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A Comparison between Signal-to-Noise Ratios of Stutterers and Normal Speakers

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A COMPARISON BETWEEN SIGNAL-TO-NOISE RATIOS OF STUTTERERS AND NORMAL SPEAKERS

by

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CHAPTER I

THE PROBLEM AND ITS BACKGROUND

The Problem

The problem with which this study deals, involves the question: do adult stutterers and non-stutterers differ in their ability to separate auditorily a designated sound from a background of noise?

Review of Research

Research in the field of stuttering has covered a wide area. Stutterers' metabolism has been measured, their handedness determined, and their personalities evaluated. Recently, however, the research has taken a new direction. Since the early 1950's with the development of the discipline of cybernetics, it has dealt increasingly with stuttering in terms of auditory and proprioceptive feedback, self perception of voice, and automatic control of speech. The act of speaking itself, normal as well as pathological, has come to be considered a servomechanism with the auditory abilities of the speaker playing an all important part.[1] Several studies have shown the importance of various character-

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[1]Grant Fairbanks, "Systematic Research in Phonetics: 1. A Theory of the Speech Mechanism as a Servo-system." Journal of Speech and Hearing Disorders, 1957, 22, 385-389.

istics of hearing upon the flow of speech. Lee[1] and many others found that stuttering-like behavior could be induced in normal speakers by simply delaying the air-conducted auditory feedback of their own voices a fraction of a second. Newby[2] noted that people automatically raise the level of their voice if the noise level of the situation in which they are talking goes up. Black reports that changes in intensity and rate of speech occur when the size of a room and its reverberation time are altered,[3] or when the speaker has been previously exposed to loud sounds.[4] This knowledge of the changes that can be produced in normalspeakers by altering their hearing has led to some research on the general auditory abilities of speech defective subjects. Berry,[5] for example, found that nearly 60 per cent of 383 children with cleft palate had noticable hear-

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[1]Bernard Lee, "Artificial Stutter," Journal of Speech and Hearing Disorders, 1951, 16, 53-55.

[2]Hayes Newby, Audiology, New York: Appleton-Century-Crofts, Inc., 1958, p. 156.

[3]J. W. Black, "The Effect of room characteristics upon vocal intensity and rate." J. Acoust. Soc. Amer., 1950, 22, 174-176.

[4]J. W. Black, "The effect of noise induced temporary deafness upon vocal intensity," Jt. proj. No. NM 001 064. 01. 07, Ohio State University Res. Found. and U. S. Nav. Sch. Av. Med. Rept. No. 7., 1947.

[5]Mildred F. Berry, Jon Eisenson, Speech Disorders, New York: Appleton-Century-Crofts, 1956, p. 324.

ing losses. Harms and Malone[1] indicate that the incidence of stuttering among the deaf and hard-of-hearing is almost negligible.

As yet, however, there has been very little research on more complex auditory abilities of speech defective subjects. Consequently, a little is known about the auditory perception of adult stutterers, and its effects on their speech, except that as Maraist and Hutton[2] have shown, stutterers tend to stutter less when they cannot hear their own voices due to masking noise.

One of the least explored areas of auditory perception in stutterers is that involved with the exposure of the subject to two or more sounds simultaneously. Investigation of this condition in subjects with normal hearing and speech has led to the establishment of several concepts. The most important concept to arise is that of masking. When one sound is loud enough that it interferes with the perception of another sound, it is said to "mask" that sound. The amount of masking done by a particular sound is measured by the increase in intensity which the masked or unaudible sound must undergo to again be

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[1] M. Harms and Arline Malone, "The relationship of hearing acuity to stammering," Journal of Speech Disorders, 1941, 4, pp. 363-370.

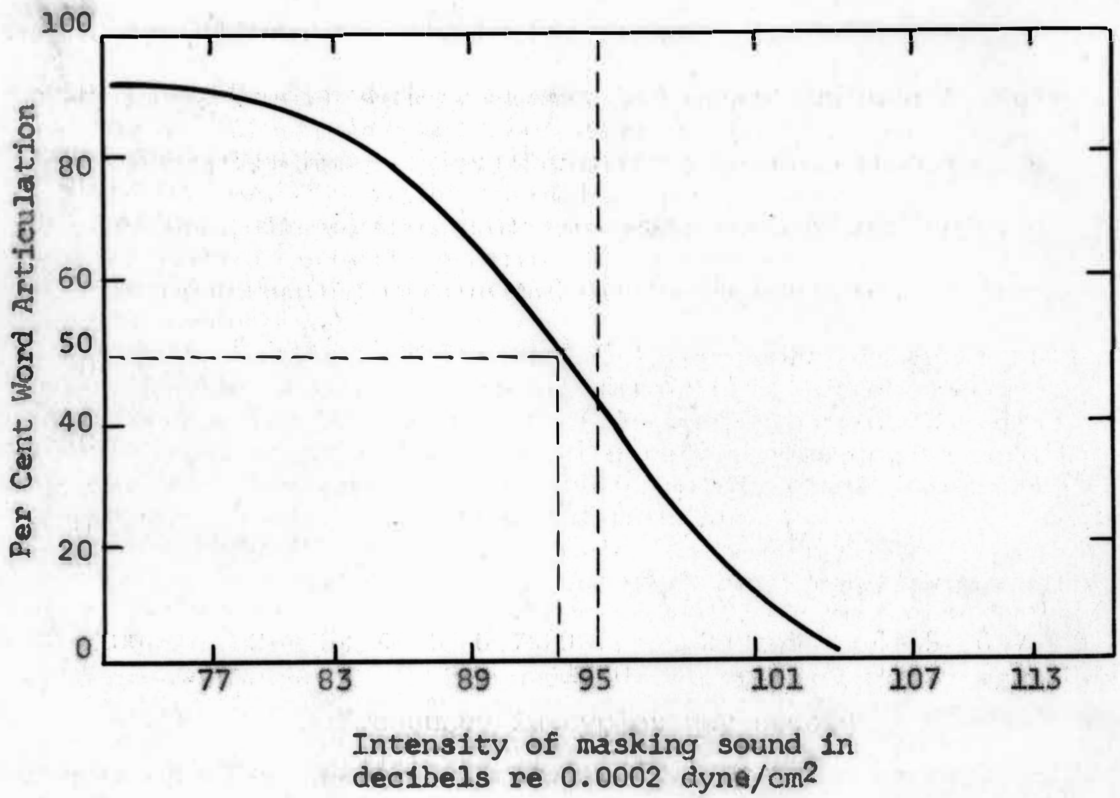
[2] Jean Maraist and Charles Hutton, "Effects of Auditory Masking Upon the Speech of Stutterers," Journal of Speech and Hearing Disorders, 1954, 19, 133-139.

