THE EFFECT OF SPEECH ON METABOLISM: A COMPARISON
BETWEEN STUTTERERS AND NON-STUTTERERS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the
Graduate School of The Ohio State
University

By

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The Ohio State University
1956

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ACKNOWLEDGEMENT

The author wishes to express his gratitude for the assistance given by Dr. Henry M. Moser, adviser.

The author is deeply indebted to Dr. Eric Ogden and Dr. Robert Grubbs of the Department of Physiology for the guidance they provided throughout this investigation.

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

Extensive investigations, directed toward clinical and experimental tests of metabolism, reveal little research related to speech. Studies comparing the basal metabolism of normal and stuttering speakers have been conducted, but apparently no attempt has been made to investigate the energy requirements for the act of speech, to investigate whether the act of stuttering requires more energy than that of normal speech, or if the metabolic method provides a means of measuring progress in therapy.

I. THE PROBLEM

Statement of the problem. The purpose of this experiment was to study the energy cost of the act of speech and to investigate the possibility of a differential effect on the metabolism of normal and stuttered speech.

In order to assess the requirements for speech, three consecutive measures were taken on each subject on each of two separate occasions. These measures were: (1) a basal metabolic rate, (2) a speech metabolic rate, and (3) a post-speech metabolic rate.

II. DEFINITIONS OF TERMS USED

Metabolic rate. The metabolic rate is a measure of total heat production over a given period of time during the postabsorptive state (basal state). In this study the metabolic rate is defined as the rate at which an individual consumed oxygen. It is noted that oxygen consumption is an index of the amount of heat produced. Metabolism is simply the name given to energy transformations which go on continuously in living forms, and when work is done, more of these metabolic processes swing into action, and still others proceed at a more rapid rate.¹ The net result

¹Langley, L. L. and Cheraskin, E., The Physiology of Man, McGraw-Hill Book Company, Inc., New York, 1954, p. 427.

is that the total heat production increases, and since this heat is produced by the metabolic processes, and the quantity of heat liberated varies directly with the rate at which these processes operate and is reflected by the metabolic rate, this study refers to metabolic rate rather than to heat production.

The rate of oxygen consumption will be increased by any influence that stimulates heat production, such as the digestion, absorption, and utilization of food; hence, a basal (postabsorptive) state was demanded of the subjects participating in the experiment.

Basal state. A basal state on the part of the subject

indicated that (1) he did not eat for a period of twelve hours preceding the test, (2) he received at least eight hours sleep the night before the test, (3) he did not eat, drink, or smoke on the morning of the test, (4) he arose early enough to prevent rushing to the laboratory, and (5) he maintained a state of celibacy for a period of twenty-four hours preceding the test.

Basal metabolic rate. The basal metabolic rate (BMR) presumably represents the minimum oxygen requirement of an individual when he is in a basal state. The BMR is simply an expression of the rate at which oxygen is consumed when the body is performing no work except that required to maintain itself in a state of rest.

Speech metabolic rate. The speech metabolic rate (SMR) is defined as the rate at which oxygen is consumed during speech.

Post-speech metabolic rate. The post-speech metabolic rate (PSMR) is defined as the rate at which oxygen is consumed during silence and rest immediately following the speech act.

III. THE HYPOTHESES

In order to investigate questions raised by the problem of the study, the following six statistical hypotheses were formulated:

1. There is no difference between the Basal Metabolic

Rates of stutterers and non-stutterers.

2. There is no difference between the Basal and the Speech Metabolic Rates for non-stutterers.

3. There is no difference between the Basal and the Speech Metabolic Rates for stutterers.

4. There is no difference between stutterers and non-stutterers with respect to the obtained differences between their Basal and Speech Metabolic Rates.

5. There is no difference between stutterers who have completed a therapy program and stutterers who have not completed a therapy program, with respect to differences between their Basal and Speech Metabolic Rates.

6. There is no difference between post-therapy stutterers and normal speakers with respect to the increase in metabolic rate during speech.

CHAPTER II

REVIEW OF THE LITERATURE

There appear to be no published data which show the effect of speech on the metabolic rate of the stutterer. No reference to the effect of speech on the metabolism of the non-stutterer has been found in the literature.

