A STUDY OF BRASS MOUTHPIECE INTONATION

by

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INTRODUCTION

The purpose of this report is to explore the intonation characteristics of different types of mouthpieces used upon the same trumpet by three individual players. It is hoped that the research will accomplish these three premises:

1. To show a definite difference between individuals in an overall intonation pattern.
2. To show a difference in intonation pattern, either sharper or flatter, when the size of the mouthpiece cup differs.
3. To show a difference in intonation patterns in selected registers when the size of the throat changes and the rest of the measurements of the mouthpiece remain constant.

It is believed that this type of information and research will make it easier for music educators in their evaluation and selection of brass mouthpieces.

This study is in no way intended to refute or support any existing studies or to prove or disprove any published reports. It is, rather, an outcome of the author's curiosity, and a desire on his part to make a first-hand investigation of the behavior of certain types of mouthpieces under controlled conditions.

Literature concerning trumpet mouthpieces is found in periodicals, manufacturer's publications, dissertations, and in books on acoustics and on musical instruments in general. The most important of the periodicals is _The Instrumentalist_, which contains articles and research findings by recognized authorities.

Occasionally _The Journal of the Acoustical Society of America_ has information on the trumpet mouthpiece. The material found in this publication consists of data and findings based on measurements of vibrations, existance of acoustical properties, new patents, etc.

There are three manufacturers' publications that present technical information concerning the mouthpiece. These are the _Embouchure and Mouthpiece Manual_ published by the Bach Corporation, which is now a division of Selmer Corporation; _The Proper Selection of Cup Mouthpieces_ and _The Inside Story of Brass Instruments_, both of which are published by the C. G. Conn Corporation. In the preparation of this report, the three publications just mentioned were of considerable value. The first two were especially important.

A Masters' Report on the brass mouthpiece, by David Stuewe, was of invaluable assistance in finding reference and background material. This report, entitled _A Study of the Brass Mouthpiece_, presents a general study of the brass mouthpiece, problems of standardization, physical operation, and information to aid in the selection of a mouthpiece.

TECHNICAL BACKGROUND

Figure 1 identifies the parts of a trumpet mouthpiece. All of these parts are interacting, and one cannot be changed to too great a degree without necessitating a change in the others. When these parts are in the proper relationship to each other, the mouthpiece is considered "usable". If any of these parts are out of relationship, an irregularity will show up in either the tone produced or the intonation pattern.[1]

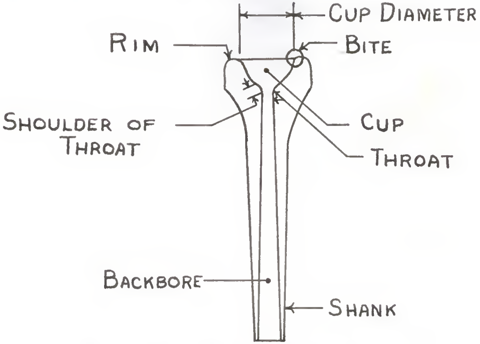

Fig. 1. The Brass Mouthpiece Cut in Half with the Parts Labeled.

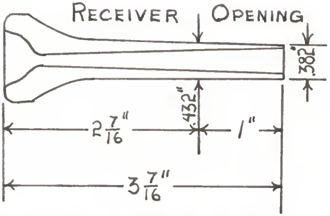

Fig. 2. Outer Dimensions of Mouthpieces Used in the Research.

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[1]Jody Hall, <u>The Proper Selection of Cup Mouthpieces</u>, p. 17.

Figure 2 illustrates the outside dimensions of the trumpet mouthpieces used in the research which did not change as the cup and rim dimensions were varied.

