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A VIDEOFLUOROGRAPHIC STUDY OF THE TEETH APERTURE,
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INFLUENCE ON TRUMPET PERFORMANCE.

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A VIDEOFLUOROGRAPHIC STUDY OF THE
TEETH APERTURE, INSTRUMENT PIVOT AND
TONGUE ARCH AND THEIR
INFLUENCE ON TRUMPET PERFORMANCE

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A VIDEOFUOROGRAPHIC STUDY OF THE
TEETH APERTURE, INSTRUMENT PIVOT AND
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INFLUENCE ON TRUMPET PERFORMANCE

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TABLE OF CONTENTS

| | Page |
|---|------|
| LIST OF TABLES | vii |
| LIST OF ILLUSTRATIONS | viii |
| Chapter | |
| I. INTRODUCTION | 1 |
| Related Studies | |
| Purpose of the Study | |
| The Exercises | |
| Delimitations in Exercise Design | |
| II. PROCEDURES | 10 |
| Terminology and Physiology Relating to the Oral Cavity | |
| Equipment | |
| Subject Determination | |
| State Board of Health Approval | |
| The Subjects | |
| Method of Data Collection | |
| Physical Abnormalities | |
| Measurements | |
| III. PRESENTATION OF DATA | 23 |
| Teeth Aperture Tables | |
| Instrument Pivot Tables | |
| Tongue Arch Tables | |
| IV. INTERPRETATION OF DATA | 36 |
| Statistical Analysis | |
| Teeth Aperture | |
| Instrument Pivot | |
| Tongue Arch | |
| Interaction | |

| Chapter | Page |
|--|------|
| V. CONCLUSIONS AND RECOMMENDATIONS. . . . | 47 |
| Conclusions | |
| Recommendations | |
| BIBLIOGRAPHY. | 51 |
| APPENDICES. | 53 |
| APPENDIX A. ORGANIZATIONAL MATERIALS. . | 53 |
| APPENDIX B. SUBJECT RESUMES. | 64 |
| APPENDIX C. INDIVIDUAL MEASUREMENT COMPUTATIONS | 91 |

LIST OF TABLES

| Table | Page |
|--|------|
| 1. Glossary | 10 |
| 2. Teeth Aperture Averages - Exercise 1 | 26 |
| 3. Teeth Aperture Averages - Exercise 2 | 27 |
| 4. Teeth Aperture Averages - Exercise 3 | 28 |
| 5. Instrument Pivot Averages - Exercise 1 | 30 |
| 6. Instrument Pivot Averages - Exercise 2 | 31 |
| 7. Instrument Pivot Averages - Exercise 3 | 32 |
| 8. Tongue Arch Averages - Exercise 1. | 33 |
| 9. Tongue Arch Averages - Exercise 2. | 34 |
| 10. Tongue Arch Averages - Exercise 3. | 35 |
| 11. True Mean Measurements | 37 |
| 12. True Mean Confidence Limits. | 38 |
| 13. Combined Average Measurements for Five Subjects with Minimal Teeth Aperture Change | 45 |
| 14. Combined Average Measurements for Five Subjects with Minimal Instrument Pivot Change | 46 |

LIST OF ILLUSTRATIONS

| Figure | Page |
|--|------|
| 1. Major Organs within the Oral Cavity. | 13 |
| 2. Subject Positioned Between Roentgenographic Machine and Fluoroscopic Table | 15 |
| 3. Image Projected on Monitor Screen. | 16 |
| 4. Tongue Arch Motion: Example of Anticipated Pattern. | 24 |
| 5. Tongue Arch Motion: Example of Variance from Anticipated Pattern | 25 |

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CHAPTER I

INTRODUCTION

During the past decades, trumpet instructors have been forced to rely on two basic forms of diagnosis in their attempts to solve the performance difficulties of their students. The most obvious method of analysis has been to listen to the performer and make recommendations based on the desired qualities either present or absent from a given passage. The second means of analysis is to examine the student externally for some physiological difficulty which can then be related to the difficulties he experiences.

Regardless of the approach used for diagnosis, most modification in student performance has been the product of empiricism. The teacher is apt to emphasize his personal performance practices, assuming that that which is satisfactory for him will also benefit the student.

In situations where this approach is inadequate, the instructor will often seek assistance from other successful educators with the hope that they can prescribe an effective remedy. The last resort in empirical trumpet instruction seems to be to ignore the problem and hope that perhaps it will be eliminated with time and practice. While it is difficult to argue with the methodology of a successful teacher, it is reasonable to assume that the progress of many trumpet students has been impeded by inaccurate diagnosis.

During the last five years the science of video-fluorography has progressed to the point where it can be safely and effectively applied to the analysis of trumpet performance. Under proper medical supervision the functions of the oral cavity and related organs can be fluorographed during performance and recorded with sound on video tape. This affords repeated analysis without subjecting the performer to excessive radiation. It is this method of analysis which has been employed in this study of the tongue arch, teeth aperture, and instrument pivot and their influence on trumpet performance.

It is hoped that the results of this study will stimulate a more efficient and effective approach to trumpet instruction. Given precise knowledge of the role performed by the tongue, aperture, and pivot, an instructor would be able to recommend change in a more intelligent and

logical manner, thereby simplifying the difficulties experienced by younger trumpet performers. The writer realizes that the aforementioned functions represent a very small facet of the physiological relationships required for accurate trumpet performance. However, if this research can stimulate discussion and additional research, the result will be instruction through diagnosis instead of trial and error.

Related Studies

The application of either cinefluorography or videofluorography for brass performance analysis has been limited to the studies of Joseph A. Meidt, Fay Hanson, and John J. Haynie. However, the interest and enthusiasm generated by these studies has created a demand for specific research concerning the physiological phenomena which influence instrumental performance.

In his doctoral dissertation, "A Cinefluorographic Investigation of Oral Adjustments for Various Aspects of Brass Instrument Performance,"¹ Meidt studied the supralaryngeal adjustments which occur in trumpet and French horn performance. The performance areas researched included the slurring of ascending and descending scales,

¹Joseph A. Meidt, "A Cinefluorographic Investigation of Oral Adjustments for Various Aspects of Brass Instrument Performance" (unpublished Ph.D. dissertation, The University of Iowa, 1967).

performance in extreme registers, pitch isolation under varied conditions, tongued notes in various registers, and multiple tonguing. Ten subjects, five trumpet and five French horn performers, were filmed in this cinefluorographic study. Meidt reported tendencies regarding supra-laryngeal adjustments; however, due to the limited number of subjects, this writer would consider the results inconclusive. Meidt recommends additional research under more controlled circumstances.

Mrs. Fay Hanson, Brass Specialist at Weber College, is currently involved in a cinefluorographic study using the facilities of the Thomas Dee Memorial Hospital in Ogden, Utah.² Her observations are derived from the examination of 16-mm movies (without sound) taken while she performed exercises designed to isolate performance difficulties. Each excerpt was limited to less than ten seconds in duration. She concludes that while the tongue seems to follow a consistent pattern during register changes, the role of instrument pivot is insignificant in effective performance. In her opinion the larynx provides the controlling influence for most aspects of flexibility and dynamic contrast. She has obtained a federal grant to test this hypothesis during the 1969-70 academic year.

²Fay Hanson, private interview held during Second National Trumpet Symposium, Denver, Colorado, August, 1969.

The most extensive study of the functions within the oral cavity which affect trumpet performance is the work of Professor John J. Haynie at North Texas State University. Professor Haynie began his studies over seven years ago and progressed from individual X-ray photographs to 16-millimeter film and finally to the videofluorographic process utilizing the combined advantages of video tape recording and synchronized sound. In 1965 the writer became associated with this research project and, as Prof. Haynie's associate trumpet instructor, followed the study to its conclusion in the spring of 1968. The present study is designed to continue the research initiated by Mr. Haynie and to study in depth three of the trends indicated by his pilot work.

During the course of the research at North Texas State University over 70 students were studied for clarification and diagnosis of individual difficulties. While this sampling is representative, the subjects varied from exercise to exercise so that it was not possible to attempt an accurate cross-analysis of performance techniques. The general performance tendencies were divided into seven areas: jaw position, teeth and jaw aperture, tongue arching, pivot, mouthpiece pressure, position of tongue for attack and position of tongue for double and triple tongue. The final report of the Haynie research presents the observed tendencies but does not attempt a critical evaluation of the data.

Purpose of the Study

The purpose of this study is three-fold: (1) to reveal the physical variation of the teeth aperture, instrument pivot, and tongue arch in effective trumpet performance, (2) to examine the predictability of these motions and their consistency with a change of register and, (3) to determine the significance of any interaction between the aforementioned physical changes. The null hypothesis is that neither the teeth aperture, instrument pivot, nor tongue arch function in a consistent and predictable manner during trumpet performance and, therefore, have no direct effect on trumpet performance. The alternative hypothesis is that at least one of the previously stated variables directly influences trumpet performance.

The Exercises

Each subject was asked to tongue and slur three exercises at a mezzo forte dynamic level. The exercises were presented with the least difficult first and the most difficult last. To facilitate accuracy the exercises were first performed tongued and then repeated slurred. The subject could hesitate between the tongued and slurred segments of each exercise, and the camera was stopped between each exercise to provide the subject an opportunity to relax or make any physical adjustment he desired. The performance tempo was governed by a metronome. The exercises will be described in the order of performance.

Exercise #1 (performed both tongued and slurred)



Exercise #1 is a concert Bb arpeggio descending from a written C' (for the Bb trumpet) one octave and then ascending two octaves before reversing to return to the tonic pitch. This exercise provides a gradual change in register in an uninterrupted and flowing manner, utilizing the basic harmonic series of the instrument.

Exercise #2 (performed both tongued and slurred)



Exercise #2 is also a concert Bb arpeggio but ascends by skipping one chord tone and then descending to the omitted pitch before ascending again by skip. The pattern is reversed for the descending portion of the exercise.

Exercise #3 (performed both tongued and slurred)



Exercise #3 represents the extremes in normal performance. The repeated C' provides a middle register reference for the performer and thus aids in preventing an over-correction for the two-octave change.

Delimitations in Exercise Design

Each of the exercises was designed so that each section could be performed easily in one breath. In this manner the subject did not have the opportunity to remove the mouthpiece from the lips and "set" his embouchure for a specific note or interval. A metronome set at 84 beats per minute was used to insure consistency of tempo. In order to minimize the amount of roentgen exposure to the subjects the total elapsed time for the exercises was limited to a maximum of two minutes.

All of the notes used in the exercises are limited to the C major arpeggio on the Bb trumpet. The acoustical problems are thus minimized; the air column within the instrument is interrupted only for the first line "e". Since only one note requires the use of valves, the problem of technical facility is eliminated. The use of the arpeggio restricts the subject to the performance of familiar intervals, which reduces indecision in pitch location.

The two-octave register limitation is based on the normal performance requirements for high school and college students. The dynamic level of mezzo forte is

considered an average performance volume. It is assumed that by designing the exercises within these limitations the subjects will perform in a normal manner and that any change during performance will be the result of normal physical adjustment and not forced response to abnormal circumstances.

CHAPTER II

PROCEDURES

Terminology and Physiology Relating to the Oral Cavity

The following glossary (Table 1) represents the basic terminology which will be utilized during the analysis and discussion of this study. Figure 1 outlines and identifies the major organs within the oral cavity.

TABLE 1

GLOSSARY³

| | |
|-------------------|--|
| Aperture | The opening between the upper and lower teeth. |
| Bite | The closure of the lower teeth against the upper teeth. |
| Cricoid cartilage | One of the cartilages of the larynx. |
| Dilatation | The state of being stretched, enlarged. |
| Hard palate | The anterior part of the palate, consisting of the bony palate covered above by the mucous membrane of the |

³Definitions compiled from:

Blakiston, New Gould Medical Dictionary (2nd ed. 1956).

Stedman, Medical Dictionary (21st ed. 1966).

floor of the nose and below by the mucoperiosteum of the roof of the mouth.

| | |
|-----------------|---|
| Hyoid bone | The bone between the root of the tongue and the larynx, supporting the tongue and giving attachment to some of its muscles. |
| Laryngocoele | A saccular dilatation of the mucosa of the larynx occurring between the hyoid bone and the cricoid cartilage, hernia. |
| Larynx | The organ of the voice, situated between the trachea and the base of the tongue. |
| Mandible | The lower jaw bone. |
| Maxilla | The bone of the upper jaw. |
| Mucosa | A mucous membrane. |
| Palate | The roof of the mouth. |
| Pharynx | The throat; the joint opening of the gullet and windpipe. |
| Pivot | The motion of the face of the trumpet mouthpiece in relation to a line from the face of the lower teeth to the tip of the mandible. |
| Pyriform sinus | A small space lateral to the laryngeal orifice, bounded laterally by the thyroid cartilage and the thyroid membrane. |
| Retrolabiocoele | A saccular dilatation of the mucosa of the lips. |
| Roentgen | The international unit of x- or gamma-radiation. |
| Soft palate | The posterior muscular portion of the palate, forming an incomplete septum between the mouth and the pharynx; and between the pharynx and the nasal fossae. |

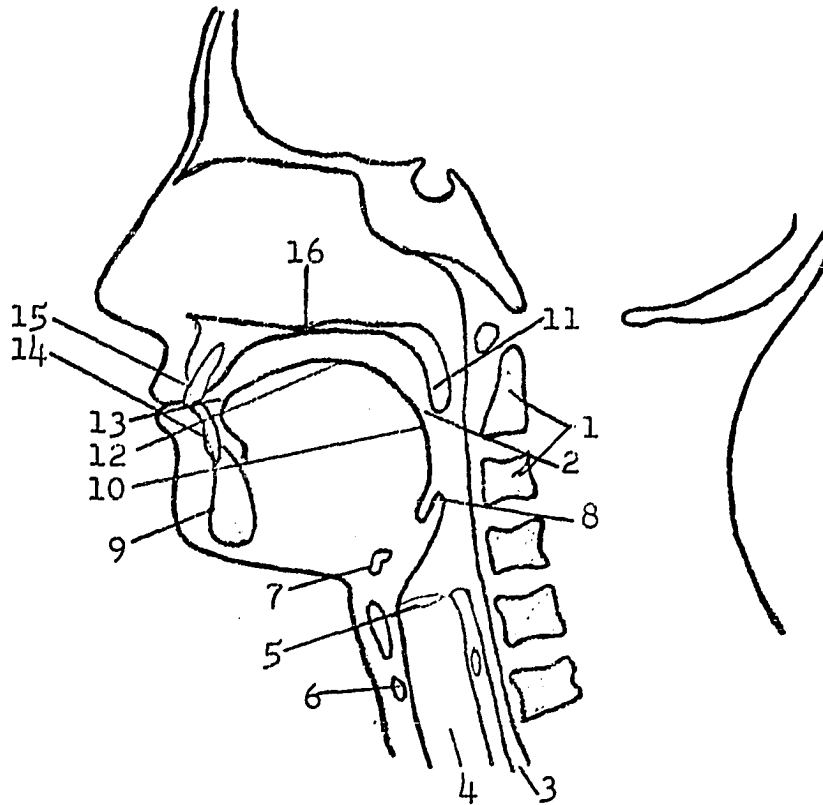
| | |
|------------------------|--|
| Temporomandibular | Pertaining to the temporal bone and the mandible, used specifically for a ligament of the mandibular joint. |
| Tongue arch | The motion of the tongue between the palate and its fully depressed position. |
| Vallecula | A depression between the median and lateral glossoepiglottil folds on either side |
| Velopharyngeal closure | Pertaining to the soft palate and the posterior nasopharyngeal wall; velopharyngeal closure is essential for many speech sounds and to separate the nose from the pharynx during swallowing. |

Equipment

The videofluorographic equipment used in this study is located in the radiology laboratory of Dr. Alexander M. Finlay, Radiologist, in Denton, Texas. The roentgenographic machine was a General Electric "Aristocrat," motor driven, combination radiographic and fluoroscopic table with a HRT-3 anode tube unit beneath the table. The tube has two concentric 1.5 millimeter focal spots and an air circulator. The control panel was also the standard "Aristocrat" model. Coupled with the roentgenographic table was a Fluoricon image intensifier, No. 645524 with a 5,000 gain tube, Type 1459. The image intensifier was mounted on a fluoroscopic mount and thus provided the fluoroscopic image.

A Type B4501BA television camera was mounted inside the housing of the image intensifier with the appropriate cables leading to an Ampex Model 5100 video tape

Fig. 1.--MAJOR ORGANS WITHIN THE ORAL CAVITY



1. Cervical vertebrae
2. Oropharyngeal isthmus
3. Oesophagus
4. Trachea
5. Vocal folds
6. Cricoid cartilage
7. Hyoid bone
8. Epiglottis
9. Mandible
10. Pharyngeal part of dorsum of tongue
11. Soft palate
12. Dorsum of tongue
13. Tip of tongue
14. Lower central incisor tooth
15. Upper dental incisor tooth
16. Hard palate

recorder. The image was monitored on a 14-inch General Electric monitor, Type B4501DB. Both the television camera and monitor were of the 875 scan-line variety. Figures 2 and 3 are photographs of the apparatus utilized in this study. Figure 3 shows an image as projected on the screen of the 875 scan-line monitor.

Subject Determination

Each of the trumpet instructors at North Texas State University was asked to compile a list of his most accomplished students. The lists were checked against the list of students previously x-rayed, and those subjects exposed to radiation for earlier diagnosis or study were not considered for additional radiation exposure. The remaining subjects were sent a brief letter describing the study and asked to schedule a personal interview if they would consent to an active role in this research.

At the close of the interview the subjects who were still interested were asked to sign a statement of voluntary participation. In cases where the subject was under legal age, a descriptive letter accompanied by a letter from Dr. Finlay was sent to his parents or legal guardian. No subject under the age of twenty-one was considered for participation until a signed participation statement had been returned. (See Appendix A for copies of the aforementioned letters and forms.)



Fig. 2.--Subject positioned between roentgenographic machine and fluoroscopic table



Fig. 3.--Image projected on monitor screen

State Board of Health Approval

In November 1969 approval for the project was granted by Dr. Robert Escue, the radiation control agent for North Texas State University. With this approval a letter was sent to Jack M. Long, Supervisor of the Compliance and Inspection Section of the Division of Occupational Health and Radiation Control, requesting permission from the Texas State Department of Health to continue the videofluorographic study following the protocol established by Professor John J. Haynie. On December 1 permission was granted, providing the aforementioned protocol was continued. In a telephone conversation with Mr. Long, the number of subjects permissible was increased from twenty to thirty with the understanding that the total elapsed exposure time would not exceed two minutes per subject. The final report for this study was submitted to the Texas State Department of Health on January 27, 1970. (See Appendix A for copies of these materials.)

The Subjects

Twenty-seven music majors and faculty at North Texas State University volunteered for participation in this study. A malfunction in the video camera resulted in a loss of recorded image during the performance of several subjects. Two of the subjects did not wish further radiation exposure and therefore were not included in the

final presentation. The division by classification of the remaining twenty-five subjects is as follows: 5 freshmen, 6 sophomores, 4 juniors, 4 masters candidates, 3 doctoral students, and 3 trumpet faculty members. While all of the subjects were currently involved in the instructional program at North Texas State University, the performance practices they exhibited represented the culmination of many years of tutorship prior to their appearance on the campus. Represented in this study are the products of public school music programs in twelve states and the tutelage of sixty-three private trumpet instructors. Each subject performed on his own instrument and mouthpiece. (See Appendix B for individual resumes.)

Method of Data Collection

The subjects were assembled at 5:00 p.m. on January 14 and 15, 1970, in the radiology laboratory of Dr. Alexander Finlay. It was requested that each subject complete his daily practice routine before the taping session. Each subject had received a copy of the exercises at least ten days prior to the date the data were collected. After a verbal review of the procedure the subjects were permitted to observe the preceding performers through the window of a radiation-proof partition.

Each subject was positioned between the fluoroscopic screen and the table top, with the shoulders per-

pendicular to the table top as in Figure 2. This position allowed a lateral visualization of the head and facial bones. The motion of the head was not restricted in any manner. The radiographic beam was filtered by 1.5 millimeters of aluminum placed between the anode tube and the table top, thus limiting the roentgen exposure to approximately .85 r. per minute. The beam was limited to a 10 x 15 centimeter area by lead shutters measuring approximately 4 millimeters in thickness. Additional protection was provided by a .5 millimeter lead protective apron which was placed between the subject and the x-ray source to further shield the body and reproductive organs from radiation exposure.

In the studies of both Meidt⁴ and Hanson⁵ the tongue was coated with a Rugar or barium solution to provide a positive outline for observation purposes. During the Haynie study a barium coating was introduced only to find that it created a negative reaction on the part of the subjects themselves. Philip Farkas states that "after many years of observation I have concluded that a large majority of brass players - I would estimate about 75% - prefer to keep their lips moist while playing."⁶

⁴Meidt, A Cinefluorographic Investigation, p. 21.

⁵Hanson, from a personal interview

⁶Philip Farkas, The Art of Brass Playing (Bloomington, Indiana: Brass Publications, 1962), p. 35.

Since the moistening of the lips is an unconscious response in moist-lip performers, the barium coating not only covers the tongue but also is placed on the lips and/or mouth-piece prior to the attack. Thus the barium creates an unnatural sensation of the tongue and lips which is not experienced in normal performance. To request that a subject not moisten his lips prior to the initial attack is also a deviation from his established performance practice and has a negative effect on his performance. Therefore no coating was applied to the tongues of the subjects in this study.

Physical Abnormalities

During the execution of the exercises Dr. Finlay studied each subject for any physical abnormalities relating to the throat or oral cavity. The tongue size, bite, tongue mobility, tongue arch, velopharyngeal closure, maxillo-mandibular distance, and the motion of the temporo-mandibular joint were normal in all of the subjects. Although none of the subjects had developed laryngocoele, subject number 16 showed a first degree dilatation of the pyriform sinuses and vallecula. Two subjects, numbers 9 and 17, suffered from dental problems. Subject 17 performed with an upper plate and several missing teeth while subject 9 had protruding upper teeth ("buck" teeth).

The only physical abnormality present in greater magnitude was the retrolabiocoele. Dr. Finlay graded this condition in 1st, 2nd, 3rd and 4th degrees. In the group studied there was none greater than the 1st degree. Five of the seven appearances of this condition occur behind the lower lip (in subjects 11, 13, 15, 22 and 25). In subject 3 the condition occurs behind the upper lip; subject 24 shows retrolabiocoeles behind both lips. The importance of the retrolabiocoele is that it apparently tends to cause a breakdown of the embouchure either as the result of poor blood supply or as a result of abnormal stretching of the musculature.

Measurements

The measurements were taken directly from the video screen of the 875 scan-line monitor. The slow motion and stop action capabilities of the Ampex model 7800 video tape recorder were employed for the purpose of measurement. Since the image on the video screen is enlarged approximately 2.8 times, the measurements have been rounded to the nearest millimeter or degree. (See Appendix C for the measurements and amounts of change.)

The teeth aperture measurement is the distance between the upper and lower front teeth. The measurement was taken the moment the pitch was established. (Several subjects displayed a tendency to "chew" each attack, and

measurement was delayed in these cases until this brief motion ceased.) The measuring device was a center-wheel, double-pointed compass. The amount of separation was recorded on a millimeter scale.

The tongue arch measurement is the distance between the highest point of the tongue and the palate. The measurement was taken after the initial snap of the tongued articulation or at the moment the slurred pitch was established. (After the initial attack or sounding of the pitch, many subjects utilized a change in elevation of the tongue as a means for controlling intonation. The measurements in each such instance were taken prior to this change in position.) The same measuring procedure was used for both the teeth aperture and the tongue arch.

Instrument pivot was measured by placing one straight edge across the face of the mouthpiece and another in the line determined by the face of the lower teeth and the tip of the mandible. (The use of the mandible and lower teeth for the second line compensates for any motion of the head during the execution of the exercises.) The lines were extended and their angle measured with a protractor at the point of intersection.

CHAPTER III

PRESENTATION OF DATA

Data in the study were collected by measuring, for each subject on each note in the exercises, the teeth aperture, instrument pivot, and tongue arch. Difference figures were then computed in terms of increase or decrease from the previous pitch. The difference figures for each individual on each exercise were then averaged for the ascending and descending portions with the tongued and slurred sections considered separately. Any deviation from the anticipated motion was deducted from the sum of the series and the average computed on the adjusted total. For example, the first exercise contains six ascending and six descending intervals. The consensus of brass authorities indicates that the tongue arch measurement will decrease for ascending intervals and increase for descending intervals. Figure 4, below, is an example from a subject whose tongue arch motion follows the "anticipated" pattern. The sample measurements are from subject 3.

Exercise #1 (performed tongued)



Fig. 4.--Tongue arch motion: example of anticipated pattern

The six ascending difference figures total -7 and the descending difference figures total +7. The averages are - 1.2 and + 1.2, respectively. The combined average for this example would be stated as +2.4, indicating that the total range for the combined motion is 2.4; the positive sign indicating the motion is in the anticipated direction. Figure 5 exhibits the measurements from a subject (No. 1) whose tongue arch is less consistent with the anticipated pattern. The six ascending figures total -8 with -1.3 as the average amount of change. The trend in the descending series is inconsistent, with five instances of an increased tongue arch and one appearance of a decrease in arch. To compensate for this inconsistency the decrease (-1) is added to the sum of the five increase figures (+7). The resultant +6 represents the adjusted total used for computing the average, which results in a figure of +1.0. Subject No. 1 changed the aperture between his tongue and palate an average of 1.3 millimeters

for ascending intervals and 1.0 millimeters for descending intervals. These changes, since they are in opposite directions, represent a total average change of 2.3 millimeters for this subject (given as +2.3, since the changes are in the anticipated directions).