heard over the masking sound. Since most masking in ordinary conditions is done by complex noises such as those arising from traffic, conversation, music, etc., the phrase "masking noise" is used to mean any masking sound except a pure tone. Masking noise,rather than masking tone, is used exclusively in this study. The sound that is masked or blotted out by the masking noise is called the signal. If a person's voice is rendered inaudible by the passing of a heavy truck, his voice is the signal, the truck's noise is the masking noise.

Frequently it is convenient to compare the intensities of the masking noise and the signal as measured in decibels. The logarithmic nature of the decibel makes it possible to express this "signal-to-noise" ratio in a single figure. For example, if the noise of the passing truck had an intensity of 68 decibels and the speakers voice had an average intensity of 62 decibels, the signal-to-noise ratio would be -6 decibels. This single figure represents the ratio of the intensity of the desired sound to the intensity of the masking sound.

The person's speech was probably not entirely masked by the truck, however, as speech is not all of an equal intensity or intelligibility. It becomes necessary, then, to define a percent of intelligibility to designate when a speech signal is to be considered masked. Figure I indicates the relationship of intelligibility to intensity level of masking noise. Intelligibility in Figure I is measured in terms of per cent word articulation, that is, in terms of a percentage of a list

FIGURE I



Articulation scores as a function of the intensity of the masking noise. The masking noise was an even white noise which ranged in frequency from 20 to 4000 cycles per second. The signal (articulation words) was kept at a constant intensity of 95 decibels. (From Miller[1])

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[1] G. A. Miller, "The Masking of Speech," Psychological Bulletin, 1947, 44, p. 112.

of words which are correctly identified at a given intensity level. It can be seen that a wide range of signal-to-noise ratios could be obtained, depending on the percentage of words heard correctly over the noise. The percent of intelligibility used in the present study is 50 per cent. This was chosen because as Hirsh[1] says:

> The 50-per cent criterion was chosen for the threshold for pure tones because it is the most representative statistic about the distribution of responses. There is also the fact that the frequency of response is rising most steeply when it passes through the 50- per cent point.

From Figure I, then, it can be seen that under this condition a signal-to-noise ratio of 93/95 or -2 decibels would be chosen.

Of special interest to this study is the condition mentioned above when one or more of the sounds perceived is speech. This is a common condition, as Licklider and Miller[2] indicate:

> In most situations speech is accompanied by other sounds. Masking, the shift in the threshold due to the presence of an interfering sound, is a serious problem in many situations, and the masking produced by a wide variety of sounds has been explored.

There remains some uncertainty about the exact auditory mechanism

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[1] Ira J. Hirsh, The Measurement of Hearing, New York: McGraw Hill Book Company, Inc., 1952, p. 143.

[2] J. C. R. Licklider, and George A. Miller, "The Perception of Speech in S. S. Stevens," Ed., Handbook of Experimental Psychology, New York: John Wiley and Sons, Inc., 1951, p. 1048.

involved in masking. Hirsh, et al[1] describe the state of research as follows:

> A coherent theory of hearing should include the ability to predict the amount of masking for any combination of signal (sound to be masked) and masker. Even for the relatively simple masking that involves only one ear, we have not yet enough general information to predict quantitative results without making further *ad hoc* measurements.

Enough is known about the general characteristics of speech, auditory masking and signal-to-noise ratio, however, to permit the presentation of the following basic facts.

Speech is a complex sound. It contains frequencies as low as 100 cycles per second and as high as 8000 cycles per second, as shown in Figure II. Figure II shows the acoustic spectrum for speech. The intensity of speech sounds of various frequencies is shown by the placement of the line near the top of the graph. It can be seen that most of the intense sounds have frequencies below 2000 cycles. The shaded area at the bottom of the graph designates the threshold of hearing for the various frequencies. Sounds of an intensity and frequency which place them in the shaded area, are inaudible to the average ear under quiet conditions.

The masking of speech is accordingly complex, because as

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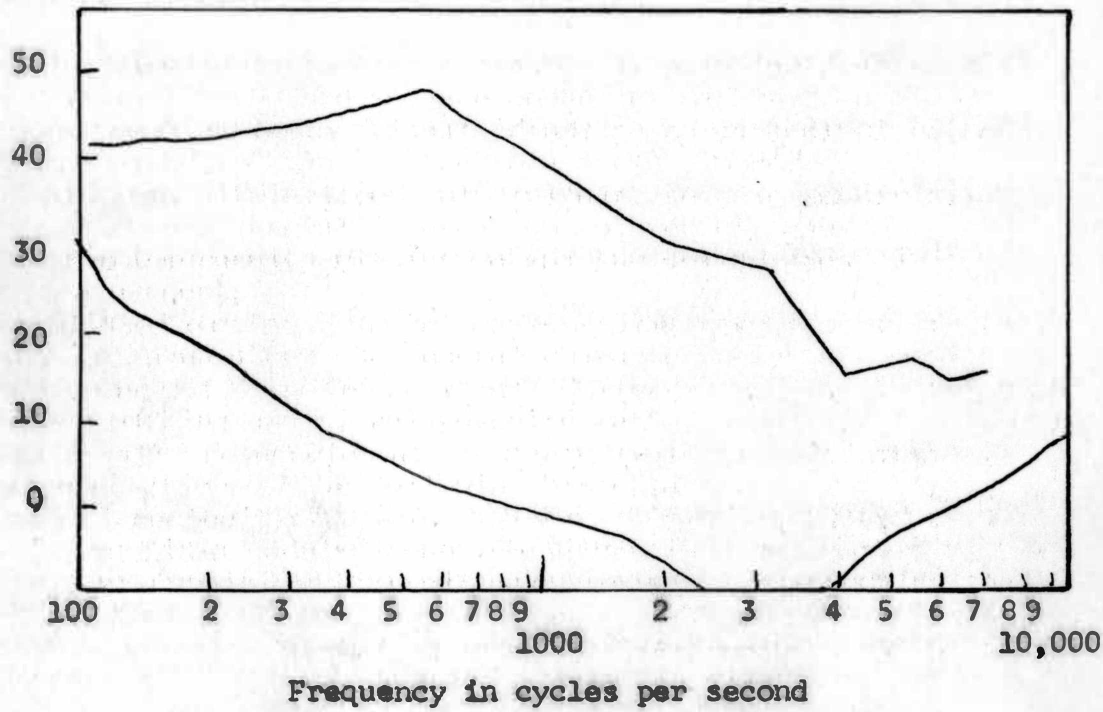
[1] I. J. Hirsh, W. A. Rosenblith, W. D. Ward, "An Investigation of the detection of clicks under masking noise," *Journal Acoustical Society of America,* 1951, *22*, 631-637.