Metabolic studies to date have dealt with subjects under a condition of silence and rest, but not during speech. Reports found in the literature which explore the metabolism of stutterers give conflicting evidence; for example, Ritzman² conducted a

²Ritzman, C. H., "A Comparative Cardiovascular and Metabolic Study of Stutterers and Non-stutterers," Journal of Speech and Hearing Disorders, 7, 1942, p. 367.

study of metabolism on stutterers and non-stutterers and found no differences in their BMR scores. These measures were taken during silence and under conditions of rest. Starr³ reported differences,

³Starr, H. E., "Psychological Concomitants of High Alveolar CO₂; A Psychobiochemical Study of the Etiology of Stammering," Psychology Clinics, 17, 1928, pp. 1-12.

depending upon the type of stuttering involved; however, his data were not treated statistically.

In a study of nerve and muscle metabolism, Kopp⁴ analyzed

⁴Kopp, George, "The Metabolism of the Stutterer as Evidenced by Biochemical studies of Blood, Alveolar Air and Urine," Unpublished Doctoral Dissertation, University of Wisconsin, 1933, pp. 1-183.

body fluids. He points out that the stutterers, as compared with the normals, have: (1) higher phosphates, (2) lower potassium, (3) lower total protein, albumin, and globulin, and (4) higher blood sugar. He concludes that " . . . the stutterers are not the same as the normals."⁵ However, Kopp found that no differences

⁵Ibid., p. 133.

exist between stutterers and normals with respect to alveolar CO₂ tension. It should be noted that " . . . CO₂ tension change is concomitant with and possibly caused by changes of metabolism."⁶

⁶Ibid., p. 148.

On the other hand, the results obtained by M. A. Trumper⁷ indicate

⁷Trumper, M. A., "A Hemato-Respiratory Study of 101 Consecutive Cases of Stammering," Unpublished Doctoral Dissertation, University of Pennsylvania, 1928, pp. 1-72.

that stutterers are different from normals; however, the differences were not evaluated statistically.

These studies are pertinent only to the extent that they are metabolic investigations of individuals with a speech defect. They are not metabolic studies of speech itself.

It is apparent that conflicting experimental evidence exists. The metabolic studies thus far reported treated the subject under a condition of silence and at rest. The present investigation repeated these conditions, by having each subject in a basal state, and went on to study the metabolic rates during and following speech.

CHAPTER III

EXPERIMENTAL PROCEDURE AND RATIONALE

A method of indirect calorimetry was employed in this experiment to arrive at a measure of heat production during a specified activity. The metabolism would have been more properly determined by direct calorimetry; however, this would have resulted in a considerable loss to the over-all efficiency of the experiment without a corresponding gain in accuracy. Langley and Cheraskin have indicated that, "Results obtained by indirect methods agree within one per cent with the results derived by the direct method."⁸

⁸Langley and Cheraskin, op. cit., p. 428.

DuBois has pointed out that because of the technical difficulties of the direct method, and for the reason that, "Carbon dioxide production and oxygen consumption are accurate indices of the amount of heat produced, . . . "⁹ the measurement of gaseous exchange

⁹DuBois, E. F., Basal Metabolism in Health and Disease, Lea and Febiger, Philadelphia, 1936.

has proved to be both practical and accurate. DuBois also states that indirect calorimetry, " . . . is best accomplished by measuring the amount of oxygen utilized over a given period of time by

a patient under a standard set of conditions."¹⁰

¹⁰DuBois, loc. cit.

Test conditions. Every effort was made to keep test conditions constant from subject to subject. All tests were administered between the hours of eight and ten o'clock in the morning, with the exception of two which were scheduled an hour earlier. All subjects received the same pre-test instructions (see Appendix I). Uniform speech stimulus material was used by all subjects for the determination of the SMR. The same equipment was used for all subjects under all conditions.

Equipment. The Benedict-Roth Metabolism Apparatus was employed in this experiment. The usual mouthpiece used in obtaining a BMR with this device could not be used since it prohibited speech. The standard mouthpiece was replaced with a United States Army Gas Mask, Type U (MIVAI, EAE, Lot 26, C5-2-229), which was adapted to fit the regular air lines of the Benedict-Roth Apparatus. A special wide band of rubber sheeting, and foam-rubber pressure pads were utilized to help insure against oxygen leaks which might occur during speech due to excursions of the mandible.

