A Cinefluorographic Investigation of Selected Clarinet Playing Techniques
Author(s): Roland E. Anfinson
Source: *Journal of Research in Music Education*, Vol. 17, No. 2 (Summer, 1969), pp. 227-239
Published by: Sage Publications, Inc. on behalf of MENC: The National Association for Music Education
Stable URL: http://www.jstor.org/stable/3344328
Accessed: 21/09/2013 16:57

Roland E. Anfinson

A Cinefluorographic Investigation of Selected Clarinet Playing Techniques

A PROBLEM CONFRONTING music educators and teachers of the clarinet has been a lack of knowledge about the function of the internal oral structures of the performer during actual clarinet performance. The application of cinefluorography (x-ray motion pictures) has made it possible to photograph in synchronous sound and motion supralaryngeal adjustments in speech and voice. On the basis of available cinefluorographic studies, such as those by Moll[1] and Whitworth,[2] it was believed that an application of cinefluorographic research techniques to clarinet playing would yield information of value to clarinet teachers and performers. Specific areas of research were:

1. The feasibility of applying cinefluorography to investigate clarinet playing.
2. Systematic changes in supralaryngeal structure in: (a) staccato vs. legato tonguing at a set tempo; (b) staccato tonguing at various rates of speed; and (c) tonguing and slurring of notes in different registers.

Equipment and Procedures

The primary x-ray equipment consisted of an x-ray tube, an image intensifier tube, a fluoroscopic viewer, and a camera. The equipment was mounted so that the subject could sit upright in an adjustable dental chair. A head positioner assured immobility and placed the subject's mid-sagittal plane at right angles to the x-ray beam. A magnetic film recorder and unidirectional microphone were used. A plastic rod containing steel bearings of known size was included for filming to insure life-size projection of the film for analysis.

A camera speed of 48 frames per second was used, which helped define the rapid movement of the tongue. Slower speeds proved to be unsatisfactory for this definition.

[1] Kenneth L. Moll, "Cinefluorographic Techniques in Speech Research," *Journal of Speech and Hearing Research,* 3 (September 1960), 238.

[2] James Ralph Whitworth, *A Cinefluorographic Investigation of the Supralaryngeal Adjustments in the Male Voice Accompanying the Singing of Low Tones and High Tones* (unpublished doctoral dissertation, State University of Iowa, Iowa City, Iowa, 1961).

In order to better identify the tongue in single frame viewing, it was marked at the mid-line, back to front, with radiopaque paste. In preliminary filmings neither the reed nor the mouthpiece were visible in their natural state. The most satisfactory solution was a radiopaque paint that could be applied to the exterior surface of a subject's mouthpiece and would delineate it on film.

The nine subjects in this study were enrolled at the State University of Iowa as graduate and undergraduate music students, and ranged in age from 19 to 31 years. At the time of filming, all were taking private lessons with members of the faculty, using B-flat clarinets, mouthpieces, and reeds of professional quality.

The performance task (Figure 1) was designed to allow observations of supralaryngeal adjustments in three different conditions: (a) staccato vs. legato tonguing at a set tempo; (b) staccato tonguing at various rates of speed; and (c) tonguing and slurring of notes in different registers. Because of radiation exposure, the performance time was limited to approximately 35 seconds.