FIGURE II



The long-interval spectrum of conversational speech for seven male voices, expressed in terms of RMS pressure in frequency bands one cycle wide. The overall level of the speech measured 18 inches in front of the talkers' lips was 76 decibels, ref. 0.0002 dyne/cm^2. From Rudmose et al.[1]

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[1] H. W. Rudmose and K. C. Clark, "The effects of high altitude on the human voice," Electro-Acoustic Laboratory, Harvard University, Jan. 1944, OSRD Report no. 3106.

Licklider and Miller[1] point out "masking is greatest at and above the frequency of the masking tone." That is, a pure tone is selective in its masking power. It effectively masks only sounds whose frequency is very similar to, or somewhat higher than its own. This means that to mask speech effectively, a large range of pure tones would have to be employed. This is accomplished easily by using any of three types of sound: (1) other speech, (2) white noise or (3) complex noise. White noise contains all frequencies at an approximately equal intensity over a wide specified range. Complex noise is similar to white noise, but emphasizes low frequency sounds. It resembles the sound as a power saw cutting wood. Miller[2] points out that:

> Human speech is most seriously masked by an uninterrupted noise which has its power concentraded in the lower third of a spectrum covering the frequency-range from 100 to 4000 or 5000 cycles.

This is in essential agreement with Stevens, et al.[3] who show that low tones produce more interference with speech than high tones. Because of the resemblance of complex noise to the "ideal" masking noise described by Stevens, et. al., and Miller,

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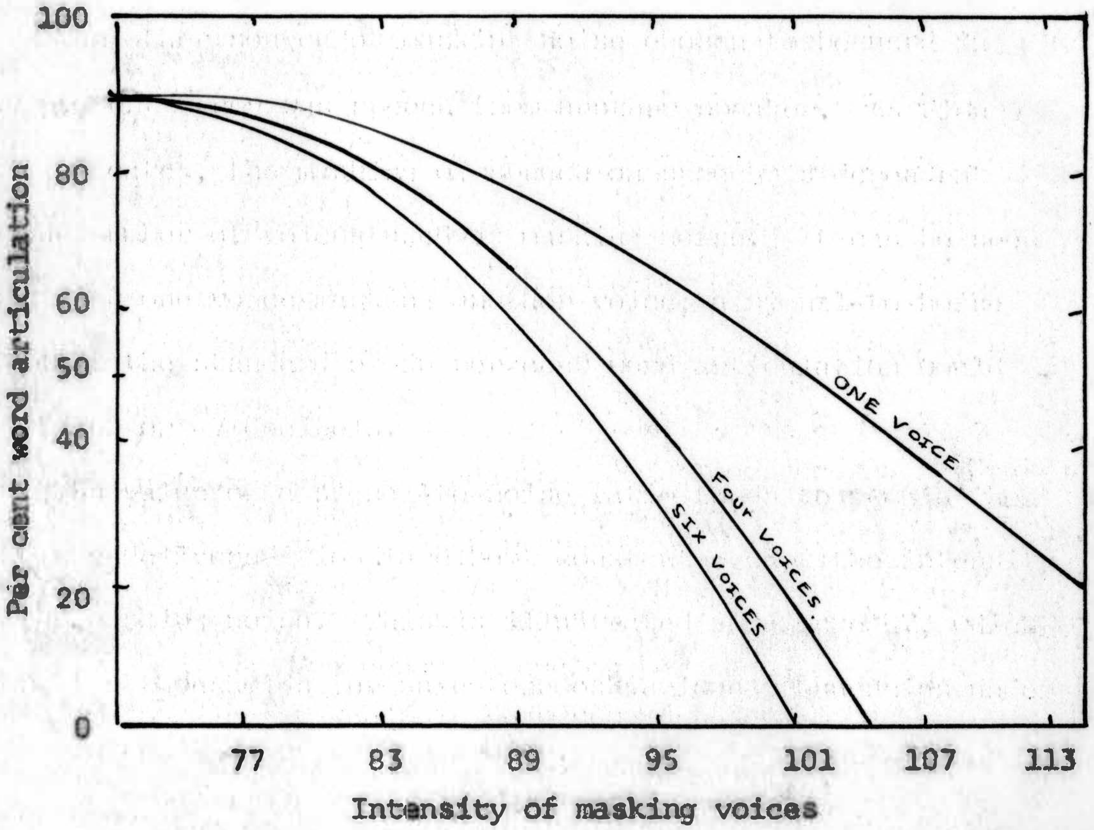
[1] Licklider and Miller, loc. cit.

[2] George A. Miller, "The Masking of Speech," Psychological Bulletin, 1947, 44, p. 106.

[3] S. S. Stevens, G. Miller, and I. Truscott, The Masking of Speech by sine waves, square waves, and regular and irregular pulses, Report PNR-14 from the Psycho-Acoustic Laboratory, Harvard University, 1945.