A standard leak test was made in the course of each experimental session; a weight of 160 grams was used.

The equipment (see Figure 1) is designed with flutter valves

FIGURE 1
THE BENEDICT-ROTH METABOLISM APPARATUS

- A Army Gas Mask
- B Rubber Sheeting and pressure pad
- C Exhalation Tube
- D Inhalation Tube
- E Room-air Valve
- F Flutter Valve
- G Soda Lime Container
- H Flutter Valve
- I Water Seal
- J Oxygen Bell
- K Kymograph Drum
- L Recording Pen
- M Drum Rotating Switch

which permit a one-way flow of O_2 . There is one flutter valve located at the entrance of the inhalation tube and another at the exit of the exhalation tube on top of the soda lime container. These served to guide each respiration so that the inhalations were drawn from the O_2 in the bell and the exhalations passed up through a soda lime container which removed the CO_2 , a certain amount of the moisture, and allowed the unused O_2 to re-enter the bell.

The O_2 entered the mask through inlets under the eye-pieces. This was convenient in that it prevented fogging of the glass, tended to cool the subject's face, and contributed to complete circulation of gas within the mask. The outlet for the mask was located directly in front of the subject's mouth. As the subject breathed, the bell rose and fell in time with his respiration. The Benedict-Roth Apparatus has a large electrically driven kymograph drum which rotates at a fixed rate. The subject's inspirations, expirations, and rate of O_2 consumption were recorded on a chart placed around the kymograph drum.

The equipment used in obtaining measures of height, weight, body temperature, and barometric pressure remained constant throughout the experiment.

Subjects. Forty subjects participated in the experiment. They were evenly divided with seventeen males and three females in each of two groups. Group one was comprised of non-stutterers;

these were individuals who did not, and had never considered themselves as stutterers. Group two was made up of stutterers; these people evaluated themselves as being stutterers. Group two included nine individuals who had completed a therapy program, and eleven persons who were currently receiving therapy. Group one had an age range from 23 to 45, with a mean of 30.5 years. Group two had an age range from 18 to 34 years, with a mean age of 21.7 years. It should be noted that age disparity was not a factor which contributed to group differences; norms have been established for various age levels and the statistics for this experiment were computed on the per cent above or below the norm for a stated age level (p.19 infra).

Instruction of subjects. Each subject received his pre-test instruction in both oral and a written form. These covered the conditions necessary for the subject to be in a basal state when the test was given (see Appendix I), as well as a general statement concerning what he would be expected to do and the order in which the experimental events would occur.

Specific testing procedure. When the subject arrived at the laboratory he was asked if he were in a basal state. He was then instructed to lie down for thirty minutes. The experimenter orally reviewed the test procedure and attempted to anticipate events during the test which might upset the subject. He was told that in the early moments of the test he would be aware of having

to pull the air in and to push it out, although he would experience no difficulty in getting enough air. It was also explained that approximately three minutes after the test had begun he might hear a weight being placed upon the bell and its purpose was to test for O_2 leaks by putting the gas under pressure and thus accentuate any leak that might be present. It was further pointed out that the presence of the weight would make inhalation easier and, therefore, when it was removed the act of inspiration would seem relatively more difficult. The subject was asked if there were any questions before the test began.

The bell was filled to approximately two-thirds of its total capacity, the kymograph drum set into motion, and the valve admitting O_2 to the subject opened at a moment of complete expiration. The subject, still in a prone position, continued to breathe normally for a period of six minutes. The major function of this pre-test breathing was to give the experimenter an opportunity to test for O_2 leaks and to correct them if they appeared; moreover, the pre-test breathing allowed time for the subject to adapt.

At the close of the first six minutes of breathing, the kymograph drum was returned to its original starting position and the valve was turned so that simultaneously the flow of O_2 to the mask was stopped and room air was admitted. The bell was then filled to capacity and the actual test began.

The subject continued to breathe quietly and normally for a period of four minutes; it was on this portion of the breathing

record that the BMR was computed. At the close of the first four-minute segment, the subject was instructed to begin talking. He recited the Pledge of Allegiance continuously during the next four-minute segment of the breathing record, and it was on this portion that the SMR was determined. At the end of the second four-minute period, the subject was instructed to resume normal breathing. The PSMR was taken from this last segment.

