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ABSTRACT

To determine if a relationship exists between temporal patterns of hearing and temporal patterns of speech, and between personality and temporal patterns of speech and hearing, normally hearing subjects were measured on the following: Critical Fusion Frequency, tone burst durations, fusion over silent intervals, interrupted speech, interrupted synthetic sentences, interrupted numbers, paired comparisons of tone burst durations, and the Eysenck Personality Inventory. Results indicated that the longer the phonation time and pause time of speech, the longer the integration time of hearing. It was suggested that the time involved in hearing affects the ease with which a person processes another's speech. Phonation time and pause time were thought to be related to the ability of the auditory system to bridge silent intervals. The left ear appeared to be more sensitive to speech timing than the right ear. Significant correlations existed between personality measure and timing measures of speech and hearing, but data did not indicate whether personality measures dictated the speech and hearing measures. (JM)

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RELATIONSHIP OF SELECTED ASPECTS OF HEARING TO SPEECH DISORDERS

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SUMMARY

That speech is dependent upon a feedback monitoring system is well known; however very little is known about the parameters which exist in both the speech and hearing mechanisms or of the parameters which may be interdependent. Even though the integration time of the ear has been rather well researched, data have been gathered and treated in a normative manner and little attention has been paid to individual differences in this timing and how it might relate to the individual's own speech.

The purpose of this study was first to isolate several temporal parameters of hearing and several of speech; and then by means of a correlational analysis to determine if a relation might exist between a person's temporal patterns of hearing and the temporal patterns of his speech. Concurrently, the study was to determine, by means of a personality inventory, if any relationship exists between an individual's personality and the temporal parameters of his speech and hearing.

The temporal patterns of the integration time of the auditory system was measured through several techniques:
1) the fusion of clicks into a percept of rough tonal quality,
2) the matching of tone-burst durations at several frequencies,
3) the fusion over silent intervals in an interrupted pure tone,
and 4) the threshold of comprehension of interrrupted speech. The temporal parameters of speech were derived from the instrumental analysis of the average pause time and the average phonation time in running speech.

Results of the experiment have indicated that there exists a primitive relationship between a person's hearing and his speech. Indications are that the longer the phonation time and pause time of a person's speech, the longer will be the integration time of his hearing. This relationship was found to exist primarily in the lower frequencies, in the range of the fundamental frequency of the voice. Relationships were also found between Critical Fusion Frequency and speech timing, indicating an ability of the ear to average over brief silent intervals in sound and possibly in speech.

When the characteristics of the ears were examined separately, it was found that significant relationships only existed with the left ear. This suggests the dominance of that ear over the right ear, particularly where the perception of linguistic material is involved. Results of the personality indexes indicated that the personality of an individual might have an effect upon certain characteristics of his speech and hearing. The findings of these studies present many possible routes to the researcher interested in applying empirical data to the improving of speech diagnostics and therapy techniques.

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INTRODUCTION

Speech correction has made few advances since its origin in "getting at the source" of the speech problem. Speech therapy remains essentially an art, dependent upon the therapist's techniques and the classical therapy procedures. Very little research has been designed to isolate parameters within the feedback system which may initiate speech problems or augment existing problems. The overall purpose of this study has been to continue a systematic investigation into variables which might contribute to speech and language disorders. Huffman and McReynolds (1968) have investigated temporal sequencing of auditory stimuli, and Withrow (1964) has pointed out that temporal order is a "major dimension of language." Their emphasis was on signal durations which approximate units of language. The timing factors of interest in the present study correspond to sub-language units, such as phonemes or pauses in speech.

In this group of studies two aspects of communication were under investigation: first, temporal or time-length characteristics of a person's speech; and secondly, temporal or time-length aspects of a person's hearing. Also under investigation were the relationships of these two temporal parameters with certain personality indexes. The purpose of these studies was to take certain temporal aspects of speech, certain temporal aspects of hearing, and the personality indexes and compare them to determine if the characteristics of a person's speech might be related to the temporal characteristics of his hearing and with certain characteristics of his personality.