FIGURE III



The articulation score as a function of the intensity of different numbers of masking voices. The level of the desired speech signal was held constant at 95 decibels. (From Miller[1])

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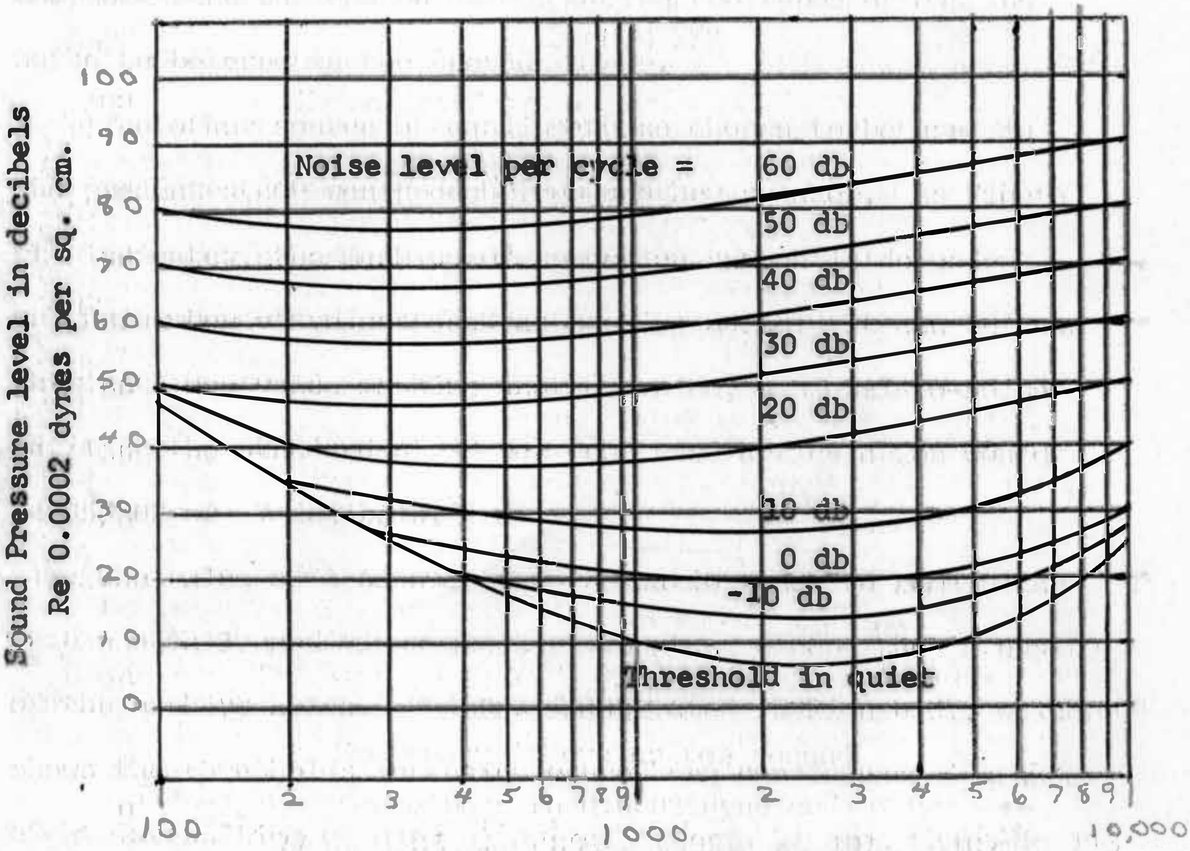
[1]George A. Miller, "The masking of speech," Psychological Bulletin, Vol. 44, p. 119, 1947.

FIGURE IV



Frequency in cycles per second

Absolute and masked thresholds for pure tones as a function of frequency measured in the presence of different background noise intensities. The parameter is Sound Pressure Level per cycle of masking noise. Parametric values may be converted to over-all Sound Pressure Levels by adding 40 decibels. (From Hawkins and Stevens[1])

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[1] J. E. Hawkins Jr. and S. S. Stevens, "The masking of pure tones and of speech by white noise." J. Acoust. Soc. Amer., Vol. 22, p. 10, 1951.

complex noise was chosen as one of the two types of masking noise to be used in the present study.

The other source of masking noise chosen to be used in the present study was speech from another speaker. As Figure III indicates, the masking of speech on speech is dependent on the number of voices used as masking noise. It can be seen that with one voice masking another voice, a signal-to-noise ratio at the standard of 50 per cent word articulation would be 95/102 or -7 decibels.

The value of a signal-to-noise ratio tends to remain the same when all conditions are kept constant except the intensity of the masking noise. This is illustrated in Figure IV, which shows the thresholds for pure tone of various frequencies under eight intensities of masking noise. It can be seen that the lines denoting thresholds are essentially parallel and equally spaced above about 10 decibels of masking, a very soft sound. This means that for every 10 decibel increase in masking noise, the pure tone threshold is increased 10 decibels. A constant signal-to-noise ratio is the result.

Justification of Study

Three studies have shown the importance of stutterers' auditory processes:

1. Lee,[1] in a widely duplicated and confirmed experiment,

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[1] Lee, op. cit.

found that stuttering-like behavior could be induced in many, but not all, normal speakers by delaying the auditory feedback of their own voices. An important factor in determining a subject's susceptibility to this phenomenon is the subject's ability to ignore the air-conducted sound of his own voice and concentrate on the bone-conducted sound or the feel of his mouth movements. If the subject is able to do this, he willtend not to exhibit pseudostuttering. It would appear that if a person had a high signal-to-noise ratio, he would be able to hear his bone-conducted auditory feedback better than normal. Therefore, if stutterers are people who have a "built in," neurologically delayed auditory feedback, as is suggested by Mysak,[1] then a significant per cent of stutterers would have low signal-to-noise ratios. That is, people who had neurologically delayed auditory feedbackwho also had a low signal-to-noise ratio would tend to become stutterers because they could not compensate for their delayed feedback by monitoring their bone-conducted speech.

2. Maraist and Hutton[2] found that stutterers exhibit a marked reduction in stuttering when they are unable to hear their own voices due to masking noise. It is conceivable that stutterers could develop a low signal-to-noise ratio to uncon-

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[1]Edward D. Mysak, "Servo theory and stuttering," Journal of Speech and Hearing Disorders, 1960, 25, 189-195.

[2]Maraist and Hutton, op. cit.

sciously take advantage of this phenomenon in ordinary conversation. That is, if they develop a low signal-to-noise ratio, the noise present in conversational surroundings will have a greater masking effect on their self hearing of their own speech than if they did not develop a low signal-to-noise ratio. Thus a low signal-to-noise ratio would tend to produce some unexpected fluency.

