		
	D	1	1		1		1	1	1	1		1	1		1	1
60-60	S	1	1	1	1	1	1	1	1	1	1	1		1	1	1
	D												1			
60-70	S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	D															

Discrimination Task Data for Individual Subjects (cont'd.)

Stimulus Pair (in msec) (from "rabid")	Judgment	Group and Subject Number Control					C.P./Good Speech					C.P./Dysarthric				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
60-80	S	1	1	1	1	1	1	1	1	1		1	1	1		1
	D										1				1	
60-90	S	1		1		1			1					1	1	
	D		1		1		1	1		1	1	1	1			1
60-100	S	1	1	1	1	1		1		1		1		1	1	1
	D						1		1		1		1			
60-110	S		1	1	1	1		1	1		1	1		1		1
	D	1					1			1			1		1	
60-120	S		1	1	1			1	1		1	1		1	1	1
	D	1				1	1			1			1			
60-130	S			1		1		1	1		1		1	1	1	1
	D	1	1		1		1			1		1				
60-140	S			1					1	1	1	1		1	1	1
	D	1	1		1	1	1	1					1			
60-150	S			1		1		1	1					1		
	D	1	1		1		1			1	1	1	1		1	1
70-70	S	1	1	1	1	1	1	1	1	1		1	1	1	1	1
											1					
70-80	S	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	D										1					
70-90	S	1	1		1			1	1		1	1		1	1	1
	D			1		1	1			1			1			
70-100	S		1	1	1	1	1	1	1		1	1	1	1	1	1
	D	1								1						
70-110	S	1		1				1	1		1	1			1	1
	D		1		1	1	1			1			1	1		
70-120	S	1	1	1	1	1		1	1		1			1	1	1
	D						1			1		1	1			
70-130	S	1	1	1		1					1	1				1
	D				1		1	1	1	1			1	1	1	

Discrimination Task Data for Individual Subjects (cont'd.)

Stimulus Pair (in msec) (from "rabid")	Judgment	Group and Subject Number Control 1	2	3	4	5	C.P./Good Speech 1	2	3	4	5	C.P./Dysarthric 1	2	3	4	5
70-140	S			1		1		1	1			1		1		1
	D	1	1		1		1			1	1		1		1	
70-150	S			1	1	1			1	1	1			1	1	
	D	1	1				1	1				1	1			1
80-80	S		1	1	1	1	1	1	1	1	1	1		1	1	1
	D	1											1			
80-90	S		1	1	1	1		1	1	1			1	1	1	1
	D	1					1				1	1				
80-100	S	1	1	1	1	1		1	1	1		1		1	1	1
	D						1				1		1			
80-110	S	1	1	1	1	1	1	1	1	1	1	1		1		1
	D												1		1	
80-120	S		1	1	1	1		1		1				1	1	1
	D	1					1		1		1	1	1			
80-130	S		1	1	1	1		1		1	1					1
	D	1					1		1			1	1	1	1	
80-140	S			1		1			1		1			1	1	1
	D	1	1		1		1	1		1		1	1			
80-150	S			1		1				1	1	1		1	1	
	D	1	1		1		1	1	1				1			1
90-90	S	1	1	1	1	1	1	1	1	1	1			1		
	D											1	1		1	1
90-100	S	1		1	1	1	1	1	1	1	1	1		1	1	1
	D		1										1			
90-110	S	1		1	1	1		1	1	1	1	1		1	1	1
	D		1				1						1			
90-120	S		1	1	1	1			1			1	1	1	1	1
	D	1					1	1		1	1					
90-130	S	1	1	1	1	1		1	1	1		1	1	1		1
	D						1				1				1	

Discrimination Task Data for Individual Subjects (cont'd.)