Exercise #1 (performed tongued)



Tongue

Arch 22 24 26 27 26 24 22 21 20 19 20 21 20

Meas (mm)

Dif +2 +2 +1 -1 -2 -2 -1 -1 -1 +1 +1 -1

Meas

Fig. 5.--Tongue Arch motion: example of variance from anticipated pattern

Teeth Aperture Tables

In the generally accepted theories regarding teeth aperture change, the aperture decreases as the pitch ascends and increases as the pitch descends. Thus, ascending average figures are represented as negative and descending as positive. A positive combined average indicates the subject responded in the predicted pattern of movement. (Tables 2, 3 and 4 represent the teeth aperture averages for the three exercises.)

TABLE 2

TEETH APERTURE AVERAGES
(Exercise #1)

| Sub- ject | Tongued | | | Slurred | | |
|--------------|-----------|-----------|------------|-----------|-----------|------------|
| | Asc Av | Des Av | Comb Av | Asc Av | Des Av | Comb Av |
| 1 | - 1.2* | + 1.2 | + 2.4 | - 1.5 | + 1.7 | + 3.2 |
| 2 | - 1.2 | + 1.3 | + 2.5 | - 1.3 | + 2.0 | + 3.3 |
| 3 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 4 | - 2.0 | + 2.0 | + 4.0 | - 4.3 | + 4.0 | + 8.3 |
| 5 | - 0.1 | + 0.1 | + 0.2 | - 0.3 | + 0.3 | + 0.6 |
| 6 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 7 | - 2.5 | + 2.5 | + 5.0 | - 3.5 | + 3.5 | + 7.0 |
| 8 | - 0.5 | + 0.5 | + 1.0 | - 0.7 | + 0.7 | + 1.4 |
| 9 | + 0.3 | - 0.3 | - 0.6 | - 0.2 | + 0.2 | + 0.4 |
| 10 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 11 | - 0.3 | + 0.3 | + 0.6 | - 0.3 | + 0.3 | + 0.6 |
| 12 | - 1.5 | + 1.5 | + 3.0 | - 1.8 | + 1.5 | + 3.3 |
| 13 | - 0.2 | + 0.2 | + 0.4 | - 0.3 | + 0.3 | + 0.6 |
| 14 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 15 | - 1.3 | + 1.3 | + 2.6 | - 1.7 | + 1.7 | + 3.4 |
| 16 | - 1.0 | + 1.0 | + 2.0 | - 1.2 | + 1.2 | + 2.4 |
| 17 | - 1.3 | + 1.7 | + 3.0 | - 1.0 | + 1.5 | + 2.5 |
| 18 | - 1.7 | + 1.7 | + 3.4 | - 2.2 | + 2.3 | + 4.5 |
| 19 | - 1.0 | + 1.0 | + 2.0 | - 1.2 | + 1.0 | + 2.2 |
| 20 | - 1.5 | + 1.5 | + 3.0 | - 1.5 | + 1.7 | + 3.2 |
| 21 | - 0.7 | + 0.5 | + 1.2 | - 0.7 | + 0.5 | + 1.2 |
| 22 | + 0.1 | + 0.0 | - 0.1 | - 0.0 | + 0.0 | + 0.0 |
| 23 | - 1.2 | + 1.2 | + 2.4 | - 1.0 | + 0.8 | + 1.8 |
| 24 | - 0.7 | + 0.8 | + 1.5 | - 1.2 | + 1.2 | + 2.4 |
| 25 | - 0.7 | + 0.7 | + 1.4 | - 0.8 | + 0.8 | + 1.6 |

* measurements in millimeters

TABLE 3

TEETH APERTURE AVERAGES
(Exercise #2)

| Sub- ject | Tongued | | | Slurred | | |
|--------------|-----------|-----------|------------|-----------|-----------|------------|
| | Asc Av | Des Av | Comb Av | Asc Av | Des Av | Comb Av |
| 1 | - 1.8* | + 1.9 | + 3.7 | - 1.8 | + 2.0 | + 3.8 |
| 2 | - 2.1 | + 2.1 | + 4.2 | - 1.0 | + 1.0 | + 2.0 |
| 3 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 4 | - 3.6 | + 3.6 | + 7.2 | - 6.4 | + 6.4 | +12.8 |
| 5 | - 0.8 | + 0.9 | + 1.7 | - 0.6 | + 0.6 | + 1.2 |
| 6 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 7 | - 3.0 | + 3.2 | + 6.2 | - 2.5 | + 3.0 | + 5.5 |
| 8 | - 0.4 | + 0.4 | + 0.8 | - 0.4 | + 0.4 | + 0.8 |
| 9 | - 0.1 | + 0.0 | + 0.1 | + 0.2 | - 0.4 | - 0.6 |
| 10 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 11 | - 0.4 | + 0.4 | + 0.8 | - 0.6 | + 0.6 | + 1.2 |
| 12 | - 2.4 | + 2.4 | + 4.8 | - 3.1 | + 3.1 | + 6.2 |
| 13 | - 0.1 | + 0.1 | + 0.2 | - 0.7 | + 0.6 | + 1.3 |
| 14 | - 0.7 | + 0.7 | + 1.4 | - 0.8 | + 0.8 | + 1.6 |
| 15 | - 0.6 | + 0.6 | + 1.2 | - 0.8 | + 0.8 | + 1.6 |
| 16 | - 0.7 | + 0.9 | + 1.6 | - 1.0 | + 1.0 | + 2.0 |
| 17 | - 0.7 | + 0.7 | + 1.4 | - 1.7 | + 1.7 | + 3.4 |
| 18 | - 2.8 | + 2.7 | + 5.5 | - 3.1 | + 3.4 | + 6.5 |
| 19 | - 0.8 | + 0.8 | + 1.6 | - 1.0 | + 0.8 | + 1.8 |
| 20 | - 1.8 | + 1.9 | + 3.7 | - 1.7 | + 1.7 | + 3.4 |
| 21 | - 0.6 | + 0.7 | + 1.3 | - 0.8 | + 0.8 | + 1.6 |
| 22 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 23 | - 1.3 | + 1.4 | + 2.7 | - 1.6 | + 1.7 | + 3.3 |
| 24 | - 0.9 | + 1.0 | + 1.9 | - 1.4 | + 1.4 | + 2.8 |
| 25 | - 1.2 | + 1.3 | + 2.5 | - 1.3 | + 1.4 | + 2.7 |

* measurements in millimeters

TABLE 4

TEETH APERTURE AVERAGES
(Exercise #3)

| Sub- ject | Tongued | | | Slurred | | |
|--------------|-----------|-----------|------------|-----------|-----------|------------|
| | Asc Av | Des Av | Comb Av | Asc Av | Des Av | Comb Av |
| 1 | - 4.0* | + 4.0 | + 8.0 | - 5.5 | + 5.5 | +11.0 |
| 2 | - 3.5 | + 3.5 | + 7.0 | - 4.0 | + 4.0 | + 8.0 |
| 3 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 4 | -10.0 | +10.0 | +20.0 | -13.0 | +13.5 | +26.5 |
| 5 | - 2.5 | + 2.5 | + 5.0 | - 3.0 | + 3.0 | + 6.0 |
| 6 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 7 | -10.0 | +10.0 | +20.0 | -10.5 | +10.5 | +21.0 |
| 8 | - 1.5 | + 1.5 | + 3.0 | - 2.0 | + 2.0 | + 4.0 |
| 9 | + 1.0 | - 1.0 | - 2.0 | + 1.5 | - 1.5 | - 3.0 |
| 10 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 11 | - 3.0 | + 3.0 | + 6.0 | - 3.0 | + 3.0 | + 6.0 |
| 12 | - 5.0 | + 5.0 | +10.0 | - 6.0 | + 6.0 | +12.0 |
| 13 | - 3.0 | + 3.0 | + 6.0 | - 3.5 | + 3.5 | + 7.0 |
| 14 | - 4.5 | + 4.5 | + 9.0 | - 4.5 | + 4.5 | + 9.0 |
| 15 | - 4.0 | + 4.0 | + 8.0 | - 3.5 | + 3.5 | + 7.0 |
| 16 | - 4.0 | + 4.0 | + 8.0 | - 4.0 | + 4.0 | + 8.0 |
| 17 | - 4.0 | + 5.0 | + 9.0 | - 2.5 | + 4.0 | + 6.5 |
| 18 | - 5.0 | + 5.0 | +10.0 | - 7.0 | + 7.0 | +14.0 |
| 19 | - 3.0 | + 3.0 | + 6.0 | - 3.5 | + 3.5 | + 7.0 |
| 20 | - 4.5 | + 4.5 | + 9.0 | - 6.0 | + 6.0 | +12.0 |
| 21 | - 2.0 | + 2.0 | + 4.0 | - 3.0 | + 3.0 | + 6.0 |
| 22 | + 0.5 | - 0.5 | - 1.0 | + 0.5 | - 0.5 | - 1.0 |
| 23 | - 5.0 | + 5.0 | +10.0 | - 6.0 | + 6.0 | +12.0 |
| 24 | - 3.5 | + 3.5 | + 7.0 | - 3.5 | + 3.5 | + 7.0 |
| 25 | - 5.0 | + 5.0 | +10.0 | - 5.5 | + 5.5 | +11.0 |

* measurements in millimeters

Instrument Pivot Tables

In the commonly held theories about instrument pivot, the angle between the face of the mouthpiece and the line determined by the lower teeth and the tip of the mandible increases as the pitch ascends and decreases as the pitch descends. Thus, ascending average figures are represented as positive and descending as negative. A positive combined average indicates the subject responded in the predicted pattern of movement. (Tables 5, 6 and 7 represent the instrument pivot averages for the three exercises.)

Tongue Arch Tables

In the generally accepted theories regarding tongue arch, the tongue arches as the pitch ascends, creating a smaller aperture between the tongue and the palate. The pattern would be reversed for the descending pitches. Thus, ascending average figures are represented as negative and descending as positive. A positive combined average indicates the subject responded in the predicted pattern of movement. (Tables 8, 9 and 10 represent the tongue arch averages for the three exercises.)

TABLE 5

INSTRUMENT PIVOT AVERAGES
(Exercise #1)

| Sub- ject | Tongued | | | Slurred | | |
|--------------|-----------|-----------|------------|-----------|-----------|------------|
| | Asc Av | Des Av | Comb Av | Asc Av | Des Av | Comb Av |
| 1 | + 3.7* | - 3.8 | + 7.5 | + 3.7 | - 3.7 | + 7.4 |
| 2 | + 0.3 | - 0.3 | + 0.6 | + 0.8 | - 0.8 | + 1.6 |
| 3 | + 1.3 | - 1.3 | + 2.6 | + 1.3 | - 1.3 | + 2.6 |
| 4 | + 0.8 | - 1.0 | + 1.8 | + 1.0 | - 1.0 | + 2.0 |
| 5 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 6 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 7 | + 0.3 | - 0.3 | + 0.6 | + 0.3 | - 0.3 | + 0.6 |
| 8 | + 0.7 | - 0.7 | + 1.4 | + 0.7 | - 0.7 | + 1.4 |
| 9 | - 0.5 | + 0.5 | - 1.0 | - 0.5 | + 0.7 | - 1.2 |
| 10 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 11 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 12 | + 1.2 | - 1.2 | + 2.4 | + 1.3 | - 1.3 | + 2.6 |
| 13 | + 0.0 | - 0.0 | + 0.0 | + 0.3 | - 0.3 | + 0.6 |
| 14 | + 0.7 | - 0.7 | + 1.4 | + 0.8 | - 1.0 | + 1.8 |
| 15 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 16 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 17 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 18 | + 0.5 | - 0.5 | + 1.0 | + 0.8 | - 0.8 | + 1.6 |
| 19 | + 1.0 | - 1.0 | + 2.0 | + 1.2 | - 1.3 | + 2.5 |
| 20 | + 0.8 | - 1.0 | + 1.8 | + 0.8 | - 0.8 | + 1.6 |
| 21 | + 0.3 | - 0.3 | + 0.6 | + 0.3 | - 0.3 | + 0.6 |
| 22 | + 0.5 | - 0.5 | + 1.0 | + 0.7 | - 0.7 | + 1.4 |
| 23 | + 0.7 | - 0.7 | + 1.4 | + 1.0 | - 1.0 | + 2.0 |
| 24 | + 0.3 | - 0.3 | + 0.6 | + 0.3 | - 0.3 | + 0.6 |
| 25 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |

* measurement in degrees

TABLE 6

INSTRUMENT PIVOT AVERAGES
(Exercise #2)

| Sub- ject | Tongued | | | Slurred | | |
|--------------|-----------|-----------|------------|-----------|-----------|------------|
| | Asc Av | Des Av | Comb Av | Asc Av | Des Av | Comb Av |
| 1 | + 4.7* | - 4.7 | + 9.4 | + 5.0 | - 5.0 | +10.0 |
| 2 | + 1.6 | - 1.6 | + 3.2 | + 1.6 | - 1.6 | + 3.2 |
| 3 | + 1.9 | - 1.9 | + 3.8 | + 2.3 | - 2.3 | + 4.6 |
| 4 | + 0.9 | - 0.8 | + 1.7 | + 0.2 | - 0.2 | + 0.4 |
| 5 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 6 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 7 | + 0.2 | - 0.2 | + 0.4 | + 0.2 | - 0.2 | + 0.4 |
| 8 | + 0.6 | - 0.7 | + 1.3 | + 1.0 | - 1.1 | + 2.1 |
| 9 | - 0.8 | + 0.8 | - 1.6 | - 0.4 | + 0.4 | - 0.8 |
| 10 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 11 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 12 | + 2.0 | - 2.1 | + 4.1 | + 1.3 | - 1.4 | + 2.7 |
| 13 | + 0.1 | - 0.1 | + 0.2 | + 0.2 | - 0.2 | + 0.4 |
| 14 | + 0.3 | - 0.3 | + 0.6 | + 0.8 | - 0.9 | + 1.7 |
| 15 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 16 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 17 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 18 | + 1.0 | - 1.0 | + 2.0 | + 1.1 | - 1.1 | + 2.2 |
| 19 | + 1.8 | - 1.8 | + 3.6 | + 1.3 | - 1.4 | + 2.7 |
| 20 | + 1.0 | - 1.0 | + 2.0 | + 1.1 | - 1.2 | + 2.3 |
| 21 | + 0.2 | - 0.1 | + 0.3 | + 0.3 | - 0.3 | + 0.6 |
| 22 | + 0.7 | - 0.7 | + 1.4 | + 1.3 | - 1.3 | + 2.6 |
| 23 | + 0.6 | - 0.7 | + 1.3 | + 0.9 | - 1.1 | + 2.0 |
| 24 | + 0.0 | - 0.0 | + 0.0 | + 0.2 | - 0.2 | + 0.4 |
| 25 | + 0.0 | - 0.3 | + 0.3 | + 0.1 | - 0.4 | + 0.5 |

* measurement in degrees

TABLE 7

INSTRUMENT PIVOT AVERAGES
(Exercise #3)

| Sub- ject | Tongued | | | Slurred | | |
|--------------|-----------|-----------|------------|-----------|-----------|------------|
| | Asc Av | Des Av | Comb Av | Asc Av | Des Av | Comb Av |
| 1 | +13.0* | -13.0 | +26.0 | +11.5 | -11.5 | +23.0 |
| 2 | + 3.0 | - 3.0 | + 6.0 | + 3.0 | - 3.0 | + 6.0 |
| 3 | + 4.0 | - 4.0 | + 8.0 | + 4.0 | - 4.0 | + 8.0 |
| 4 | + 5.5 | - 5.5 | +11.0 | + 5.5 | - 5.5 | +11.0 |
| 5 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 6 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 7 | + 1.0 | - 1.0 | + 2.0 | + 1.0 | - 1.0 | + 2.0 |
| 8 | + 2.5 | - 2.5 | + 5.0 | + 2.5 | - 2.5 | + 5.0 |
| 9 | - 1.5 | + 1.5 | - 3.0 | - 1.5 | + 1.5 | - 3.0 |
| 10 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 11 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 12 | + 3.0 | - 3.0 | + 6.0 | + 3.5 | - 3.5 | + 7.0 |
| 13 | - 0.5 | + 0.5 | - 1.0 | + 0.0 | - 0.0 | + 0.0 |
| 14 | + 3.5 | - 3.5 | + 7.0 | + 3.5 | - 6.0 | + 9.5 |
| 15 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 16 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 17 | + 0.0 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 |
| 18 | + 2.0 | - 2.0 | + 4.0 | + 3.0 | - 3.0 | + 6.0 |
| 19 | + 4.5 | - 4.5 | + 9.0 | + 5.0 | - 5.0 | +10.0 |
| 20 | + 1.5 | - 1.5 | + 3.0 | + 2.5 | - 2.5 | + 5.0 |
| 21 | + 3.0 | - 3.0 | + 6.0 | + 3.5 | - 3.5 | + 7.0 |
| 22 | - 5.0 | + 5.0 | -10.0 | - 5.5 | + 5.5 | -11.0 |
| 23 | + 2.0 | - 2.0 | + 4.0 | + 3.0 | - 3.0 | + 6.0 |
| 24 | + 1.5 | - 1.5 | + 3.0 | + 1.5 | - 1.5 | + 3.0 |
| 25 | + 2.0 | - 2.0 | + 4.0 | + 2.5 | - 2.5 | + 5.0 |

* measurement in degrees

TABLE 8

TONGUE ARCH AVERAGES
(Exercise #1)

| Sub- ject | Tongued | | | Slurred | | |
|--------------|-----------|-----------|------------|-----------|-----------|------------|
| | Asc Av | Des Av | Comb Av | Asc Av | Des Av | Comb Av |
| 1 | - 1.3* | + 1.0 | + 2.3 | - 2.8 | + 2.7 | + 5.5 |
| 2 | - 1.5 | + 1.8 | + 3.3 | - 1.5 | + 1.3 | + 2.8 |
| 3 | - 1.2 | + 1.2 | + 2.4 | - 1.7 | + 1.7 | + 3.4 |
| 4 | - 1.0 | + 1.0 | + 2.0 | - 2.0 | + 2.3 | + 4.3 |
| 5 | - 1.3 | + 1.2 | + 2.5 | - 4.0 | + 3.8 | + 7.8 |
| 6 | - 1.8 | + 1.8 | + 3.6 | - 6.2 | + 1.7 | + 7.9 |
| 7 | - 0.2 | + 0.2 | + 0.4 | - 3.2 | + 3.2 | + 6.4 |
| 8 | - 3.0 | + 3.2 | + 6.2 | - 3.2 | + 3.3 | + 6.5 |
| 9 | - 1.5 | + 1.5 | + 3.0 | - 1.5 | + 1.2 | + 2.7 |
| 10 | - 0.0 | + 0.0 | + 0.0 | - 0.8 | + 0.5 | + 1.3 |
| 11 | - 1.5 | + 1.7 | + 3.2 | - 6.7 | + 8.0 | +14.7 |
| 12 | - 0.0 | + 0.0 | + 0.0 | + 2.8 | - 2.8 | - 5.6 |
| 13 | - 2.5 | + 3.0 | + 5.5 | - 4.0 | + 4.2 | + 8.2 |
| 14 | - 5.0 | + 3.2 | + 8.2 | - 8.0 | + 6.8 | +14.8 |
| 15 | - 4.5 | + 4.2 | + 8.7 | - 5.8 | + 1.8 | + 7.6 |
| 16 | - 1.0 | + 1.0 | + 2.0 | - 2.3 | + 2.0 | + 4.3 |
| 17 | - 4.7 | + 4.0 | + 8.7 | - 3.5 | + 3.0 | + 6.5 |
| 18 | + 0.2 | + 0.3 | + 0.1 | - 3.0 | + 3.3 | + 6.3 |
| 19 | - 0.0 | + 0.0 | + 0.0 | - 4.3 | + 5.5 | + 9.8 |
| 20 | - 1.3 | + 1.5 | + 2.8 | - 1.2 | + 0.8 | + 2.0 |
| 21 | - 3.3 | + 5.0 | + 8.3 | - 3.3 | + 3.7 | + 7.0 |
| 22 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 23 | - 1.3 | + 1.2 | + 2.5 | - 1.5 | + 0.7 | + 2.2 |
| 24 | - 1.7 | + 1.7 | + 3.4 | - 1.0 | + 1.0 | + 2.0 |
| 25 | - 1.7 | + 1.7 | + 3.4 | - 6.8 | + 6.8 | +13.6 |

* measurement in millimeters

TABLE 9

TONGUE ARCH AVERAGES
(Exercise #2)

| Sub- ject | Tongued | | | Slurred | | |
|--------------|-----------|-----------|------------|-----------|-----------|------------|
| | Asc Av | Des Av | Comb Av | Asc Av | Des Av | Comb Av |
| 1 | - 2.4* | + 2.4 | + 4.8 | - 7.6 | + 7.6 | +15.2 |
| 2 | - 2.4 | + 2.4 | + 4.8 | - 2.7 | + 2.4 | + 5.1 |
| 3 | - 1.8 | + 1.8 | + 3.6 | - 3.9 | + 4.0 | + 7.9 |
| 4 | - 3.6 | + 3.6 | + 7.2 | - 5.0 | + 5.0 | +10.0 |
| 5 | - 1.1 | + 1.1 | + 2.2 | - 4.7 | + 4.4 | + 9.1 |
| 6 | - 1.6 | + 1.6 | + 3.2 | - 9.2 | + 8.3 | +17.5 |
| 7 | - 0.4 | + 1.3 | + 1.7 | - 4.6 | + 5.7 | +10.3 |
| 8 | - 8.4 | + 9.2 | +17.6 | - 7.7 | + 8.2 | +15.9 |
| 9 | - 3.0 | + 3.2 | + 6.2 | - 2.8 | + 2.8 | + 5.6 |
| 10 | - 0.0 | + 0.0 | + 0.0 | - 2.6 | + 2.7 | + 5.3 |
| 11 | - 3.3 | + 2.8 | + 6.1 | - 4.1 | + 3.2 | + 7.3 |
| 12 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 13 | - 2.4 | + 2.4 | + 4.8 | - 6.8 | + 7.1 | +13.9 |
| 14 | - 6.3 | + 6.4 | +12.7 | -12.3 | +14.0 | +26.3 |
| 15 | - 5.3 | + 5.4 | +10.7 | - 5.9 | + 6.9 | +12.8 |
| 16 | - 1.2 | + 1.4 | + 2.6 | - 4.0 | + 3.8 | + 7.8 |
| 17 | - 4.6 | + 3.7 | + 8.3 | - 3.0 | + 3.1 | + 6.1 |
| 18 | - 1.7 | + 0.1 | + 1.8 | - 5.6 | + 5.1 | +10.7 |
| 19 | - 4.1 | + 4.1 | + 8.2 | -12.2 | +12.0 | +24.2 |
| 20 | - 2.6 | + 2.7 | + 5.3 | - 2.9 | + 2.4 | + 5.3 |
| 21 | - 5.7 | + 5.9 | +11.6 | - 7.0 | + 6.4 | +13.4 |
| 22 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 23 | - 2.7 | + 3.2 | + 5.9 | - 4.4 | + 4.6 | + 9.0 |
| 24 | - 1.0 | + 1.0 | + 2.0 | - 4.2 | + 4.2 | + 8.4 |
| 25 | - 3.4 | + 3.1 | + 6.5 | -13.6 | +13.3 | +26.9 |

* measurement in millimeters

TABLE 10

TONGUE ARCH AVERAGES
(Exercise #3)

| Sub- ject | Tongued | | | Slurred | | |
|--------------|-----------|-----------|------------|-----------|-----------|------------|
| | Asc Av | Des Av | Comb Av | Asc Av | Des Av | Comb Av |
| 1 | - 3.0* | + 3.0 | + 6.0 | - 8.0 | + 8.0 | +16.0 |
| 2 | - 4.5 | + 5.0 | + 9.5 | - 9.0 | + 9.0 | +18.0 |
| 3 | - 5.5 | + 5.5 | +11.0 | - 6.5 | + 6.0 | +12.5 |
| 4 | - 6.0 | + 6.5 | +12.5 | - 7.5 | + 7.5 | +15.0 |
| 5 | -13.5 | +13.5 | +27.0 | -11.0 | +11.0 | +22.0 |
| 6 | -12.5 | +12.5 | +25.0 | -30.5 | +18.0 | +48.5 |
| 7 | - 1.0 | + 1.0 | + 2.0 | -13.5 | +14.0 | +27.5 |
| 8 | - 6.5 | + 9.0 | +15.5 | - 8.0 | + 9.5 | +17.5 |
| 9 | - 5.0 | + 5.0 | +10.0 | - 8.0 | + 8.0 | +16.0 |
| 10 | - 0.0 | + 0.0 | + 0.0 | - 5.5 | + 4.5 | +10.0 |
| 11 | -12.5 | +13.5 | +26.0 | - 9.5 | + 8.5 | +18.0 |
| 12 | + 6.0 | - 6.0 | -12.0 | + 8.5 | - 8.5 | +17.0 |
| 13 | - 6.0 | + 6.5 | +12.5 | -12.0 | +14.0 | +26.0 |
| 14 | -16.0 | +13.0 | +29.0 | - 5.0 | +14.0 | +19.0 |
| 15 | -14.5 | +16.0 | +30.5 | -14.5 | + 9.0 | +23.5 |
| 16 | - 4.0 | + 4.0 | + 8.0 | - 5.5 | + 4.5 | +10.0 |
| 17 | - 6.0 | + 7.0 | +13.0 | - 8.0 | + 6.0 | +14.0 |
| 18 | + 0.5 | + 0.0 | - 0.5 | - 9.0 | + 9.0 | +18.0 |
| 19 | -10.5 | +10.5 | +21.0 | - 6.0 | + 6.5 | +12.5 |
| 20 | - 5.5 | + 6.0 | +11.5 | - 6.5 | + 5.0 | +11.5 |
| 21 | -13.0 | +12.0 | +25.0 | -12.0 | +10.0 | +22.0 |
| 22 | - 0.0 | + 0.0 | + 0.0 | - 0.0 | + 0.0 | + 0.0 |
| 23 | - 6.5 | + 7.5 | +14.0 | - 7.0 | + 9.0 | +16.0 |
| 24 | - 3.5 | + 3.5 | + 7.0 | - 5.5 | + 5.0 | +10.5 |
| 25 | -11.0 | + 9.0 | +20.0 | -13.0 | + 8.5 | +21.5 |

* measurement in millimeters

CHAPTER IV

INTERPRETATION OF DATA

Statistical Analysis

The null hypothesis states that neither the teeth aperture, instrument pivot, nor tongue arch functions in a consistent manner during trumpet performance and, therefore, has no direct effect on trumpet performance. Thus, the null hypothesis to be tested, using Hotelling's T^2 statistic, is that the true mean of each set of measurements is equal to zero: $\mu_1 = \mu_2 = \mu_3 = 0$. The alternate hypothesis is that at least one of the previously stated variables directly influences trumpet performance and, therefore, at least one of the means is different from zero. The mean of each set of measurements is presented in Table 11. The null hypothesis was rejected; the means are not all equal to zero, indicating that during trumpet performance the teeth aperture, instrument pivot, and tongue arch function in a consistent manner and have a direct effect on trumpet performance. The "F" statistic computed with three and 22 degrees of freedom (for the factors considered and the number of subjects, respectively) exceeded the critical value at the .005 level of confidence.