Explanation of Mouthpiece Parts and Their Interaction

The rim

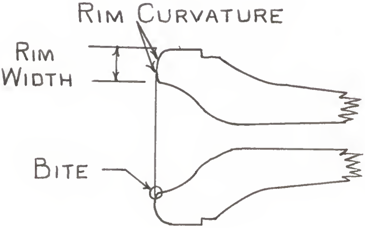

Fig. 3. The Mouthpiece

Figure 3 illustrates the three basic portions of a mouthpiece rim. By far the most commonly used mouthpiece has a medium wide rim (Rim Width), with a somewhat rounded curvature (Rim Curvature), and a rather sharp inner edge (Bite). If the rim is too rounded, it will cut into the lips and the player's endurance will suffer.[1]

The most important part of the mouthpiece rim is undoubtedly the inner edge or "bite". The rim of a mouthpiece must have a

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[1] Jody Hall, <u>The Proper Selection of Cup Mouthpieces</u>, p. 17.

sharp inner edge, but it should be low enough in the mouthpiece so as not to cut into the lip. In order to produce a clear tone there must be a definite contact point for the embouchure at the inner edge of the rim, just as one has to press his finger down tightly on a stringed instrument to produce a clear tone.[1]

A mouthpiece with a sharper bite often responds like a mouthpiece with a slightly smaller diameter. The sharper bite will tend to produce a tone with a little more "edge", a brighter sound, and sometimes even a slightly higher pitch.[2]

Cup diameter

The cup diameter is one of the most important factors in a mouthpiece. If the same basic cup shape is retained and the cup diameter is enlarged, the volume of the cup is obviously enlarged. When the diameter of the cup is enlarged, both the area and the length of the lips' surface in contact with the inside of the rim are increased. As a result, the lips tend to vibrate at a lower frequency; this tends to emphasize the lower partials unless the player compensates. Also, the resonance pattern of the larger cup makes the higher notes less responsive.[3]

Because the larger diameter of the cup covers a greater area of the player's lips, he must utilize greater muscular development and control. A greater volume of tone in the low

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[1]Vincent Bach, Embouchure and Mouthpiece Manual, p. 13.
[2]Jody Hall, The Proper Selection of Cup Mouthpieces, p. 17.
[3]Ibid., p. 15.

and middle register is usually easier to produce with a mouthpiece having a larger diameter. The player whose muscular control has developed sufficiently, and who is accustomed to playing a larger cup diameter, is able to produce uniform low, high, and middle registers with great flexibility.[1]

Cup depth

The tone quality, pitch level, and intonation of a mouthpiece is determined primarily by the volume of the cup and the depth of the cup. A cup which has a wide diameter and a deep cup will play lower in pitch than will a mouthpiece which has a small diameter and a small cup. Some players play as much as a quarter of a tone sharper than others using the same mouthpiece in the same instrument.[2]

Experiments done with mouthpieces which have exactly the same volume, the same throat diameter, the same rim, but different cup shapes, display only slight variations in intonation patterns. This tends to indicate that cup volume and depth are probably more important than cup shape, especially in intonation patterns.[3]

A mouthpiece with a reasonably shallow cup might prove to be excellent, providing that the backbore taper and the throat opening are in the proper relationship to compensate for the small cup. Unless there are some exceptional circumstances,

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[1]Jody Hall, The Proper Selection of Cup Mouthpieces, p. 15.
[2]Vincent Bach, Embouchure and Mouthpiece Manual, p. 16.
[3]Hall, op. cit. p. 14.

it is usually best to choose a medium cup for the average player. Mouthpieces which have large deep cups should be recommended for players with strong well-developed embouchures.[1]

The throat

A small throat in a brass mouthpiece does not produce an easier high register. If a mouthpiece with a small throat is used, the extreme registers will be constricted, the high register will be flat, and the low register very sharp.[2]

If the size of the throat changes and the volume of the cup stays the same, the "resistance" of the mouthpiece is changed. When the throat is enlarged, the resistance of the mouthpiece is changed. When the throat is enlarged, the resistance of the mouthpiece will be reduced and a greater amount of physical endurance will be required. As the throat size becomes larger, it becomes more and more difficult to play pianissimo, especially in the higher register. With a larger throat the player will find it easier to produce a greater volume of tone.[3]

A medium-sized throat is recommended for average players since it is conducive to physical endurance and produces a good intonation pattern and an even response in all registers.[4]

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[1]Bernard Fitzgerald, "Selecting a Mouthpiece." The Instrumentalist, Sept.-Oct., 1947, 2:20-21.

[2]Vincent Bach, Embouchure and Mouthpiece Manual, p. 18.