The rationale behind this study relies upon the fact that individuals have set patterns in their behavior, and that these patterns vary from person to person; these patterns also tend to vary within a person from time to time: Each person's speech is unique to himself. Researchers measuring auditory reception find individual differences in the way that people process temporal aspects of acoustic stimuli. An example of this is critical fusion frequency; for some persons, a series of clicks will fuse into a tonal quality at a much lower click-rate than it will for others.

The design of this study relies heavily upon individual differences not only in speech, but in hearing and personality. A very general hypothesis underlying this study has been that the manner in which the auditory system processes acoustic stimuli, as a function of time, is related to the manner in which the speech mechanism produces speech as a function of time; and that both of these factors, in turn, are related to certain dimensions of the person's personality.

It was assumed for the purpose of this study that the auditory system processes, at least in part, acoustic stimuli as an integrative function through time. In other words, it was assumed that the auditory system, like a Fourier analysis, produces results which are highly dependent upon the duration of the signal under analysis. It was assumed that signals of less than this duration would be processed in such a way as to produce the perception of aliases and artifacts not actually present in the signal.

To reach the objectives of the project, several substudies were completed in which various measures of temporal integration by the auditory system were evaluated. These measures were designed to measure the efficiency of the auditory system in handling of short-duration auditory stimuli: both meaningful and nonmeaningful. The durations which indicated the greatest efficiency in handling were taken, in this study, as measures of temporal integration by the auditory system. Temporal measures were also derived from the subjects' speech patterns and compared with the auditory measures by means of correlational analyses. Personality measures were also obtained and compared with the speech and hearing measures.

BACKGROUND FOR THE STUDY

It is a truism that the production of speech is highly dependent upon the auditory monitoring of the speech production. The cybernetic relationship between speech and hearing processes is exhibited through the "pseudo-stuttering" caused by delayed auditory feedback. In this phenomenon the deteriorating effects of feedback on speech are caused by the temporal distortion of the feedback signal. Conversely, Peters (1954), Van Riper (1958), and Mysak (1967) have emphasized the facilitory effect which controlled auditory feedback can have on modification of speech patterns, if used properly. The speech signal, however, is complex, consisting of many parameters. Since it is probable that the central nervous system does not use all of these parameters in its control of on-going speech, it is theorized that there are certain auditory parameters having dimensions unique to each person which are employed in the cybernetic control of speech.

A study by Stromsta and Mahaffey (1965) investigated the relative unimportance of intelligibility of delayed auditory feedback as the initiator of "pseudo-stuttering." The data showed that feedback rendered unintelligible by peak-clipping and center-clipping had virtually the same "pseudo-stuttering-effect" as did undistorted feedback. This led to the tentative conclusion that certain temporal parameters of the speech were at least as important to its timing as was the intelligibility of the speech itself.

One of the basic parameters of auditions to be investigated in this study is that of temporal integration. In a previous study by Mahaffey (1966), one of the subjects' tasks was to match the pitch of a sustained tone with that of a tone burst of short duration. The purpose of this task was to determine the shortest duration of tone burst to which the subjects were able to assign a consistent pitch. The data were interpreted to be indicative of the time over which an auditory signal must be integrated at the various frequencies for pitch to be determined. If this process is analogous to a Fourier analysis, it might be assumed that very short signals are confounded by the on- and off-transients of the tone bursts. In an ex post facto analysis of the data, it was determined that a small number of stutterers in the sample population consistently were able to match frequencies accurately to tone bursts of shorter duration than were normal speakers. It was proposed that stutterers might be abnormally sensitive to auditory temporal patterns and that speaking rate, on a continuum with normal speakers, may be to some extent dependent upon these temporal parameters. The purpose of this study has been to investigate selective aspects of this dependency.