3. Harms and Malone[1] found that there are almost no stutterers among the deaf and severely hard-of-hearing, but that most stutterers have some type of hearing loss, usually mild. If this is true, then stutterers would exhibit either an abnormally high or abnormally low signal-to-noise ratio. That is, if a stutterer had a conduction type hearing loss, he would hear his own voice as being abnormally loud, and if he had a nerve type loss, he would hear his voice as being abnormally soft, although it could be the right intensity in relation to other sounds.

To summarize, then, in justification of the present study, it may be said that research indicates stutterers may possess an abnormal signal-to-noise ratio. This particular aspect of stutterers' hearing has never been studied, as far as it has been possible to determine. Accordingly, it is the purpose of the present study to determine signal-to-noise ratios for stutterers and to compare them to those of comparable normal speakers.

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[1] Harms and Malone, op. cit.

In as much as the acuity of stutterers' hearing has been questioned, and in as much as hearing acuity is an important consideration in the determination of signal-to-noise ratios, this characteristic will be examined in the present study, as well.

Null Hypotheses

It is the purpose of this study to examine two null hypotheses:

1. Major hypothesis: There is no difference between male college age stutterers and male college age normal speakers with respect to their ability to differentiate speech from masking noise.

2. Minor hypothesis: There is no difference between male college age stutterers and male college age normal speakers with respect to their hearing acuity.

CHAPTER II

PROCEDURE

The Selection of Subjects

The subjects who comprised the two groups used in this study were all male college students. The experimental group consisted of thirty stutterers, and the control group consisted of thirty normal speakers. Specifically, the stutterers were selected to satisfy the following criteria:

1. They must be male undergraduate or graduate college students.

2. They must have received college speech therapy for their stuttering or be receiving it in the spring semester of the 1960-61 school year.

3. They must have normal hearing acuity.

The normal speakers were selected on the basis of the same criteria, with the exception that it was required they did not present a noticable speech defect at the time of the test, and that they did not consider themselves to be stutterers.

The stutterers were drawn from the speech clinics of three universities: Western Michigan University in Kalamazoo, Michigan, Indiana University in Bloomington, Indiana, and Miami University in Oxford, Ohio. The normal speakers were drawn from the student body of Western Michigan University. The subjects were tested with the audiometric equipment of the speech clinics of Miami University and Indiana University, and of the Constance Brown Society for Better Hearing in Kalamazoo, Michigan.

Apparatus and Preparation of Materials

The test procedure, which consisted of administering four sub-tests, made use of a two channel audiometer with microphone, tape recorder, and phonograph circuits; a sound treated room with a sound field speaker connected to the audiometer; a tape recorder; and an assistant.

The audiometer in each of the three audiometric settings was an Allison model 21A. All had been recently calibrated, and were considered by their regular operators to be accurate within a range of plus or minus one decibel. A two channel audiometer made it possible to control independently the intensity and use of two separate sources of sound.

The audiometric rooms were sound treated and all had an ambient noise level of less than 40 decibels above 0.0002 dynes per square centimeter, a standard reference level. This is fairly low, and is generally considered to be adequate for all common audiometric procedures.

The tape recorder was a Wollensak, model T-1500, serial number 139116. It was played at a speed of seven and one half inches per second.

The assistants, who required no special training, were students at the three universities who were majoring in speech correction.

The first sub-test yielded a measurement of the subject's speech reception threshold, hereafter abbreviated as SRT. The speech reception threshold is defined as the "sensation level at which the patient can repeat 50 per cent of the (spondee) words correctly."[1] This is a good estimation of the subject's hearing, and provides a threshold upon which the intensities of subsequent tests can be based to insure equal loudness for all subjects. To arrive at this measurement the materials described by Newby were used:

> Although a variety of speech materials are suitable for arriving at the SRT, two tests are more common than others. One consists of lists of two-syllable words, referred to as spondees, although most of these words would normally not be pronounced with equal stress on both syllables. They are words such as doorway, footstool, airplane, and armchair. Two recorded forms of the spondee test are available. They are called Auditory Tests W-1 and W-2: spondaic word lists. Test W-1 consists of lists of thirty-six spondaic words which have been recorded at a constant level. The audiometrist introduces as much attenuation as he needs in the course of the test to arrive at the patient's SRT.[2]

In the determination of the subject's speech reception threshold, it was necessary to introduce the spondee words to the subject through a sound-field speaker at a known but vari-

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[1] Hayes Newby, Audiology, New York: Appleton-Century-Crofts, Inc., 1958, p. 111.

[2] Newby, loc. cit.

able intensity. This was accomplished by the tape recording of seventy-two spondee words and the calibration tone from Auditory Test W-1 Phonograph records,[1] lists 4C and 4D at a constant volume level. During the testing, these words were introduced into the audiometer for calibration and attenuation either through the microphone circuit, which was the procedure at the Constance Brown Society, or through the tape recorder circuit of the audiometer, which was the procedure at Miami University and Indiana University.

The second, third and fourth sub-tests yielded measurements of the subject's signal-to-noise ratio under three conditions. The three conditions involved three types or intensities of masking noise. These were: (1) low intensity speech, (2) high intensity speech and (3) high intensity complex noise. In the computation of the signal-to-noise ratio, the intensity of the signal in the form of spondee words, was that intensity at which the subject could hear approximately one-half of the spondee words over the masking noise. To obtain these measurements, it was necessary to introduce the noise into the sound-field speaker at a known, constant intensity level, and to introduce the signal, in the form of spondee words, into the speaker at a known, variable intensity level.

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[1] Adapted from older records by Central Institute for the Deaf, St. Louis, Missouri, available from Technisonic Studios, 1201 Brentwood Blvd., Richmond 17, Missouri.

This was accomplished by using the two channels of the audiometer independently. Channel one was used to control the intensity of the spondee words whose source was the microphone or tape circuit, and channel two was used to control the intensity of the noise. The source of this masking noise was the phonograph circuit on the second and third sub-tests, and the complex noise circuit for the fourth sub-test.