Stimulus Pair (in msec) (from "rabid")	Judgment	Group and Subject Number Control 1	2	3	4	5	C.P./Good Speech 1	2	3	4	5	C.P./Dysarthric 1	2	3	4	5
90-140	S			1		1		1	1	1	1	1			1	
	D	1	1		1		1						1	1		1
90-150	S	1		1	1	1	1	1	1		1	1	1	1	1	1
	D		1							1						
100-100	S		1	1	1	1	1	1	1	1	1	1	1	1	1	1
	D	1														
100-110	S	1		1	1	1	1	1	1	1	1	1		1		
	D		1										1		1	1
100-120	S	1	1	1		1		1	1			1		1	1	1
	D				1		1			1	1		1			
100-130	S	1		1		1		1		1	1	1		1	1	1
	D		1		1		1		1				1			
100-140	S	1		1		1			1	1		1	1	1		1
	D		1		1		1	1			1				1	
100-150	S	1		1		1		1	1			1		1		1
	D		1		1		1			1	1		1		1	
110-110	S			1	1	1	1	1	1	1	1	1		1	1	
	D	1	1										1			1
110-120	S	1		1	1	1		1	1	1	1	1		1		
	D		1				1						1		1	1
110-130	S	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	D										1					
110-140	S	1	1	1	1	1	1	1	1	1	1	1		1	1	1
	D												1			
110-150	S			1	1	1		1	1		1	1		1	1	1
	D	1	1				1			1			1			
120-120	S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	D															
120-130	S	1	1	1	1	1	1	1	1	1			1	1	1	1
	D										1	1				

Discrimination Task Data for Individual Subjects (cont'd.)

Stimulus Pair (in msec) (from "rabid")	Judgment	Group and Subject Number Control 1	2	3	4	5	C.P./Good Speech 1	2	3	4	5	C.P./Dysarthric 1	2	3	4	5
120-140	S			1	1	1		1	1	1		1	1	1		1
	D	1	1				1				1				1	
120-150	S			1	1	1	1	1	1	1		1	1	1	1	1
	D	1	1								1					
130-130	S	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	D										1					
130-140	S			1	1	1	1	1	1	1		1	1	1	1	1
	D	1	1								1					
130-150	S	1	1	1	1	1	1	1	1	1	1	1		1	1	1
	D												1			
140-140	S	1	1	1	1	1	1	1		1	1	1		1	1	1
	D								1				1			
140-150	S	1		1	1	1	1	1	1	1	1	1		1	1	1
	D		1										1			
150-150	S	1	1	1	1	1			1	1		1	1	1	1	1
	D						1	1			1					

LIST OF REFERENCES

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Ali, L., Gallagher, T., Goldstein, J., and Daniloff, R., Perception of Coarticulated Nasality. J. Acoust. Soc. Amer., 49, 538-540, (1971).

Aungst, L. F., and Frick, J. V., Auditory Discrimination Ability and Consistency of Articulation of /r/. J. Speech Hearing Res., 29, 76-85, (1964).

Beare, A., Color Name as a Function of Wavelength. Amer. J. of Psy., 76, 248-256, (1963).

Broadbent, D., and Gregory, M., Accuracy of Recognition for Speech Presented to the Right and Left Ears. Quar. J. Exp. Psy., 16, 359-360, (1964).

Bryden, M., Ear Preference in Auditory Perception. J. Exp. Psy., 65, 103-105, (1963).

Cutter, J., A Parallel Between Degree of Encodedness and the Ear Advantage: Evidence from an Ear-Monitoring Task. J. Acoust. Soc. Amer., 53, 368, (1973) (Abstract).

Day, R. and Vigorito, J., A Parallel Between Degree of Encodedness and the Ear Advantage: Evidence from a Temporal-Order Judgment Task. J. Acoust. Soc. Amer., 53, 368, (1973) (Abstract).

Delattre, P., Liberman, A., and Cooper, F., Acoustic Loci and Transitional Cues for Consonants. J. Acoust. Soc. Amer., 27, 769-773, (1955).

Denhoff, E. and Robinault, I., Cerebral Palsy and Related Disorders: A Developmental Approach to Dysfunction, McGraw-Hill Book Co., Inc., New York, (1960).