[3]Jody Hall, The Proper Selection of Cup Mouthpieces, p. 10.

[4]Jody Hall, "There is No Magic in Choosing a Brasswind Mouthpiece." ConnChord, January, 1964, 7:8-11.

But a mouthpiece with the larger symphony throat is recommended for players with strong embouchures who do a great deal of playing in larger ensembles, since the larger bore lends itself to the greater volume of tone and a wider variation in tonal color.[1]

Many mouthpieces are found to have throat sizes which are too small for obtaining best results. In this case, it is advisable to enlarge the throat opening. Players who play with a pinched high register are often helped by this procedure.[2]

The backbore

The backbore of a mouthpiece is very important because it has a definite effect upon tone quality and intonation. It bears a relationship to the throat, cup, and rim; but its relationship to the make and bore of the instrument in which it is used is especially important.[3] The backbores of the mouthpieces used in the experiment were all matched to the instrument at the factory. If the backbore had been too small, the upper register would have been "stuffy" and flat. If the backbore had been too large, the upper register would have tended to be sharp, and the resistance of the horn would have been decreased.[4]

EQUIPMENT USED

The equipment used in this research consisted of the items

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[1]Vincent Bach, Embouchure and Mouthpiece Manual, p. 18.

[2]Bernard Fitzgerald, "Selecting a Mouthpiece." The Instrumentalist, Sept.-Oct., 1947, 2:20-21.

[3]Jody Hall, The Proper Selection of Cup Mouthpieces, p. 12.

[4]Ibid.

listed below:

Conn Chromatic Stroboscope

Fork Unit

Conn Dynalevel

Two microphones

Transformer

Leblanc Sonic 707 trumpet with a medium-large bore

Five sets of Bach trumpet mouthpieces

1¼C	Standard Throat
1¼C	Symphony Throat
3C	Standard Throat
3C	Symphony Throat
7B	Standard Throat
7B	Symphony Throat
7C	Standard Throat
7C	Symphony Throat
10½C	Standard Throat
10½C	Symphony Throat

The subjects for the research were: Joe Hostetter, Senior in music education at Kansas State University; Russell Berlin, Senior in music education at Kansas State University; and the author, who was Assistant Director of Bands at Kansas State University. The observer was Keith Meredith, Junior in music education at Kansas State University.

Table 1, which describes the mouthpieces used, is taken from the publication, Embouchure and Mouthpiece Manual by Vincent Bach.[1]

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[1]Vincent Bach, Embouchure and Mouthpiece Manual, pp. 30-43.

Table 1. Description of mouthpieces used in research.

<table>
<tr><th>Model</th><th>Approximate cup diameter</th><th>Depth of cup</th><th>Rim Shape</th></tr>
<tr><td>1¼C</td><td>17mm
43/64"</td><td>Medium shallow</td><td>Medium wide</td></tr>
<tr><td colspan="4">Description:
Extra large cup diameter for powerful symphony, opera, and solo trumpeters. Well suited for interchanging between Bb, C, and D trumpet used in modern symphony compositions. Crystal clear, brilliant, yet compact tone of great carrying power throughout its entire register.</td></tr>
<tr><td>3C</td><td>16.3mm
21/32"</td><td>Medium shallow</td><td>Medium wide</td></tr>
<tr><td colspan="4">Description:
A brilliant tone. For players who must use a large mouthpiece but want an easier high register. Excellent for large symphony orchestra.</td></tr>
<tr><td>7B</td><td>16.2mm
21/32"</td><td>Medium</td><td>Medium wide, lowered toward the outside. Medium sharp inside edge with a perfect grip. A most comfortable "lay".</td></tr>
<tr><td colspan="4">Description:
Although full in the low and middle registers, this mouthpiece responds very easily on high tones and is therefore well suited to orchestra work where an effective all-around register is essential.</td></tr>
<tr><td>7C</td><td>16.2mm
21/32"</td><td>Medium shallow</td><td>Medium wide (same as 7B)</td></tr>
<tr><td colspan="4">Description:
It has a sparkling, brilliant tone, free of nasal twang, is ideal for dance music, stage presentations, "firework" performances and trick work where a player is required to perform the seemingly impossible. Preferred by beginners, advanced school musicians who desire to progress quickly, and by many symphony artists who regularly interchange between Bb, C, and D trumpets. It is the mouthpiece you can buy blindfolded if you are not set on any other model.</td></tr>
</table>

Table 1 (concl.)