PERFORMANCE TASK

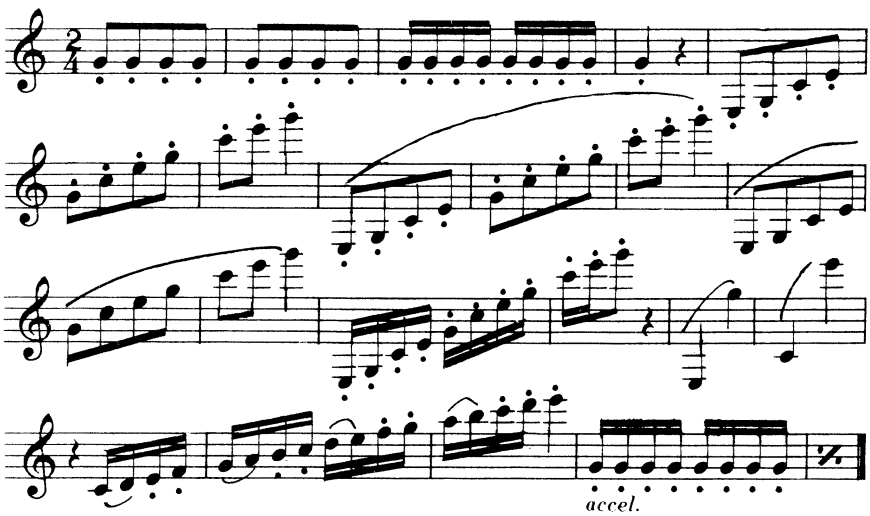

Figure 1

After an explanation of the study, the subject was allowed a warm-up period and the mouthpiece was painted. A metronome was then started and the subject played through the task once. Questions were answered and any misunderstandings as to articulation, notes, and rhythms were corrected. The subject performed the task again, this time with fluoroscopic viewing to assure correct anatomical positioning. The subject's tongue was then coated and the plastic rod with bearings was inserted in

his mouth. The filming started, the subject removed the plastic rod, inserted his clarinet, and performed the task.

The procedure for analyzing supralaryngeal adjustments consisted of selecting, tracing, and measuring frames picturing the oral cavity of the three chosen conditions. Frames showing the beginning, middle, and end of each note were marked for identification on the film.

Each tongued note was represented by two frames: one showing the contact of the tongue, reed, and mouthpiece, with the tongue at the maximum anterior placement in the oral cavity; and the other showing the tongue at its maximum point of withdrawal from the mouthpiece.

The following reference lines were established (see Figure 2): (A) an upper horizontal reference line from the pterogomaxillary fissure through the anterior nasal spine; (B) a vertical reference line, through the tip of the anterior upper incisor; and (C) a lower horizontal reference line, through the tip of the anterior upper incisor to the posterior wall of the pharynx. The following dimensions were then measured.

1. From the high point of the tongue to the upper horizontal reference line.
2. From the high point of the tongue to the vertical reference line.
3. From the posterior wall of the pharynx on the lower horizontal reference line to the posterior position of the tongue.
4. From the posterior portion of the tongue on the lower horizontal reference line to the vertical reference line.
5. From the tip of the anterior upper incisor to the tip of the lower anterior incisor.
6. From the upper portion of the tongue touching the mouthpiece to the lower portion during contact.
7. From the closest anterior portion of the tongue to the upper incisor during withdrawal.
8. From the high point of the above-mentioned anterior portion of the tongue during withdrawal to the upper horizontal reference line.

Results

After tracing and measuring the dimensions for each selected photographic frame, the data were submitted to statistical analysis. Dimensions one through five were analyzed in a three-dimensional analysis of variance, treatment-by-treatment-by-subjects. Dimensions six through eight were analyzed in treatment-by-subjects analysis. Where the F tests were significant, critical differences were computed to evaluate the difference between each pair of means.

Staccato vs. Legato Tonguing

The first condition analyzed represents a comparison of staccato and legato tonguing (measures 1-2). There were no significant interactions between contact-withdrawal and staccato-legato conditions for any dimension.