The decision to collect the data on three four-minute segments was made because of certain equipment limitations. The rate of rotation of the kymograph drum, the limited O₂ supply, and the fact that the paper on which the record was made permits only fourteen minutes of continuous measurement all contributed to the decision to use three four-minute periods; further, the rate of O₂ consumption and depth of respiration varies from subject to subject and it was necessary to allow for this variation by requiring only twelve minutes of continuous measurement.

It should be noted that the subjects remained in a prone position throughout the test. This seemed necessary in the light of a report made by Durnin and Weir¹¹ on an investigation of stan-

¹¹Durnin, J. V. and Weir, J. B., "Variations in the Metabolic Cost of Standard Activities," Journal of Physiology, Volume 125, Number 2, August 27, 1954, p. 60P.

dard activities: lying, sitting, standing, and walking. The variance among these activities was found to be significant.

The speech sample. The Pledge of Allegiance was selected as the speech sample on which the SMR would be taken. Perhaps it would have been more representative of the true metabolic cost of speech if each subject had been permitted to speak extemporaneously for four minutes, but this may have introduced uncontrolled variables such as extra mental effort, and the possibility that some subjects would be unable to speak continuously for four minutes. Wiggers¹² has indicated that mental activity is known to increase

¹²Wiggers, C. J., Physiology in Health and Disease, Lea and Febiger, Philadelphia, 1935, p. 898.

the basal metabolic rate up to 20.7 per cent, and accompanying emotional exhibitions up to 30 per cent.

The fixed, familiar, memorized passage was selected over a standard reading selection for two main reasons: (1) glasses could not be worn with the mask in position, and the strain of reading could have introduced both physical and psychological effects on the results; and (2) the reading act itself may involve work. Ponzo¹³ has stated that there is an alteration of the res-

¹³Ponzo, M. "Der Ausdruck des Willensfaktors in der Atmungskurve," Procedures of the Eighth International Congress of Psychology, 1927, p. 370.

piratory pattern during reading and other mental work.

Rose¹⁴ reports that reading aloud results in a 40 per cent increase

¹⁴Rose, Mary Swartz, The Foundations of Nutrition, The Macmillan Company, New York, 1938, p. 606.

over the basal metabolic rate. It seemed logical, therefore, to avoid having the subject read if this investigation hoped to measure the energy cost of speech alone.

On the memorized passage, there was the expected reduction in inflectional variety and the phrasing tended to become fixed as the subject continued to recite. If these factors introduced error into the experiment, the error was in the direction of making observed differences less significant.

Determining the rate of oxygen consumption. The selection of a line which is most representative of the slope of the respiratory pattern is subject to considerable error. The most properly placed line strikes the tips of the greatest possible number of respiratory excursions (see Figure 2), the point of expiration ordinarily being most suitable, for the degree of expiration is less variable than that of inspiration.¹⁵

¹⁵Kyle, Laurence, "Clinical Application of the Basal Metabolism Test," Medical Clinics of North America, Volume 34, November, 1950, p. 1843.

The charts (see Figure 2) used in this experiment are ruled vertically so that the time required for the pen to move from one

FIGURE 2
RECORD OF RATE OF OXYGEN CONSUMPTION
FOR NON-STUTTERING SPEAKER, 7

Legend

Line A-B: Pre-test record
Line C-D: BMR
Line D-E: SMR
Line E-F: PSMR

FIGURE 2

vertical line to the next is one minute. Horizontal lines correspond to the change in position of the spirometer as the oxygen is consumed; the space between two lines corresponds to a definite caloric value.

A line drawn along the points which mark each expiration permits the determination of the difference between the first and last readings. The charts employed are designed so that the difference between the first and last reading, over a six minute period, will render the calories per hour for an individual. This value is then corrected for temperature and barometric pressure and reported in terms of per cent above or below the accepted normal value for individuals of the same age, size, and sex. The mean per cent obtained on two tests for each subject, for the three experimental conditions, was the criterion measure used in the statistical evaluation.