In a study similar to that just described, Doughty and Garner (1947), determined the temporal threshold of tonal processing of persons with normal hearing. Although responses varied from person to person, the average listener heard a 10-msec burst with a frequency of 1000Hz as a short tone of questionable pitch; however, if the duration of the tone was reduced below this 10-msec time, the tone burst would reach a point where it was heard as a click lacking tonal quality. Boomsliter, Creel, and Powers (1964) utilized this temporal threshold as an approach to measurement of neural processes in pitch perception by persons with pathological hearing. Their subjects were a group of surgical patients with vertebro-artery insufficiency. In these patients, lesions had restricted the blood flow to the brain stem, including the nerve centers for hearing and to the cochlea. They found that unlike normal listeners, the patients often required tone bursts 200 to 300 miliseconds in duration for the perception of tonality. Their data indicate a broad continuum of intra-subject variability in temporal thresholds of tonality.

Liang and Chistovich (1961) have shown that frequency-discrimination performance depends upon signal duration within a given range of short durations. Corliss (1966) and Henning (1967) have posed models to explain the processing of auditory stimuli. However, Garner and Miller (1944) found amplitude discrimination performance to be independent of signal durations for signals above a critical intensity level. These findings have been substantiated by Henning and Pstoka (1969), and serve as the rationale for deleting intensity from the variables to be manipulated in the present study.

Dallos and Olsen (1964) have described temporal integration of acoustic energy by the auditory system, at threshold, as a function of duration. They reported that within a limited range of frequencies, the threshold of stimulus intensity was a nearly linear function of signal duration up to about 200 msec for a 1000Hz tone. The threshold of sensitivity varied inversely with the stimulus duration within the range of 10 to 200 msec. Green, Birdsall, and Tanner (1957) have described an additional characteristic of temporal integration by the auditory system. They formulated a model which utilizes evidence that below a critical sound pressure level, the auditory system is incapable of processing the acoustic input; however, when the energy exceeds that level, the total acoustic input is utilized, including that portion below threshold. Their data also show considerable intra-personal variability with regard to this temporal integration of energy.

Wright (1964) investigated the phenomenon of backward masking. He presented a pure tone of short but constant duration which began at selected periods before a superimposed masking noise and lasted well into the noise. His criterion measure was a change in threshold which he attributed to an effective shortening of the tone due to the back-reaching effect of the masking. In general, the backward masking effect reached only about 100msec into the tone burst; however, the effects of this backward masking varied considerably from subject to subject.

Integration of acoustic energy over brief silent intervals was investigated by Gol'dburt (1964). He demonstrated that the interval separating tone bursts contributes to the percept of these tones. When two 1000Hz tones of equal intensity and of 30-msec duration were separated by a 5-msec silent interval, a percept was of two tones sounded simultaneously. Although considerable intra-subject variability was apparent, an average sound interval of 68 msec was required for the perception of two separate tones. In view of the present study, it is hypothesized that the auditory system tends to average over or compensate for slight interruptions of an acoustic stimulus, such as brief pauses in speech.

The findings relative to the signal duration and its effects on perception suggest the integration of acoustic energy as a function of time. Garner (1947) demonstrated that the rate of temporal integration of energy by the ear (at threshold) is dependent upon the width of the frequency band to be integrated. In effect, the band width is defined as the reciprocal of the duration of the tone. As the duration of the tone decreases, the band width of the energy increases. Garner's data would indicate a type of temporal integration. This author would suggest that the temporal integration process contains a constant which is unique to the individual listener.

Creelman (1962) presented a theoretical model for auditory perception based on a "counting mechanism" which functions on impulses generated over relevant durations. Creelman also discounts the consequence of loudness in perception of pitch and duration after a critical intensity level has been reached.

Sheely and Bilger (1964) investigated the temporal integration of acoustic power at three frequencies. Their results agreed with the findings of other investigators. The integrations of short and medium durations were constant and most efficient when the band width of the signal did not exceed the critical band width of the auditory system.

Swigart (1966) investigated pitch perception as a function of temporal integration over 1 msec interruptions in a 1000Hz tone. By varying the interruption rate, she established minimum signal durations from normal pitch perception, and the existence of perceptual bridging over short silent intervals.

It has been stated (Clack, 1965) that the temporal integration of energy by the auditory system is dependent upon signal duration and to a lesser extent upon intensity. When in limits, the integration rate may be determined by varying either loudness or signal duration and holding the other constant. Since intensity has the lesser effect, stimulus duration was chosen as the independent variable of this study. Observable changes in perception at these durations have been used to guage integration time in the tasks.