TABLE 11

TRUE MEAN MEASUREMENTS

| | Teeth Aperture | Instrument Pivot | Tongue Arch |
|---------------|-------------------|---------------------|----------------|
| Ex. 1 Tongued | 2.068 | 1.800 | 2.096 |
| Slurred | 3.376 | 2.584 | 3.064 |
| Ex. 2 Tongued | 3.552 | 2.312 | 3.188 |
| Slurred | 5.488 | 4.012 | 5.576 |
| Ex. 3 Tongued | 9.100 | 7.160 | 7.560 |
| Slurred | 12.220 | 6.980 | 9.028 |

The .01 level of confidence was established for the rejection of the null hypothesis on each of the three means for each of the exercises. These confidence limits hold simultaneously and, therefore, are conservative. Each one of the true means of the averaged measurements of all subjects was significantly greater than zero, indicating the null hypothesis had been rejected: $\mu_1 > 0$, $\mu_2 > 0$, and $\mu_3 > 0$. It is reasonable to conclude at the .01 level of confidence that all three variates contributed to the rejection of the null hypothesis. Therefore, the alternative hypothesis, that at least one of the three variables--teeth aperture, instrument pivot, or tongue arch--affect trumpet performance, may be accepted.

It is evident that at the .01 confidence level the true mean of the population lies within the confidence limits stated in Table 12.

TABLE 12

TRUE MEAN CONFIDENCE LIMITS

| | True Mean | True Mean Confidence Limits |
|-------------|--------------|-----------------------------------|
| Exercise 1 | | |
| Tongued | | |
| Aperture | 2.068 | 1.11 - 3.03 |
| Pivot | 1.800 | 1.18 - 2.42 |
| Tongue Arch | 2.096 | .89 - 3.30 |
| Slurred | | |
| Aperture | 3.376 | 2.57 - 4.18 |
| Pivot | 2.584 | 1.78 - 3.39 |
| Tongue Arch | 3.064 | 2.36 - 3.77 |
| Exercise 2 | | |
| Tongued | | |
| Aperture | 3.552 | 2.50 - 4.61 |
| Pivot | 2.312 | 2.50 - 4.61 |
| Tongue Arch | 3.188 | 2.18 - 4.20 |
| Slurred | | |
| Aperture | 5.488 | 3.58 - 7.40 |
| Pivot | 4.012 | 2.87 - 5.15 |
| Tongue Arch | 5.576 | 4.95 - 6.20 |
| Exercise 3 | | |
| Tongued | | |
| Aperture | 9.100 | 6.06 - 12.14 |
| Pivot | 7.160 | 4.91 - 9.41 |
| Tongue Arch | 7.560 | 6.34 - 8.78 |
| Slurred | | |
| Aperture | 12.220 | 10.19 - 14.25 |
| Pivot | 6.98 | 4.31 - 9.65 |
| Tongue Arch | 9.028 | 7.68 - 10.38 |

Teeth Aperture

The anticipated pattern of aperture change was confirmed by the subjects in the study. The aperture decreases as the pitch ascends and increases as the pitch descends. The basic jaw position for the middle register showed an even alignment of the upper and lower teeth. While there was no horizontal jaw movement in twenty of the subjects, five (Nos. 1, 2, 4, 24 and 25) had a tendency to thrust the jaw forward during performance in the lower register.

The movement of the aperture change was observed as either smooth and flowing or rapid and definite. Those with the flowing aperture change experienced difficulty in immediately centering pitches, while those with rapid and direct changes of aperture did not experience this difficulty. Eight subjects (Nos. 3, 4, 12, 14, 17, 18, 20 and 23) performed with a slight "chewing" motion in the articulated portions of the exercises. This movement was rapid and did not seem to negatively affect performance.

In each of the three exercises, the mean measurement for teeth aperture showed a significant increase for the slurred portion of the exercise. In the tongued portion of the exercises the flow of air is momentarily interrupted by the tongue to provide the desired amount of separation between each note, while in the slurred portion the flow of air is not interrupted. Thus the change of

teeth aperture performs a more important role during slurred performance than in tongued performance.

The natural harmonic series of the trumpet was considered in the design of the exercises. The arpeggio outlined in Exercise 1 follows this series with the exception of the added first line "e" and the omitted 7th partial (Bb), which is too flat for use in effective performance. The alternating pattern of Exercise 2 requires the omission of one partial in ascending intervals during the ascending portion of the exercise, and the omission of one partial in the descending intervals during the descending portion. In Exercise 3 one partial is omitted in the lower octave and three are omitted in the upper octave. The mean measurements increase significantly from Exercise 1 through Exercise 3: 2.068, 3.552, and 9.100, respectively (tongued mean measurements). It is evident that the importance of teeth aperture change increases with the expansion of the intervals to be performed.

Instrument Pivot

The predicted tendency for instrument pivot was demonstrated by the performance of the trumpet players in the research. The angle of inclination between the face of the mouthpiece and a line determined by the face of the lower teeth and the base of the mandible increases as the pitch ascends and decreases as the pitch descends. The

natural instrument placement angle for the middle register ranged from parallel to the line between the teeth and mandible to an inclination of 21 degrees. The average angle of inclination was eight degrees. There was a marked increase in the degree of pivot in the upper register over that of the lower register.

The pivot can be achieved by either changing the tilt of the instrument, maintaining the position of the instrument and using a backward tilt of the head, or a combination of the two. Seven of the subjects (Nos. 1, 2, 3, 8, 12, 14 and 23) combined a tilt of the instrument with a motion of the head while ten subjects (Nos. 4, 7, 13, 18, 19, 20, 21, 22, 24 and 25) achieved the change by moving only the instrument. The instrument of subject 9 was the reverse of the anticipated tendency. A measurable pivot was not present in the performance of subjects 5, 6, 10, 11, 15, 16 and 17; but an extreme increase in mouth-piece pressure was observed in each instance.

The mean measurement for instrument pivot increases significantly from Exercise 1 through Exercise 3. In the first two exercises the mean for the slurred portion of the exercise exceeds the mean for the tongued segment, indicating that the instrument pivot is a greater contributing factor when the pitches are not articulated. In the third exercise, however, the mean measurement for the tongued portion (7.160) is slightly (.18) greater

than the mean for the slurred portion (6.980). It was observed that the subjects performed the slurred portion of the third exercise with a considerable increase in mouthpiece pressure above the amount of observable mouthpiece pressure used in the performance of the tongued section of the same exercise. In the opinion of the writer, this increase in mouthpiece pressure is used as a substitute for the instrument pivot to produce the octave interval for the highest note in the normal performance range of the instrument. Since the instrument pivot follows the predicted pattern of motion in each of the exercises, it is evident that the pivot is a contributing factor in effective trumpet performance.

Tongue Arch

The tongue followed the anticipated pattern of motion during each of the three exercises. The tongue arched as the pitch ascended, creating a smaller aperture between the tongue and the palate. The aperture increased as the pitch descended. While the exact placement of the arch in relationship to the palate varied with individuals, 17 of the subjects elevated the dorsum of the tongue and the other 8 arched the pharyngeal portion of the tongue. In the lower register, the tongue was either flattened against the floor of the mouth or slightly balled in the pharyngeal portion of the tongue, dependent on the size of

the tongue in relationship to the total area within the oral cavity.

The motion of the tongue was either flowing or rapid. The subjects with a flowing tongue motion seemed to experience inconsistent tone quality and intonation at the beginning of each pitch. This difficulty was not apparent in the subjects who used a rapid motion during a change in tongue elevation. After the initial sounding of the "high C" in Exercise 3, several of the subjects decreased the elevation of the tongue. The natural intonation pattern of the harmonic series results in a noted sharpness of partials six and above. (The seventh partial is the only exception to this pattern and is not used in normal trumpet performance.) One of the common performance techniques for controlling intonation on an established pitch without embouchure movement is to alter the speed of the air stream through a change in the aperture between the tongue and the palate. It is the opinion of the writer that this technique was employed by the aforementioned subjects during the performance of Exercise 3.

The mean measurements for the change in tongue arch show a progressive increase for each of the three exercises and also a significant increase in the slurred mean over the tongued mean within each exercise. Thus it is apparent that the amount of tongue motion increases as the intervals of performance increase. It is also

evident that the tongue arch movement increases when a passage is slurred rather than tongued.

Interaction

If it were found that any one of the areas of investigation did not contribute to effective trumpet performance, interaction would have been an important consideration. Since the statistical analysis confirmed, at the .01 level of confidence, that changes in each of the three levels of the performance variable considered contributes so significantly to trumpet performance, it is not possible to establish either an order of priority or interdependence without introducing physical limitations on the subject during performance. The introduction of physical limitations relating to either the teeth aperture, instrument pivot, or tongue arch would alter the physical coordination of the variables to be studied and thus would not represent actual performance. It was observed, however, that the subjects with a minimal change for either teeth aperture or instrument pivot would show a proportionally greater change in at least one of the other areas under consideration. Tables 13 and 14 compare the combined averages for the change in teeth aperture, instrument pivot, and tongue arch in the performance of Exercise 3 as performed by five subjects who display a minimal amount of teeth aperture movement and instrument pivot, respec-

tively. (Tongued and slurred figures were averaged for these tables.) The true mean measurements of the total group of subjects are included in each table to facilitate the comparison between motion utilized by the individual subjects and the true mean. It may be noticed that while the mean change of these subjects is considerably smaller than the means for the total group in both teeth aperture and instrument pivot, their changes in tongue arch are much greater than the average for the total group.

TABLE 13

COMBINED AVERAGE MEASUREMENTS FOR FIVE SUBJECTS
WITH MINIMAL TEETH APERTURE CHANGE
(Exercise 3)

| Sub- ject | Teeth Aperture Combined Average | Instrument Pivot Combined Average | Tongue Arch Combined Average |
|--------------|------------------------------------|--------------------------------------|---------------------------------|
| 3 | 0.0* | 8.0** | 11.8* |
| 5 | 5.5 | 0.0 | 24.5 |
| 6 | 0.0 | 0.0 | 36.8 |
| 8 | 7.5 | 5.5 | 16.5 |
| 21 | 5.0 | 6.5 | 23.5 |
| True Mean | 10.660 | 7.070 | 8.294 |
| | * meas. in millimeters | ** meas. in degrees | |

TABLE 14

COMBINED AVERAGE MEASUREMENTS FOR FIVE SUBJECTS
WITH MINIMAL INSTRUMENT PIVOT MOTION
(Exercise 3)

| Sub- ject | Instrument Pivot Combined Average | Teeth Aperture Combined Average | Tongue Arch Combined Average |
|--------------|--------------------------------------|------------------------------------|---------------------------------|
| 5 | 0.0** | 5.5* | 24.5 |
| 6 | 0.0 | 0.0 | 36.8 |
| 7 | 2.0 | 20.5 | 14.8 |
| 11 | 0.0 | 6.0 | 22.0 |
| 15 | 0.0 | 7.5 | 32.0 |
| True Mean | 7.070 | 10.660 | 8.294 |
| | * meas. in millimeters | ** meas. in degrees | |

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The purpose of this study was three-fold: (1) to reveal the physical variation of the teeth aperture, instrument pivot, and tongue arch in effective trumpet performance, (2) to examine the predictability of these motions and their consistency with a change of register and, (3) to determine the significance of any interaction between the previously stated physical changes. Regarding the physical variation in the three levels of the performance variable and their predictability and consistency, the following conclusions may be stated:

- (1) The teeth aperture decreased as the pitch ascended and increased as the pitch descended.
- (2) The amount of teeth aperture change was greater during the slurred portions of each exercise than during the tongued performance.
- (3) There was a significant increase in the total change of aperture which coincided with the expansion of the intervals performed.

- (4) The angle of instrument inclination increased as the pitch ascended and decreased as the pitch descended.
- (5) The degree of pivot increased proportionally with the expansion of the performance intervals.
- (6) There was a marked increase in the degree of pivot in the upper register over that of the lower register.
- (7) When a subject does not demonstrate a measurable amount of instrument pivot, an extreme increase in mouthpiece pressure appears to be used to facilitate performance.
- (8) The amount of instrument pivot was greater during the slurred portions of the exercises than during the tongued performance.
- (9) The tongue arched as the pitch ascended, creating a smaller aperture between the tongue and the palate. The motion was reversed as the pitch descended.
- (10) The amount of tongue arch was greater during the slurred portion of each exercise than during the tongued performance.
- (11) There was a significant increase in the amount of tongue motion when the intervals to be performed required the omission of at least one partial of the trumpet overtone series.

No conclusions can be determined regarding the interaction of the teeth aperture, instrument pivot, and tongue arch. Since the statistical analysis confirmed that the change in each of the previously stated variables contributed significantly to trumpet performance, it was not possible to establish either an order of priority or interdependence without introducing physical limitations on the subjects during performance. The introduction of physical limitations would alter the physical coordination of the variables and thus would not represent actual performance conditions. It was observed, however, that the subjects with a minimal change for either teeth aperture or instrument pivot demonstrated a proportionally greater change in at least one of the other areas under consideration.

Recommendations

As a result of the findings in this study, investigation of the following are recommended:

Feasible studies:

- (1) An investigation of the use of the tongue as means of intonation control in brass instrument performance.
- (2) Studies to explore the effect of the tongue arch on the movement and intensity of the air stream.

Valuable but difficult studies:

- (1) A study of the retrolabiocoele and its effect on the trumpet embouchure and endurance during performance.
- (2) Research concerning the effect instrument pivot exerts on the use of excessive mouthpiece pressure in upper register trumpet performance.
- (3) An investigation relating the effect of instrument pivot on tone quality and consistency in the upper and lower registers of trumpet performance.

The present study could be replicated, examining other factors concerning trumpet performance and their total interaction with mouthpiece pressure and the quantity and intensity of the air stream.

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BIBLIOGRAPHY

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APPENDICES

Initial Letter of Inquiry

November 18, 1969

TO:

FROM: A. Keith Amstutz

RE: Videofluorographic Research

During the next few weeks I will be developing a research project which involves the physiological aspects of the oral cavity which can not be externally observed in trumpet performance. It is my hypothesis that the coordination of the tongue arch, teeth aperture, and instrumental pivot performs a crucial role in both the ease and consistency of technical facility. Through the use of x-ray video tape recording we will be able to scientifically analyze the problems of performance and hope that this will aid in your performance and also in the performance of any students you might teach.

Your trumpet teacher has recommended that I contact you as a possible candidate for analysis. This would involve part of one evening for the x-ray taping and then I could meet with you at your convenience for a personal discussion of your performance practices.

If you are interested in taking part in this study, please stop by my studio, 301 MH, for more information. It is hoped that the taping can begin on the 2nd of December so I would appreciate knowing of your desire for participation as soon as possible.

Thanking you for your cooperation.

Sincerely,

A. Keith Amstutz

Voluntary Participation Statement
for
Subjects of Legal Age

Date _____

Mr. A. Keith Amstutz
School of Music
North Texas State Univ.
Denton, Texas 76203

Mr. Amstutz:

This is to confirm that I am of legal age, and that
I wish to take part in the videofluorographic research
project.

Signed _____

Parental Consent Statement for Subjects Under 21

Date _____

Mr. A. Keith Amstutz
School of Music
North Texas State Univ.
Denton, Texas 76203

Mr. Amstutz:

We the parents (or guardian) of _____
hereby give our consent for him to take part in the video-
fluorographic research project.

Signed _____

NORTH TEXAS STATE UNIVERSITY
DENTON, TEXAS

School of Music

November 20, 1969

During the next few weeks I will be developing a research project which involves the physiological aspects of the oral cavity which can not be externally observed in trumpet performance. It is my hypothesis that the coordination of the tongue arch, teeth aperture, and instrumental pivot performs a crucial role in both the ease and consistency of technical facility. Through the use of X-ray video taping we will be able to scientifically analyze the problems of performance and hope that this will aid in your son's performance and also the performance of any students he may teach.

With this brief explanatory note I am requesting permission for your son to take part in this research project. Since each individual will be exposed to a very small amount of radiation, we want each to take part voluntarily and with parental approval. I have attached a letter from Dr. Alexander M. Finlay, the radiologist who will be performing the X-ray taping, which outlines the exact amount of radiation involved. May I assure you that every precaution will be taken and that the research is under the direction of the most competent medical-radiological experts.

If you wish to have your son participate in this project, please sign the attached form and return it to me in the enclosed envelope so that we may proceed as soon as possible.

Yours truly,



A. Keith Amstutz
Instructor of Trumpet

DRS. FINLAY, LOCKWOOD AND KING

RADIOLOGY

TELEPHONE 387-6189

1614 SCRIPTURE STREET

DENTON, TEXAS 76201

November 17, 1969

Mr. A. Keith Amstutz
School of Music
North Texas State Univ.
Denton, Texas 76203

Dear Keith,

With regard to the radiation output of the video photo fluoroscopic unit which we plan to use in the research project: the amount of radiation received over a six inch square area of the mouth and throat area would represent approximately 0.85 roentgens per minute to the exposed side of the skin. Since the area of exposure is small this is not thought to be a significant amount of radiation. In addition the maximum time that exposure would be obtained would be approximately 2 minutes or a total of not more than 1.7 roentgens. Based on our previous experience with the video taping procedure, the images recorded should be very satisfactory with sufficient contrast for accurate analysis and measurement.

Sincerely,

Alex. M. Finlay, M.D.
Alex M. Finlay, M.D.

AMF:ha

NORTH TEXAS STATE UNIVERSITY

DENTON, TEXAS

SCHOOL OF MUSIC

November 17, 1969

Mr. Jack M. Long, Acting Supervisor
Compliance and Inspection
Radiation Control Program
Div. of Occupational Health and Radiation Control
Texas State Department of Health
Austin, Texas

Dear Mr. Long:

I am writing concerning the continuance of the videofluorographic study of the physiological phenomena influencing trumpet performance which was initiated in 1966 by Professor John J. Haynie of the NTSU School of Music. I am Mr. Haynie's associate trumpet teacher and have been directly involved with his project from its beginning.

Mr. Haynie's research has shown definite performance tendencies and is serving as an extremely valuable educational document for both educators and performers. In my research I am specifically interested in the correlation between the use of the arched tongue, the teeth aperture, and instrumental pivot during performance. While these are shown in the general patterns used in the previous tapings, the studies were not designed for as detailed an analysis as I wish to undertake.

Mr. Haynie is cooperating with me in this research and the exact protocol used in the previous study will be continued. Dr. Alexander M. Finlay, Jr., the radiologist on the previous taping, will be operating all of the x-ray equipment. I have attached a copy of a letter from Dr. Finlay stating the exact exposure to be used in this research.

The individuals studied will be selected from our trumpet students with selection based on their performing ability and desire to take part in the study. I will obtain signed releases from all students over 21 and parental approval for those under the age of 21. The age span will be centered between 18 and 30 with no one under 18 or over 45 involved. With the exception of our trumpet faculty (Mr. Haynie, Mr. Max Morley and myself) the subjects will not have been involved in any of the previous x-ray study at NTSU.

NORTH TEXAS STATE UNIVERSITY

DENTON, TEXAS

SCHOOL OF MUSIC

On Friday, November 14th, I discussed this proposal with Dr. R. B. Escue who is the Radiation Control Agent on this campus, and he has given his approval for the continuance of this project.

In your letter to Mr. Haynie dated December 30, 1968, you stated the approval of the Radiation Advisory Board with one stipulation: that the board will be provided "with a list of those individuals who were subjected to this diagnosis, approximate exposure to the individuals, and an assessment of the success of diagnosis through this technique." Dr. Finlay and I would provide this material to you not later than 45 days following the close of the calendar year.

I would appreciate your approval for my continuing this research program. (If at all possible Dr. Finlay would like to begin the taping on December 1st so that all the radiation work could be completed before the end of the year.) Please contact me if you would like additional materials or information.

Thanking you for your prompt attention.

Sincerely,

A. Keith Amstutz
Trumpet Instructor

enclosures



Texas State Department of Health

JAMES E. PEAVY, M.D., M.P.H.
COMMISSIONER OF HEALTH

AUSTIN, TEXAS

J. B. COPELAND, M.D.
DEPUTY COMMISSIONER

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ROYCE E. WISENBAKER, M.S. ENG.

December 1, 1969

Mr. A. Keith Amstutz
Trumpet Instructor
North Texas State University
Denton, Texas

Dear Mr. Amstutz:

I am in receipt of your letter of November 17, 1969, concerning proposed additional studies on trumpet players utilizing videofluorographics.

The reporting condition as outlined in your letter is acceptable. We would, however, like to see you limit the study to not more than 20 people, if it is practical.

Thank you for your notification of this program concerning radiographic safety.

If we may be of further service, please let me know.

Sincerely,

A handwritten signature in cursive script, appearing to read "Jack M. Long".

Jack M. Long, Supervisor
Compliance and Inspection
Radiation Control Program
Division of Occupational Health
and Radiation Control

cc: Dr. Finlay

NORTH TEXAS STATE UNIVERSITY

DENTON, TEXAS

January 27, 1970

SCHOOL OF MUSIC

Mr. Jack M. Long, Acting Supervisor
Compliance and Inspection
Radiation and Control Program
Division of Occupational Health and Radiation Control
Texas State Department of Health
Austin, Texas

Dear Mr. Long:

Attached is a list of the subjects included in my videofluorographic study of trumpet players at North Texas State University. All of the data was collected between the dates of December 2nd, 1969, and January 15, 1970. I believe that the material on the chart is self-explanatory. Under the term "retrolabiocoele" you will occasionally notice arrows. An upward arrow indicates the condition is behind the upper lip, while a downward arrow indicates the lower lip. Dr. Finlay graded the condition in 1st, 2nd, 3rd, and 4th degrees. In the group studied there was none greater than the 1st degree. The importance of the retrolabiocoele is that it apparently has to do with causing a breakdown of the embouchure either as a result of poor blood supply or as a result of abnormal stretching of musculature, we are not sure which.

Both Dr. Finlay and I were pleased at the enthusiasm shown by the subjects and their desire to know exactly what is happening within the oral cavity. We believe that this study has been so designed that relevant tendencies will be confirmed and thus provide a valid basis for teaching and performance practices which have previously been supported only by speculation.

I hope that this report is satisfactory. If you desire any additional information please contact me, and I will be happy to provide you with the materials you desire.