To insure that each subject heard the sounds coming from the sound field speaker at an equal loudness or equal sensation level, it was necessary to base the intensity of the noise used in the second, third, and fourth sub-tests on the subject's speech reception threshold. That is, the intensity of the noise used in each test for each subject was the sum of the decibel level of the subject's speech.reception threshold and the decibel level of a constant. To approximate normal conversational conditions, the value of these constants was determined on the basis of Davis' estimation of the intensity of average soft conversational speech (33 decibels) and average loud conversational speech (63 decibels).[1] For example, if a subject had a speech reception threshold of +6 decibels, the noise level in the second sub-test would be (6 + 33) decibels, or 39 decibels. To approximate normal conditions further, it was

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[1]Hallowell Davis, quoted in Hayes A. Newby, Audiology, New York: Appleton-Century-Crofts, Inc., 1958, p. 118.

decided that connected speech of a fairly even intensity and rate should be used as the masking noise. It was also decided that the test should be repeated with complex noise substituted for the speech to provide a comparison between speech and non-speech as background noise.

The sub-tests, following the reasoning described above, were chosen as follows:

Sub-test 1: a determination of the subject's speech reception threshold using spondee words presented over a sound-field speaker.

Sub-test 2: a determination of the subject's signal-to-noise ratio using spondee words as the signal of variable intensity, and a newscast of Fulton Lewis, Jr. which is available on a standardized audiometric record as the noise. The noise level is to be the subject's SRT plus 33 decibels.

Sub-test 3: a determination of the subject's signal-to-noise ration under the same conditions as sub-test 2, with the exception that the intensity of the noise level is to be the subject's SRT plus 63 decibels.

Sub-test 4: a determination of the subject's signal-to-noise ratio using spondee words of variable intensity as the signal, and complex noise as the noise. The noise level is to be the subject's speech reception threshold plus 63 decibels.

Experimental Procedure

The subject was seated in a straight-backed chair facing the sound-field speaker. The chair was located at a fixed, predetermined distance from the sound-field speaker to insure accurate knowledge of the intensity of sound reaching the subject's ears. An assistant who had a list of the spondee words used in the test was seated close enough to the subject to permit her to see the words which the subject wrote down. (It had been decided that to insure honest answers from the stutterers, all subjects would be asked to write down the words they heard, rather than say them.) The following instructions for sub-test 1 were read to the subject by the tester:

> "You will hear a man say several two-syllable words, each one preceded by the phrase 'say the word'. Instead of saying the word, however, you are to write it down on this paper. The observer will then check it with her list and signal me if you were able to hear it or not. The words will start out fairly loud and gradually get fainter until you are unable to hear them. Are there any questions?"

The tester then returned to the control room and introduced spondee word list W-1, list 4C, through the sound field speaker at an intensity of thirty decibels. The subject's SRT (Speech Reception Threshold) was then determined by following the standard audiometric procedure described by Newby.[1] This involves

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[1]Hayes Newby, op. cit., p. 112.

gradually decreasing the intensity of the spondee words until only approximately one-half of them are heard correctly by the subject. The results were recorded on a data sheet under the heading SRT.

The instructions for the second sub-test were then read to the subject by the tester. The instructions were as follows:

> "Now this procedure will be repeated, but in addition to the words, you will hear a newscast in the background. You are to ignore the newscast and write down the words as before."

The tester then calibrated the standard phonograph record of Fulton Lewis Jr., which was the source of noise for the second sub-test, and introduced the newscast to the subject at a level of 33 decibels above his SRT. The tester then waited six seconds and introduced the spondee words to the subject at a <u>starting</u> level of 38 decibels above his SRT. The tape of the spondee words was started from the point where it had been stopped at the completion of the previous test to insure that none of the words would be repeated. The procedure used to determine the subject's SRT was followed. This involved gradually decreasing the intensity level of the spondee words until the subject could make out only one-half of them over the noise, which was held at a constant level. The results, in the form of a signal-to-noise ratio were recorded on the data sheet under the heading of S/N I.

The tester then told the subject the instructions for the third sub-test, as follows:

> "Now this procedure will be repeated, but the sounds will be somewhat louder than before."

The procedure for the determination of the signal-to-noise ratio in sub-test 2 was then repeated, with the exceptions that the newscast was introduced at an intensity of 63 decibels above the subject's SRT and the spondee words were introduced at an intensity level of 68 decibels above the subject's SRT. The spondee words were introduced at an intensity level of 5 decibels higher than the newscast to insure the subject's hearing of the first two spondee words. The results were recorded as a signal-to-noise ratio under the heading S/N II on the data sheet.

The tester then read the following instructions for sub-test 4 to the subject:

> "Now this procedure will be repeated, with an even noise replacing the newscast."

The procedure for the determination of the signal-to-noise ratio in the second sub-test was then repeated, with the exceptions that complex noise, generated in the audiometer, was introduced to the subject at 63 decibels above his SRT instead of the newscast, and the spondee words were introduced to the subject at a level of 68 decibels above his SRT. The results were recorded as a signal-to-noise ratio under the heading S/N III on the data sheet. This completed the experimental procedure.

Treatment of Data

The data obtained on the signal-to-noise ratios for the experimental group and the control group were treated in the following manner. The arithmetic mean and standard deviation were computed for each of the four sub-tests in the experimental group and control group, and for the total experimental and control group. To make these and subsequent computations easier, the raw data in the form of signal-to-noise ratios were transformed to a form much more easily understood and much more easily analyzed by computing a signal-to-noise difference from each signal-to-noise ratio. This was done by subtracting the noise level (N) from the signal level (s). This resulted in a single figure for each ratio, expressed in decibels, which represented the difference between the arbitrarily chosen intensity level of the background noise and the corresponding intensity level of the spondee words when one-half of those presented could be heard over the background noise. The means and standard deviations computed with these figures are presented in Tables I and II, page 28.

Then, to determine whether or not the experimental group differed significantly from the control group, a Pearson product-moment measure of correlation was computed for the fifteen possible combinations of the three control group S-N differences and the three experimental group S-N differences. This made possible the computation of the standard error of the difference between correlated means, which then permitted the computation of a *z* ratio or "critical ratio," as a test of the significance of the differences between the means of the pairs of the sub-groups were compared (Table III, page 30). Fisher's *t* test of a coefficient of correlation was applied to determine the significance of each of the fifteen Pearson product-moments (Table IV, page 32). In addition, the *t* test for difference between uncorrelated means was applied to the three sets of data as obtained at the three universities. This was done to determine whether or not there was any significant variance among these sets of data due to undetected discrepancies in equipment or procedure at the three universities.