METHODS

Because the data for this project were gathered in a series of substudies and pilot studies, the procedures and experimental design will be discussed collectively. Except for the measures of personality, all measures are intended to measure temporal aspects of hearing or speech. The express purpose for obtaining these measures is to ascertain possible interrelationships between timing parameters of audition and timing parameters of speech and, in turn, to relate these timing parameters to certain personality traits.

All facets of this study were conducted in the Psychoacoustics Laboratory at the University of Southern Mississippi. All stimuli were presented at 65dB SPL to subjects seated in a double-wall IAC sound-treated room. In the initial stages of the project, stimuli were presented via high-fidelity earphones. This method of presentation was later replaced by the use of free field presentation. All subjects were over the age of 14 and under the age of 50; all had normal hearing. The subjects were on a speech-fluency continuum from the very fluent to the non-fluent. The testing sessions were limited to two-hour periods of time with frequent breaks so as to minimize fatigue and boredom.

The initial stages of this project were devoted to the development and testing of temporal measures of both speech and hearing. The following measures of processing by the auditory system were investigated:

a. Critical Fusion Frequency (CFF): A series of clicks is presented to the subject, and he indicates the minimum rate or frequency at which the clicks fuse into a percept of rough tonal quality.

b. Matching of Tone Burst Durations: Pairs of tone bursts are presented to the subject. The duration of the first burst is fixed by the experimenter whereas the duration of the second burst is adjusted to that of the first by the subject. A 700msec silent interval separates the two bursts. The criterion measure is the duration to which the subject can most accurately match the duration of the variable tone bursts to that of the fixed tone bursts. The rationale underlying this measure is that the signal duration which most closely approximates the integration time of the auditory system should be the duration which is most accurately matched by the subject.

c. Fusion over Silent Intervals: Sustained pure tones are interrupted every 150msec by a silent period of varying duration. The subject's responses indicate the maximum duration of the silent interval at which he does hear an interruption in the signal. As the silent period lengthens, the tone period becomes shorter so that the total cycle time equals 150msec. This procedure, which approximates that of Gol'dburt (1964), was repeated at three frequencies: 150Hz, 500Hz, and 3000Hz.

d. Interrupted Speech: Continual, unemotional narrative (recorded by James Jerger) is interrupted with a duty cycle of 150msec, so that if the signal is passed to the subject for 70msec, it is off the following 80msec; the switching rise-fall times were 5msec. The subject indicates the minimum duration of the "on-time" required for him to understand the meaning of the story.

e. Interrupted Synthetic Sentences: Synthetic sentences, as generated by Jerger and Speaks, are interrupted with a duty cycle of 150msec, as is task d. Multiple-choice responses are made as to which of the ten synthetic sentences is being spoken. The criterion measure is the minimum duration of the "on-time" required for the subject to make the multiple-choice response.

f. Interrupted Numbers: This task is similar to d and e except that 4- and 5-digit numbers are used as the stimulus materials. The subject is required to write on an answer form the numbers as he hears them through the interruptions. A 60% correct criterion is used to determine the minimum duration of the "on-time" required for him to correctly perceive the spoken numbers.

g. Paired Comparisons of Tone Burst Durations: Pairs of recorded tone bursts are presented to the subject. The duration of the first tone burst is either longer than or shorter than the second tone burst. The subjects' task is to respond as to whether they feel that the first tone burst is longer than or shorter than the second tone burst. The criterion measure is that point at which the subject, on the average, judges the two tone bursts to be of equal length.

The Eysenck Personality Inventory (EPI), Form A, was used as an index for the personality measures of extrovert-introvert and neurotic-stability. On the extroversion-introversion measure, a high-scoring individual tends to be "out-going, impulsive, and uninhibited, having many social contacts and frequently taking part in group activities." A typical introvert is a "quiet, retiring sort of person, introspective, preferring books rather than people; he is reserved and distant except to intimate friends. He tends to plan ahead, 'looks before he leaps', and distrusts the impulse of the moment."