Sincerely,

A. Keith Amstutz
Trumpet Instructor

cc: Dr. Alexander M. Finlay, M.D.
Professor John J. Haynie

| | Tongue Size | Bite | Tongue Mobility | Tongue Arch | Dental Problems | Retrolabiocoele | Laryngocoele | Velopharyngeal Closure | Maxillo-mandibular Interdental Distance | Motion of Temporomandibular Joint | Dilatation of Pyriform Sinuses and Vallecula | Approximate Roentgens to 10 x 15 cm. Area |
|-------------------|-------------|------|-----------------|-------------|-----------------|-----------------|--------------|------------------------|---|-----------------------------------|--|---|
| Amstutz, K. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Arnett, J. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Barnett, K. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Blocher, S. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Cowperthwaite, D. | N | N | N | N | O | O | O | N | N | N | N | 2.7* |
| Evans, J. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Gloyd, R. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Haynie, J. | N | N | | N | O | O | O | N | N | N | N | 1.35 |
| Kieley, K. | N | N | N | N | O | 1 ^o | O | N | N | N | N | 1.35 |
| Lanebe, R. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Langford, G. | N | N | N | N | O | O | O | N | N | N | 1 ^o | 1.35 |
| Lark, J. | N | N | N | N | ** | O | O | N | N | N | N | 1.35 |
| Loveless, M. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Morley, M. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Nebe, R. | N | N | N | N | O | 1 ^o | O | N | N | N | N | 2.7* |
| Noble, H. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Nopson, D. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Osborn, J. | N | N | N | N | O | 1 ^o | O | N | N | N | N | 1.35 |
| Rodriguez, J. | N | N | N | N | O | O | O | N | N | N | N | 1.35 |
| Rosa, P. | N | N | N | N | *** | O | O | N | N | N | N | 1.35 |
| Stone, J. | N | N | N | N | O | 1 ^o | O | N | N | N | N | 1.35 |

* - two exposures six weeks apart

** - several teeth missing

*** - buck-teeth

| | | | | | | | | | | | | | |
|--------------|---|---|---|---|---|---|---|-------|---|---|---|---|---|
| Stone, R. | N | N | N | N | N | N | N | N | N | N | N | N | 1.35 |
| Smith, M. | N | N | N | N | N | N | O | O | O | N | N | N | 1.35 |
| Sullivan, T. | N | N | N | N | N | N | O | O | O | N | N | N | 1.35 |
| Thomas, J. | N | N | N | N | N | N | O | 1 1/2 | O | N | N | N | 2.7* |
| Turner, G. | N | N | N | N | N | N | O | O | O | N | N | N | 1.35 |
| Waddell, R. | N | N | N | N | N | N | O | O | O | N | N | N | 1.35 |
| | | | | | | | | | | | | | Approximate Roentgens to 10 x 15 cm. Area |
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| | | | | | | | | | | | | | |

* - two exposures six weeks apart

Subject Resume

Name _____ Age _____

Local Address _____
Street City

Local Telephone _____

Permanent Address _____
Street City StateClassification _____ Major _____
(please be specific)

Present Trumpet Teacher _____

Trumpet History:

(Began playing at the age of _____)

Musical Organizations: (Please include name of school,
city, state and name of director)

Elementary:

Jr. High:

Sr. High:

College:

Professional Organizations:

Private Instruction:

| Teacher | City or School | Inclusive |
|---------|----------------|----------------|
| | | dates of study |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

Any other information which you feel would be important and relevant to this research project:

Instrument: (List your Bb trumpet only)

Make and model _____ Bore _____

Mouthpiece: Make _____ Size _____

Have you ever had any concentrated radiation treatment?

Yes _____ No _____ (If "yes" please elaborate.)

Thanking you for your cooperation. Please return completed form to:

A. Keith Amstutz
301 MH NTSU

APPENDIX B

SUBJECT RESUME

Subject Number 1

Name: A. Keith Amstutz

Age: 28

Hometown: Midland, Michigan

Classification: Faculty

Major:

Manufacturer of Bb trumpet used in this study: DEG

Mouthpiece used in this study: Byron L. Autrey (special)

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|-------------------|--|-----------------------------|
| Byron L. Autrey | Mich. State Univ. | 1957-64 |
| Earl D. Irons | Arlington St. Coll. Arlington, Tex. | 1964-67 |
| John J. Haynie | North Tex. St. Univ. | 1965-67 |
| Legh Burns | Univ. of Oklahoma | 1967 |
| Gary Stollsteimer | Univ. of Oklahoma | 1968-69 |

APPENDIX B

SUBJECT RESUME

Subject Number 2

Name: Joe Arnett

Age: 27

Hometown: Waco, Texas

Classification: Graduate Student Major: Music Education

Manufacturer of Bb trumpet used in this study: Getzen

Mouthpiece used in this study: Purviance - 7C3

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|----------------|----------------------|-----------------------------|
| Bernard Smith | Baylor University | 1959-60 |
| John J. Haynie | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 3

Name: Jack Stone

Age: 34

Hometown: Dallas, Texas

Classification: Graduate Student Major: Music Education

Manufacturer of Bb trumpet used in this study: Bach

Mouthpiece used in this study: Bach - 7

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|----------------|----------------------|-----------------------------|
| Don Thomas | Dallas, Texas | 1952-53 |
| John J. Haynie | North Tex. St. Univ. | 1953-56 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 4

Name: John J. Haynie

Age: 43

Hometown: Denton, Texas

Classification: Faculty

Major:

Manufacturer of Bb trumpet used in this study: Conn

Mouthpiece used in this study: Bach - 7B

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|------------------|-------------------|-----------------------------|
| R. L. Maddox | Mexia, Texas | 1937-42 |
| Earl D. Irons | Arlington, Texas | Periodic Lessons |
| H. A. Vandercook | Abilene, Texas | Summer of 1938 |
| Haskell Sexton | Univ. of Illinois | 1947-50 |

APPENDIX B

SUBJECT RESUME

Subject Number 5

Name: Robert M. Lanese Age: 28

Hometown: South Euclid, Ohio

Classification: Graduate Student Major: Trumpet

Manufacturer of Bb trumpet used in this study: Benge

Mouthpiece used in this study: Bach - 7C

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|--------------------|---------------------|-----------------------------|
| Richard Lionbauch | Cleveland, Ohio | 1949-57 |
| Harry B. Henforth | Cleveland, Ohio | 1957-59 |
| Richard Suddendorf | Ohio State Univ. | 1959-61 1963-65 |
| Louis Davidson | Cleveland, Ohio | Summer, 1963 |
| John J. Haynie | North Tex. St. Univ | 1968-70 |

APPENDIX B

SUBJECT RESUME

Subject Number 6

Name: Dick Waddell

Age: 18

Hometown: Denton, Texas

Classification: Freshman

Major: Music Education

Manufacturer of Bb trumpet used in this study: Benge 3X

Mouthpiece used in this study: Bach - 7C

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|------------------|-----------------------|-----------------------------|
| John J. Haynie | Denton, Texas | 1962-64 |
| Pat Hasty | Denton, Texas | 1964-65 |
| Doug Smith | Denton, Texas | 1965-67 |
| A. Keith Amstutz | Denton, Texas | 1967-68 |
| John J. Haynie | Denton, Texas | 1968-69 |
| Max Morley | North Texas St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 7

Name: Max L. Morley

Age: 28

Hometown: Dallas, Texas

Classification: Graduate Student Major: Trumpet

Manufacturer of Bb trumpet used in this study: Reynolds

Mouthpiece used in this study: Bach - 5B

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|----------------|--|-----------------------------|
| Joe Cinquemani | Dallas, Tex. | 1958-60 |
| Earl D. Irons | Arlington St. Coll. Arlington, Tex. | 1960-63 |
| John J. Haynie | North Tex. St. Univ. | 1963-66 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 8

Name: Steve Blocher

Age: 20

Hometown: Greenville, Ohio

Classification: Sophomore

Major: Music Education

Manufacturer of Bb trumpet used in this study: Getzen

Mouthpiece used in this study: Schilke - 11

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|---------------|----------------------------------|-----------------------------|
| Gene Brown | Greenville, Ohio | 1966-68 |
| Edwin Betts | Univ. of Ohio (Bowling Green) | 1967-68 |
| Robert Lanese | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 9

Name: Peter J. Rosa

Age: 23

Hometown: North Dartmouth, Massachusetts

Classification: Sophomore

Major: Music Education

Manufacturer of Bb trumpet used in this study: Benge

Mouthpiece used in this study: Giardinelli - 7F

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|------------------|----------------------|-----------------------------|
| Joseph Rebeiro | New Bedford, Mass. | 1950-60 |
| John Coffey | Barnstable, Mass. | 1960-63 |
| Robert Lanese | North Tex. St. Univ. | 1968-69 |
| A. Keith Amstutz | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 10

Name: David Cowperthwaite Age: 28

Hometown: Cranford, New Jersey

Classification: Graduate Student Major: Trumpet

Manufacturer of Bb trumpet used in this study: Bach

Mouthpiece used in this study: Bach - 5C

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|----------------|------------------------|-----------------------------|
| Louis Haar | Cranford, N.J. | 1954-55 |
| Calsimir Berk | Cranford, N.J. | 1955-57 |
| Edward Treutle | Juilliard Sch. of Mus. | 1957-59 |
| Ted Weis | NYC Ballet | 1963-64 |
| Melvin Broiles | Metropolitan Opera | 1966-67 |
| John J. Haynie | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 11

Name: Robert F. Nebe

Age: 19

Hometown: Houston, Texas

Classification: Sophomore

Major: Music Education

Manufacturer of Bb trumpet used in this study: Bach

Mouthpiece used in this study: Schilke - 10A4

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|------------------|----------------------|-----------------------------|
| Juan Husak | Palos, Ill. | 1959 |
| Ron Scheruble | Palos, Ill. | 1960-62 |
| Neil Dunlap | Chicago, Ill. | 1962-68 |
| John J. Haynie | North Tex. St. Univ. | 1968-69 |
| A. Keith Amstutz | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 12

Name: Russell Gloyd

Age: 20

Hometown: Springfield, Virginia

Classification: Junior

Major: Music Education

Manufacturer of Bb trumpet used in this study: Olds

Mouthpiece used in this study: Bach - 3C

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|-------------------|----------------------|-----------------------------|
| Sgt. Taylor | Washington, D. C. | 1963-64 |
| Sgt. Phil Rittman | Washington, D. C. | 1964-66 |
| Sgt. Glen Bell | Washington, D. C. | 1966-67 |
| Mr. Charles Brady | Washington, D. C. | 1967-69 |
| Max Morley | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 13

Name: Kenneth C. Kieley

Age: 19

Hometown: Richardson, Texas

Classification: Sophomore

Major: Music Education

Manufacturer of Bb trumpet used in this study: Getzen

Mouthpiece used in this study: Bach - 5B

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|------------------|----------------------|-----------------------------|
| George Gaidosh | Richardson, Tex. | 1964-68 |
| Gary Barrow | North Tex. St. Univ. | 1968-69 |
| A. Keith Amstutz | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 14

Name: John Thomas

Age: 19

Hometown: Arlington, Texas

Classification: Sophomore

Major: Music Education

Manufacturer of Bb trumpet used in this study: Getzen

Mouthpiece used in this study: Schilke - 9

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|----------------|----------------------|-----------------------------|
| Don Thomas | Ft. Worth, Tex. | 1950-68 |
| Robert Lanese | North Tex. St. Univ. | 1968-69 |
| John J. Haynie | North Tex. St. Univ. | 1968 |

APPENDIX B

SUBJECT RESUME

Subject Number 15

Name: Ken Barnett

Age: 21

Hometown: Haskell, Texas

Classification: Junior

Major: Compositon

Manufacturer of Bb trumpet used in this study: Blessing

Mouthpiece used in this study: Bach - 7C

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|------------------|----------------------|-----------------------------|
| Steve Graham | North Tex. St. Univ. | 1967-68 |
| A. Keith Amstutz | North Tex. St. Univ. | 1968 |
| Robert Lanese | North Tex. St. Univ. | 1968-69 |
| James Lark | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 16

Name: Gary Langford

Age: 29

Hometown: Susquehanna, Pennsylvania

Classification: Graduate Student Major: Trumpet

Manufacturer of Bb trumpet used in this study: Olds

Mouthpiece used in this study: Schilke - 11

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|------------------|----------------------|-----------------------------|
| Bernie Schrifrin | Binghamton, N. Y. | 1955-58 |
| Allen Flock | Bucknell Univ. | 1958-62 |
| Roger Steward | Oklahoma City, Okla. | 1964-65 |
| John J. Haynie | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 17

Name: James H. Lark, Jr.

Age: 45

Hometown: Dallas, Texas

Classification: Faculty

Major:

Manufacturer of Bb trumpet used in this study: Reynolds

Mouthpiece used in this study: Bach - 5A

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|----------------|-----------------------|-----------------------------|
| Norman Irvine | Washington, D. C. | 1938-39 |
| John Eagan | NBC Studios, New York | 1945-47 |
| Roger Fenn | Tulsa, Oklahoma | 1950-51 |
| John J. Haynie | North Tex. St. Univ. | 1959-60 |

APPENDIX B

SUBJECT RESUME

Subject Number 18

Name: Marshall Smith

Age: 26

Hometown: Toledo, Ohio

Classification: Junior

Major: Trumpet

Manufacturer of Bb trumpet used in this study: Bach

Mouthpiece used in this study: Bach - 7B

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|-----------------|-------------------------|-----------------------------|
| Bernard Sanchez | Toledo, Ohio | 1964-65 |
| Edwin Betts | Bowling Green St. Univ. | 1968-69 |
| Max Morley | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 19

Name: Jack Evans

Age: 19

Hometown: Wichita, Kansas

Classification: Sophomore

Major: Music Education

Manufacturer of Bb trumpet used in this study: Bach

Mouthpiece used in this study: Giardinelli - 6M

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|------------------|----------------------|-----------------------------|
| Philip Nicoli | Wichita, Kansas | 1963-65 |
| Cliff Sproul | Wichita, Kansas | 1965-68 |
| A. Keith Amstutz | North Tex. St. Univ. | 1968-69 |

APPENDIX B

SUBJECT RESUME

Subject Number 20

Name: Joe Rodriguez

Age: 18

Hometown: San Antonio, Texas

Classification: Freshman

Major: Dance Band

Manufacturer of Bb trumpet used in this study: Getzen

Mouthpiece used in this study: Bach - 1

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|-------------------|----------------------|-----------------------------|
| Juan C. Rodriguez | San Antonio, Tex. | 1956- |
| Jim May | San Antonio, Tex. | 1962-64 |
| Dale Schultz | San Antonio, Tex. | 1965-68 |
| Erroll Green | San Antonio, Tex. | 1966-67 |
| Jack Stone | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 21

Name: Mike Loveless

Age: 20

Hometown: Ennis, Texas

Classification: Junior

Major: Dance Band

Manufacturer of Bb trumpet used in this study: Besson

Mouthpiece used in this study: Schilke - 5C4B

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|-----------------|----------------------|-----------------------------|
| George Gaidosh | Seagoville, Tex. | 1962-63 |
| Richard Young | Seagoville, Tex. | 1963-64 |
| Bob Hibbs | Ennis, Tex. | 1964-67 |
| Conrad Bauschka | East Tex. St. Univ. | 1967-68 |
| Charles Herring | East Tex. St. Univ. | 1968-69 |
| James Lark | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 22

Name: Richard Stone, Jr.

Age: 19

Hometown: Dallas, Texas

Classification: Freshman

Major: Dance Band

Manufacturer of Bb trumpet used in this study: Getzen

Mouthpiece used in this study: Getzen - ML

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|------------|----------------------|-----------------------------|
| James Lark | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 23

Name: Tommy M. Sullivan

Age: 18

Hometown: Dallas, Texas

Classification: Freshman

Major: Music Education

Manufacturer of Bb trumpet used in this study: Bach

Mouthpiece used in this study: Bach - 7C

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|------------------|----------------------|-----------------------------|
| Jerry Stover | Mustang, Oklahoma | 1965-67 |
| Mac Guderian | Dallas, Texas | 1967-69 |
| A. Keith Amstutz | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 24

Name: James R. Osborn Age: 22

Hometown: Fayette, Missouri

Classification: Graduate Student Major: Music Education

Manufacturer of Bb trumpet used in this study: Selmer

Mouthpiece used in this study: Bach - 7C

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|----------------|----------------------|-----------------------------|
| Don Riddle | Okla. Baptist Univ. | 1965-69 |
| John J. Haynie | North Tex. St. Univ. | 1969 |

APPENDIX B

SUBJECT RESUME

Subject Number 25

Name: Glenn Turner

Age: 19

Hometown: Denton, Texas

Classification: Freshman

Major: Composition

Manufacturer of Bb trumpet used in this study: Getzen

Mouthpiece used in this study: Bach - 6

History of private instruction in trumpet:

| Teacher | Location | Inclusive Dates of Study |
|------------------|----------------------|-----------------------------|
| Norman Lang | Denton, Texas | 1964-65 |
| Doug Smith | Denton, Texas | 1965-66 |
| Norman Lang | Denton, Texas | 1968-69 |
| Purris Williams | North Tex. St. Univ. | 1969 |
| A. Keith Amstutz | North Tex. St. Univ. | 1969 |

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 1

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 19 | 20 | 21 | 22 | 21 | 20 | 19 | 16 | 15 | 15 | 15 | 16 | 19 |
| | +1 | +1 | +1 | -1 | -1 | -1 | -3 | -1 | 0 | 0 | +1 | +3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 21 | 20 | 20 | 19 | 21 | 18 | 19 | 17 | 18 | 15 | 19 | 16 | 19 | 19 | 20 | 18 | 21 | 20 | 22 |
| | -1 | 0 | -1 | +2 | -3 | +1 | -2 | +1 | -3 | +4 | -3 | +3 | 0 | +1 | -2 | +3 | -1 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 19 | 25 | 19 | 17 | 19 |
| | +6 | -6 | -2 | +2 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.2

-1.8

-4.0

+1.2

+1.9

+4.0

+2.4

+3.7

+8.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 1

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 19 | 20 | 21 | 23 | 22 | 21 | 19 | 17 | 15 | 14 | 16 | 17 | 20 |
| | +1 | +1 | +2 | -1 | -1 | -2 | -2 | -2 | -1 | +2 | +1 | +3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 21 | 20 | 20 | 18 | 20 | 18 | 19 | 16 | 18 | 14 | 19 | 17 | 19 | 18 | 20 | 19 | 20 | 20 | 23 |
| | -1 | 0 | -2 | +2 | -2 | +1 | -3 | +2 | -4 | +5 | -2 | +2 | -1 | +2 | -1 | +1 | 0 | +3 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 19 | 27 | 19 | 16 | 19 |
| | +8 | -8 | -3 | +3 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.5

+1.7

+3.2

-1.8

+2.0

+3.8

-5.5

+5.5

+11.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 2

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 14 | 18 | 19 | 20 | 19 | 18 | 14 | 14 | 14 | 13 | 14 | 14 | 15 |
| | +4 | +1 | +1 | -1 | -1 | -4 | 0 | 0 | -1 | +1 | 0 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 20 | 18 | 19 | 14 | 18 | 13 | 14 | 13 | 14 | 13 | 14 | 13 | 15 | 15 | 19 | 16 | 19 | 18 | 20 |
| | -2 | +1 | -5 | +4 | -5 | +1 | -1 | +1 | -1 | +1 | -1 | +2 | 0 | +4 | -3 | +3 | -1 | +2 |

93

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 14 | 20 | 14 | 13 | 14 |
| | +6 | -6 | -1 | +1 |

Asc Av

Des Av

Total Av

| | | | |
|--------|------|------|------|
| Ex. #1 | -1.2 | +1.3 | +2.5 |
| Ex. #2 | -2.1 | +2.1 | +4.2 |
| Ex. #3 | -3.5 | +3.5 | +7.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 2

| | | | | | | | | | | | | | |
|------------------|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| Exercise #1 | C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| Measurement* | 14 | 18 | 20 | 22 | 21 | 20 | 15 | 14 | 14 | 12 | 14 | 14 | 16 |
| Amount of Change | | +4 | +2 | +2 | -1 | -1 | -5 | -1 | 0 | -2 | +2 | 0 | +2 |

| | | | | | | | | | | | | | | | | | | | |
|--------|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 20 | 18 | 19 | 14 | 18 | 13 | 14 | 13 | 13 | 12 | 13 | 13 | 14 | 19 | 19 | 19 | 17 | 17 | 20 |
| Amt/Ch | | -2 | +1 | -5 | +4 | -5 | +1 | -1 | 0 | -1 | +1 | 0 | +1 | +5 | 0 | 0 | -2 | 0 | +3 |

76

| | | | | | | | | | |
|--------|----|----|----|-----|----|--------|--------|----------|------|
| Ex. #3 | C' | C | C' | C'' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 14 | 21 | 14 | 13 | 14 | Ex. #1 | -1.3 | +2.0 | +3.3 |
| Amt/Ch | | +7 | -7 | -1 | +1 | Ex. #2 | -1.0 | +1.0 | +2.0 |
| | | | | | | Ex. #3 | -4.0 | +4.0 | +8.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 3

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

| | | |
|------|------|------|
| -0.0 | +0.0 | +0.0 |
| -0.0 | +0.0 | +0.0 |
| -0.0 | +0.0 | +0.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 3

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

96

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 |

Asc Av

Des Av

Total Av

Ex. #1

-0.0

+0.0

+0.0

Ex. #2

-0.0

+0.0

+0.0

Ex. #3

-0.0

+0.0

+0.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 4

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|-----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C'' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 16 | 18 | 19 | 20 | 16 | 13 | 12 | 10 | 9 | 8 | 10 | 13 | 16 |
| | +2 | +1 | +1 | -4 | -3 | -1 | -2 | -1 | -1 | +2 | +3 | +3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 20 | 16 | 18 | 14 | 16 | 13 | 14 | 8 | 11 | 6 | 12 | 8 | 15 | 13 | 16 | 14 | 18 | 16 | 20 |
| | -4 | +2 | -4 | +2 | -3 | +1 | -6 | +3 | -5 | +6 | -4 | +7 | -2 | +3 | -2 | +4 | -2 | +4 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|-----|
| C' | C | C' | C'' | C' |
| 18 | 28 | 16 | 8 | 18 |
| | +10 | -12 | -8 | +10 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-2.0

-3.6

-10.0

+2.0

+3.6

+10.0

+4.0

+7.2

+20.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 4

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|-----|----|-----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 16 | 20 | 30 | 32 | 22 | 15 | 10 | 8 | 7 | 6 | 8 | 12 | 16 |
| | +4 | +10 | +2 | -10 | -7 | -5 | -2 | -1 | -1 | +2 | +4 | +4 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|-----|----|----|----|----|----|----|----|-----|----|----|----|----|-----|----|----|----|-----|
| C' | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 30 | 18 | 24 | 15 | 19 | 11 | 14 | 8 | 11 | 5 | 12 | 8 | 15 | 10 | 20 | 16 | 22 | 18 | 30 |
| | -12 | +6 | -9 | +4 | -8 | +3 | -6 | +3 | -6 | +7 | -4 | +7 | -5 | +10 | -4 | +6 | -4 | +12 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|-----|
| C' | C | C' | C'' | C' |
| 18 | 32 | 15 | 6 | 19 |
| | +14 | -17 | -9 | +13 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-4.3

-6.4

-13.0

+4.0

+6.4

+13.5

+8.3

+12.8

+26.5

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 5

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|-----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C'' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 16 | 16 | 16 | 16 | 16 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | +1 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 15 | 15 | 15 | 15 | 13 | 14 | 13 | 14 | 13 | 14 | 13 | 14 | 13 | 15 | 14 | 15 | 15 | 16 |
| | 0 | 0 | 0 | 0 | -2 | +1 | -1 | +1 | -1 | +1 | -1 | +1 | -1 | +2 | -1 | +1 | 0 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 19 | 20 | 19 | 15 | 19 |
| | +1 | -1 | -4 | +4 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.1

-0.8

-2.5

+0.1

+0.9

+2.5

+0.2

+1.7

+5.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 5

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 15 | 16 | 16 | 16 | 15 | 15 | 15 | 15 | 14 | 15 | 15 | 15 |
| | 0 | +1 | 0 | 0 | -1 | 0 | 0 | 0 | -1 | +1 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 14 | 14 | 13 | 14 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 15 | 14 | 15 | 14 | 15 |
| | -1 | 0 | -1 | +1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | +1 | 0 | +1 | -1 | +1 | -1 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 19 | 21 | 19 | 15 | 19 |
| | +2 | -2 | -4 | +4 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.3

-0.6

+3.0

+0.3

+0.6

+3.0

+0.6

+1.2

+6.0

100

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 6

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 |

Asc Av

Des Av

Total Av

Ex. #1

-0.0

+0.0

+0.0

Ex. #2

-0.0

+0.0

+0.0

Ex. #3

-0.0

+0.0

+0.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 6

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | -0.0 | +0.0 | +0.0 |
| Ex. #2 | -0.0 | +0.0 | +0.0 |
| Ex. #3 | -0.0 | +0.0 | +0.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 7

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 13 | 17 | 23 | 17 | 13 | 10 | 9 | 8 | 8 | 8 | 8 | 10 |
| | +3 | +4 | +6 | -6 | -4 | -3 | -1 | -1 | 0 | 0 | 0 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 21 | 14 | 16 | 10 | 14 | 9 | 10 | 9 | 9 | 7 | 9 | 9 | 10 | 9 | 14 | 10 | 15 | 14 | 23 |
| | -7 | +2 | -6 | +4 | -5 | +1 | -1 | 0 | -2 | +2 | 0 | +1 | -1 | +5 | -4 | +5 | -1 | +9 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|----|
| C' | C | C' | C'' | C' |
| 10 | 27 | 10 | 7 | 10 |
| | +17 | -17 | -3 | +3 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

| | | |
|-------|-------|-------|
| -2.5 | +2.5 | +5.0 |
| -3.0 | +3.2 | +6.2 |
| -10.0 | +10.0 | +20.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 7