REFERENCE LINES FOR CONTACT AND WITHDRAWAL

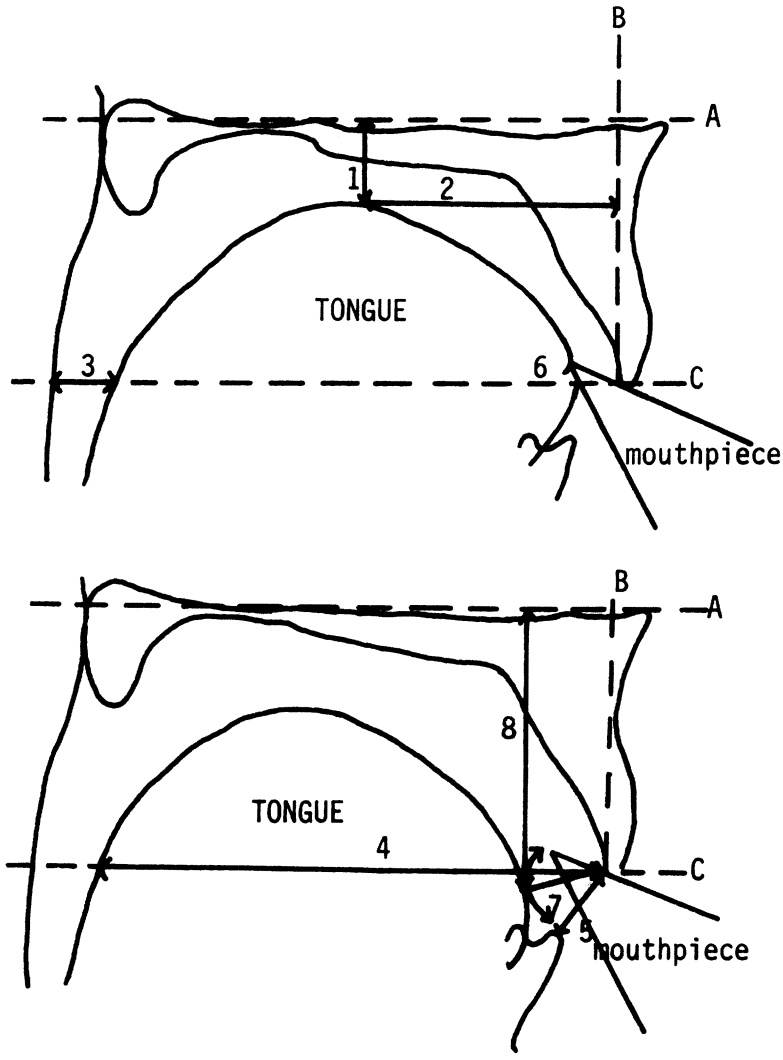

Figure 2

It can be seen in Table 1 that statistically significant differences between the two articulation conditions were found for only two dimensions. In the measure of tongue high point the tongue was, on the average, .10 cm. higher in staccato than in legato articulation. This occurred during both contact and withdrawal. Analysis showed that the anterior portion of the tongue withdrew a significantly greater distance during legato than for staccato.

TABLE 1
MEANS (IN CM.) FOR STACCATO VS. LEGATO TONGUING

Dimension	*Staccato*	*Legato*
1. Tongue high point (vertical dimension)	1.52	1.62*
2. Tongue high point (horizontal dimension)	4.92	5.04
3. Throat opening	0.64	0.71
4. Posterior tongue (horizontal dimension)	8.36	8.26
5. Incisal opening	1.27	1.24
6. Contact size	0.31	0.30
7. Anterior tongue (horizontal withdrawal)	1.33	1.70*
8. Anterior tongue (vertical withdrawal)	3.66	3.93

* Statistically significant at .05 level of confidence.

Table 2 presents the means of the first five dimensions for contact and withdrawal averaged over articulation conditions. Statistically significant differences were found in two dimensions indicating that the tongue high point and the posterior portion of the tongue were farther back in the mouth for withdrawal than for contact. Retraction of the tongue was also reflected in the dimension of throat opening, which was smaller for withdrawal than for contact, although this difference was not statistically significant.

Speed

The second group of analyses compared tonguing of staccato notes: eighths (measure 1), sixteenths (measure 3), and accelerating sixteenths (measures 21-24). No significant interaction between contact and withdrawal conditions was found for any dimension. Means for all dimensions of the different notes, averaged over contact-withdrawal conditions, are presented in Table 3. The overall F tests indicated statistically significant differences between note values for two dimensions. Analysis of individual mean differences indicated that the throat opening was significantly larger for the accelerated sixteenths than for other note values. There was a decrease in the means for the anterior tongue as the speed increased. Only the difference between the accelerated sixteenths and the eighth notes was significant.

TABLE 2
MEANS (IN CM.) FOR CONTACT AND WITHDRAWAL,
STACCATO VS. LEGATO TONGUING

Dimension	*Contact*	*Withdrawal*
1. Tongue high point (vertical dimension)	1.58	1.56
2. Tongue high point (horizontal dimension)	4.60	5.36*
3. Throat opening	0.70	0.64
4. Posterior tongue (horizontal dimension)	8.27	8.34*
5. Incisal opening	1.23	1.28

* Statistically significant at .05 level of confidence.