A person scoring high on the neuroticism scale tends to be "emotionally over-responsive and, in extreme cases, ---more prone to neurotic breakdown under stress." It was assumed for the purposes of this study that personality traits might be caused by one's perceptual characteristics or that one's perceptual characteristics might be a function of one's personality; and that in turn, if a person's speech timing is dependent upon one's perception, one's personality might indirectly, or directly, dictate some of the timing patterns of that person's speech.

The two derived speech measures which were used throughout the study were the average pause time within the speech of the subject and the average phonation time within the speech of the subject. These two measures were chosen because they are indicative of non-linguistic elements of the speech pattern. The average phonation time indicates the average duration of a burst of phonation, whereas the average pause time indicates the silent interval between bursts of phonation. The two measures were derived from the total time of the speech signal, the total phonation time, and the total number of bursts of phonation. Pauses in the speech signal were defined as the periods in the speech where the acoustic output did not exceed 20dB above noise level. These measures were taken from recorded speech samples from the subjects.

In each facet of the experiment an attempt was made to randomly select subjects and to give them ample practice time at each of the various tasks. In most instances, the data were obtained from the subjects on several days with repeated measures to increase the reliability of the measures. Considerable attention was devoted to the randomness of the stimuli and the giving of instructions to the subjects.

The experimental design was complicated by the intra-subject variability which is present in any perceptual measure. Temporal measures of a subject's audition and speech may vary greatly from one hour to the next, thus requiring that the battery of tasks be completed within a reasonably short period of time. The assumption must also be made that these temporal features remain constant throughout the tasks; this is probably an unjustifiable assumption and a source of experimental error and large standard deviation in the analysis. All measures in any one of the substudies were derived within a given short period of time so that the speech, hearing, and personality measures were all representative of that one period.

RESULTS

Two types of analysis were used to analyze the data: the Pearson Product Moment Correlation and Multiple Correlation. The latter method was used when it was suspected that two measures from the same measuring device might collectively predict a third measure whereas the individual measures themselves might not. The two sets of data which were treated collectively as predictors were the extrovert-introvert and neurotic-stability measures and the average pause and average phonation time measures. The remainder of the data were treated with a Pearson Product Moment Correlation Analysis. To reiterate, the purpose of these analyses was to demonstrate variance in speech, hearing, and personality measures which varied concurrently.

Study A

In the first substudy the temporal measures of audition derived from the tone-matching task were compared with average pause time and average phonation time measures. The purpose of this study was to determine if the integration time for bursts of pure tone coincided with the average pause and average phonation times. The tone bursts were of three frequencies, 150Hz, 500Hz, and 3000Hz. Of these three frequencies, the only significant correlation coefficients were derived from the 150Hz tone bursts. These measures, when correlated with average pause time measures, yielded a correlation of r = +.30. When correlated with average phonation time, the relation yielded a coefficient of r = +.43. These correlations are interpreted by this author to mean that both the pause time and the phonation time in on-going speech vary from subject to subject as does the auditory integration time as measured by the tone burst matching task at 150Hz.

Table 1. Correlation coefficients between two measures of phonation and the tone-burst durations most accurately matched at three frequencies.

Tone-Burst Frequencies	Average Pause Time	Average Phonation Time
150Hz	+.30*	+.43*
500Hz	+.16	+.01
3000Hz	+.10	-.03

N=42
*Significant at .05 level

STUDY B

A second relationship exists between the Critical Fusion Frequency (CFF) and the average phonation time. This relationship yielded a correlation coefficient of r = -.31. This would seem to indicate that as the phonation time decreases, the rate of fusion as measured by the CFF increases and vice versa. This is in agreement with the tone-burst-matching task correlation with average phonation time in that the CFF measures are in terms of frequency or the reciprocal of time whereas the tone burst durations were directly in terms of time.

Table 2. Correlation Coefficients between critical fusion frequencies and average pause time and average phonation time.