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|-----|-----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 14 | 16 | 27 | 16 | 14 | 10 | 9 | 8 | 6 | 8 | 8 | 10 |
| | +4 | +2 | +11 | -11 | -2 | -4 | -1 | -1 | -2 | +2 | 0 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|-----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G' | C' | E | G | C |
| 18 | 14 | 20 | 10 | 14 | 11 | 10 | 12 | 11 | 9 | 11 | 13 | 11 | 11 | 15 | 11 | 18 | 14 | 22 |
| | -4 | +6 | -10 | +4 | -3 | -1 | +2 | -1 | -2 | +2 | +2 | -2 | 0 | +4 | -4 | +7 | -4 | +8 |

101

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|----|
| C' | C | C' | C'' | C' |
| 10 | 27 | 10 | 16 | 10 |
| | +17 | -17 | -4 | +4 |

Asc Av

Des Av

Total Av

Ex. #1

Ex. #2

Ex. #3

-3.5

-2.5

-10.5

+3.5

+3.0

+10.5

+7.0

+5.5

+21.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 8

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|-----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C'' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 4 | 7 | 7 | 7 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -3 | +3 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -4 | +4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 7 | 7 | 7 | 4 | 7 |
| | 0 | 0 | -3 | +3 |

Asc Av

Des Av

Total Av

Ex. #1

-0.5

+0.5

+1.0

Ex. #2

-0.4

+0.4

+0.8

Ex. #3

-1.5

+1.5

+3.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 8

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 3 | 7 | 7 | 7 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -4 | +4 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -4 | +4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 7 | 7 | 7 | 3 | 7 |
| | 0 | 0 | -4 | +4 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.7

-0.4

-2.0

+0.7

+0.4

+2.0

+1.4

+0.8

+4.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 9

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 20 | 19 | 19 | 18 | 19 | 19 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| | -1 | 0 | -1 | +1 | 0 | +1 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 19 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 19 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | +1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 20 | 18 | 20 | 20 | 20 |
| | -2 | +2 | 0 | 0 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | +0.3 | -0.3 | -0.6 |
| Ex. #2 | -0.1 | +0.0 | +0.1 |
| Ex. #3 | +1.0 | -1.0 | -2.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 9

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 19 | 20 | 20 | 20 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | +1 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 20 | 20 | 20 | 21 | 20 | 21 | 20 | 20 | 20 | 19 | 20 | 20 | 20 | 20 | 20 | 20 | 19 | 20 | 19 |
| | 0 | 0 | +1 | -1 | +1 | -1 | 0 | 0 | -1 | +1 | 0 | 0 | 0 | 0 | 0 | -1 | +1 | -1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 20 | 17 | 20 | 20 | 20 |
| | -3 | +3 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.2

+0.2

+1.5

+0.2

-0.4

-1.5

+0.4

-0.6

-3.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 10

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 23 | 23 | 23 | 23 | 23 |
| | 0 | 0 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.0

+0.0

+0.0

-0.0

+0.0

+0.0

-0.0

+0.0

+0.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 10

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 23 | 23 | 23 | 23 | 23 |
| | 0 | 0 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.0

+0.0

+0.0

-0.0

+0.0

+0.0

-0.0

+0.0

+0.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 11

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 7 | 9 | 9 | 9 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2 | +2 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 5 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -4 | +4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 9 | 9 | 9 | 3 | 9 |
| | 0 | 0 | -6 | +6 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.3 +0.3 +0.6

-0.4 +0.4 +0.8

-3.0 +3.0 +6.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 11

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 7 | 9 | 9 | 9 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2 | +2 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 6 | 7 | 5 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -3 | +1 | -2 | +4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 9 | 9 | 9 | 3 | 9 |
| | 0 | 0 | -6 | +6 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.3

-0.6

-3.0

+0.3

+0.6

+3.0

+0.6

+1.2

+6.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 12

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 12 | 13 | 13 | 14 | 13 | 13 | 12 | 9 | 7 | 5 | 8 | 11 | 12 |
| | +1 | 0 | +1 | -1 | 0 | -1 | -3 | -2 | -2 | +3 | +3 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 17 | 15 | 16 | 11 | 15 | 10 | 11 | 14 | 12 | 7 | 12 | 10 | 11 | 10 | 15 | 11 | 17 | 16 | 17 |
| | -2 | +1 | -5 | +4 | -5 | +1 | +3 | -2 | -5 | +5 | -2 | -1 | -1 | +5 | -4 | +6 | -1 | +1 |

113

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 12 | 15 | 12 | 5 | 12 |
| | +3 | -3 | -7 | +7 |

Asc Av

Des Av

Total Av

Ex. #1

-1.5

+1.5

+3.0

Ex. #2

-2.4

+2.4

+4.8

Ex. #3

-5.0

+5.0

+10.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 12

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 12 | 13 | 14 | 15 | 14 | 13 | 12 | 10 | 8 | 4 | 6 | 8 | 10 |
| | +1 | +1 | +1 | -1 | -1 | -1 | -2 | -2 | -4 | +2 | +2 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 16 | 14 | 15 | 11 | 15 | 9 | 10 | 7 | 9 | 4 | 11 | 8 | 10 | 9 | 14 | 11 | 16 | 15 | 16 |
| | -1 | +1 | -4 | +4 | -6 | +1 | -3 | +2 | -5 | +7 | -3 | +2 | -1 | +5 | -3 | +5 | -1 | +1 |

114

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 12 | 16 | 12 | 4 | 12 |
| | +4 | -4 | -8 | +8 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -1.8 | +1.5 | +3.3 |
| Ex. #2 | -3.1 | +3.1 | +6.2 |
| Ex. #3 | -6.0 | +6.0 | +12.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 13

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 18 | 19 | 19 | 19 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | +1 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 18 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | +1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

115

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 19 | 19 | 19 | 13 | 19 |
| | 0 | 0 | -6 | +6 |

Asc Av

Des Av

Total Av

Ex. #1

-0.2

+0.2

+0.4

Ex. #2

-0.1

+0.1

+0.2

Ex. #3

-3.0

+3.0

+6.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 13

| | | | | | | | | | | | | | |
|------------------|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| Exercise #1 | C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| Measurement* | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 17 | 19 | 19 | 19 |
| Amount of Change | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2 | +2 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | |
|--------|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 19 | 19 | 19 | 18 | 18 | 18 | 18 | 17 | 17 | 13 | 14 | 14 | 15 | 15 | 16 | 16 | 17 | 17 | 18 |
| Amt/Ch | | 0 | 0 | -1 | 0 | 0 | 0 | -1 | 0 | -4 | +1 | 0 | +1 | 0 | +1 | 0 | +1 | 0 | +1 |

| | | | | | | | | | |
|--------|----|----|----|-----|----|--------|--------|----------|------|
| Ex. #3 | C' | C | C' | C'' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 19 | 19 | 19 | 12 | 19 | Ex. #1 | -0.3 | +0.3 | +0.6 |
| Amt/Ch | | 0 | 0 | -7 | +7 | Ex. #2 | -0.7 | +0.6 | +1.3 |
| | | | | | | Ex. #3 | -3.5 | +3.5 | +7.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 14

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 15 | 15 | 15 | 15 | 14 | 15 | 14 | 15 | 12 | 15 | 15 | 16 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | -1 | +1 | -1 | +1 | -3 | +3 | 0 | +1 | -1 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 20 | 15 | 11 | 15 |
| | +5 | -5 | -4 | +4 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.0

-0.7

-4.5

+0.0

+0.7

+4.5

+0.0

+1.4

+9.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 14

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 15 | 15 | 15 | 15 | 14 | 15 | 14 | 15 | 11 | 15 | 15 | 16 | 15 | 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 | -1 | +1 | -1 | +1 | -4 | +4 | 0 | +1 | -1 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 21 | 15 | 12 | 15 |
| | +6 | -6 | -3 | +3 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.0

-0.8

-4.5

+0.0

+0.8

+4.5

+0.0

+1.6

+9.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 15

Exercise #1

| | | | | | | | | | | | | | |
|------------------|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| | C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| Measurement* | 33 | 33 | 33 | 35 | 33 | 33 | 33 | 33 | 33 | 27 | 33 | 33 | 33 |
| Amount of Change | | 0 | 0 | +2 | -2 | 0 | 0 | 0 | 0 | -6 | +6 | 0 | 0 |

Ex. #2

| | | | | | | | | | | | | | | | | | | | |
|--------|----|----|----|----|----|----|-----|----|----|------|----|----|----|----|----|----|----|----|----|
| | C | G | E | C' | G | E' | C'' | G' | E' | C''' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 27 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |
| Amt/Ch | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -6 | +6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

119

Ex. #3

| | | | | | |
|--------|----|----|----|-----|----|
| | C' | C | C' | C'' | C' |
| Meas. | 33 | 36 | 33 | 28 | 33 |
| Amt/Ch | | +3 | -3 | -5 | +5 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -1.3 | +1.3 | +2.6 |
| Ex. #2 | -0.6 | +0.6 | +1.2 |
| Ex. #3 | -4.0 | +4.0 | +8.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 15

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 33 | 33 | 33 | 36 | 33 | 33 | 33 | 33 | 33 | 26 | 33 | 33 | 33 |
| | 0 | 0 | +3 | -3 | 0 | 0 | 0 | 0 | -7 | +7 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 26 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -7 | +7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 33 | 35 | 33 | 28 | 33 |
| | +2 | -2 | -5 | +5 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.7 +1.7 +3.4

-0.8 +0.8 +1.6

-3.5 +3.5 +7.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 16

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 18 | 19 | 20 | 21 | 20 | 19 | 18 | 18 | 17 | 15 | 16 | 17 | 18 |
| | +1 | +1 | +1 | -1 | -1 | -1 | 0 | -1 | -2 | +1 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 22 | 21 | 22 | 20 | 21 | 20 | 21 | 20 | 20 | 19 | 20 | 20 | 21 | 21 | 20 | 20 | 21 | 21 | 22 |
| | -1 | +1 | -2 | +1 | -1 | +1 | -1 | 0 | -1 | +1 | 0 | +1 | 0 | -1 | 0 | +1 | 0 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 20 | 23 | 20 | 15 | 20 |
| | +3 | -3 | -5 | +5 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.0

-0.7

-4.0

+1.0

+0.9

+4.0

+2.0

+1.6

+8.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 16

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 20 | 21 | 21 | 22 | 21 | 20 | 19 | 18 | 17 | 15 | 18 | 18 | 20 |
| | +1 | 0 | +1 | -1 | -1 | -1 | -1 | -1 | -2 | +3 | 0 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 22 | 21 | 21 | 20 | 20 | 19 | 19 | 18 | 18 | 17 | 19 | 18 | 20 | 19 | 21 | 20 | 22 | 21 | 22 |
| | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | +2 | -1 | +2 | -1 | +2 | -1 | +2 | -1 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 20 | 22 | 20 | 14 | 20 |
| | +2 | -2 | -6 | +6 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.2

-1.0

-4.0

+1.2

+1.0

+4.0

+2.4

+2.0

+8.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 17

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 18 | 21 | 23 | 20 | 20 | 17 | 17 | 17 | 15 | 16 | 16 | 17 |
| | +3 | +3 | +2 | -3 | 0 | -3 | 0 | 0 | -2 | +1 | 0 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 19 | 19 | 19 | 18 | 19 | 17 | 18 | 17 | 17 | 15 | 17 | 17 | 18 | 18 | 18 | 18 | 18 | 18 | 19 |
| | 0 | 0 | -1 | +1 | -2 | +1 | -1 | 0 | -2 | +2 | 0 | +1 | 0 | 0 | 0 | 0 | 0 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 24 | 18 | 16 | 17 |
| | +9 | -6 | -2 | +1 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.3

-0.7

-4.0

+1.7

+0.7

+5.0

+3.0

+1.4

+9.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 17

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 17 | 19 | 21 | 19 | 19 | 17 | 16 | 16 | 15 | 16 | 17 | 18 |
| | +2 | +2 | +2 | -2 | 0 | -2 | -1 | 0 | -1 | +1 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 17 | 16 | 17 | 16 | 17 | 15 | 16 | 15 | 16 | 14 | 17 | 16 | 17 | 16 | 17 | 16 | 17 | 17 | 17 |
| | -1 | +1 | -1 | +1 | -2 | +1 | -1 | +1 | -2 | +3 | -1 | +1 | -1 | +1 | -1 | +1 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 22 | 19 | 17 | 18 |
| | +7 | -3 | -2 | +1 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

| | | |
|------|------|------|
| -1.0 | +1.5 | +2.5 |
| -1.7 | +1.7 | +3.4 |
| -2.5 | +4.0 | +6.5 |

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 18

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 19 | 20 | 21 | 24 | 21 | 20 | 19 | 18 | 17 | 14 | 17 | 18 | 19 |
| | +1 | +1 | +3 | -3 | -1 | -1 | -1 | -1 | -3 | +3 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 26 | 22 | 24 | 20 | 23 | 19 | 21 | 19 | 20 | 14 | 17 | 17 | 20 | 19 | 24 | 21 | 24 | 23 | 25 |
| | -4 | +2 | -4 | +3 | -4 | +2 | -2 | +1 | -6 | +3 | 0 | +3 | -1 | +5 | -3 | +3 | -1 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 20 | 26 | 20 | 16 | 20 |
| | +6 | -6 | -4 | +4 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.7

-2.8

-5.0

+1.7

+2.7

+5.0

+3.4

+5.5

+10.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 18

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 19 | 20 | 21 | 25 | 22 | 21 | 19 | 17 | 15 | 12 | 15 | 18 | 20 |
| | +1 | +1 | +4 | -3 | -1 | -2 | -2 | -2 | -3 | +3 | +3 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 25 | 22 | 24 | 19 | 22 | 21 | 20 | 16 | 18 | 12 | 18 | 16 | 21 | 18 | 22 | 20 | 24 | 22 | 26 |
| | -3 | +2 | -5 | +3 | -1 | -1 | -4 | +2 | -6 | +6 | -2 | +5 | -3 | +4 | -2 | +4 | -2 | +4 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 20 | 28 | 20 | 14 | 20 |
| | +8 | -8 | -6 | +6 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-2.2

-3.1

-7.0

+2.3

+3.4

+7.0

+4.5

+6.5

+14.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 19

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 8 | 4 | 8 | 9 | 10 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -1 | -1 | -4 | +4 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|---|----|---|---|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 10 | 10 | 10 | 10 | 10 | 9 | 9 | 8 | 9 | 3 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 9 |
| | 0 | 0 | 0 | 0 | -1 | 0 | -1 | +1 | -6 | +4 | 0 | +1 | 0 | 0 | 0 | 0 | 0 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 10 | 9 | 10 | 3 | 10 |
| | -1 | +1 | -7 | +7 |

Asc Av

Des Av

Total Av

Ex. #1

-1.0

+1.0

+2.0

Ex. #2

-0.8

+0.8

+1.6

Ex. #3

-3.0

+3.0

+6.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 19

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 8 | 3 | 7 | 8 | 9 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -1 | -1 | -5 | +4 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 12 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 3 | 4 | 4 | 8 | 8 | 10 | 10 | 10 | 10 | 10 |
| | -2 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | -6 | +1 | 0 | +4 | 0 | +2 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 10 | 9 | 10 | 2 | 10 |
| | -1 | +1 | -8 | +8 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.2

-1.0

-3.5

+1.0

+0.8

+3.5

+2.2

+1.8

+7.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 20

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 18 | 20 | 21 | 22 | 21 | 21 | 18 | 16 | 16 | 13 | 16 | 17 | 18 |
| | +2 | +1 | +1 | -1 | 0 | -3 | -2 | 0 | -3 | +3 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 22 | 19 | 20 | 18 | 20 | 17 | 18 | 16 | 17 | 15 | 17 | 16 | 18 | 17 | 19 | 18 | 21 | 20 | 23 |
| | -3 | +1 | -2 | +2 | -3 | +1 | -2 | +1 | -2 | +2 | -1 | +2 | -1 | +2 | -1 | +3 | -1 | +3 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 18 | 23 | 18 | 14 | 18 |
| | +5 | -5 | -4 | +4 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.5

-1.8

-4.5

+1.5

+1.9

+4.5

+3.0

+3.7

+9.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 20

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 18 | 21 | 22 | 23 | 23 | 22 | 19 | 17 | 17 | 14 | 16 | 17 | 19 |
| | +3 | +1 | +1 | 0 | -1 | -3 | -2 | 0 | -3 | +2 | +1 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 22 | 20 | 21 | 18 | 20 | 17 | 18 | 16 | 16 | 14 | 16 | 16 | 18 | 17 | 19 | 18 | 21 | 20 | 23 |
| | -2 | +1 | -3 | +2 | -3 | +1 | -2 | 0 | -2 | +2 | 0 | +2 | -1 | +2 | -1 | +3 | -1 | +3 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 18 | 25 | 18 | 13 | 18 |
| | +7 | -7 | -5 | +5 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | -1.5 | +1.7 | +3.2 |
| Ex. #2 | -1.7 | +1.7 | +3.4 |
| Ex. #3 | -6.0 | +6.0 | +12.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 21

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 23 | 23 | 24 | 24 | 24 | 24 | 23 | 22 | 22 | 20 | 21 | 21 | 22 |
| | 0 | +1 | 0 | 0 | 0 | -1 | -1 | 0 | -2 | +1 | 0 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 24 | 23 | 23 | 23 | 23 | 22 | 22 | 22 | 22 | 19 | 21 | 21 | 20 | 20 | 21 | 21 | 22 | 22 | 23 |
| | -1 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | -3 | +2 | 0 | -1 | 0 | +1 | 0 | +1 | 0 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 23 | 24 | 23 | 20 | 23 |
| | +1 | -1 | -3 | +3 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -0.7 | +0.5 | +1.2 |
| Ex. #2 | -0.6 | +0.7 | +1.3 |
| Ex. #3 | -2.0 | +2.0 | +4.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 21

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 23 | 23 | 24 | 24 | 24 | 24 | 23 | 22 | 21 | 20 | 21 | 21 | 22 |
| | 0 | +1 | 0 | 0 | 0 | -1 | -1 | -1 | -1 | +1 | 0 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 24 | 23 | 23 | 23 | 23 | 23 | 23 | 21 | 22 | 18 | 21 | 21 | 22 | 22 | 23 | 23 | 23 | 23 | 24 |
| | -1 | 0 | 0 | 0 | 0 | 0 | -2 | +1 | -4 | +3 | 0 | +1 | 0 | +1 | 0 | 0 | 0 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 23 | 25 | 23 | 19 | 23 |
| | +2 | -2 | -4 | +4 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.7

-0.8

-3.0

+0.5

+0.8

+3.0

+1.2

+1.6

+6.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 22

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | +1 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 6 | 6 | 6 | 7 | 6 |
| | 0 | 0 | +1 | -1 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.1

-0.0

+0.5

-0.0

+0.0

-0.5

-0.1

+0.0

-1.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 22

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

134

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 6 | 6 | 6 | 7 | 6 |
| | 0 | 0 | +1 | -1 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.0

-0.0

+0.5

+0.0

+0.0

-0.5

+0.0

+0.0

-1.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 23

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 16 | 17 | 18 | 17 | 16 | 15 | 14 | 14 | 11 | 13 | 13 | 15 |
| | +1 | +1 | +1 | -1 | -1 | -1 | -1 | 0 | -3 | +2 | 0 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 19 | 17 | 18 | 15 | 16 | 14 | 15 | 13 | 13 | 11 | 13 | 13 | 15 | 14 | 16 | 16 | 18 | 18 | 20 |
| | -2 | +1 | -3 | +1 | -2 | +1 | -2 | 0 | -2 | +2 | 0 | +2 | -1 | +2 | 0 | +2 | 0 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 21 | 15 | 11 | 15 |
| | +6 | -6 | -4 | +4 |

Asc Av

Des Av

Total Av

Ex. #1

-1.2

+1.2

+2.4

Ex. #2

-1.3

+1.4

+2.7

Ex. #3

-5.0

+5.0

+10.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 23

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 16 | 17 | 18 | 17 | 16 | 15 | 14 | 14 | 12 | 13 | 13 | 14 |
| | +1 | +1 | +1 | -1 | -1 | -1 | -1 | 0 | -2 | +1 | 0 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 19 | 17 | 17 | 15 | 16 | 14 | 15 | 13 | 14 | 11 | 14 | 13 | 15 | 14 | 18 | 17 | 19 | 19 | 20 |
| | -2 | 0 | -2 | +1 | -2 | +1 | -2 | +1 | -3 | +3 | -1 | +2 | -1 | +4 | -1 | +2 | 0 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 22 | 15 | 10 | 15 |
| | +7 | -7 | -5 | +5 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.0

-1.6

-6.0

+0.8

+1.7

+6.0

+1.8

+3.3

+12.0

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 24

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 20 | 21 | 21 | 22 | 21 | 21 | 20 | 19 | 18 | 17 | 19 | 19 | 20 |
| | +1 | 0 | +1 | -1 | 0 | -1 | -1 | -1 | -1 | +2 | 0 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 22 | 21 | 21 | 20 | 20 | 19 | 19 | 18 | 18 | 16 | 18 | 17 | 19 | 18 | 20 | 20 | 21 | 21 | 23 |
| | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -2 | +2 | -1 | +2 | -1 | +2 | 0 | +1 | 0 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 20 | 24 | 20 | 17 | 20 |
| | +4 | -4 | -3 | +3 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.7

-0.9

-3.5

+0.8

+1.0

+3.5

+1.5

+1.9

+7.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 24

| | | | | | | | | | | | | | |
|------------------|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| Exercise #1 | C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| Measurement* | 20 | 21 | 22 | 23 | 22 | 21 | 20 | 19 | 18 | 16 | 18 | 19 | 20 |
| Amount of Change | | +1 | +1 | +1 | -1 | -1 | -1 | -1 | -1 | -2 | +2 | +1 | +1 |

| | | | | | | | | | | | | | | | | | | | |
|--------|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 23 | 22 | 22 | 20 | 21 | 19 | 20 | 18 | 19 | 16 | 18 | 17 | 19 | 18 | 20 | 19 | 21 | 21 | 23 |
| Amt/Ch | | -1 | 0 | -2 | +1 | -2 | +1 | -2 | +1 | -3 | +2 | -1 | +2 | -1 | +2 | -1 | +2 | 0 | +2 |

| | | | | | | | | | |
|--------|----|----|----|-----|----|--------|--------|----------|------|
| Ex. #3 | C' | C | C' | C'' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 20 | 24 | 20 | 17 | 20 | Ex. #1 | -1.2 | +1.2 | +2.4 |
| Amt/Ch | | +4 | -4 | -3 | +3 | Ex. #2 | -1.4 | +1.4 | +2.8 |
| | | | | | | Ex. #3 | -3.5 | +3.5 | +7.0 |

* in millimeters

APPENDIX C

TEETH APERTURE - TONGUED

Subject # 25

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 20 | 21 | 21 | 22 | 21 | 21 | 20 | 19 | 19 | 18 | 19 | 19 | 20 |
| | +1 | 0 | +1 | -1 | 0 | -1 | -1 | 0 | -1 | +1 | 0 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 21 | 20 | 20 | 19 | 20 | 18 | 19 | 17 | 17 | 15 | 17 | 17 | 19 | 18 | 20 | 19 | 21 | 20 | 22 |
| | -1 | 0 | -1 | +1 | -2 | +1 | -2 | 0 | -2 | +2 | 0 | +2 | -1 | +2 | -1 | +2 | -1 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 17 | 22 | 17 | 12 | 17 |
| | +5 | -5 | -5 | +5 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.7

-1.2

-5.0

+0.7

+1.3

+5.0

+1.4

+2.5

+10.0

* in millimeters

APPENDIX C

TEETH APERTURE - SLURRED

Subject # 25

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 20 | 21 | 21 | 22 | 21 | 21 | 20 | 19 | 19 | 17 | 18 | 19 | 20 |
| | +1 | 0 | +1 | -1 | 0 | -1 | -1 | 0 | -2 | +1 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 22 | 20 | 21 | 19 | 20 | 18 | 19 | 18 | 18 | 16 | 18 | 18 | 20 | 19 | 21 | 20 | 22 | 21 | 23 |
| | -2 | +1 | -2 | +1 | -2 | +1 | -1 | 0 | -2 | +2 | 0 | +2 | -1 | +2 | -1 | +2 | -1 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 17 | 23 | 17 | 12 | 17 |
| | +6 | -6 | -5 | +5 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.8

-1.3

-5.5

+0.8

+1.4

+5.5

+1.6

+2.7

+11.0

* in millimeters

071

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 1

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 19 | 12 | 10 | 4 | 10 | 12 | 19 | 22 | 23 | 26 | 23 | 22 | 19 |
| | -7 | -2 | -6 | +6 | +2 | +7 | +3 | +1 | +3 | -3 | -1 | -3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|-----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|-----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 4 | 17 | 13 | 19 | 17 | 21 | 19 | 22 | 21 | 26 | 21 | 22 | 19 | 21 | 17 | 19 | 13 | 17 | 4 |
| | +13 | -4 | +6 | -2 | +4 | -2 | +3 | -1 | +5 | -5 | +1 | -3 | +2 | -4 | +2 | -6 | +4 | -13 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|----|
| C' | C | C' | C'' | C' |
| 22 | 2 | 22 | 28 | 22 |
| | -20 | +20 | +6 | -6 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+3.7