The respiratory excursions remain fairly constant during the first four-minute period (BMR) and the last four-minute period (PSMR); however, during speech there may be little regularity to the pattern and the drawing of a straight line through the points of maximum expiration becomes impossible. To obtain the SMR, it has been assumed that if the speech act involved no additional oxygen requirement the line drawn for the PSMR would be an extension of the line drawn for the BMR; to the extent that the line for the PSMR is not an extension, it represents increased rate of oxygen consumption (see Figure 2). An example of the complete

computation on Figure 2 may be found in Appendix II.

CHAPTER IV

RESULTS AND DISCUSSION

The metabolism of two groups, stutterers and non-stutterers, was studied under three consecutive conditions: (1) silent and at rest while in a basal state, (2) during speech, and (3) following speech. These conditions were administered twice, but not on the same day. A mean metabolic rate was determined for each of the three conditions for each subject, and these were the criterion measures used in the analysis. An analysis of variance, classified by Lindquist¹⁶ as a Type I mixed design, was the method of evalu-

¹⁶Lindquist, E. F., Design and Analysis of Experiments in Psychology and Education, Cambridge: The Riverside Press, 1953, p. 269.

ation.

The general hypothesis under test was whether the trend for the three treatment means was the same for both groups of subjects (see Table I). Two aspects of this hypothesis may be studied: (1) the sub-hypothesis that the difference between the means of the two groups is the same at each treatment level, and (2) the sub-hypothesis that the difference between the successive treatment means for the two groups is equal to zero.

Neither the F-ratio for the interaction between treatments

TABLE I

MEAN PER CENTS AND STANDARD DEVIATIONS
FOR BMR, SMR, AND PSMR
OF STUTTERERS AND NON-STUTTERERS

	NON-STUTTERERS	STUTTERERS
MEAN BMR (%)	-15.116	-14.165
s. d.	5.76	14.21
MEAN SMR (%)	- 3.874	+ 2.634
s. d.	8.43	15.97
MEAN PSMR (%)	-10.69	- 8.107
s. d.	5.61	9.78

and groups, nor for the differences between groups was significant. The F-ratio for testing differences among the three conditions was significant beyond the .01 per cent level (see Table II).

These data indicate that the act of speaking does result in a significant increase in metabolic rate. They also imply that the effect of speech on metabolism is the same for both groups.

This apparent lack of difference between the stutterers and non-stutterers may have been influenced by the fact that the former group was made up of two classes of speakers: (1) stutterers who had completed a therapy program, and (2) stutterers who were currently receiving therapy. The data obtained on these two classes within the stuttering group reveal: (1) a significant difference between the SMR values for post-therapy and in-therapy stutterers ($t=3.59$, with 18 d. f.), and (2) a significant difference in the mean per cent increase in metabolism between the two classes ($t=2.10$, with 18 d. f.). These results are summarized in Table III.

It would appear that the metabolic cost of speech in the stutterer who has completed therapy was significantly lower than for the stutterer who was in the early stages of therapy. This may indicate that it is possible to get a physiological measure of stuttering severity.

The next question was whether the BMR-SMR difference for non-stutterers was significantly different from the BMR-SMR difference of the post-therapy stutterers. In this instance, the

TABLE II

SUMMARY OF ANALYSIS OF VARIANCE:
EFFECT OF SPEECH ON METABOLISM

SOURCE	df	SUMS OF SQUARES	MEAN SQUARE	F
Between Subjects	39	$SS_B = 10555.0986$		
B	1	$SS_B = 336.2061$	336.2061	1.25
error (b)	38	$SS_{\text{error}(b)} = 10218.8925$	268.9182	
Within Subjects	80	$SS_{WS} = 7795.0590$		
A	2	$SS_A = 4014.8668$	2007.4334	42.18 *
AB	2	$SS_{AB} = 163.1496$	81.5748	1.71
error (w)	76	$SS_{\text{error}(w)} = 3617.0426$	47.5926	
Total	119	$SS_T = 18350.1576$		

* Significant beyond the .01 level for 2 and 76 degrees of freedom

TABLE III

A COMPARISON OF SMR_s AND BMR-SMR DIFFERENCES
WITHIN THE GROUP OF STUTTERERS

TREATMENT	POST-THERAPY	IN-THERAPY	<u>t</u>
Mean SMR	- 8.77	+11.96-	3.59 *
Mean BMR-SMR difference	+11.11	+21.46	2.17 **

* Significant beyond the .01 level for 18 d. f.