	Average Pause Time	Average Phonation Time
Critical Fusion Frequency	-.27**	-.31*

N=42
*Significant at the .05 level
**Significant at the .10 level

STUDY C

A third relationship was found between average pause time and the fusion of interrupted tone measures derived at 150Hz and 500Hz. The relationship between the 150Hz interrupted tone measures and averages pause time yielded an r = -.344; whereas, the 500Hz interrupted tone task and average pause time yielded an r = -.355. At first evaluation, the negative relationships with this measure of temporal integration seems in conflict with the positive correlations mentioned above. However, when taking into consideration that the interrupted tone may be viewed as a series of tone bursts, the reversal of the coefficient's sign is understandable. The fusion of interrupted tone task afforded the subjects a great deal of confusion; it is therefore suggested that this measure may be the reverse of its intended purpose.

Table 3. Correlation Coefficients between Interrupted Tone Measures at Three Frequencies and Average pause and Average Phonation Times.

Fusion of Interrupted Tones	Average Pause Time	Average Phonation Time
150Hz	-.344*	-.180
500Hz	-.355*	-.117
3000Hz	-.287**	-.101

N=32
*Significant at the .05 level
**Significant at the .10 level

STUDY D

All of the measures up to this point have pertained to both ears, and all of the auditory temporal integration measures used have been non-linguistic, that is to say, without meaningful stimuli. However, when the temporal integration of non-linguistic stimuli are compared an interesting difference between ears results. When comparing the results from the interrupted tone task at 150Hz with the interrupted speech task in the left ear, there is a relationship of r = -.406. This relationship does not exist for the right ear. When the interrupted tone task at 500Hz is compared with the interrupted speech task in the left ear, a correlation exists of r = -.430. This relationship does not exist for the right ear. When the interrupted tone task at 3000Hz in the left ear is compared with the interrupted speech task in the left ear, a correlation coefficient of r = -.307 results. This relationship also does not exist for the right ear. On the basis of unilateral correlations between the interrupted tone tasks and the interrupted speech task in the left ear and the lack of these correlations in the right ear, it is suggested that the left ear is more time sensitive to speech timing than is the right ear, and that this may account for the frequent labelling of the left ear as the "dominant ear" even though there may be no difference between the ears in terms of intensity threshold.

Table 4. Correlation Coefficients between Interrupted Speech Measures and Interrupted Tone Measures from the Left Ears of Subjects

Tone Frequencies	150Hz	500Hz	3000Hz
Inter. Speech	-.406*	-.430	-.307

N=36
*Significant at the .05 level
**Significant at the .10 level

Table 5. Correlation Coefficients between Interrupted Speech Measures and Interrupted Tone Measures from the Right Ears of the Subjects

Tone Frequencies	150Hz	500Hz	3000Hz
Inter. Speech	+.018	-.170	-.089

N=36

Similarly, when the extrovert and neurotic scores were collectively compared with the interrupted tone task scores at 150Hz, by means of multiple correlation, a significant correlation coefficient was realized for the left ear (r = .4370). For 500Hz, the multiple correlation coefficient was r = .3937, and for 3000Hz, the multiple correlation coefficient was r = .4047. All significant correlations were in the left ear only.

Table 6. Multiple Correlation Coefficients with the Extrovert and Neurotic Scores from the Eysenck Personality Inventory as Collective Predictors of Interrupted Tone Task Scores by Ear

Left Ear Measures	150Hz	500Hz	3000Hz
Extrovert-Neurotic	R=.4370*	R=.3937*	R=.4047*
Right Ear Measures			
Extrovert-Neurotic	R=.2406	R=.1861	R=.2061

N=36
*Significant at the .05 level

STUDY E

In a free-field study, a significant correlation of R=.5190 was found between the collective comparison of the extrovert and neurotic scores with the interrupted tone task scores at 150Hz. This would tend to substantiate to some degree the earlier theory of the relationship between personality traits and auditory perception.

In the same free-field study, the two personality scores were compared with average phonation time, yielding a significant multiple correlation of R=.4497. This would tend to substantiate the earlier theory of the relationship between personality traits and speech timing.