TABLE 3
MEANS (IN CM.) FOR THREE CONDITIONS OF SPEED

Dimension	*8ths*	*16ths*	*Accelerated 16ths*
1. Tongue high point (vertical dimension)	1.52	1.50	1.54
2. Tongue high point (horizontal dimension)	4.92	4.95	4.71
3. Throat opening	0.64	0.64	0.84*
4. Posterior tongue (horizontal dimension)	8.36	8.11	8.12
5. Incisal opening	1.27	1.26	1.25
6. Contact size	0.31	0.34	0.34
7. Anterior tongue (horizontal withdrawal)	1.34	1.21	1.16**
8. Anterior tongue (vertical withdrawal)	3.66	3.72	3.77

* A difference of 0.16 between any two means is significant at the .05 level of confidence.
** A difference of 0.14 between any two means is significant at the .05 level of confidence.

Means for contact and withdrawal conditions averaged over the three note values are shown in Table 4. The results are consistent with those noted in the previous analyses: the tongue high point was farther back and the throat opening was smaller during withdrawal than during contact. Although not statistically significant, the difference between means for the measure of the posterior tongue also reflected the backward movement of the tongue.

Change of Register

The third analysis represented a comparison of oral formations seen in playing notes in different registers (measures 5-20). The results in both tonguing and slurring were quite similar. The first four dimensions all exhibit the same tendency to change at higher pitches. The mean dimensions remained approximately the same until the sixth or seventh note (b′ flat or d′′) was reached, and then continued to change until the highest tone (f′′′) had been reached. Although the trend was noted at the sixth or seventh note, statistically significant differences occurred generally at the seventh or eighth note when compared to the first or second (tones are referred to at concert pitch).

The tongue high point stayed the same until the sixth or seventh note and then moved forward and down in the oral cavity for each successively

TABLE 4
MEANS (IN CM.), CONTACT AND WITHDRAWAL, FOR SPEED

Dimension	*Contact*	*Withdrawal*
1. Tongue high point (vertical dimension)	1.54	1.51
2. Tongue high point (horizontal dimension)	4.58	5.14*
3. Throat opening	0.74	0.67*
4. Posterior tongue (horizontal dimension)	8.05	8.34
5. Incisal opening	1.24	1.27

* Statistically significant at the .05 level of confidence.

higher note. Simultaneously, the throat opening became larger, the posterior portion of the tongue moved forward, and the withdrawing tongue moved slightly downward. The trends of these dimensions indicated that similar adjustments occurred in tongued as well as slurred passages. Those dimensions that did not appear to change as a function of pitch were anterior tongue, incisal opening, and contact size.

In measuring the difference in the mean dimensions of contact and withdrawal tonguing, the means remained approximately the same until the sixth or seventh note. At this point the tongue high point was farther down for withdrawal than for contact, and for all tones the high point remained farther back in the mouth, the throat became larger, and the back of the tongue moved farther forward for withdrawal than for contact. The tongue tip withdrew slightly farther down for each higher note played but not farther back. For sample tracings showing supralaryngeal positions for the notes d and f′′′ see Figure 3.

The placement of the tongue followed the same trend for slurring as for the tonguing of notes, with the exception of contacting the reed. The differences in the mean dimensions for beginning and mid-tone conditions slurred indicated that there was little or no adjustment between the beginning and middle of a tone before the sixth or seventh note. After these notes, adjustments occurred for each successively higher note. The tongue high point was farther forward and farther down, the throat opening was larger, the back portion of the tongue was farther forward, and the anterior tongue was lower in the oral cavity for mid-tone than for beginning.

A comparison of the dimensions for contact and withdrawal for tonguing respectively with those of beginning and mid-tone for slurring showed that for certain measurements the adjustments from contact to withdrawal position tended to be the same as those from the beginning to the mid-tone position. In addition they occurred at the same notes, although there was less adjustment in slurring than in tonguing. The tongue was lower in the mouth, the throat opening was larger, and the back of the tongue was farther forward for withdrawal and mid-tone than for contact and beginning. Slight adjustments, similar in nature, were evident for the withdrawal and mid-tone dimensions of the anterior tongue. One major difference was that the tongue high point was farther back for withdrawal than for contact in all the tongued notes. For slurred notes the mid-tone position was slightly farther back than for the beginning of a tone until the seventh note. After this note the relationship reversed and the high point of the tongue was farther forward at mid-tone than at the beginning of a tone.