Model	Approximate cup diameter	Depth of cup	Rim Shape
10½C	15.9mm 5/8"	Medium shallow	Medium wide comfortable rim

Description:

This marvelous mouthpiece is an even contender with the 7C in popularity. It has a remarkable fine high register, a rich, resonating low register, and offers great endurance. It is one of the best selling models and particularly useful to players with a not too strong embouchure or women performers. It is the ideal mouthpiece for solo work and for "C" trumpet as nothing superior can be found.

PROCEDURES

The equipment used in this research was stored and used in the band office where the temperature remained at a constant level. The player sat in a special cubicle in order to avoid any tendency to adjust his embouchure and intonation because of observing the window patterns of the Stroboscope.

During the tests, the tuning slides of the trumpet were completely closed, and the subjects were instructed not to compensate for faulty intonation by changing either embouchure or air support. The commonly accepted fingerings for the chromatic scale were used consistently in each test. The level of the Stroboscope and the Dynalevel, the placement of the microphones, and the distance and angle of the trumpet bell in relation to the microphones remained constant in all research sessions.[1]

[1] For a description of the Conn Chromatic Stroboscope and Dynalevel, see Appendix B.

Five sets of mouthpieces were used for the research, each set containing two mouthpieces which were identical in all dimensions except that of the throat size. At each session all subjects played upon the same set. The number indicating the manufacturer's identification for each mouthpiece was covered throughout the entire experiment so that the players could not know which mouthpiece was in use. In order to insure that the mouthpieces being used for a particular session were in the same set, the observer used a code of colors and numbers.

The players were instructed to make every effort to use a constant type of embouchure, and to produce the same quality of sound. To maintain a constant dynamic level, the Conn Dynalevel was placed in sight of the subject so as to give a visual picture of the dynamic level. The players were instructed to keep this level constant from session to session and from player to player.

Before each player began his series, a period of warm-up practice took place. The purpose of this period was to let the player become used to the mouthpiece being used at that time, to let the trumpet's temperature adjust to the player's playing level, and to let the observer check the levels and placement of the equipment used.

A chart listing the chromatic tones to be used in the research was used by the observer in selecting the sequence of tones to be played by a subject during his session. These tones were called at random, with special care being taken that no two successive tones were half-steps, octaves, or sevenths.

This procedure was adopted in order to isolate each tone by obliterating as much as possible its relationship with any other tone. It was hoped that this procedure would sharpen the objectivity of the player.

Certain techniques were developed during the preliminary tests used for setting up procedures. The observer discovered that the accuracy of the readings was improved if a tone of approximately three-seconds' duration, used to orient the Fork Unit, was followed by consecutive tones of approximately one-second duration. Before a particular reading was recorded, a stationary window pattern was required for three consecutive tones.

Each player was subjected to two series of intonation readings for each set of mouthpieces. These series were accomplished on separate days. The Stroboscope readings were then sent to the Statistics Laboratory where they were processed. The following sections of this report are based upon the results of the Statistics Laboratory analysis of the data collected from the research. Throughout the remainder of the report the mouthpieces used are identified by the research observer's identification number followed by the manufacturer's identification number in parentheses.

INDIVIDUALS SHOW A DIFFERENCE IN OVERALL INTONATION PATTERN

The first premise of this report was that individuals show a difference in their overall intonation patterns. In order to substantiate that premise the following table was used to illustrate the mean reading, in cents, of the two tests which were conducted on different days using the thirty chromatic tones from G3 to C6. A cent is defined as one-hundredth of a semitone based upon the equally tempered scale. The tones used were the written pitches and not the concert pitches. The numbers used in Table 2 were arrived at by adding the Stroboscope readings for the sixty tones played during the two days and dividing that sum by the total tones played, which was sixty. The result was the mean reading for the player's overall intonation pattern.

The Statistics Laboratory analysis of the data presented in this table stated that any two numbers compared horizontally or vertically which equal or exceed 2.60 cents can be termed a significant difference. Individual means were recorded for both symphony and standard throat sizes.