Table 7. Multiple Correlation Coefficients with the Extrovert and Neurotic Scores from the Eysenck Personality Inventory as Collective Predictors of the Interrupted Tone Task in Free Field and of Average Phonation and Pause Times.

	Extrovert-Neurotic
150 Hz Tone	R=.5190**
500 Hz Tone	R=.1697
3000 Hz Tone	R=.1536
Average Pause Time	R=.2042
Average Phonation Time	R=.4497*

N=32
*Significant at the .05 level
**Significant at the .01 level

CONCLUSIONS AND RECOMMENDATIONS

In review, the purpose of this project has been to investigate possible primitive relationships between the speech and hearing processes which may serve to facilitate or impair normal speech production, and the knowledge of which may provide a basis for more productive speech therapy techniques. The gathering of data from subjects has been affected by intrasubject variability. However, it is this same variability in the hearing process which might result in varying speech patterns and theoretically the varying susceptibility of some persons to stuttering behavior.

The results have demonstrated several promising relationships among speech, hearing, and personality traits. The first of these relationships showed that auditory integration time, as measured by a tone-burst matching task, relates both to average pause time and average phonation time in the listener's speech. The longer the integration time, the longer the bursts of phonation and the longer the pauses between bursts in the speaker's voice. This relationship exists only in the fundamental frequency range of the voice (i.e. 150Hz). It is suggested that the temporal sensitivity of the ear in this frequency range contributes, via the neural feedback circuit to the control of speech rate. It is also suggested that this temporal factor may determine to some extent the ease with which a person processes the spoken language of other persons. It may be hypothesized that speech-patterns with given temporal constants "fit" into some listener's auditory systems better than do other patterns. No hypothesis is being made as to the etiology of this characteristic; it may be learned or inherent to the individual.

This relationship between audition and speech was further emphasized by the Critical-Fusion Frequency (CFF) results. These results indicated that phonation time and pause time are related to the ability of the auditory system to "bridge" over silent intervals in order to form an auditory perception of closure between stimuli. It is theorized that a person with a long "closure" ability and therefore a long integration time would tend to speak with longer bursts of phonation and longer pauses between bursts in order to produce the temporal cues in his speech necessary for easy processing in his own feedback process. It is also proposed that deviations in the auditory system's timing may result in deviations in speech and the person's ability to understand others. It would appear that the data might suggest that a difference exists between the contralateral ears with their ability or their basic functioning to handle the timing properties of meaningful stimuli. In review, a significant correlation was established between the interrupted speech task and tone tasks for the left ear whereas no such relationship was found for the right ear. In view of many previous studies, both psychoacoustic and neurological, that have attributed much of the processing of speech to the left ear and the left hemisphere of the brain, it is suggested that work be continued to investigate this possible relationship with an experimental design so constructed to test for differences between the ears in their temporal processing of speech signals.

The personality indexes used in this study have also suggested an untested relationship. There have been significant correlations between these measures and timing measures of speech; there have also been significant correlations between these personality measures and the timing measures of audition. The question remains as to the direction of the dependency; the data do not indicate whether the personality measures dictate the speech and hearing measures.

Perhaps the most questionable measures throughout the study have been the two temporal measures of the speech signal.

In the proposal for this project, it was stated that the speech signals would be analyzed with the aid of an analog-to-digital converter and a digital computer . Manufacturer delays and purchasing delays have prevented the use of this equipment. Therefore, the speech measures are less valid than this experimenter had hoped they would be. Accordingly, it is predicted that stronger relationships will be established when this equipment is operable and used to reanalyze the recorded speech samples. Of course, it is impossible to predict the actual effect that the more refined measure of speech timing will have on the correlation coefficients.

In summary, these studies have indeed established a relationship among several primitive parameters of speech, hearing, and personality. However, more extensive work is required to obtain more reliable measures from the subjects and to obtain these measures in a much shorter period of time. The ideal experiment would obtain running speech measures and auditory-integration time measures concurrently, so as to negate the intrasubject variability. The author intends to pursue this procedure with the use of a digital computer well interfaced with the subject to obtain real-time measures of fluctuations in speech and hearing behavior.

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