+4.7

+13.0

-3.8

-4.7

-13.0

+7.5

+9.4

+26.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 1

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 19 | 11 | 9 | 3 | 9 | 11 | 19 | 22 | 24 | 25 | 24 | 22 | 19 |
| | -8 | -2 | -6 | +6 | +2 | +8 | +3 | +2 | +1 | -1 | -2 | -3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|-----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|-----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 4 | 14 | 11 | 19 | 14 | 21 | 19 | 23 | 21 | 25 | 21 | 23 | 19 | 21 | 14 | 19 | 11 | 14 | 4 |
| | +10 | -3 | +8 | -5 | +7 | -2 | +4 | -2 | +4 | -4 | +2 | -4 | +2 | -7 | +5 | -8 | +3 | -10 |

142

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|----|
| C' | C | C' | C'' | C' |
| 19 | 3 | 19 | 26 | 19 |
| | -16 | +16 | +7 | -7 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | +3.7 | -3.7 | +7.4 |
| Ex. #2 | +5.0 | -5.0 | +10.0 |
| Ex. #3 | +11.5 | -11.5 | +23.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 2

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 11 | 10 | 9 | 9 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | +1 | +1 | -1 | -1 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 6 | 8 | 7 | 9 | 8 | 10 | 9 | 11 | 10 | 12 | 10 | 11 | 9 | 10 | 8 | 9 | 7 | 8 | 6 |
| | +2 | -1 | +2 | -1 | +2 | -1 | +2 | -1 | +2 | -2 | +1 | -2 | +1 | -2 | +1 | -2 | +1 | -2 |

143

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 9 | 7 | 9 | 13 | 9 |
| | -2 | +2 | +4 | -4 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.3 -0.3 +0.6

+1.6 -1.6 +3.2

+3.0 -3.0 +6.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 2

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|---|----|----|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 9 | 8 | 8 | 7 | 8 | 8 | 9 | 10 | 11 | 12 | 11 | 10 | 9 |
| | -1 | 0 | -1 | +1 | 0 | +1 | +1 | +1 | +1 | -1 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 6 | 8 | 7 | 9 | 8 | 10 | 9 | 11 | 10 | 12 | 10 | 11 | 9 | 10 | 8 | 9 | 7 | 8 | 6 |
| | +2 | -1 | +2 | -1 | +2 | -1 | +2 | -1 | +2 | -2 | +1 | -2 | +1 | -2 | +1 | -2 | +1 | -2 |

111

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 9 | 7 | 9 | 13 | 9 |
| | -2 | +2 | -4 | +4 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | +0.8 | -0.8 | +1.6 |
| Ex. #2 | +1.6 | -1.6 | +3.2 |
| Ex. #3 | +3.0 | -3.0 | +6.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 3

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 11 | 9 | 7 | 5 | 7 | 9 | 11 | 12 | 12 | 13 | 12 | 12 | 11 |
| | -2 | -2 | -2 | +2 | +2 | +2 | +1 | 0 | +1 | -2 | 0 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 5 | 9 | 7 | 11 | 9 | 12 | 12 | 13 | 13 | 14 | 13 | 13 | 12 | 12 | 9 | 11 | 7 | 9 | 5 |
| | +4 | -2 | +4 | -2 | +3 | 0 | +1 | 0 | +1 | -1 | 0 | -1 | 0 | -3 | +2 | -4 | +2 | -4 |

145

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 11 | 5 | 11 | 13 | 11 |
| | -6 | +6 | +2 | -2 |

Asc Av

Des Av

Total Av

Ex. #1

Ex. #2

Ex. #3

+1.3

+1.9

+4.0

-1.3

-1.9

-4.0

+2.6

+3.8

+8.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 3

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 11 | 9 | 7 | 5 | 7 | 9 | 11 | 12 | 12 | 13 | 12 | 12 | 11 |
| | -2 | -2 | -2 | +2 | +2 | +2 | +1 | 0 | +1 | -1 | 0 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 4 | 8 | 6 | 11 | 10 | 12 | 11 | 13 | 12 | 14 | 12 | 13 | 11 | 12 | 9 | 11 | 6 | 8 | 4 |
| | +4 | -2 | +5 | -1 | +2 | -1 | +2 | -1 | +2 | -2 | +1 | -2 | +1 | -3 | +2 | -5 | +2 | -4 |

146

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 11 | 5 | 11 | 13 | 11 |
| | -6 | +6 | +2 | -2 |

Ex. #1

Ex. #2

Ex. #3

| | | |
|--------|--------|----------|
| Asc Av | Des Av | Total Av |
| +1.3 | -1.3 | +2.6 |
| +2.3 | -2.3 | +4.6 |
| +4.0 | -4.0 | +8.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 4

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 13 | 12 | 11 | 10 | 11 | 12 | 13 | 14 | 14 | 15 | 14 | 13 | 12 |
| | -1 | -1 | -1 | +1 | +1 | +1 | +1 | 0 | +1 | -1 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 10 | 12 | 11 | 13 | 12 | 14 | 14 | 15 | 15 | 16 | 15 | 15 | 14 | 14 | 13 | 13 | 12 | 12 | 11 |
| | +2 | -1 | +2 | -1 | +2 | 0 | +1 | 0 | +1 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -1 |

117

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 13 | 4 | 13 | 15 | 13 |
| | -9 | +9 | +2 | -2 |

Asc Av

Des Av

Total Av

Ex. #1

Ex. #2

Ex. #3

+0.8

+0.9

+5.5

-1.0

-0.8

-5.5

+1.8

+1.7

+11.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 4

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 13 | 12 | 11 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 15 | 14 | 13 |
| | -1 | -1 | -1 | +1 | +1 | +1 | +1 | +1 | +1 | -1 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 10 | 12 | 12 | 13 | 12 | 13 | 13 | 14 | 14 | 16 | 14 | 15 | 13 | 11 | 12 | 10 | 11 | 9 | 10 |
| | +2 | 0 | +1 | -1 | +1 | 0 | +1 | 0 | +2 | -2 | +1 | -2 | -2 | +1 | -2 | +1 | -2 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | G' | C'' | C' |
| 13 | 4 | 13 | 15 | 13 |
| | -9 | +9 | +2 | -2 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+1.0

+0.2

+5.5

-1.0

-0.2

-5.5

+2.0

+0.4

+11.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 5

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 11 | 11 | 11 | 11 | 11 |
| 0 | 0 | 0 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

| | | |
|------|------|------|
| +0.0 | -0.0 | +0.0 |
| +0.0 | -0.0 | +0.0 |
| +0.0 | -0.0 | +0.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 5

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

150

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 11 | 11 | 11 | 11 | 11 |
| | 0 | 0 | 0 | 0 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | +0.0 | -0.0 | +0.0 |
| Ex. #2 | +0.0 | -0.0 | +0.0 |
| Ex. #3 | +0.0 | -0.0 | +0.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 6

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

151

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 6 | 6 | 6 | 6 | 6 |
| | 0 | 0 | 0 | 0 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | +0.0 | -0.0 | +0.0 |
| Ex. #2 | +0.0 | -0.0 | +0.0 |
| Ex. #3 | +0.0 | -0.0 | +0.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 6

| | | | | | | | | | | | | | |
|------------------|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| Exercise #1 | C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| Measurement* | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Amount of Change | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | |
|--------|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Amt/Ch | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

152

| | | | | | | | | | |
|--------|----|---|----|-----|----|--------|--------|----------|------|
| Ex. #3 | C' | C | C' | C'' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 6 | 6 | 6 | 6 | 6 | Ex. #1 | +0.0 | -0.0 | +0.0 |
| Amt/Ch | | 0 | 0 | 0 | 0 | Ex. #2 | +0.0 | -0.0 | +0.0 |
| | | | | | | Ex. #3 | +0.0 | -0.0 | +0.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 7

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|----|----|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 | 7 | 6 | 6 | 6 |
| | 0 | 0 | -1 | +1 | 0 | 0 | 0 | 0 | +1 | -1 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | |
|--------|---|----|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 |
| Amt/Ch | | +1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | +1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 |

153

| | | | | | |
|--------|----|----|----|-----|----|
| Ex. #3 | C' | C | C' | C'' | C' |
| Meas. | 6 | 5 | 6 | 7 | 6 |
| Amt/Ch | | -1 | +1 | +1 | -1 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | +0.3 | -0.3 | +0.6 |
| Ex. #2 | +0.2 | -0.2 | +0.4 |
| Ex. #3 | +1.0 | -1.0 | +2.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 7

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|----|----|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 | 7 | 6 | 6 | 6 |
| | 0 | 0 | -1 | +1 | 0 | 0 | 0 | 0 | +1 | -1 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 |
| | +1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | +1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 |

154

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 6 | 5 | 6 | 7 | 6 |
| | -1 | +1 | +1 | -1 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | +0.3 | -0.3 | +0.6 |
| Ex. #2 | +0.2 | -0.2 | +0.4 |
| Ex. #3 | +1.0 | -1.0 | +2.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 8

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 0 | -1 | -2 | -3 | -2 | -1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| | -1 | -1 | -1 | +1 | +1 | +1 | +1 | 0 | 0 | 0 | 0 | -1 |

| | | | | | | | | | | | | | | | | | | | |
|--------|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | -3 | -2 | -2 | -1 | -1 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 0 | 0 | -1 | -1 | -2 | -2 | -4 |
| Amt/Ch | | +1 | 0 | +1 | 0 | +1 | 0 | +1 | 0 | +1 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -2 |

| | | | | | | | | | |
|--------|----|----|----|-----|----|--------|--------|----------|------|
| Ex. #3 | C' | C | C' | C'' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 0 | -3 | 0 | +2 | 0 | Ex. #1 | +0.7 | -0.7 | +1.4 |
| Amt/Ch | | -3 | +3 | +2 | -2 | Ex. #2 | +0.6 | -0.7 | +1.3 |
| | | | | | | Ex. #3 | +2.5 | -2.5 | +5.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 8

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 0 | -1 | -2 | -3 | -2 | -1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| | -1 | -1 | -1 | +1 | +1 | +1 | +1 | 0 | 0 | 0 | 0 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| -3 | -2 | -2 | -1 | -1 | 0 | 0 | +1 | +1 | +2 | 0 | +1 | -1 | 0 | -2 | -1 | -3 | -2 | -4 |
| | +1 | 0 | +1 | 0 | +1 | 0 | +1 | 0 | +1 | -2 | +1 | -2 | +1 | -2 | +1 | -2 | +1 | -2 |

156

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 0 | -3 | 0 | +2 | 0 |
| | -3 | +3 | +2 | -2 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.7

+1.0

+2.5

-0.7

-1.1

-2.5

+1.4

+2.1

+5.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 9

| | | | | | | | | | | | | | |
|------------------|----|----|---|----|----|---|----|----|----|-----|----|----|----|
| Exercise #1 | C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| Measurement* | 4 | 5 | 5 | 6 | 5 | 5 | 4 | 3 | 3 | 3 | 3 | 4 | 4 |
| Amount of Change | | +1 | 0 | +1 | -1 | 0 | -1 | -1 | 0 | 0 | 0 | +1 | +1 |

| | | | | | | | | | | | | | | | | | | | |
|--------|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|---|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 6 | 5 | 6 | 4 | 5 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 5 | 4 | 5 | 5 | 6 |
| Amt/Ch | | -1 | +1 | -2 | +1 | -2 | +1 | -1 | 0 | 0 | 0 | 0 | +1 | 0 | +1 | -1 | +1 | 0 | +1 |

157

| | | | | | | | | | |
|--------|----|----|----|-----|----|--------|--------|----------|------|
| Ex. #3 | C' | C | C' | C'' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 4 | 6 | 4 | 3 | 4 | Ex. #1 | -0.5 | +0.5 | -1.0 |
| Amt/Ch | | +2 | -2 | -1 | +1 | Ex. #2 | -0.8 | +0.8 | -1.6 |
| | | | | | | Ex. #3 | -1.5 | +1.5 | -3.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 9

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|---|----|----|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 4 | 5 | 5 | 6 | 5 | 5 | 4 | 4 | 4 | 3 | 4 | 4 | 5 |
| | +1 | 0 | +1 | -1 | 0 | -1 | 0 | 0 | -1 | +1 | 0 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|---|----|----|----|----|-----|----|----|----|----|----|----|----|---|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 6 | 5 | 6 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| | -1 | +1 | -2 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | +1 | 0 | +1 | 0 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 4 | 6 | 4 | 3 | 4 |
| | +2 | -2 | -1 | +1 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-0.5

-0.4

-1.5

+0.7

+0.4

+1.5

-1.2

-0.8

-3.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 10

| | | | | | | | | | | | | | |
|------------------|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| Exercise #1 | C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| Measurement* | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Amount of Change | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | |
|--------|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|----|---|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G' | C |
| Meas. | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Amt/Ch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

159

| | | | | | | | | | |
|--------|----|---|----|-----|----|--------|--------|----------|------|
| Ex. #3 | C' | C | C' | C'' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 2 | 2 | 2 | 2 | 2 | Ex. #1 | +0.0 | -0.0 | +0.0 |
| Amt/Ch | 0 | 0 | 0 | 0 | 0 | Ex. #2 | +0.0 | -0.0 | +0.0 |
| | | | | | | Ex. #3 | +0.0 | -0.0 | +0.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 10

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 2 | 2 | 2 | 2 | 2 |
| 0 | 0 | 0 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.0

+0.0

+0.0

-0.0

-0.0

-0.0

+0.0

+0.0

+0.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 11

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 2 | 2 | 2 | 2 | 2 |
| 0 | 0 | 0 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.0 -0.0 +0.0

+0.0 -0.0 +0.0

+0.0 -0.0 +0.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 11

Exercise #1

| | | | | | | | | | | | | | |
|------------------|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| | C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| Measurement* | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Amount of Change | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | |
|--------|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Amt/Ch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

162

| | | | | | | | | | |
|--------|----|---|----|-----|----|--------|--------|--------|----------|
| Ex. #3 | C' | C | C' | C'' | C' | | Asc Av | Des Av | Total Av |
| Meas. | 2 | 2 | 2 | 2 | 2 | Ex. #1 | +0.0 | -0.0 | +0.0 |
| Amt/Ch | 0 | 0 | 0 | 0 | 0 | Ex. #2 | +0.0 | -0.0 | +0.0 |
| | | | | | | Ex. #3 | +0.0 | -0.0 | +0.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 12

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 9 | 8 | 6 | 3 | 5 | 7 | 9 | 10 | 10 | 10 | 10 | 10 | 9 |
| | -1 | -2 | -3 | +2 | +2 | +2 | +1 | 0 | 0 | 0 | 0 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 3 | 7 | 5 | 9 | 7 | 11 | 10 | 11 | 11 | 11 | 11 | 11 | 10 | 11 | 7 | 9 | 5 | 7 | 2 |
| | +4 | -2 | +4 | -2 | +4 | -1 | +1 | 0 | 0 | 0 | 0 | -1 | +1 | -4 | +2 | -4 | +2 | -5 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 9 | 3 | 9 | 9 | 9 |
| | -6 | +6 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+1.2

+2.0

+3.0

-1.2

-2.1

-3.0

+2.4

+4.1

+6.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 12

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 9 | 7 | 5 | 2 | 5 | 7 | 9 | 10 | 10 | 10 | 10 | 10 | 9 |
| | -2 | -2 | -3 | +3 | +2 | +2 | +1 | 0 | 0 | 0 | 0 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 4 | 6 | 5 | 9 | 8 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 9 | 10 | 5 | 7 | 3 |
| | +2 | -1 | +4 | -1 | +2 | 0 | +1 | 0 | 0 | 0 | 0 | 0 | 0 | -2 | +1 | -5 | +2 | -4 |

791

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 9 | 3 | 9 | 10 | 9 |
| | -6 | +6 | +1 | -1 |

Asc Av

Des Av

Total Av

Ex. #1

Ex. #2

Ex. #3

+1.3

+1.3

+3.5

-1.3

-1.4

-3.5

+2.6

+2.7

+7.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 13

| | | | | | | | | | | | | | |
|------------------|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| Exercise #1 | C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| Measurement* | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Amount of Change | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | |
|--------|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 8 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Amt/Ch | | 0 | 0 | 0 | 0 | +1 | -1 | +1 | -1 | -1 | +1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

165

| | | | | | | | | | |
|--------|----|---|----|-----|----|--------|--------|----------|------|
| Ex. #3 | C' | C | C' | C'' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 8 | 8 | 8 | 7 | 8 | Ex. #1 | +0.0 | -0.0 | +0.0 |
| Amt/Ch | 0 | 0 | 0 | -1 | +1 | Ex. #2 | +0.1 | -0.1 | +0.2 |
| | | | | | | Ex. #3 | -0.5 | +0.5 | -1.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 13

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 8 | 7 | 6 | 5 | 6 | 7 | 8 | 8 | 8 | 7 | 8 | 8 | 8 |
| | -1 | -1 | -1 | +1 | +1 | +1 | 0 | 0 | -1 | +1 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 8 | 9 | 8 | 9 | 8 | 9 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 |
| | +1 | -1 | +1 | -1 | +1 | -1 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | +1 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 8 | 7 | 8 | 7 | 8 |
| | -1 | +1 | -1 | +1 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

| | | |
|------|------|------|
| +0.3 | -0.3 | +0.6 |
| +0.2 | -0.2 | +0.4 |
| +0.0 | -0.0 | +0.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 14

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 0 | -2 | -3 | -4 | -3 | -2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | -2 | -1 | -1 | +1 | +1 | +2 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C' |
| -2 | -2 | -2 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | -1 | -1 | -1 | -2 |
| | 0 | 0 | +2 | -1 | +1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | -1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 0 | -7 | 0 | 0 | 0 |
| | -7 | +7 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

| | | |
|------|------|------|
| +0.7 | -0.7 | +1.4 |
| +0.3 | -0.3 | +0.6 |
| +3.5 | -3.5 | +7.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 14

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 0 | -2 | -3 | -4 | -2 | -1 | 0 | 1 | 1 | 1 | 1 | 0 | -1 |
| | -2 | -1 | -1 | +2 | +1 | +1 | +1 | 0 | 0 | 0 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| -2 | -1 | -2 | 0 | -1 | +1 | 0 | 1 | 0 | 0 | 0 | 0 | -1 | 0 | -1 | -1 | -2 | -2 | -3 |
| | +1 | -1 | +2 | -1 | +2 | -1 | +1 | -1 | 0 | 0 | 0 | -1 | +1 | -1 | 0 | -1 | 0 | -1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 0 | -7 | 0 | 0 | -5 |
| | -7 | +7 | 0 | -5 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.8 -1.0 +1.8

+0.8 -0.9 +1.7

+3.5 -6.0 +9.5

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 15

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

169

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 2 | 2 | 2 | 2 | 2 |
| 0 | 0 | 0 | 0 | 0 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | +0.0 | -0.0 | +0.0 |
| Ex. #2 | +0.0 | -0.0 | +0.0 |
| Ex. #3 | +0.0 | -0.0 | +0.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 15

| | | | | | | | | | | | | | |
|------------------|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| Exercise #1 | C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| Measurement* | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Amount of Change | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | |
|--------|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Amt/Ch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

170

| | | | | | | | | | |
|--------|----|---|----|-----|----|--------|--------|----------|------|
| Ex. #3 | C' | C | C' | C'' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 2 | 2 | 2 | 2 | 2 | Ex. #1 | +0.0 | -0.0 | +0.0 |
| Amt/Ch | 0 | 0 | 0 | 0 | 0 | Ex. #2 | +0.0 | -0.0 | +0.0 |
| | | | | | | Ex. #3 | +0.0 | -0.0 | +0.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 16

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

171

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 12 | 12 | 12 | 12 | 12 |
| 0 | 0 | 0 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

| | | |
|------|------|------|
| +0.0 | -0.0 | +0.0 |
| +0.0 | -0.0 | +0.0 |
| +0.0 | -0.0 | +0.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 16

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

172'

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 12 | 12 | 12 | 12 | 12 |
| 0 | 0 | 0 | 0 | 0 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | +0.0 | -0.0 | +0.0 |
| Ex. #2 | +0.0 | -0.0 | +0.0 |
| Ex. #3 | +0.0 | -0.0 | +0.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 17

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 8 | 8 | 8 | 8 | 8 |
| 0 | 0 | 0 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.0 -0.0 +0.0

+0.0 -0.0 +0.0

+0.0 -0.0 +0.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 17

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

174

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 8 | 8 | 8 | 8 | 8 |
| 0 | 0 | 0 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.0

-0.0

+0.0

+0.0

-0.0

+0.0

+0.0

-0.0

+0.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 18

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 0 | -1 | -2 | -2 | -2 | -1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| | -1 | -1 | 0 | 0 | +1 | +1 | +1 | 0 | 0 | 0 | -1 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| -3 | -1 | -2 | 0 | -1 | 0 | -1 | 0 | -1 | +2 | 1 | 1 | 0 | 0 | -1 | -1 | -2 | -2 | -3 |
| | +2 | -1 | +2 | -1 | +1 | -1 | +1 | -1 | +3 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 0 | -2 | 0 | +2 | 0 |
| | -2 | +2 | +2 | -2 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

| | | |
|------|------|------|
| +0.5 | -0.5 | +1.0 |
| +1.0 | -1.0 | +2.0 |
| +2.0 | -2.0 | +4.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 18

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 0 | -1 | -1 | -2 | -1 | -1 | 0 | 1 | 2 | 3 | 2 | 1 | 0 |
| | -1 | 0 | -1 | +1 | 0 | +1 | +1 | +1 | +1 | -1 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| -3 | -1 | -2 | 0 | -1 | 0 | -1 | 0 | -1 | +2 | 1 | 1 | -1 | -1 | -2 | -1 | -2 | -2 | -3 |
| | +2 | -1 | +2 | -1 | +1 | -1 | +1 | -1 | +3 | -1 | 0 | -2 | 0 | -1 | +1 | -1 | 0 | -1 |

176

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 0 | -3 | 0 | 3 | 0 |
| | -3 | +3 | +3 | -3 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | +0.8 | -0.8 | +1.6 |
| Ex. #2 | +1.1 | -1.1 | +2.2 |
| Ex. #3 | +3.0 | -3.0 | +6.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 19

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 21 | 20 | 19 | 17 | 18 | 18 | 20 | 21 | 21 | 23 | 22 | 22 | 21 |
| | -1 | -1 | -2 | +1 | 0 | +2 | +1 | 0 | +2 | -1 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 17 | 19 | 17 | 21 | 19 | 21 | 20 | 22 | 21 | 23 | 21 | 22 | 20 | 21 | 19 | 20 | 18 | 19 | 17 |
| | +2 | -2 | +4 | -2 | +2 | -1 | +2 | -1 | +2 | -2 | +1 | -2 | +1 | -2 | +1 | -2 | +1 | -2 |

177

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 21 | 15 | 21 | 24 | 21 |
| | -6 | +6 | +3 | -3 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+1.0

+1.8

+4.5

-1.0

-1.8

-4.5

+2.0

+3.6

+9.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 19

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 21 | 19 | 17 | 16 | 17 | 19 | 20 | 21 | 21 | 23 | 22 | 21 | 20 |
| | -2 | -2 | -1 | +1 | +2 | +1 | +1 | 0 | +2 | -1 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 17 | 19 | 18 | 20 | 19 | 21 | 21 | 23 | 22 | 25 | 23 | 24 | 22 | 22 | 20 | 20 | 18 | 18 | 16 |
| | +2 | -1 | +2 | -1 | +2 | 0 | +2 | -1 | +3 | -2 | +1 | -2 | 0 | -2 | 0 | -2 | 0 | -2 |

178

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 21 | 15 | 21 | 25 | 21 |
| | -6 | +6 | +4 | -4 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | +1.2 | -1.3 | +2.5 |
| Ex. #2 | +1.3 | -1.4 | +2.7 |
| Ex. #3 | +5.0 | -5.0 | +10.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 20

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 9 | 8 | 7 | 8 | 9 | 10 | 11 | 11 | 12 | 11 | 10 | 9 |
| | -1 | -1 | -1 | +1 | +1 | +1 | +1 | 0 | +1 | -1 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|---|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 7 | 9 | 8 | 10 | 9 | 11 | 10 | 11 | 10 | 12 | 11 | 11 | 10 | 10 | 9 | 9 | 8 | 8 | 7 |
| | +2 | -1 | +2 | -1 | +2 | -1 | +1 | -1 | +2 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 10 | 8 | 10 | 11 | 10 |
| | -2 | +2 | +1 | -1 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.8

+1.0

+1.5

-1.0

-1.0

-1.5

+1.8

+2.0

+3.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 20

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 9 | 8 | 7 | 8 | 9 | 10 | 11 | 11 | 12 | 11 | 11 | 10 |
| | -1 | -1 | -1 | +1 | +1 | +1 | +1 | 0 | +1 | -1 | 0 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 8 | 9 | 7 | 10 | 8 | 11 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 9 | 10 | 8 | 9 | 7 |
| | +1 | -2 | +3 | -2 | +3 | -1 | +1 | 0 | 0 | 0 | 0 | 0 | 0 | -2 | +1 | -2 | +1 | -2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 10 | 6 | 10 | 11 | 10 |
| | -4 | +4 | +1 | -1 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.8