** Significant between the .02 and .05 level for 18 d. f.

obtained t was .052 (not significant). The data indicated that the effect of speech on the metabolism of normals and post-therapy stutterers was essentially the same. This implied that the effectiveness of a therapy program may be measured in terms of a decreased BMR-SMR difference for the stutterer.

During speech the mean per cent increase in metabolism for non-stutterers and stutterers was 11.24 and 16.8 respectively. Data taken from Schneider¹⁷ provided a comparison of the increases

¹⁷Schneider, Edward C., Physiology of Muscular Activity, W. B. Saunders Company, Philadelphia, 1936, p. 44.

found in this study with other more frequently measured activities. He indicates that it takes about 11 per cent more energy to keep the body in a relaxed standing position than in the reclining posture; this compares with the per cent increase due to speech by non-stutterers. Schneider's data further indicate that a 16 per cent increase occurs if the body is maintained in a standing position at attention; this may be compared with the per cent increase due to speech by stutterers.

Langley¹⁸ also presents caloric requirements for various

¹⁸Langley and Cheraskin, op. cit., p. 435.

activities. From these data, it appears that the typist's activities represent approximately a 12 per cent increment over the energy

required for the reclining position.

Morehouse and Miller have stated that "within certain limits, the oxygen requirement of work is directly proportional to its duration."¹⁹ The measurements in this study were taken on a speech

¹⁹Morehouse, L. E. and Miller, A. T., Physiology of Exercise, The C. V. Mosby Company, St. Louis, 1948, p. 66.

sample of four minutes duration. The authors state that the strength and frequency of muscular contractions are also factors contributing to an increased oxygen requirement.

It is generally agreed that a likely source of error in the computation of a metabolic rate by this method is in the assigning of a representative line to the slope of the breathing record. It seemed necessary that some estimate be made of the reliability of the lines drawn by this experimenter (see Figure 3).

It will be noted that the longer sample of respiration may be divided into three four-minute segments (see Figure 2). To eliminate bias, twenty unscored metabolism records were cut into three parts, corresponding respectively to the BMR, SMR, and PSMR. These sixty segments were randomized and independently presented ten times. At each presentation the caloric difference was observed and recorded in a separate tabulation without marking the metabolism record itself. These six-hundred judgments were then arranged according to the three original groupings.

THE STANDARD DEVIATION OF ASSIGNED
REPRESENTATIVE LINES TO VIBRATING RECORDS

FIGURE 3

The median standard deviation was determined for each of the three conditions (see Figure 3). The range of standard deviations under condition BMR was from 1.2 to 4.78; the raw score range was from 54 to 97.5; and the median standard deviation was 1.83. The range of standard deviations under condition SMR was from .6 to 4.24; the raw score range was from 69 to 144; and the median standard deviation was 1.65. For the last condition, the PSMR, the range of standard deviations was from .6 to 4.74, with a raw score range of 63 to 109.5, and a median standard deviation of 1.37. The magnitude of the differences is such that the experimenter's error, with respect to the drawing of representative slopes, was of an order not to influence the results.

The results of this study raised questions, the answers for which must await future investigation. In the present experiment the subjects remained in a prone position throughout the test; it may be of interest to study the effect of speech on metabolism when the subjects are permitted to use gestures, or are tested in both sitting and standing postures. A more complete picture of the energy required for speech may be obtained by systematically varying duration, loudness and rate.

It may be possible to arrive at quantitative values for other types of speech disorders; for example, if one may assume that the functional articulatory disorder represents a simplification of the rather complex act of speaking, then one might expect the rate of oxygen consumption during speech to be less for

the person with the articulatory problem than it is for the normal speaker.

It is probably true that a part of the increase in metabolism shown by the stutterers in this study was due to anxiety over the speech act. The idea of studying the effect of varying social situations is not new; however, it may be possible to quantify the effect of varying degrees of social complexity on the metabolism of the stutterer. The study of metabolism may also shed new light on present concepts of the adaptation effect in stuttering.