Dollard, J. and Miller, N., Personality and Psychotherapy, McGraw-Hill Book Co., Inc., New York, (1950).

Eimas, P., The Relation Between Identification and Discrimination Along Speech and Non-Speech Continua. Lang. & Sp., 6, 206-217, (1963).

Eimas, P., Siqueland, Jusczyk, and Vigorito, J., Infants Can Categorically Perceive Speech Sounds. Science, 171, 303-306, (1971).

Kimura, D., Some Effects of Temporal Lobe Damage on Auditory Perception. Cana. J. Psy., 15, 156-165, (1961).

Kimura, D., Functional Assymmetry of the Brain in Dichotic Listening. Cortex, III, 163-177, (1967).

Lane, H. The Motor Theory of Speech Perception: A Critical Review. Psy. Rev., 72 (4), 275-309, (1965).

Liberman, A., Harris, K., Hoffman, H., and Griffith, B., The Discrimination of Speech Sounds Within and Across Phoneme Boundaries. J. Exp. Psy., 54, 358-368, (1957).

Liberman, A., Cooper, F., Shankweiler, P., and Studdert-Kennedy, M., Perception of the Speech Code. Psy. Rev., 74, 431-461, (1967).

Liberman, A., Some Results of Research on Speech Perception. J. Acoust. Soc. Amer., 29, 117-123, (1957).

Liberman, A., Harris, K., Eimas, P., Lisker, L., and Bastian, J., An Effect of Learning on Speech Perception: The Discrimination of Durations of Silence with and without Phonemic Significance. Lang. and Sp., 4, 175-195, (1961).

Liberman, A., The Grammars of Speech and Language. Cog. Psy., 1 (4), 301-323, (1970).

Locke, J., Discriminative Learning in Children's Acquisition of Phonology. Speech Hearing Res., 11, 428-434, (1968).

MacNeilage, P., Rootes, T., and Chase, R., Speech Production and Perception in a Patient with Severe Impairment of Somesthetic Perception and Motor Control. J. Speech Hearing Res., 10, 449-467, (1967).

Mattingly, I., Liberman, A., Syrdal, A., and Halwes, T., Discrimination in Speech and Nonspeech Modes. Cog. Psy., 2, 131-157, (1971).

Molfere, D., Cerebral Asymmetry in Infants, Children and Adults: Auditory Evoked Response to Speech and Music Stimuli. J. Acoust. Soc. Amer., 53, 363, (1973) (Abstract).

Monnin, L. and Huntington, D., Relationship of Articulatory Defects to Speech-Sound Identification. J. Speech Hearing Res., 17, 352-366, (1974).

Schatz, C., The Role of Context in the Perception of Stops. Lang., 30, 47-56, (1952).

Shankweiler, P. and Harris, K., An Experimental Approach to the Problem of Articulation in Aphasia. Aphasia: Selected Readings, Mary Taylor-Sarno, Appleton Century Crofts, N.Y., (1972).

Stevens, K. and House, A., Studies of Formant Transitions Using Vocal Tract Analog. J. Acoust. Soc. Amer., 28, 578-585, (1956).

Studdert-Kennedy, M., Liberman, A., Harris, K., and Cooper, F., Motor Theory of Speech Perception: A Reply to Lane's Critical Review. Psy. Rev., 77, 234-249, (1970).

Studdert-Kennedy, M., Liberman, A., and Stevens, K., Reaction Time During the Discrimination of Synthetic Stop Consonants. J. Acoust. Soc. Amer., 36, (1963).

Van Riper, C., Speech Correction: Principles and Methods. Prentice-Hall, N.J., (1963).

Weiner, P., Auditory Discrimination and Articulation. J. Speech Hearing Dis., 32, 19-28, (1967).

Westlake, H. and Rutherford, D., Speech Therapy for the Cerebral Palsied. National Easter Seal Society, Chicago, (1961).