+1.1

+2.5

-0.8

-1.2

-2.5

+1.6

+2.3

+5.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 21

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 11 | 11 | 11 | 10 | 9 |
| | 0 | 0 | 0 | 0 | 0 | 0 | +1 | +1 | 0 | 0 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 8 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| | +1 | -1 | +1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 9 | 6 | 9 | 12 | 9 |
| | -3 | +3 | +3 | -3 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

| | | |
|------|------|------|
| +0.3 | -0.3 | +0.6 |
| +0.2 | -0.1 | +0.3 |
| +3.0 | -3.0 | +6.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 21

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|----|----|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 9 | 9 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 9 |
| | 0 | 0 | -1 | +1 | 0 | 0 | 0 | 0 | +1 | 0 | 0 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|---|----|---|----|----|----|----|-----|----|----|----|----|----|----|----|---|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 7 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 8 | 8 | 7 |
| | +1 | 0 | +1 | 0 | 0 | 0 | 0 | 0 | +1 | 0 | 0 | 0 | 0 | -1 | 0 | -1 | 0 | -1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 9 | 6 | 9 | 13 | 9 |
| | -3 | +3 | +4 | -4 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.3

-0.3

+0.6

+0.3

-0.3

+0.6

+3.5

-3.5

+7.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 22

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 8 | 7 | 6 | 5 | 6 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| | -1 | -1 | -1 | +1 | +1 | +1 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|---|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 5 | 7 | 6 | 8 | 7 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 7 | 7 | 6 | 6 | 5 |
| | +2 | -1 | +2 | -1 | +2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2 | 0 | -1 | 0 | -1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|----|
| C' | C | C' | C'' | C' |
| 8 | 18 | 8 | 8 | 8 |
| | +10 | -10 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.5 -0.5 +1.0

+0.7 -0.7 +1.4

-5.0 +5.0 +10.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 22

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 8 | 7 | 6 | 4 | 6 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| | -1 | -1 | -2 | +2 | +1 | +1 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 5 | 7 | 6 | 8 | 7 | 9 | 10 | 11 | 10 | 11 | 10 | 11 | 10 | 11 | 8 | 9 | 7 | 8 | 4 |
| | +2 | -1 | +2 | -1 | +2 | +1 | +1 | -1 | +1 | -1 | +1 | -1 | +1 | -3 | +1 | -2 | +1 | -4 |

187

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|----|
| C' | C | C' | C'' | C' |
| 8 | 19 | 8 | 8 | 8 |
| | +11 | -11 | 0 | 0 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | +0.7 | -0.7 | +1.4 |
| Ex. #2 | +1.3 | -1.3 | +2.6 |
| Ex. #3 | -5.5 | +5.5 | -11.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 23

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 15 | 15 | 14 | 14 | 14 | 15 | 16 | 17 | 18 | 17 | 16 | 15 |
| | 0 | 0 | -1 | 0 | 0 | +1 | +1 | +1 | +1 | -1 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 14 | 15 | 15 | 15 | 15 | 16 | 16 | 17 | 17 | 19 | 17 | 17 | 16 | 16 | 15 | 15 | 14 | 14 | 13 |
| | +1 | 0 | 0 | 0 | +1 | 0 | +1 | 0 | +2 | -2 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -1 |

185

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 14 | 15 | 18 | 15 |
| | -1 | +1 | +3 | -3 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | +0.7 | -0.7 | +1.4 |
| Ex. #2 | +0.6 | -0.7 | +1.3 |
| Ex. #3 | +2.0 | -2.0 | +4.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 23

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 14 | 14 | 13 | 14 | 14 | 15 | 16 | 16 | 19 | 17 | 16 | 15 |
| | -1 | 0 | -1 | +1 | 0 | +1 | +1 | 0 | +3 | -2 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 14 | 14 | 14 | 15 | 14 | 16 | 15 | 17 | 16 | 18 | 16 | 17 | 15 | 15 | 14 | 14 | 13 | 13 | 12 |
| | 0 | 0 | +1 | -1 | +2 | -1 | +2 | -1 | +2 | -2 | +1 | -2 | 0 | -1 | 0 | -1 | 0 | -1 |

186

Ex. #3

Meas.

Amt/Ch†

| | | | | |
|----|----|----|-----|----|
| C' | C | G' | C'' | C' |
| 15 | 14 | 15 | 20 | 15 |
| | -1 | +1 | +5 | -5 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | +1.0 | -1.0 | +2.0 |
| Ex. #2 | +0.9 | -1.1 | +2.0 |
| Ex. #3 | +3.0 | -3.0 | +6.0 |

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 24

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|----|----|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 4 |
| | 0 | 0 | -1 | +1 | 0 | 0 | 0 | 0 | +1 | -1 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 4 | 4 | 4 | 7 | 4 |
| | 0 | 0 | +3 | -3 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.3

+0.0

+1.5

-0.3

-0.0

-1.5

+0.6

+0.0

+3.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 24

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | +2 | -2 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|---|---|---|----|---|----|----|----|----|-----|----|----|----|----|---|----|---|---|---|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | +2 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|---|----|-----|----|
| C' | C | C' | C'' | C' |
| 4 | 4 | 4 | 7 | 4 |
| | 0 | 0 | +3 | -3 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.3

-0.3

+0.6

+0.2

-0.2

+0.4

+1.5

-1.5

+3.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - TONGUED

Subject # 25

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|---|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 8 | 8 | 7 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2 | 0 | -1 |

189

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 10 | 6 | 10 | 10 | 10 |
| | -4 | +4 | 0 | 0 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

+0.0

-0.0

+0.0

+0.0

-0.3

+0.3

+2.0

-2.0

+4.0

*in degrees

APPENDIX C

INSTRUMENT PIVOT - SLURRED

Subject # 25

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|---|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 8 | 8 | 7 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | +1 | -2 | 0 | -1 |

190

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 10 | 5 | 10 | 10 | 10 |
| | -5 | +5 | 0 | 0 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | +0.0 | -0.0 | +0.0 |
| Ex. #2 | +0.1 | -0.4 | +0.5 |
| Ex. #3 | +2.5 | -2.5 | +5.0 |

*in degrees

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 1

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 22 | 24 | 26 | 27 | 26 | 24 | 22 | 21 | 20 | 19 | 20 | 21 | 20 |
| | +2 | +2 | +1 | -1 | -2 | -2 | -1 | -1 | -1 | +1 | +1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 25 | 20 | 22 | 19 | 20 | 17 | 18 | 15 | 16 | 14 | 16 | 17 | 21 | 19 | 23 | 20 | 23 | 21 | 25 |
| | -5 | +2 | -3 | +1 | -3 | +1 | -3 | +1 | -2 | +2 | +1 | +4 | -2 | +4 | -3 | +3 | -2 | +4 |

191

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 20 | 24 | 20 | 18 | 20 |
| | +4 | -4 | -2 | +2 |

Asc Av

Des Av

Total Av

Ex. #1

-1.3

+1.0

+2.3

Ex. #2

-2.4

+2.4

+4.8

Ex. #3

-3.0

+3.0

+6.0

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 1

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 22 | 25 | 26 | 28 | 26 | 25 | 21 | 16 | 14 | 11 | 15 | 17 | 21 |
| | +3 | +1 | +2 | -2 | -1 | -4 | -5 | -2 | -3 | +4 | +2 | +4 |

| | | | | | | | | | | | | | | | | | | | |
|--------|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 25 | 25 | 25 | 20 | 23 | 16 | 20 | 13 | 15 | 4 | 21 | 7 | 22 | 9 | 23 | 12 | 25 | 25 | 25 |
| Amt/Ch | | 0 | 0 | -5 | +3 | -7 | +4 | -7 | +2 | -11 | +17 | -14 | +15 | -13 | +14 | -11 | +13 | 0 | 0 |

| | | | | | | | | | |
|--------|----|----|----|------|-----|--------|--------|----------|-------|
| Ex. #3 | C' | C | C' | C''' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 20 | 26 | 20 | 10 | 20 | Ex. #1 | -2.8 | +2.7 | +5.5 |
| Amt/Ch | | +6 | -6 | -10 | +10 | Ex. #2 | -7.6 | +7.6 | +15.2 |
| | | | | | | Ex. #3 | -8.0 | +8.0 | +16.0 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 2

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 12 | 14 | 16 | 15 | 14 | 10 | 8 | 7 | 5 | 7 | 8 | 10 |
| | +2 | +2 | +2 | -1 | -1 | -4 | -2 | -1 | -2 | +2 | +1 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 13 | 14 | 10 | 12 | 8 | 10 | 6 | 8 | 4 | 8 | 7 | 9 | 8 | 11 | 10 | 13 | 12 | 15 |
| | -2 | +1 | -4 | +2 | -4 | +2 | -4 | +2 | -4 | +4 | -1 | +2 | -1 | +3 | -1 | +3 | -1 | +3 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 10 | 15 | 10 | 6 | 11 |
| | +5 | -5 | -4 | +5 |

Asc Av

Des Av

Total Av

Ex. #1

-1.5

+1.8

+3.3

Ex. #2

-2.4

+2.4

+4.8

Ex. #3

-4.5

+5.0

+9.5

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 2

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 11 | 12 | 13 | 12 | 11 | 10 | 8 | 6 | 4 | 6 | 7 | 9 |
| | +1 | +1 | +1 | -1 | -1 | -1 | -2 | -2 | -2 | +2 | +1 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 13 | 14 | 11 | 12 | 9 | 10 | 7 | 8 | 3 | 8 | 5 | 10 | 8 | 11 | 9 | 12 | 11 | 13 |
| | -2 | +1 | -3 | +1 | -3 | +1 | -3 | +1 | -5 | +5 | -3 | +5 | -2 | +3 | -2 | +3 | -1 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|----|
| C' | C | C' | C'' | C' |
| 10 | 20 | 10 | 2 | 10 |
| | +10 | -10 | -8 | +8 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.5

-2.7

-9.0

+1.3

+2.4

+9.0

+2.8

+5.1

+18.0

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 3

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 12 | 13 | 14 | 15 | 14 | 13 | 12 | 10 | 9 | 8 | 10 | 11 | 12 |
| | +1 | +1 | +1 | -1 | -1 | -1 | -2 | -1 | -1 | +2 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 14 | 14 | 12 | 13 | 9 | 10 | 6 | 8 | 4 | 6 | 8 | 10 | 9 | 12 | 11 | 14 | 13 | 15 |
| | -1 | 0 | -2 | +1 | -4 | +1 | -4 | +2 | -4 | +2 | +2 | +2 | -1 | +3 | -1 | +3 | -1 | +2 |

195

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 11 | 15 | 11 | 4 | 11 |
| | +4 | -4 | -7 | +7 |

Asc Av

Des Av

Total Av

Ex. #1

-1.2

+1.2

+2.4

Ex. #2

-1.8

+1.8

+3.6

Ex. #3

-5.5

+5.5

+11.0

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 3

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 11 | 11 | 11 | 11 | 11 | 9 | 7 | 5 | 3 | 6 | 8 | 10 |
| | +1 | 0 | 0 | 0 | 0 | -2 | -2 | -2 | -2 | +3 | +2 | +2 |

| | | | | | | | | | | | | | | | | | | | |
|--------|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 15 | 12 | 14 | 10 | 12 | 8 | 11 | 5 | 9 | 3 | 9 | 6 | 12 | 8 | 13 | 10 | 14 | 12 | 16 |
| Amt/Ch | | -3 | +2 | -4 | +2 | -4 | +3 | -6 | +4 | -6 | +6 | -3 | +6 | -4 | +5 | -3 | +4 | -2 | +4 |

| | | | | | |
|--------|----|----|----|-----|----|
| Ex. #3 | C' | C | C' | C'' | C' |
| Meas. | 11 | 16 | 10 | 3 | 10 |
| Amt/Ch | | +5 | -6 | -7 | +7 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -1.7 | +1.7 | +3.4 |
| Ex. #2 | -3.9 | +4.0 | +7.9 |
| Ex. #3 | -6.5 | +6.0 | +12.5 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 4

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 20 | 22 | 24 | 26 | 24 | 22 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| | +2 | +2 | +2 | -2 | -2 | -2 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 30 | 24 | 26 | 22 | 25 | 19 | 22 | 18 | 19 | 16 | 19 | 18 | 22 | 19 | 24 | 21 | 28 | 26 | 30 |
| | -6 | +2 | -4 | +3 | -6 | +3 | -4 | +1 | -3 | +3 | -1 | +4 | -3 | +5 | -3 | +7 | -2 | +4 |

197

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 22 | 29 | 22 | 17 | 23 |
| | +7 | -7 | -5 | +6 |

Asc Av

Des Av

Total Av

Ex. #1

Ex. #2

Ex. #3

-1.0

-3.6

-6.0

+1.0

+3.6

+6.5

+2.0

+7.2

+12.5

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 4

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 20 | 23 | 26 | 29 | 27 | 24 | 20 | 17 | 14 | 16 | 14 | 18 | 21 |
| | +3 | +3 | +3 | -2 | -3 | -4 | -3 | -3 | +2 | -2 | +4 | +3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 30 | 23 | 26 | 21 | 25 | 18 | 22 | 16 | 19 | 14 | 19 | 17 | 23 | 18 | 25 | 20 | 27 | 24 | 30 |
| | -7 | +3 | -5 | +4 | -7 | +4 | -6 | +3 | -5 | +5 | -2 | +6 | -5 | +7 | -5 | +7 | -3 | +6 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 22 | 30 | 22 | 15 | 22 |
| | +8 | -8 | -7 | +7 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-2.0

-5.0

-7.5

+2.3

+5.0

+7.5

+4.3

+10.0

+15.0

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 5

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 25 | 26 | 27 | 28 | 26 | 25 | 24 | 23 | 21 | 20 | 22 | 23 | 24 |
| | +1 | +1 | +1 | -2 | -1 | -1 | -1 | -2 | -1 | +2 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 26 | 25 | 26 | 23 | 24 | 22 | 24 | 22 | 21 | 20 | 22 | 21 | 20 | 22 | 24 | 23 | 25 | 24 | 26 |
| | -1 | +1 | -3 | +1 | -2 | +2 | -2 | -1 | -1 | +2 | -1 | -1 | +2 | +2 | -1 | +2 | -1 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 25 | 32 | 25 | 5 | 25 |
| | +7 | -7 | -20 | +20 |

Asc Av

Des Av

Total Av

Ex. #1

-1.3

+1.2

+2.5

Ex. #2

-1.1

+1.1

+2.2

Ex. #3

-13.5

+13.5

+27.0

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 5

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 24 | 26 | 28 | 30 | 24 | 21 | 15 | 10 | 8 | 6 | 19 | 21 | 23 |
| | +2 | +2 | +2 | -6 | -3 | -6 | -5 | -2 | -2 | +13 | +2 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|-----|----|-----|----|----|-----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 22 | 21 | 23 | 20 | 22 | 15 | 20 | 6 | 8 | 4 | 8 | 5 | 20 | 14 | 21 | 20 | 22 | 21 | 22 |
| | -1 | +2 | -3 | +2 | -7 | +5 | -14 | +2 | -4 | +4 | -3 | +15 | -6 | +7 | -1 | +2 | -1 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 25 | 27 | 25 | 5 | 25 |
| | +2 | -2 | -20 | +20 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | -4.0 | +3.8 | +7.8 |
| Ex. #2 | -4.7 | +4.4 | +9.1 |
| Ex. #3 | -11.0 | +11.0 | +22.0 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 6

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 40 | 43 | 46 | 51 | 48 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| | +3 | +3 | +5 | -3 | -8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 50 | 44 | 46 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 44 | 42 | 50 |
| | -6 | +2 | -6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | +4 | -2 | +8 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|-----|
| C' | C | C' | C'' | C' |
| 50 | 60 | 50 | 35 | 50 |
| | +10 | -10 | -15 | +15 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -1.8 | +1.8 | +3.6 |
| Ex. #2 | -1.6 | +1.6 | +3.2 |
| Ex. #3 | -12.5 | +12.5 | +25.0 |

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 6

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|-----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 40 | 42 | 44 | 41 | 25 | 20 | 15 | 12 | 9 | 4 | 6 | 8 | 13 |
| | +2 | +2 | -3 | -16 | -5 | -5 | -3 | -3 | -5 | +2 | +2 | +5 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|-----|----|-----|----|-----|----|----|----|-----|----|----|-----|-----|-----|-----|-----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 50 | 25 | 30 | 20 | 25 | 12 | 16 | 8 | 8 | 4 | 6 | 5 | 20 | 10 | 30 | 20 | 36 | 34 | 42 |
| | -25 | +5 | -10 | +5 | -13 | +4 | -8 | 0 | -4 | +2 | -1 | +15 | -10 | +20 | -10 | +16 | -2 | +8 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|-----|
| C' | C | C' | C'' | C' |
| 50 | 65 | 10 | 4 | 25 |
| | +15 | -55 | -6 | +21 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-6.2

-9.2

-30.5

+1.7

+8.3

+18.0

+7.9

+17.5

+48.5

*in millimeters

APPENDIX C
TONGUE ARCH - TONGUED

Subject # 7

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 20 | 22 | 24 | 26 | 23 | 21 | 18 | 21 | 22 | 25 | 22 | 21 | 20 |
| | +2 | +2 | +2 | -3 | -2 | -3 | +3 | +1 | +3 | -3 | -1 | -1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 16 | 14 | 15 | 15 | 16 | 15 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 23 | 22 | 24 |
| | -2 | +1 | 0 | +1 | -1 | +5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | +3 | -1 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 20 | 24 | 18 | 22 | 20 |
| | +4 | -6 | +4 | -2 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | -0.2 | +0.2 | +0.4 |
| Ex. #2 | -0.4 | +1.3 | +1.7 |
| Ex. #3 | -1.0 | +1.0 | +2.0 |

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 7

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|-----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 20 | 21 | 22 | 23 | 10 | 8 | 8 | 6 | 5 | 4 | 7 | 15 | 20 |
| | +1 | +1 | +1 | -13 | -2 | 0 | -2 | -1 | -1 | +3 | +8 | +5 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|-----|----|-----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 13 | 14 | 10 | 12 | 9 | 11 | 5 | 6 | 4 | 16 | 7 | 17 | 8 | 22 | 18 | 24 | 22 | 25 |
| | -2 | +1 | -4 | +2 | -3 | +2 | -6 | +1 | -2 | +12 | -9 | +10 | -9 | +14 | -4 | +6 | -2 | +3 |

201

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|-----|
| C' | C | C' | C'' | C' |
| 20 | 31 | 18 | 4 | 21 |
| | +11 | -13 | -14 | +17 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-3.2

-4.6

-13.5

+3.2

+5.7

+14.0

+6.4

+10.3

+27.5

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 8

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 16 | 20 | 24 | 19 | 15 | 10 | 8 | 7 | 6 | 7 | 8 | 11 |
| | +6 | +4 | +4 | -5 | -4 | -5 | -2 | -1 | -1 | +1 | +1 | +3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 22 | 16 | 18 | 15 | 21 | 11 | 20 | 9 | 20 | 6 | 20 | 8 | 20 | 10 | 27 | 20 | 26 | 23 | 29 |
| | -6 | +2 | -3 | +6 | -10 | +9 | -11 | +11 | -14 | +14 | -12 | +12 | -10 | +17 | -7 | +6 | -3 | +6 |

205

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 15 | 23 | 20 | 10 | 20 |
| | +8 | -3 | -10 | +10 |

Asc Av

Des Av

Total Av

Ex. #1

Ex. #2

Ex. #3

-3.0

-8.4

-6.5

+3.2

+9.2

+9.0

+6.2

+17.6

+15.5

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 8

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 11 | 18 | 21 | 23 | 17 | 10 | 8 | 6 | 5 | 4 | 6 | 7 | 12 |
| | +7 | +3 | +2 | -6 | -7 | -2 | -2 | -1 | -1 | +2 | +1 | +5 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|-----|----|----|----|-----|----|----|----|-----|-----|----|-----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 22 | 10 | 16 | 8 | 17 | 7 | 10 | 6 | 15 | 4 | 15 | 6 | 17 | 10 | 19 | 14 | 22 | 19 | 27 |
| | -12 | +6 | -8 | +9 | -10 | +3 | -4 | +9 | -11 | +11 | -9 | +11 | -7 | +9 | -5 | +8 | -3 | +8 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 12 | 20 | 11 | 4 | 15 |
| | +8 | -9 | -7 | +11 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -3.2 | +3.3 | +6.5 |
| Ex. #2 | -7.7 | +8.2 | +15.9 |
| Ex. #3 | -8.0 | +9.5 | +17.5 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 9

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 11 | 12 | 13 | 12 | 11 | 10 | 8 | 6 | 4 | 5 | 7 | 10 |
| | +1 | +1 | +1 | -1 | -1 | -1 | -2 | -2 | -2 | +1 | +2 | +3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 10 | 12 | 8 | 12 | 8 | 10 | 8 | 9 | 7 | 10 | 8 | 12 | 9 | 13 | 10 | 15 | 13 | 17 |
| | -5 | +2 | -4 | +4 | -4 | +2 | -2 | +1 | -2 | +3 | -2 | +4 | -3 | +4 | -3 | +5 | -2 | +4 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 20 | 14 | 10 | 15 |
| | +5 | -6 | -4 | +5 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -1.5 | +1.5 | +3.0 |
| Ex. #2 | -3.0 | +3.2 | +6.2 |
| Ex. #3 | -5.0 | +5.0 | +10.0 |

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 9

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 12 | 12 | 12 | 12 | 11 | 10 | 9 | 8 | 6 | 3 | 5 | 8 | 10 |
| | 0 | 0 | 0 | -1 | -1 | -1 | -1 | -2 | -3 | +2 | +3 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 11 | 13 | 10 | 12 | 8 | 10 | 6 | 9 | 5 | 8 | 6 | 9 | 7 | 11 | 10 | 13 | 12 | 15 |
| | -4 | +2 | -3 | +2 | -4 | +2 | -4 | +3 | -5 | +3 | -2 | +3 | -2 | +4 | -1 | +3 | -1 | +3 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 20 | 24 | 15 | 8 | 20 |
| | +4 | -9 | -7 | +12 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.5

-2.8

-8.0

+1.2

+2.8

+8.0

+2.7

+5.6

+16.0

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 10

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 15 | 15 | 15 | 15 |
| | 0 | 0 | 0 | 0 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -0.0 | +0.0 | +0.0 |
| Ex. #2 | -0.0 | +0.0 | +0.0 |
| Ex. #3 | -0.0 | +0.0 | +0.0 |

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 10

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 12 | 12 | 12 | 12 | 11 | 11 | 10 | 9 | 8 | 7 | 8 | 9 | 10 |
| | 0 | 0 | 0 | -1 | 0 | -1 | -1 | -1 | -1 | +1 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 11 | 9 | 10 | 8 | 10 | 7 | 10 | 6 | 10 | 5 | 9 | 6 | 10 | 9 | 10 | 8 | 10 | 9 | 12 |
| | -2 | +1 | -2 | +2 | -3 | +3 | -4 | +4 | -5 | +4 | -3 | +4 | -1 | +1 | -2 | +2 | -1 | +3 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 15 | 15 | 10 | 4 | 13 |
| | 0 | -5 | -6 | +9 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

| | | |
|------|------|-------|
| -0.8 | +0.5 | +1.3 |
| -2.6 | +2.7 | +5.3 |
| -5.5 | +4.5 | +10.0 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 11

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 40 | 41 | 42 | 44 | 42 | 41 | 40 | 38 | 37 | 35 | 37 | 38 | 41 |
| | +1 | +1 | +2 | -2 | -1 | -1 | -2 | -1 | -2 | +2 | +1 | +3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 45 | 42 | 43 | 40 | 42 | 37 | 40 | 35 | 37 | 30 | 38 | 36 | 40 | 37 | 43 | 40 | 44 | 45 | 50 |
| | -3 | +1 | -3 | +2 | -5 | +3 | -5 | +2 | -7 | +8 | -2 | +4 | -3 | +6 | -3 | +4 | +1 | +5 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 50 | 55 | 48 | 30 | 52 |
| | +5 | -7 | -18 | +22 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -1.5 | +1.7 | +3.2 |
| Ex. #2 | -3.3 | +2.8 | +6.1 |
| Ex. #3 | -12.5 | +13.5 | +26.0 |

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 11

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|-----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 32 | 40 | 46 | 50 | 47 | 44 | 40 | 31 | 22 | 10 | 21 | 33 | 40 |
| | +8 | +6 | +4 | -3 | -3 | -4 | -9 | -9 | -12 | +11 | +12 | +7 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 50 | 45 | 48 | 45 | 47 | 40 | 42 | 39 | 41 | 36 | 40 | 34 | 42 | 37 | 41 | 39 | 41 | 40 | 42 |
| | -5 | +3 | -3 | +2 | -7 | +2 | -3 | +2 | -5 | +4 | -6 | +8 | -5 | +4 | -2 | +2 | -1 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 50 | 54 | 49 | 35 | 48 |
| | +4 | -5 | -14 | +13 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-6.7