All of the numbers are positive, which indicates that all of the tones are sharp. This was to be expected because all tuning slides were closed. If the players had played perfectly in tune to the equally tempered scale, the mean numbers would have all been 0.00.

Table 2. Table of overall intonation means

	Player 1		Player 2		Player 3	
	Std.	Sym.	Std.	Sym.	Std.	Sym.
M1(7C)	48.58	41.60	44.58	43.45	42.62	41.33
M2(3C)	54.07	50.53	47.33	47.02	46.08	49.92
M3(7B)	38.08	44.75	46.45	44.90	40.55	42.72
M4(10½C)	54.00	54.17	48.52	49.97	49.98	49.58
M5(1½C)	36.02	42.93	41.17	42.63	45.97	39.57

Table 2 reveals that individuals differ in their overall intonation means. Among the three players used in the research, there was not an excessive amount of difference observed when comparing them upon the same mouthpiece. However, there were enough differences of significant size to warrant the above conclusion.

There would seem to be a tendency for the symphony throat mouthpiece to even out individual differences, thereby making it easier for individual players to match their intonation patterns to one another. This tendency became apparent after an examination of the thirty combinations of individual comparison possible for each throat size. Of the thirty possible comparisons from player to player for the standard throat, twenty-two equaled or exceeded the significant level. Of the thirty possible comparisons from player to player for the symphony throat, only twelve differed to the extent of becoming significant. In order to make any statements to the significance of this tendency, further research will have to be undertaken.

The differences in means for the throat sizes are shown in Table 3, with the numbers equaling or exceeding the significant level marked by asterisks. The first column gives the mouthpiece identification number. The second column shows the overall intonation mean for the player who is being compared to the other players. The third and fourth columns show the difference between the player in the first column in comparison with the other two players. A minus sign placed before a number in column three or four indicates the player referred to is playing sharper than the player referred to in the second column by the number of cents shown, while a plus sign indicates he is playing flatter.

Table 3. Difference of intonation level by individual comparison.

		Standard Throat	
	Player 1	Player 2	Player 3
M1(7C)	48.58	+4.00*	+5.96*
M2(3C)	54.07	+6.74*	+7.99*
M3(7B)	38.08	-8.37*	-2.47
M4(10½C)	54.00	+5.48	+4.02*
M5(1¼C)	36.02	-5.15*	-9.95*
	Player 2	Player 1	Player 3
M1(7C)	44.58	-4.00*	+1.96
M2(3C)	47.33	-6.74*	+1.25
M3(7B)	46.45	+8.37*	+5.90*
M4(10½C)	48.52	-5.48*	-1.46
M5(1¼C)	41.17	+5.15*	-4.80*
	Player 3	Player 1	Player 2
M1(7C)	42.62	-5.96*	-1.96
M2(3C)	46.08	-7.99*	-1.25
M3(7B)	40.55	+2.47	-5.90*
M4(10½C)	49.98	-4.02*	+1.46
M5(1¼C)	45.97	+9.95*	+4.80*
		Symphony Throat	
	Player 1	Player 2	Player 3
M1(7C)	41.60	-1.85	+ .27
M2(3C)	50.53	+3.51*	+ .61
M3(7B)	44.75	- .15	+2.03
M4(10½C)	54.17	+4.20*	+4.59*
M5(1¼C)	42.93	+ .30	+3.36*
	Player 2	Player 1	Player 3
M1(7C)	43.45	+1.85	+2.12
M2(3C)	47.02	-3.51*	-2.90*
M3(7B)	44.90	+ .15	+2.18
M4(10½C)	49.97	-4.20*	+ .39
M5(1¼C)	42.63	- .30	+3.06*

Table 3. (concl.)

	Player 3	Player 2	Player 1
M1(7C)	41.33	-2.12	- .27
M2(3C)	49.92	+2.90*	- .61
M3(7B)	42.72	-2.18	-2.03
M4(10½C)	49.58	- .39	-4.59*
M5(1¼C)	39.57	-3.06*	-3.36*

DIFFERENCES IN INTONATION PATTERNS
WHEN MOUTHPIECE CUP SIZES DIFFER

The second premise of this report was that there is a difference in intonation patterns, either sharper or flatter, when the cup dimensions change. This premise is supported by the data presented in the following comparisons of extremes in cup diameter and extremes in cup depth and volume.