Discussion

Tonguing Method

In this study two methods of tonguing were used. Four of the subjects performed with the tip of the tongue placed behind the lower anterior

SAMPLE TRACINGS OF NOTES D AND F'''

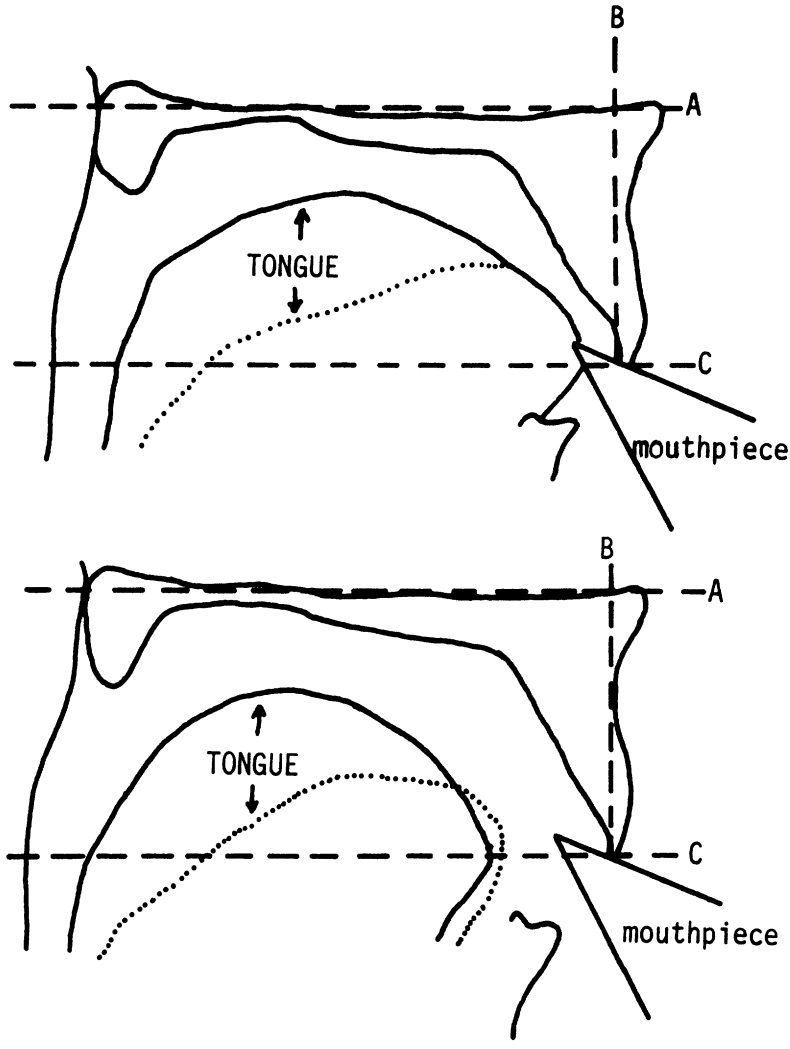

Figure 3

incisor. This was not a permanent placement in any sense of the word, since movement could be detected during tongued passages. These subjects employed what could be termed mid-tonguing articulation or a modification of it. The remaining five subjects tongued with the tip of the tongue. All subjects contacted the reed at or near the tip on the underside.

The tongue tip operated with some independence while contacting and withdrawing from the reed, but any movement was accompanied by movement of the whole tongue.

Staccato vs. Legato Tonguing

Staccato tonguing was produced by the tongue contacting, withdrawing, and contacting the reed as rapidly as desired. Legato tonguing was done by contacting the reed momentarily and allowing the tone to sound longer than for staccato tonguing.

A comparison of the dimensions indicated that in staccato the tongue remained higher in the oral cavity, and the tongue tip withdrew less back and down from the mouthpiece than for the playing of legato notes. The difference in tongue positions for these articulations appears to be one of expediency. For the playing of legato notes the tongue was off the reed most of the time. The tongue was lower in the mouth and the tip withdrew farther because there was no need to stop the tone by a rapid return of the tongue to the reed.

Speed

The results of the data for different rates of speed in staccato tonguing generally indicated that less retraction of the tongue occurred at faster rates of speed. This was in agreement with general teaching advice that as one plays faster less movement of the tongue should be used.