The results of this study indicated that speech resulted in an elevated metabolism, and that the effect of this activity was still present for four minutes following the act. It has been pointed out that " . . . both the production of heat and the consumption of oxygen remain increased for 10 or 15 minutes after a period of activity."²⁰ This same physiological lag has been noted

²⁰Gerard, Ralph E., "Metabolism of Nerves and the Problem of Degeneration," Archives of Neurology and Psychiatry, Volume 26, 1931, p. 884.

by Hall, Black, Neely and Hall²¹ in a report which indicated that

²¹Hall, F. G., Black, J. W., Neely, K., and Hall, K., "Part I: The Influence of Loud Speaking upon Pulmonary Gas Exchange," Some Physiological Accompaniments of Speaking, United States Naval School of Aviation Medicine, Joint Project Report Number 10, Project Number NM 001 064.01.10, April, 1952, p. 5.

the gaseous balance was not regained within six minutes following loud reading. This indicates that the physician or technician should require the patient to be silent for 10 to 15 minutes preceding the basal metabolism test.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to investigate the effect of speech on metabolism, with particular emphasis on the comparison of stutterers with non-stutterers.

Three consecutive measures were taken on each subject on each of two separate occasions. These measures were: (1) a basal metabolic rate, (2) a speech metabolic rate, and (3) a post-speech metabolic rate. The subjects were twenty stutterers and twenty non-stutterers.

All conditions normally required for obtaining a BMR were included in this study. All tests were administered by the experimenter using the same equipment throughout the experiment. The Benedict-Roth Metabolism Apparatus was adapted, by replacing the standard mouthpiece with a full-faced army gas mask, to permit a measure of oxygen consumption during speech.

The following conclusions were drawn:

1. There is no significant difference between the stutterer and the non-stutterer with respect to basal metabolic rate.
2. The speech act results in a significant increase in metabolism over the basal metabolic rate for normal speakers.
3. The speech act results in a significant increase in metabolism over the basal metabolic rate for stutterers.

4. Stutterers (including both the in-therapy and post-therapy subjects) did not differ significantly from the normal speakers with respect to BMR-SMR differences.

5. Stutterers who have completed a therapy program show a significantly smaller BMR-SMR difference than those who are in the early stages of therapy.

6. There is no difference between post-therapy stutterers and normal speakers with regard to BMR-SMR differences.

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APPENDIX I

APPENDIX I

PRE-TEST INSTRUCTIONS

1. Eat a regular meal, but not later than 8:00 P. M. the evening preceding the test.
2. Get a full night's sleep of eight to eight-and-a-half hours.
3. A state of celibacy must be maintained for a period of twenty-four hours preceding the test.
4. Arise early enough to prevent rushing.
5. Dress in a leisurely fashion and proceed to the laboratory.
6. Do not eat, drink, or smoke on the morning of the test.

LOCATION OF TEST

You will come to the north entrance of Hamilton Hall on The Ohio State University campus, where you will be met and taken to the test room by elevator.

PROCEDURE ON ARRIVAL

You will remove your shoes and lie down for thirty minutes, during which time your body temperature and pulse will be ascertained. At the end of the rest period, while you are still in a prone position, a full-faced army gas mask will be placed on you. You will have a few moments to adjust and realize how easy it is to breathe through the apparatus.

Your basal metabolic rate will be determined from a record taken on the first six minutes of breathing. The apparatus will be reset and you will simply continue to breathe in your usual manner for an additional four minutes at which time you will hear the experimenter say, "Begin talking." You will recite the Pledge of Allegiance for a period of four minutes. You will use what you consider to be your usual conversational loudness level. You will continue reciting the Pledge of Allegiance until you hear, "Resume normal breathing." This normal breathing will continue for another four minutes. This concludes the test.