Using the means in Table 2, the two extremes of cup diameter were compared. The M4(10½C) mouthpiece with a cup diameter of 15.9mm was compared with the M5(1¼C) mouthpiece with a cup diameter of 17mm.

Table 4. Intonation differences between extremes in cup diameter.

	Player 1		Player 2		Player 3	
	Std.	Sym.	Std.	Sym.	Std.	Sym.
M4(10½C) 15.9mm	54.00	54.17	48.52	49.97	49.98	49.58
M5(1¼C) 17mm	36.02	42.93	41.17	42.63	45.97	39.57
Diff.	17.98	11.24	7.35	7.34	4.01	10.01

Table 4 shows that in all cases the mouthpiece with the smaller cup diameter played at a significantly sharper level. The reader is reminded that any difference equaling or exceeding 2.60 cents is significant.

Again using the means in Table 2, the two extremes of cup depth and volume were compared. The M4(10½C) mouthpiece with a medium shallow cup depth and a cup volume of 19.5 was compared with the M3(7B) mouthpiece with a medium cup and a cup volume of 21.5.[1]

Table 5. Intonation differences between extremes in cup depth and volume.

	Player 1		Player 2		Player 3	
	Std.	Sym.	Std.	Sym.	Std.	Sym.
M4(10½C)	54.00	54.17	48.52	49.97	49.98	49.58
M3(7B)	38.08	44.75	46.45	44.90	40.55	42.72
Diff.	15.92	9.42	2.07	5.07	9.43	6.86

Table 5 shows that in all but one instance the mouthpiece with the smaller cup depth and volume played at a significantly sharper level.

DIFFERENCES IN INTONATION BETWEEN STANDARD AND SYMPHONY THROATS

The third premise of this report was to show a difference in intonation patterns in selected registers when the size of the

[1]Specific measurements of these mouthpieces are shown in Appendix B, p. 30.

throat was changed and the other measurements of the mouthpiece remained constant. However, a comparison of player to mouthpiece per note failed to reach a level of 1.15 (which the Statistics Laboratory considered significant) by .03, and therefore could not be included in the definite findings of this report. But since this comparison came so close to the significant level, the table of means for the M2(3C) mouthpiece was included in Table 9 found in Appendix E.

Because the above data was so very close to the significant level, the author was convinced that further research should be attempted in order to obtain a significant level of correlation in a player to mouthpiece per note comparison. In making this comparison, the means for the symphony throat and standard throat should be kept separate in order that a comparison can be made between intonation at different registers of pitch. The author believes that in comparing the results of such research, the symphony throat mouthpiece will show a definite tendency to level out the variation of intonation through the low, middle, and high registers.

A definite pattern of intonation differences in regard to throat sizes is not apparent in the following table, which represents the overall intonation differences between standard and symphony throats for each mouthpiece and each player.

The numbers in Table 6 are the result of subtracting the standard and symphony throat means shown in Table 2 for each mouthpiece. The result was placed in the column corresponding to the throat size which played sharper in intonation.

Table 6. Differences in intonation between standard and symphony throats.

	Player 1		Player 2		Player 3	
	Std.	Sym.	Std.	Sym.	Std.	Sym.
M1(7C)	6.98		1.13		1.29	
M2(3C)	3.54		.31			3.84
M3(7B)		6.67	1.55			2.17
M4(10½C)		.17		1.45	.40	
M5(1½C)		6.91		1.46	6.40	

The lack of significant differences, and a definite pattern of differences for the mouthpiece throat sizes, would seem to show that the using of either the standard throat or the symphony throat would not greatly alter the overall intonation pattern. The decision of whether to use the standard or symphony throat would then probably rest upon such factors as the player's embouchure development, desired tone quality, and desired tone volume rather than a consideration of intonation differences between the two throat sizes.

CONCLUSION

The findings presented in this report substantiate the author's contention that there are significant intonation differences between players using various mouthpieces upon the same instrument. Two of the three premises were substantiated by significant statistical evidence, while the third approached a significant level to a close enough degree to warrant further research.