Significant differences did not occur for all dimensions at each faster rate of speed. However, a comparison of dimensions for the slowest speed of eighth notes and for the fastest speed of accelerated sixteenth notes indicated that considerably less retraction of the tongue took place at the fastest speed. A forward positioning of the tongue at the fastest speed was evident in the dimensions for posterior tongue and reflected in the greater throat opening as well as in the dimensions for the anterior tongue, which indicated less horizontal withdrawal from the mouthpiece at the fastest speed than for slower speeds. The whole tongue was positioned farther forward and closer to the mouthpiece for the playing of staccato notes at the fastest speed than for the slower ones.

Change of Register

Three specific conclusions may be drawn from the results of this study with regard to the playing of different registers on the clarinet: (a) all subjects made supralaryngeal adjustments while playing the upper register of the clarinet; (b) the adjustments followed a specific trend that began with the sixth or seventh tone (b′ flat or d′′) of the b-flat arpeggio; (c) the adjustments became greater as the pitch ascended to the highest tone (f′′′). It should be noted that these adjustments started with the first notes requiring the use of the speaker key and that little or no adjustment occurred in the lower register (pitches above a-flat are played with the speaker hole open). These adjustments also occurred during

slurred passages. Since directional movement of the tongue in slurred passages would appear to be unnecessary, movement would indicate that adjustments were being made for the upper register.

A graphic representation of the data for the contact and withdrawal conditions in the upper register tonguing for certain dimensions showed a divergent tendency rather than a strictly parallel relationship. It indicated that the tongue high point was lower in the oral cavity, and the back of the tongue was farther forward during withdrawal than for contact. The same divergencies from a strictly parallel relationship in the upper register could also be seen to a lesser degree in the beginning and mid-tone conditions in slurring.

This phenomenon can be explained if the lower position of the tongue when withdrawn from the mouthpiece is viewed as an anticipation of the next tongue contact position. Thus, each consecutive withdrawal position becomes an anticipation of the contact position for the next higher note as the tongue shifts forward and down in the mouth. In conjunction with this movement the throat opening and the back of the tongue adjust with the same type of anticipatory movement. This same view could possibly explain the adjustments for slurring.

Supralaryngeal Adjustments in Tonguing

Two measurements indicated opposite adjustments for the change of register from those in the staccato vs. legato and speed conditions. For staccato vs. legato and speed the throat opening became larger and the back of the tongue was closer to the mouthpiece for contact than for withdrawal. For the change of register condition the opposite occurred.

It is reasonably certain that a larger image would have shown like adjustments for the dimensions of the three tongued conditions—the throat would have been more open and the back of the tongue would have been closer to the mouthpiece for contact than withdrawal.

Vowel Formations

Certain teachers of the clarinet have advocated the use of vowel formations as an aid to playing the upper register. While tracings of spoken vowel formations were available from other studies it was not possible to compare them with accuracy to the tongue positions assumed for playing the clarinet. It did appear that positions of the tongue for slurred register changes may be analogous to those assumed for spoken vowels.

Related Research

Hall[3] in his study exploring the change of registers for trumpet playing felt that a common basis of adjustment for higher register playing was not shown. Wishing to explore this further he had three subjects play in

[3] Jody C. Hall, *A Radiographic, Spectographic, and Photographic Study of Nonlabial Physical Changes Which Occur in the Transition from Middle to Low and Middle to High Registers During Trumpet Performance* (unpublished doctoral dissertation, Indiana University, Bloomington, Indiana, 1954).

the extremely high register on the note high e′′′ and found that all three subjects shifted to an /i/ (commonly called "ee") formation.

The findings in this study for the change of register on the clarinet suggest the possibility of interesting comparisons between trumpet and clarinet playing in the high registers which could easily be explored by cinefluorography.

Whitworth[4] used cinefluorography to investigate supralaryngeal adjustments of ten tenors and baritones singing f to f′ using different vowel formations. The greater throat opening and lowered tongue position for the vowel /i/ found by Whitworth are similar to those adjustments made in playing the upper register of the clarinet. The opposite findings for /a/ (commonly called "ah"), higher tongue position and smaller throat opening, are similar to those found in playing the low register of the clarinet. Further study would be necessary to establish other comparisons.