-4.1

-9.5

+8.0

+3.2

+8.5

+14.7

+7.3

+18.0

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 12

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

213

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 40 | 32 | 40 | 44 | 40 |
| | -8 | +8 | +4 | -4 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -0.0 | +0.0 | +0.0 |
| Ex. #2 | -0.0 | +0.0 | +0.0 |
| Ex. #3 | +6.0 | -6.0 | -12.0 |

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 12

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|-----|-----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 40 | 40 | 40 | 28 | 40 | 40 | 40 | 40 | 40 | 45 | 40 | 40 | 40 |
| | 0 | 0 | -12 | +12 | 0 | 0 | 0 | 0 | +5 | -5 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

214

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|------|----|
| C' | C | C' | C''' | C' |
| 40 | 28 | 40 | 45 | 40 |
| | -12 | +12 | +5 | -5 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | +2.8 | -2.8 | -5.6 |
| Ex. #2 | -0.0 | +0.0 | +0.0 |
| Ex. #3 | +8.5 | -8.5 | -17.0 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 13

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 30 | 30 | 30 | 30 | 30 | 30 | 30 | 27 | 24 | 15 | 28 | 30 | 33 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -3 | -3 | -9 | +13 | +2 | +3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 8 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -22 | +22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

215

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 29 | 31 | 28 | 19 | 30 |
| | +2 | -3 | -9 | +11 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -2.5 | +3.0 | +5.5 |
| Ex. #2 | -2.4 | +2.4 | +4.8 |
| Ex. #3 | -6.0 | +6.5 | +12.5 |

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 13

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 29 | 30 | 31 | 32 | 27 | 27 | 20 | 15 | 11 | 8 | 23 | 27 | 30 |
| | +1 | +1 | +1 | -5 | 0 | -7 | -5 | -4 | -3 | +15 | +4 | +3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|-----|-----|-----|-----|-----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 29 | 25 | 26 | 23 | 25 | 21 | 23 | 14 | 22 | 7 | 21 | 17 | 30 | 20 | 30 | 20 | 30 | 28 | 32 |
| | -4 | +1 | -3 | +2 | -4 | +2 | -9 | +8 | -15 | +14 | -4 | +13 | -10 | +10 | -10 | +10 | -2 | +4 |

216

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|-----|
| C' | C | C' | C'' | C' |
| 20 | 30 | 15 | 6 | 24 |
| | +10 | -15 | -9 | +18 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-4.0

-6.8

-12.0

+4.2

+7.1

+14.0

+8.2

+13.9

+26.0

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 14

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|-----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 21 | 27 | 31 | 33 | 30 | 26 | 15 | 8 | 6 | 3 | 5 | 6 | 10 |
| | +6 | +4 | +2 | -3 | -4 | -11 | -7 | -2 | -3 | +2 | +1 | +4 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|-----|----|-----|----|----|----|-----|----|----|----|----|-----|----|-----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 34 | 31 | 32 | 15 | 24 | 13 | 10 | 7 | 9 | 2 | 10 | 6 | 11 | 8 | 27 | 19 | 34 | 33 | 35 |
| | -3 | +1 | -17 | +9 | -11 | -3 | -3 | +2 | -7 | +8 | -4 | +5 | -3 | +19 | -8 | +15 | -1 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|-----|-----|-----|
| C' | C | C' | C'' | C' |
| 32 | 35 | 20 | 3 | 26 |
| | +3 | -15 | -17 | +23 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-5.0

-6.3

-16.0

+3.2

+6.4

+13.0

+8.2

+12.7

+29.0

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 14

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|-----|----|----|----|-----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 19 | 37 | 44 | 50 | 43 | 14 | 10 | 6 | 5 | 2 | 4 | 8 | 12 |
| | +18 | +7 | +6 | -7 | -29 | -4 | -4 | -1 | -3 | +2 | +4 | +4 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|-----|-----|-----|-----|-----|-----|-----|----|-----|----|----|-----|-----|-----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 30 | 27 | 28 | 15 | 30 | 10 | 29 | 8 | 31 | 39 | 42 | 7 | 11 | 9 | 39 | 16 | 41 | 39 | 45 |
| | -3 | +1 | -13 | +15 | -20 | +19 | -21 | +23 | +8 | +3 | -35 | +4 | -2 | +30 | -23 | +25 | -2 | +6 |

218

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 24 | 37 | 32 | 27 | 42 |
| | +13 | -5 | -5 | +15 |

Asc Av

Des Av

Total Av

Ex. #1

Ex. #2

Ex. #3

-8.0

-12.3

-5.0

+6.8

+14.0

+14.0

+14.8

+26.3

+19.0

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 15

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 40 | 41 | 42 | 43 | 42 | 41 | 40 | 38 | 35 | 16 | 25 | 31 | 38 |
| | +1 | +1 | +1 | -1 | -1 | -1 | -2 | -3 | -19 | +9 | +6 | +7 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 42 | 40 | 41 | 38 | 39 | 37 | 38 | 37 | 39 | 6 | 31 | 27 | 36 | 35 | 38 | 37 | 40 | 39 | 43 |
| | -2 | +1 | -3 | +1 | -2 | +1 | -1 | +2 | -33 | +25 | -4 | +9 | -1 | +3 | -1 | +3 | -1 | +4 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 30 | 34 | 31 | 5 | 33 |
| | +4 | -3 | -26 | +28 |

Asc Av

Des Av

Total Av

Ex. #1

-4.5

+4.2

+8.7

Ex. #2

-5.3

+5.4

+10.7

Ex. #3

-14.5

+16.0

+30.5

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 15

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|-----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 40 | 42 | 41 | 37 | 34 | 12 | 9 | 6 | 4 | 2 | 8 | 10 | 16 |
| | +2 | -1 | -4 | -3 | -22 | -3 | -3 | -2 | -2 | +6 | +2 | +6 |

| | | | | | | | | | | | | | | | | | | | |
|--------|----|----|----|----|----|----|----|-----|----|-----|----|----|-----|----|----|----|-----|----|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 28 | 24 | 25 | 19 | 17 | 12 | 20 | 7 | 11 | 3 | 10 | 6 | 18 | 12 | 21 | 14 | 35 | 35 | 37 |
| Amt/Ch | | -4 | +1 | -6 | -2 | -5 | +8 | -13 | +4 | -8 | +7 | -4 | +12 | -6 | +9 | -7 | +21 | 0 | +2 |

| | | | | | |
|--------|----|----|-----|-----|-----|
| Ex. #3 | C' | C | C' | C'' | C' |
| Meas. | 32 | 33 | 17 | 4 | 21 |
| Amt/Ch | | +1 | -16 | -13 | +17 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -5.8 | +1.8 | +7.6 |
| Ex. #2 | -5.9 | +6.9 | +12.8 |
| Ex. #3 | -14.5 | +9.0 | +23.5 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 16

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|---|---|---|---|---|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 9 | 9 | 9 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -6 | +6 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 10 | 10 | 10 | 10 | 10 | 9 | 10 | 8 | 9 | 3 | 8 | 7 | 9 | 9 | 10 | 9 | 11 | 11 | 12 |
| | 0 | 0 | 0 | 0 | -1 | +1 | -2 | +1 | -6 | +5 | -1 | +2 | 0 | +1 | -1 | +2 | 0 | +1 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 10 | 11 | 10 | 3 | 10 |
| | +1 | -1 | -7 | +7 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | -1.0 | +1.0 | +2.0 |
| Ex. #2 | -1.2 | +1.4 | +2.6 |
| Ex. #3 | -4.0 | +4.0 | +8.0 |

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 16

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 13 | 14 | 15 | 16 | 15 | 14 | 13 | 7 | 5 | 2 | 6 | 9 | 11 |
| | +1 | +1 | +1 | -1 | -1 | -1 | -6 | -2 | -3 | +4 | +3 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 14 | 9 | 11 | 6 | 11 | 8 | 10 | 6 | 10 | 2 | 10 | 5 | 10 | 7 | 10 | 8 | 11 | 10 | 12 |
| | -5 | +2 | -5 | +5 | -3 | +2 | -4 | +4 | -8 | +8 | -5 | +5 | -3 | +3 | -2 | +3 | -1 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|------|----|
| C' | C | C' | C''' | C' |
| 10 | 13 | 9 | 2 | 8 |
| | +3 | -4 | -7 | +6 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | -2.3 | +2.0 | +4.3 |
| Ex. #2 | -4.0 | +3.8 | +7.8 |
| Ex. #3 | -5.5 | +4.5 | +10.0 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 17

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|-----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 19 | 26 | 29 | 24 | 17 | 4 | 3 | 2 | 1 | 2 | 4 | 6 |
| | +9 | +7 | +3 | -5 | -7 | -13 | -1 | -1 | -1 | +1 | +2 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 18 | 14 | 20 | 11 | 15 | 6 | 8 | 3 | 4 | 2 | 4 | 3 | 5 | 4 | 13 | 7 | 15 | 11 | 10 |
| | -4 | +6 | -9 | +4 | -9 | +2 | -5 | +1 | -2 | +2 | -1 | +2 | -1 | +9 | -6 | +8 | -4 | -1 |

223

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 10 | 14 | 9 | 2 | 12 |
| | +4 | -5 | -7 | +10 |

Asc Av

Des Av

Total Av

Ex. #1

-4.7

+4.0

+8.7

Ex. #2

-4.6

+3.7

+8.3

Ex. #3

-6.0

+7.0

+13.0

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 17

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|-----|----|----|-----|----|-----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 10 | 20 | 24 | 22 | 10 | 18 | 6 | 4 | 3 | 1 | 3 | 5 | 7 |
| | +10 | +4 | -2 | -12 | +8 | -12 | -2 | -1 | -2 | +2 | +2 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|-----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 10 | 6 | 12 | 6 | 8 | 4 | 5 | 2 | 3 | 1 | 3 | 2 | 3 | 2 | 8 | 4 | 15 | 13 | 11 |
| | -4 | +6 | -6 | +2 | -4 | +1 | -3 | +1 | -2 | +2 | -1 | +1 | -1 | +6 | -4 | +11 | -2 | -2 |

224

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | G | C' | C'' | C' |
| 12 | 17 | 9 | 1 | 8 |
| | +5 | -8 | -8 | +7 |

Asc Av

Des Av

Total Av

Ex. #1

Ex. #2

Ex. #3

-3.5

-3.0

-8.0

+3.0

+3.1

+6.0

+6.5

+6.1

+14.0

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 18

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 27 | 28 | 29 | 31 | 29 | 27 | 26 | 24 | 26 | 32 | 27 | 29 | 30 |
| | +1 | +1 | +2 | -2 | -2 | -1 | -2 | +2 | +6 | -5 | +2 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 26 | 20 | 22 | 18 | 20 | 18 | 19 | 17 | 18 | 22 | 18 | 17 | 18 | 17 | 19 | 18 | 21 | 19 | 12 |
| | -6 | +2 | -4 | +2 | -2 | +1 | -2 | +1 | +4 | -4 | -1 | +1 | -1 | +2 | -1 | +3 | -2 | -7 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 29 | 33 | 30 | 34 | 30 |
| | +4 | -3 | +4 | -4 |

Asc Av

Des Av

Total Av

Ex. #1

+0.2

+0.3

+0.1

Ex. #2

-1.7

+0.1

+1.8

Ex. #3

+0.5

+0.0

-0.5

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 18

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 16 | 19 | 21 | 22 | 19 | 15 | 11 | 9 | 7 | 4 | 9 | 13 | 18 |
| | +3 | +2 | +1 | -3 | -4 | -4 | -2 | -2 | -3 | +5 | +4 | +5 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 25 | 20 | 23 | 17 | 21 | 15 | 18 | 10 | 12 | 4 | 13 | 10 | 15 | 8 | 17 | 11 | 18 | 17 | 21 |
| | -5 | +3 | -6 | +4 | -6 | +3 | -8 | +2 | -8 | +9 | -3 | +5 | -7 | +9 | -6 | +7 | -1 | +4 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 21 | 27 | 19 | 9 | 21 |
| | +6 | -8 | -10 | +12 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-3.0

-5.6

-9.0

+3.3

+5.1

+9.0

+6.3

+10.7

+18.0

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 19

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|-----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 43 | 40 | 42 | 38 | 43 | 36 | 37 | 35 | 36 | 30 | 41 | 34 | 44 | 41 | 44 | 41 | 42 | 40 | 43 |
| | -3 | +2 | -4 | +5 | -7 | +1 | -2 | +1 | -6 | +11 | -7 | +10 | -3 | +3 | -3 | +1 | -2 | +3 |

227

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 44 | 41 | 41 | 20 | 44 |
| | -3 | 0 | -21 | +24 |

Asc Av

Des Av

Total Av

Ex. #1

-0.0

+0.0

+0.0

Ex. #2

-4.1

+4.1

+8.2

Ex. #3

-10.5

+10.5

+21.0

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 19

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 36 | 34 | 32 | 30 | 30 | 30 | 21 | 16 | 14 | 4 | 38 | 41 | 43 |
| | -2 | -2 | -2 | 0 | 0 | -9 | -5 | -2 | -10 | +34 | +3 | +2 |

| | | | | | | | | | | | | | | | | | | | |
|--------|----|----|----|----|----|----|-----|----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 41 | 37 | 42 | 36 | 41 | 32 | 43 | 34 | 44 | 20 | 43 | 16 | 42 | 19 | 43 | 37 | 44 | 42 | 39 |
| Amt/Ch | | -4 | +5 | -6 | +5 | -9 | +11 | -9 | +10 | -24 | +23 | -27 | +26 | -23 | +24 | -6 | +7 | -2 | -3 |

| | | | | | | | | | |
|--------|----|----|----|-----|-----|--------|--------|----------|-------|
| Ex. #3 | C' | C | C' | C'' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 44 | 41 | 43 | 29 | 45 | Ex. #1 | -4.3 | +5.5 | +9.8 |
| Amt/Ch | | -3 | +2 | -14 | +16 | Ex. #2 | -12.2 | +12.0 | +24.2 |
| | | | | | | Ex. #3 | -6.0 | +6.5 | +12.5 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 20

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 9 | 10 | 11 | 12 | 11 | 10 | 9 | 7 | 5 | 4 | 6 | 7 | 10 |
| | +1 | +1 | +1 | -1 | -1 | -1 | -2 | -2 | -1 | +2 | +1 | +3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 12 | 9 | 11 | 8 | 10 | 7 | 9 | 6 | 8 | 3 | 6 | 5 | 10 | 8 | 11 | 9 | 12 | 11 | 13 |
| | -3 | +2 | -3 | +2 | -3 | +2 | -3 | +2 | -5 | +3 | -1 | +5 | -2 | +3 | -2 | +3 | -1 | +2 |

229

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 9 | 15 | 11 | 4 | 10 |
| | +6 | -4 | -7 | +6 |

Asc Av

Des Av

Total Av

Ex. #1

Ex. #2

Ex. #3

-1.3

-2.6

-5.5

+1.5

+2.7

+6.0

+2.8

+5.3

+11.5

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 20

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 9 | 10 | 10 | 10 | 10 | 10 | 9 | 7 | 5 | 3 | 4 | 5 | 7 |
| | +1 | 0 | 0 | 0 | 0 | -1 | -2 | -2 | -2 | +1 | +1 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 14 | 10 | 11 | 8 | 9 | 7 | 9 | 6 | 8 | 3 | 7 | 5 | 9 | 7 | 10 | 7 | 10 | 8 | 10 |
| | -4 | +1 | -3 | +1 | -2 | +2 | -3 | +2 | -5 | +4 | -2 | +4 | -2 | +3 | -3 | +3 | -2 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 12 | 15 | 8 | 2 | 9 |
| | +3 | -7 | -6 | +7 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | -1.2 | +0.8 | +2.0 |
| Ex. #2 | -2.9 | +2.4 | +5.3 |
| Ex. #3 | -6.5 | +5.0 | +11.5 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 21

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 24 | 27 | 29 | 26 | 23 | 17 | 16 | 16 | 7 | 20 | 21 | 23 |
| | +9 | +3 | +2 | -3 | -3 | -6 | -1 | 0 | -9 | +13 | +1 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 24 | 19 | 21 | 18 | 20 | 16 | 21 | 14 | 19 | 5 | 22 | 17 | 23 | 19 | 25 | 18 | 24 | 22 | 25 |
| | -5 | +2 | -3 | +2 | -4 | +5 | -7 | +5 | -14 | +17 | -5 | +6 | -4 | +6 | -7 | +6 | -2 | +3 |

231

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|-----|-----|-----|-----|
| C' | C | C' | C'' | C' |
| 20 | 32 | 19 | 6 | 18 |
| | +12 | -13 | -13 | +12 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -3.3 | +5.0 | +8.3 |
| Ex. #2 | -5.7 | +5.9 | +11.6 |
| Ex. #3 | -13.0 | +12.0 | +25.0 |

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 21

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 16 | 19 | 21 | 24 | 18 | 14 | 10 | 8 | 5 | 4 | 11 | 15 | 18 |
| | +3 | +2 | +3 | -6 | -4 | -4 | -2 | -3 | -1 | +7 | +4 | +3 |

| | | | | | | | | | | | | | | | | | | | |
|--------|----|----|----|----|----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 23 | 15 | 17 | 12 | 20 | 8 | 19 | 6 | 18 | 4 | 10 | 6 | 9 | 7 | 12 | 8 | 16 | 15 | 18 |
| Amt/Ch | | -8 | +2 | -5 | +8 | -12 | +11 | -13 | +12 | -14 | +6 | -4 | +3 | -2 | +5 | -4 | +8 | -1 | +3 |

| | | | | | | | | | |
|--------|----|----|-----|-----|-----|--------|--------|----------|-------|
| Ex. #3 | C' | C | C' | C'' | C' | Asc Av | Des Av | Total Av | |
| Meas. | 19 | 27 | 14 | 3 | 15 | Ex. #1 | -3.3 | +3.7 | +7.0 |
| Amt/Ch | | +8 | -13 | -11 | +12 | Ex. #2 | -7.0 | +6.4 | +13.4 |
| | | | | | | Ex. #3 | -12.0 | +10.0 | +22.0 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 22

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 45 | 45 | 45 | 45 | 45 |
| | 0 | 0 | 0 | 0 |

Asc Av

Des Av

Total Av

Ex. #1

-0.0

+0.0

+0.0

Ex. #2

-0.0

+0.0

+0.0

Ex. #3

-0.0

+0.0

+0.0

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 22

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

234

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 45 | 45 | 45 | 45 | 45 |
| | 0 | 0 | 0 | 0 |

| | Asc Av | Des Av | Total Av |
|--------|--------|--------|----------|
| Ex. #1 | -0.0 | +0.0 | +0.0 |
| Ex. #2 | -0.0 | +0.0 | +0.0 |
| Ex. #3 | -0.0 | +0.0 | +0.0 |

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 23

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 13 | 11 | 7 | 9 | 11 | 14 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -2 | -2 | -4 | +2 | +2 | +3 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 15 | 15 | 12 | 15 | 8 | 14 | 7 | 13 | 10 | 15 | 13 | 15 | 14 | 20 | 18 | 17 | 18 | 20 |
| | 0 | 0 | -3 | +3 | -7 | +6 | -7 | +6 | -3 | +5 | -2 | +2 | -1 | +6 | -2 | -1 | +1 | +2 |

235

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 14 | 17 | 10 | 4 | 16 |
| | +3 | -7 | -6 | +12 |

Asc Av

Des Av

Total Av

Ex. #1

-1.3

+1.2

+2.5

Ex. #2

-2.7

+3.2

+5.9

Ex. #3

-6.5

+7.5

+14.0

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 23

Exercise #1

Measurement*

Amount of change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 15 | 15 | 15 | 15 | 14 | 13 | 12 | 10 | 8 | 6 | 8 | 9 | 10 |
| | 0 | 0 | 0 | -1 | -1 | -1 | -2 | -2 | -2 | +2 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 15 | 12 | 15 | 11 | 15 | 10 | 14 | 8 | 14 | 7 | 13 | 8 | 14 | 9 | 14 | 10 | 15 | 14 | 16 |
| | -3 | +3 | -4 | +5 | -5 | +4 | -6 | +6 | -7 | +6 | -5 | +6 | -5 | +5 | -4 | +5 | -1 | +2 |

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 13 | 18 | 11 | 4 | 17 |
| | +5 | -7 | -7 | +13 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.5

-4.4

-7.0

+0.7

+4.6

+9.0

+2.2

+9.0

+16.0

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 24

Exercise #1

| | | | | | | | | | | | | | |
|------------------|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| | C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| Measurement* | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 19 | 18 | 10 | 15 | 17 | 20 |
| Amount of Change | | 0 | 0 | 0 | 0 | 0 | 0 | -1 | -1 | -8 | +5 | +2 | +3 |

Ex. #2

| | | | | | | | | | | | | | | | | | | | |
|--------|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 11 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Amt/Ch | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -9 | +9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

237

Ex. #3

| | | | | | |
|--------|----|----|----|-----|----|
| | C' | C | C' | C'' | C' |
| Meas. | 20 | 24 | 21 | 17 | 20 |
| Amt/Ch | | +4 | -3 | -4 | +3 |

| | | | |
|--------|--------|--------|----------|
| | Asc Av | Des Av | Total Av |
| Ex. #1 | -1.7 | +1.7 | +3.4 |
| Ex. #2 | -1.0 | +1.0 | +2.0 |
| Ex. #3 | -3.5 | +3.5 | +7.0 |

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 24

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 18 | 17 | 14 | 18 | 19 | 20 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -2 | -1 | -3 | +4 | +1 | +1 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|-----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 20 | 17 | 20 | 16 | 20 | 14 | 20 | 12 | 16 | 4 | 20 | 18 | 20 | 18 | 20 | 19 | 20 | 20 | 20 |
| | -3 | +3 | -4 | +4 | -6 | +6 | -8 | +4 | -12 | +16 | -2 | +2 | -2 | +2 | -1 | +1 | 0 | 0 |

238

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|----|
| C' | C | C' | C'' | C' |
| 22 | 25 | 21 | 15 | 23 |
| | +3 | -4 | -6 | +8 |

Ex. #1

Ex. #2

Ex. #3

Asc Av

Des Av

Total Av

-1.0

-4.2

-5.5

+1.0

+4.2

+5.0

+2.0

+8.4

+10.5

*in millimeters

APPENDIX C

TONGUE ARCH - TONGUED

Subject # 25

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 40 | 41 | 42 | 43 | 42 | 41 | 40 | 38 | 35 | 33 | 36 | 38 | 40 |
| | +1 | +1 | +1 | -1 | -1 | -1 | -2 | -3 | -2 | +3 | +2 | +2 |

Ex. #2

Meas.

Amt/Ch

| | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|
| C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| 43 | 38 | 41 | 35 | 40 | 37 | 40 | 36 | 39 | 35 | 40 | 38 | 40 | 37 | 41 | 38 | 39 | 38 | 40 |
| | -5 | +3 | -6 | +5 | -3 | +3 | -4 | +3 | -4 | +5 | -2 | +2 | -3 | +4 | -3 | +1 | -1 | +2 |

239

Ex. #3

Meas.

Amt/Ch

| | | | | |
|----|----|----|-----|-----|
| C' | C | C' | C'' | C' |
| 45 | 51 | 42 | 29 | 41 |
| | +6 | -9 | -13 | +12 |

Asc Av

Des Av

Total Av

Ex. #1

-1.7

+1.7

+3.4

Ex. #2

-3.4

+3.1

+6.5

Ex. #3

-11.0

+9.0

+20.0

* in millimeters

APPENDIX C

TONGUE ARCH - SLURRED

Subject # 25

Exercise #1

Measurement*

Amount of Change

| | | | | | | | | | | | | |
|----|----|----|----|----|----|-----|----|----|-----|-----|----|----|
| C' | G | E | C | E | G | C' | E' | G' | C'' | G' | E' | C' |
| 40 | 42 | 44 | 47 | 45 | 41 | 20 | 14 | 9 | 6 | 35 | 37 | 40 |
| | +2 | +2 | +3 | -2 | -4 | -21 | -6 | -5 | -3 | +29 | +2 | +3 |

| | | | | | | | | | | | | | | | | | | | |
|--------|----|-----|-----|-----|----|-----|-----|-----|-----|-----|----|----|----|-----|-----|-----|-----|----|----|
| Ex. #2 | C | G | E | C' | G | E' | C' | G' | E' | C'' | E' | G' | C' | E' | G | C' | E | G | C |
| Meas. | 49 | 31 | 44 | 33 | 40 | 22 | 39 | 19 | 38 | 34 | 41 | 35 | 40 | 14 | 37 | 18 | 45 | 45 | 47 |
| Amt/Ch | | -18 | +13 | -11 | +7 | -18 | +17 | -20 | +19 | -4 | +7 | -6 | +5 | -26 | +23 | -19 | +27 | 0 | +2 |

210

| | | | | | | | | | | | | | | |
|--------|----|----|-----|------|-----|--|--|--|--|--|--------|--------|----------|-------|
| Ex. #3 | C' | C | C' | C''' | C' | | | | | | Asc Av | Des Av | Total Av | |
| Meas. | 49 | 54 | 31 | 28 | 40 | | | | | | Ex. #1 | -6.8 | +6.8 | +13.6 |
| Amt/Ch | | +5 | -23 | -3 | +12 | | | | | | Ex. #2 | -13.6 | +13.3 | +26.9 |
| | | | | | | | | | | | Ex. #3 | -13.0 | +8.5 | +21.5 |

*in millimeters