The first conclusion was that the tone production of individual players differs in intonation patterns when produced upon the same mouthpiece and instrument. Tendencies observed while organizing the data for this first conclusion show that further research is needed in order to determine whether the symphony throat mouthpiece might actually promote an evening of these individual differences.

On the basis of this research, it was concluded that mouthpieces with small cup diameters definitely play sharper than mouthpieces with large cup diameters, and that mouthpieces with small cup depths and volumes play sharper than mouthpieces with large cup depths and volumes.

The data to be used for the third premise of the report failed to reach a significant level by a very small margin, thereby making it impossible to come to any definite conclusions as to whether one throat size responds more accurately than the other in different registers of the trumpet. However, because the data came so very close to the significant level the author feels that further research is definitely warranted.

It was established that when choosing between the symphony throat and the standard throat, the <u>overall</u> intonation pattern would not be altered sufficiently to warrant the choice of one over the other. It would seem from this conclusion that the player's embouchure development, desired tone quality, and desired volume of tone would be the primary determinants of the throat selected.

The author had no intention of removing the personal element from the choice of the mouthpiece. The player's embouchure development, comfort, and formation should still be used in aiding in the selection. But the author is convinced that as much objective information as can be obtained is helpful in determining the proper mouthpiece selection.

The author is certain that more research of this type should be attempted on all phases of brass mouthpiece intonation to help supply such information to music educators, for the final responsibility of selection rests with them.

ACKNOWLEDGMENT

The author wishes to express sincere appreciation to Professor Thomas B. Steunenberg, Major Professor; to Professor Luther Leavengood, Head, Department of Music; and Professor Paul Shull, Director of Bands, for their examination of this report; to Professor Gary Krause, Statistical Laboratory, for his work on data analysis; to Joe Hostetter and Russell Berlin for their work as subjects; to Keith Meredith for his hours spent as observer; to Mr. Matt Betton for the use of the Conn Dynalevel; and to Mr. Vincent Bach and the Selmer Corporation, Elkhart, Indiana, for the use of the trumpet mouthpieces used in the research.

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APPENDIX

APPENDIX A

LISTING OF TEST NUMBERS, DATES, AND MOUTHPIECES USED

Test Number	Mouthpiece Number*	Date
1	3C	January 29
2	3C	February 3
3	1¼C	February 6
4	7C	February 12
5	7B	February 13
6	7C	February 18
7	10½C	February 24
8	1¼C	February 26
9	7B	February 27
10	10½C	February 28

*Includes both symphony and standard mouthpiece designation.

APPENDIX B

The following explanation from the publication by the Conn Corporation with regard to the Chromatic Stroboscope and the Dynalevel is quoted to acquaint readers who are not familiar with this equipment:

> The Conn Chromatic Stroboscope consists of two units, the Stroboscope Unit and the Fork Unit. In the Stroboscope Unit there are twelve windows having the relative positions of the white and black keys of the piano keyboard in the octave from C to B. The twelve notes of the chromatic octave are thus represented. Sound picked up by the microphone causes these windows to be illuminated.
>
> As an illustration, suppose that a piano is available tuned to exactly equal temperament with the "A" string executing 440 vibrations per second. If this A string is sounded, there will appear across the center of the "A" window a characteristic stationary pattern composed of alternating light and dark bars. Upon sounding the A an octave higher, a similar pattern appears with twice the number of bars, since the frequency is doubled. The position of the pattern is also shifted outward from the center to the next band. Space is provided for seven octaves so that any one of these seven A's within the piano range can produce its own appropriate stationary pattern.
>
> If the piano string which was previously tuned to the standard A is now tightened, making its tone sharp, the characteristic pattern which originally was stationary will move to the right. Similarly a tone which is somewhat flat will cause its pattern to move to the left. The direction of the motion thus serves to indicate whether a given tone is sharper or flatter than standard, the standard being the equally tempered scale. The A on a piano which has been flatter than standard, say to 435 vibrations per second instead of 440, will cause the pattern in the "A" window to move toward the left. By moving the knob on the Fork Unit in the same direction, thus moving the pointer to the left, the pattern may be brought to a standstill. The pointer will then read "-20" on the graduated scale above the adjusting knob, thus showing directly how much the 435-vibration tone is flat compared to the standard A of 440, the reading being expressed in hundredths of a semitone (cents). If the entire piano had been tuned to equal temperament on this lower pitch standard, then all strings would produce stationary patterns with the pointer at "-20".