It has been shown by Backus[5] that pitch adjustments can be made by "lip damping" on the clarinet. If Backus's conclusion that "the size and shape of the blowing chamber or respiratory tract and mouth are of no importance in tone production," then action of the tongue would seem to be necessary only for varying articulation. This appeared to be true for the staccato vs. legato and speed conditions, which did not, presumably, require pitch adjustment since the articulations were performed on one pitch.

However, the adjustments for the change of register condition differed from those observed for the other conditions. All subjects made similar adjustments for the tongued and slurred articulations involving a change of register. Thus the adjustments that occurred with a change of register involving a variety of pitches and articulations indicated that they were not solely a function of articulation.

It is commonly known that playing the clarinet in tune requires pitch adjustment by the performer. The performer also makes adjustment of timbre to accompany that of pitch. Because of the above factors and the change of register adjustments not related to articulation, it is possible that the adjustments for the change of register condition may have been for pitch, timbre, or a combination of the two.

Summary

Staccato vs. Legato Tonguing

The primary differences between staccato and legato tonguing were found in tongue height and tongue tip placement in the oral cavity. The measurements indicated that the high point of the tongue while in contact and when withdrawn from the mouthpiece was higher in the oral cavity for staccato than for legato tonguing. The tongue tip at its maxi-

[4] Whitworth, 44, 58.

[5] John Backus, "Acoustical Investigation of the Clarinet," *Sound; Its Uses and Control,* 2 (May-June 1963), 23; "Vibrations of the Reed and the Air Column in the Clarinet," *Journal of the Acoustical Society of America,* 33 (June 1961), 809.

mum point of retraction from the mouthpiece withdrew less for staccato than for legato tonguing. The basic action of the tongue was the same for both kinds of tonguing.

Speed

Differences in dimensions of adjustment showed that for the faster tonguing, the tongue high point remained at about the same height but was farther forward in the oral cavity. The back of the tongue was farther forward, the throat opening was larger, and the tongue tip withdrew less and slightly farther down from the mouthpiece.

Less movement of the whole tongue was exhibited for the fastest rate of speed as compared with the slowest, which is in accord with the advice of clarinet teachers.

Change of Register

For both slurring and tonguing, with the exception of the tongue tip movement, adjustments for the lower register were slight or nonexistent. Noticeable adjustments began with the playing of the notes b′ flat or d′′ and continued as the pitch ascended to the highest tone f′′′. The tongue high point became lower and farther forward in the oral cavity, the throat opening became larger, the back of the tongue moved forward and down, and the tongue tip withdrew slightly farther back and down for the highest notes. These adjustments were observed for all subjects and all parts of the performance task involving a change of register, starting with those notes requiring the depression of the register key.

Tongue Action

Four of the subjects used the mid-tongue articulation or a modification of it, in which the tongue tip was placed behind the lower anterior incisor. Contact with the reed was made on the upper surface of the tongue considerably behind the tongue tip. The remaining five subjects touched the reed with their tongue tip.

The whole tongue protracted while contacting the reed and mouthpiece and retracted for withdrawal. It was observed that the anterior portion of the tongue did not contact and withdraw from the reed without movement in the posterior portion of the tongue. Some teachers have recommended that only the tongue tip be moved for articulation; it does not appear that this can be done with complete independence.

Cinefluorography as a Means of Investigation

This study yielded information showing systematic changes in supralaryngeal adjustments. The adjustments shown were primarily of the tongue and throat. Some limitations imposed by the x-ray equipment such as the image-size, camera and recorder speed, and the radiation exposure factor have been alleviated by the use of more modern cinefluorographic equipment.

One difficulty encountered was the inability to photograph the reed. If the reed-image problem were solved, cinefluorography could be more easily applied to single and double reed instruments.

In view of the adjustments observed in playing the upper register of the clarinet, other studies might explore the effects of the oral cavity on intonation and timbre, or the use of syllables as an aid in playing the upper register. The effect of dynamic gradation or the correlation of oral cavity pressure and supralaryngeal adjustments might also be considered.

The adjustments for the change of register on the clarinet obviously raise the question of whether or not they occur on all wind instruments. Adjustments on certain wind instruments could easily be explored by means of cinefluorography.[6]

Findlay College

[6] This article is based on the author's unpublished doctoral dissertation of the same title (University of Iowa, 1965).