APPENDIX II

APPENDIX II
SAMPLE COMPUTATION
BASED ON FIGURE 2 OF TEXT

Subject 7 Age 32 Height 5' 9 1/2" Wt. 180
 Temperature 27.5° C. Barometer 746.4
 Pulse 76 Body temperature 97.5° F.
 Body surface area in square meters 1.99
 Correction factor for temperature and pressure .8656
 Normal calories per square meter per hour (age 30-34) 39.34
 Observed calories per square meter per hour:

BMR 78.75

SMR 92.25

PSMR 84

$$\text{BMR} = \frac{(78.75)(.8656)}{1.99} = 34.25$$

$$(-.1294)(100) = \underline{-12.94\%}$$

$$\begin{array}{r} 39.34 \\ -34.25 \\ \hline 5.09 \end{array}$$

$$\frac{5.09}{39.34} = -.1294$$

$$\text{SMR} = \frac{(92.25)(.8656)}{1.99} = 40.13$$

$$(+.0201)(100) = \underline{+2.01\%}$$

$$\begin{array}{r} 40.13 \\ -39.34 \\ \hline .79 \end{array}$$

$$\frac{.79}{39.34} = +.0201$$

$$\text{PSMR} = \frac{(84)(.8656)}{1.99} = 36.54$$

$$(-.0712)(100) = \underline{-7.12\%}$$

$$\begin{array}{r} 39.34 \\ -36.54 \\ \hline 2.80 \end{array}$$

$$\frac{2.80}{39.34} = -.0712$$

APPENDIX III

APPENDIX III

BMR, SMR, AND PSMR RAW SCORES FOR NON-STUTTERERS (1-20)
AND FOR STUTTERERS (21-40)

SUBJECT	MEAN BMR (%)	MEAN SMR (%)	MEAN PSMR (%)
1	-15.75	- 5.82	-14.98
2	-14.72	+ 1.99	-14.17
3	-11.95	+ 1.05	- 8.95
4	- 8.81	+10.00	-10.06
5	-10.72	+ 2.64	- 8.51
6	-12.74	- 4.18	-11.89
7	-10.52	- 1.25	- 7.86
8	-13.40	- 3.64	-12.14
9	-11.14	- 2.14	+ 2.50
10	-12.70	+ 6.55	-12.39
11	-21.33	- 2.56	-20.52
12	-18.75	- 8.42	+ 3.31
13	-10.47	+ 9.89	-13.80
14	-18.89	-19.89	-10.86
15	-12.39	- 4.90	- 2.17
16	-12.16	- 8.37	-11.81
17	-17.20	- 8.16	-16.30
18	-16.99	- 2.80	-11.76
19	-35.86	-23.92	-17.80
20	-15.83	-13.55	-13.65
21	-25.66	-11.01	-15.82
22	-25.35	- 7.69	- 3.48
23	- 6.87	+ 8.47	- 3.61
24	-11.25	+14.26	- 5.27
25	- 8.82	+13.59	- 8.25
26	-12.56	- .47	-11.99
27	+28.25	+48.59	+12.07
28	+15.00	+20.40	+10.11
29	-15.85	+13.30	-21.33
30	-25.86	- 1.81	-24.56
31	-34.87	+18.78	- 2.21
32	- 6.45	+13.35	+ 2.86
33	-15.39	- 4.01	- 2.50
34	-20.44	- 5.85	-20.87
35	-21.93	-12.10	- 9.17
36	-14.87	-7 .03	-10.32
37	-18.74	- 9.85	-16.76
38	-25.78	-22.97	-20.51
39	-10.02	+ .31	- 3.61
40	-25.84	-15.58	- 6.91

AUTOBIOGRAPHY

I, Robert Lee McGroskey, Jr., was born in Richwood, West Virginia, February 22, 1924. I received my secondary education in the public schools of Middletown and Columbus, Ohio. My undergraduate training was obtained at The Ohio State University, from which I received the degree Bachelor of Science in Education in 1948. I held the position of teacher in the public schools of Granville, Ohio, from September, 1948, until June, 1950. During this period I attended The Ohio State University and was certified by the State of Ohio in Speech and Hearing Therapy. From September, 1950, until June, 1953, I was employed in the public schools of Hamilton, Ohio, as a Speech and Hearing Therapist. From The Ohio State University, I received the degree Master of Arts in 1952. I held the position of Assistant Professor in the Department of Speech, Central Michigan State College, Mount Pleasant, Michigan, from September, 1953, until June, 1954. From June, 1954, until March, 1956, I was a student in the Department of Speech at The Ohio State University, with the exception of Autumn Quarter, 1955, when I was employed as Assistant Instructor in the Department of Education at The Ohio State University. During this period of study I completed the requirements for the degree Doctor of Philosophy.