CHAPTER III

RESULTS

This chapter is concerned with the tabulation and analysis of data and the interpretation of results.

In Tables I and II are presented the means and standard deviations for the speech reception thresholds (SRT's) the three signal-to-noise ratio conditions individually, and the three signal-to-noise ratio conditions combined, for the experimental group and the control group. To permit correlation and eliminate confusing negative numbers, a constant, 17 decibels was added to each of the signal-to-noise differences in the computations.

As Tables I and II indicate, means for corresponding conditions in the control and experimental groups do not differ by more than 4 decibels, while no standard deviation is less than 4 decibels. This casts considerable doubt on the validity of the differences between the means. The major null hypothesis states:

> *There is no difference between college age male stutterers and male college age normal speakers in their ability to differentiate speech from masking noise.*

TABLE I

MEANS AND STANDARD DEVIATIONS FOR FOUR SETS OF DATA OBTAINED ON EXPERIMENTAL GROUP (STUTTERERS)

	SRT	S/N I	S/N II	S/N III	S/N I,II,III
STANDARD DEVIATION	4.37	5.46	5.88	5.86	6.36
MEAN + 17	7.4*	12.67	9.72	16.97	13.11

Values are in decibels

TABLE II

MEANS AND STANDARD DEVIATIONS FOR FOUR SETS OF DATA OBTAINED ON CONTROL GROUP (NORMAL SPEAKERS)

	SRT	S/N I	S/N II	S/N III	S/N I,II,III
STANDARD DEVIATION	4.12	4.07	5.35	4.65	4.79
MEAN + 17	5.35*	12.90	13.71	14.67	13.77

Values are in decibels

*actual mean, not mean + 17.

To test this hypothesis, a *z* ratio or "critical ratio" for a difference between uncorrelated means was computed for four pairs of means, as indicated in Table III. The means which were analyzed for significance of difference were those from the experimental and control groups for the second, third and fourth sub-tests, and for these three sub-tests combined. The experimental group was compared with the control group in each case. It was then possible to determine the significance of the discrepancies between the various pairs of means involved. That is, a level of confidence was obtained for each pair of means. This indicated the number of times per hundred a discrimination between the means as large or larger would be obtained through the chance variation were there really no difference between the control and experimental groups in their ability to discriminate signal from noise (Table III).

As Table III indicates, the differences between the means under analysis arose very probably from chance variation. No level of confidence approached the five per cent level. That is, if there were no differences in the signal-to-noise ratio between the populations which were sampled, differences between the means as large or larger than the ones obtained would occur *by chance* more than five times in one hundred different samplings. This indicates that the major null hypothesis cannot be rejected.

There appears to be no demonstratable
difference between male college stutterers

TABLE III

$\bar{z}$ RATIOS AND LEVELS OF CONFIDENCE CONCERNING THE DISCREPANCY BETWEEN THE CORRESPONDING MEANS OF THE CONTROL AND EXPERIMENTAL GROUPS

CONTROL GROUP	EXPERIMENTAL GROUP S/N I	S/N II	S/N III	S/N I, II, III
S/N I	z = .108 cl. = .90			
S/N II		z = .525 cl. = .60		
S/N III			z = .309 cl. = .75	
S/N I, II, III (total)				z = .083 cl. = .93

cl.stands for confidence level

<u>and male college normal speakers with respect to their ability to differentiate speech from masking noise.</u>

In order to apply the <u>z</u> test for uncorrelated means, it was necessary to determine if a significant correlation existed between the pairs of sub-groups being analyzed. As Table IV shows, there were no significant correlations between any of the four sub-groups for which z ratios were computed. The significance of correlations was determined by applying Fisher's t test. It was not thought to be necessary to compute a correlation for the total groups because of the similarity of the means and the large standard deviations.

It should be noted that two of the correlations <u>not</u> involved in testing the major or minor null hypothesis were significant at a level of confidence less than .01 (one per cent). This indicates the presence of a definite correlation, in this case a positive one. The correlations were +.79 and +.49 and occurred among the sub-tests of the experimental group, specifically between signal-to-noise difference I and signal-to-noise difference II; and between signal-to-noise difference I and signal-to-noise difference III. This is a reasonable finding, as it indicates primarily that if a stutterer takes the first sub-test, he is likely to perform at a similar level on the second and third sub-tests. This indicates some internal reliability of the total test for stutterers, although not for

TABLE IV

PEARSON'S r FOR FOUR SUBTESTS, AND LEVELS OF CONFIDENCE FOR CORRELATIONS

	CONTROL GROUP				EXPERIMENTAL GROUP			
	SRT	S/NI	S/NII	S/N III	SRT	S/NI	S/NII	S/N III
CONTROL SRT					-.02 95%			
CONTROL S/NI			+.28 15%	+.02 90%		+.11 55%	-.08 68%	+.07 78%
CONTROL S/N II		+.28 15%		+.07 74%		+.30 12%	+.17 55%	+.29 12%
CONTROL S/N III		+.02 90%	+.07 74%			-.18 35%	-.08 68%	+.12 53%
EXP. SRT.	-.02 95%							
EXP. S/N I		+.11 55%	+.30 12%	-.18 35%			+.79 1%	+.49 1%
EXP. S/N II		+.08 68%	+.17 55%	-.08 68%		+.79 1%		+.34 8%
EXP. S/N III		+.07 78%	+.29 12%	+.12 53%		+.49 1%	+.34 8%	

Figures in the top of each square are correlations (r), Figures in the bottom of each square are levels of confidence.

normal speakers.

The average speech Reception Thresholds for the control group and experimental group were both well within normal range and were within one standard deviation of each other. The computation of a *z* ratio for significance between uncorrelated means produced a *z* of .342, which failed to reach the 5 per cent level of confidence by a wide margin. It was concluded that the stutterers and the normal speakers were of average hearing acuity, and did not differ significantly from each other in this characteristic. This permitted the acceptance of the minor null hypothesis:

> *There is no difference between male college age stutterers and male college age normal speakers with respect to acuity of hearing.*

To detect any significant variance between the data, as obtained at the three universities involved in the study, a *t* test for difference between uncorrelated means was applied. It was thought that important discrepancies could exist between the three sets of data due to variation in the calibration of of the audiometers, the acoustic properties of the testing rooms, and the fidelity of the speakers. The *t* test was applied to the three possible combinations of schools: Western Michigan University and Miami University, Western Michigan

TABLE V

THE MEANS, t VALUES FOR DIFFERENCES BETWEEN UNCORRELATED MEANS, AND LEVELS OF CONFIDENCE OBTAINED IN ANALYZING THE DATA FROM MIAMI UNIVERSITY, INDIANA UNIVERSITY, AND WESTERN MICHIGAN UNIVERSITY FOR SIGNIFICANT DIFFERENCES°

	MEANS	t*	CONFIDENCE LEVEL
INDIANA UNIVERSITY compared with MIAMI UNIVERSITY	11.5 ----------- 10.4	.312	75%
WESTERN MICHIGAN UNIVERSITY compared with MIAMI UNIVERSITY	17.5 ----------- 10.4	1.495	17%
WESTERN MICHIGAN UNIVERSITY Compared with INDIANA UNIVERSITY	17.1 ----------- 11.5	1.469	18%

*A t value of 2.048 is necessary for significance at the 5% level (.05). A t value of 2.763 is necessary for significance at the 1% level (.01).

University and Indiana University, and Miami University and Indiana University (Table V.). As indicated in Table V, page 34, there were no discrepancies which approached the five percent level of confidence. The conclusion was drawn that the use of three sets of equipment resulted in sets of data which were similar enough that no need for special analysis or correction factors was indicated.

CHAPTER IV

CONCLUSIONS, RECOMMENDATIONS AND SUMMARY

Conclusions

In so far as the techniques used in this study were valid, the following conclusions seem to be defensible:

1. There is no difference between stutterers and normal speakers in their ability to differentiate speech from background noise, as demonstrated on a simple signal-to-noise ratio test. There were no significant differences between the experimental group and the control group in the ability tested.

2. The acuity of adult male stutterers' hearing does not differ significantly from normal, as measured on a standard Speech Reception Threshold test. The stutterers used in this study had an average Speech Reception Threshold of +0.4 decibels, with reference to the United States audiometric zero. This is well within normal limits.

Recommendations

On the basis of the results and conclusions, the following recommendation seems reasonable:

There should be further research done in the area of stutterers' signal-to-noise ratios. Perhaps the stutterers' own voices could be used as the signal, or speech which contained stuttering used as the noise. There should also be some criteria used in the selection of stutterers in addition to the ones employed in the present study. Perhaps only stutterers who have predominately silent blocks, or those whose stuttering began before a certain age should be used.

Summary

The purpose of this study was to compare male stutterers and normal speakers of college age in their ability to differentiate speech from background noise. A control group of thirty normal speakers and an experimental group of thirty stutterers were used for this purpose. These groups were tested for their ability to hear speech over a background noise, under three conditions of noise. The results indicated that there was no testable difference between the stutterers and the normal speakers with respect to this ability. It was also noted that the stutterers as a group exhibited normal hearing for speech. Conclusions and recommendations for further research were listed.

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APPENDIX

DATA FOR EXPERIMENTAL GROUP

Subject no.	SRT	S/N I	S/N II	S/N III
1	+ 7	- 9	-11	-10
2	+ 3	- 5	- 5	- 3
3	+ 4	- 2	- 3	+ 1
4	+ 3	- 4	- 1	- 1
5	+ 8	- 8	-10	- 4
6	0	-15	-15	-16
7	+11	- 3	- 9	- 6
8	+ 5	+ 2	- 4	+ 6
9	+ 2	+ 1	- 3	- 2
10	+18	+ 8	+ 3	+11
11	+ 8	+ 2	- 6	- 3
12	+ 4	0	- 3	0
13	+10	- 3	- 2	- 5
14	+ 7	- 2	- 3	0
15	+ 9	+ 1	0	+ 5
16	+18	- 5	-10	- 1
17	+ 4	+ 9	+ 4	+ 3
18	+ 2	- 9	-15	+ 2
19	+13	-10	-15	- 7
20	+ 2	- 4	-10	+ 2
21	+ 1	- 4	- 2	+ 7
22	+18	- 3	-11	+ 8
23	+ 3	- 4	- 8	- 3
24	+13	- 9	-16	+ 1
25	+15	- 5	- 2	+ 9
26	+ 7	-13	-12	- 7
27	+ 3	- 8	-14	+ 5
28	+12	-10	-17	+ 7
29	+ 7	-10	- 4	0
30	+ 5	- 8	-15	0

DATA FOR CONTROL GROUP

Subject no.	SRT	S/N I	S/N II	S/N III
1	0	- 4	-13	0
2	0	- 4	- 1	0
3	+ 8	- 3	-11	- 7
4	+ 5	- 6	- 5	0
5	+ 4	- 2	- 5	- 6
6	+ 8	- 3	-12	- 8
7	+ 9	-10	-15	-10
8	+ 7	- 4	- 5	- 2
9	+ 8	- 3	+ 5	- 5
10	+ 4	- 2	- 3	- 5
11	+ 7	- 3	+ 6	- 7
12	+ 3	- 2	0	- 6
13	+ 5	- 3	+ 4	+ 3
14	+ 8	- 6	- 7	+13
15	+ 7	- 1	- 3	- 3
16	+ 5	- 3	- 5	- 5
17	+10	- 2	+ 5	- 5
18	+ 2	+ 8	+ 1	- 3
19	+ 7	0	- 1	+ 6
20	+ 5	-10	-12	- 2
21	+ 8	- 2	- 2	- 5
22	+ 9	- 3	+ 2	- 4
23	+ 6	- 4	- 5	- 5
24	+ 4	- 5	- 5	0
25	0	-11	- 5	0
26	+ 8	-10	- 2	- 6
27	+ 3	-10	+ 3	0
28	+ 7	+ 3	- 3	+ 5
29	+ 2	-10	- 4	0
30	+ 1	- 8	0	- 3