With the fork pointer set as zero, the Conn Chromatic Stroboscope is in exact tune with the equally tempered scale based on A-440 vibrations per second. With the pointer set to any position other than zero all notes are equally changed in parts of a semitone and the Conn Chromatic Stroboscope is still in tune with the equally tempered scale based, in this case, on an A of some other frequency. The scale on the Fork Unit is graduated to 50 hundredths of a semitone, plus or minus. The Conn Chromatic Stroboscope is essentially a logarithmic frequency meter, having an accuracy of frequency determination of about 1/20% (0.01 of a semitone) in the continuous range of 32 to 4070 cycles per second.[1]

The Dynalevel indicates the intensity or volume of sound with a column of eleven lights which are illuminated, in succession, according to the intensity of sound. Each section of the column represents a four-decibel change in intensity. Each section is illuminated with different colored lamps so that a change in sound intensity is seen as a change in color as well as a change in length of light column.

The Dynalevel responds to sound practically instantaneously, with a slight delay before the column of light recedes, so that sharp peaks of sound power can be seen. Its sensitivity can be adjusted to handle all musical situations. The range of the Dynalevel is 40 decibels, which is a 10,000 to 1 ratio of sound intensity--ample for nearly every application.[2]

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[1]C. G. Conn, Ltd., The Conn Chromatic Stroboscope Operator's Manual, pp. 3-4.

[2]C. G. Conn, Ltd., The Conn Product Manual, p. 152.

APPENDIX C

Table 7. Measurements of mouthpieces used in the research.

Mouthpiece	T	V			D	C	R	B
1C	26	26	15	20.5	68	11	20	3
3C	27	26	16	21	67	12	20	3
7B	28	27	16	21.5	67	11	20	2
7C	28	24	15	20	65	14	21	4
10½C	27	25	14	19.5	64	11	21	4

Interpreting the table:

Column T in the table of statistics indicates the throat measurements, the narrowest part of the hole. The number of the largest drill shank that will go through the throat is given in this column. One should bear in mind that the smaller the number of the drill the larger is the hole.

V consists of three columns of figures indicating cup depth and width and their combination into volume. The first of these three shows the number of sixty-fourths of an inch that the 3/16 depth gage can be inserted into the cup, down from the top of the rim. The second column shows the number of sixty-fourths the ½-inch depth gage can be inserted, and the third column figures equal the sum of the first two columns divided by 2. It is this third composite figure which is used for the single number indicating cup volume.

Column D lists the diameter of the cup at a point near its top where the curvature of the cup meets the curvature of the rim. One might call this the inside rim diameter. It is not always easy to locate the exact point where the two curves meet.

Column C shows the curvature of the rim. The numbers are in sixty-fourths; specifically, they indicate a circle that has a radius of many sixty-fourths of an inch. Similarly column B is for bite, the inside edge of the rim, and is also in sixty-fourths of an inch for a circle having this radius. Obviously, the larger the number the larger is the curve and the larger is the circle.

Column R lists the rim thickness or width. These figures are secured by measuring the outside of the rim, subtracting the inside rim diameter from it and dividing by 2. (If one did not divide by 2, the resultant figure would include two thicknesses of the rim.)[1]

This table does not include the throat measurements of the symphony throat. The author found that in all cases the symphony throat was one drill size larger than the standard throat--if the standard throat is 28 the symphony throat is 27.

The table on the preceding page also includes a mouthpiece which was not used in the research. The Rohner study did not include the measurements of the 1½C mouthpiece. However, after consulting the Bach manual it was found that the 1C and the 1½C would compare almost exactly the same in their measurements. Therefore, the measurements of the 1C are included in the table.

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[1]Traugott Rohner, "Standardization and Classification of Brass Mouthpieces." The Instrumentalist, Nov.-Dec. 1953, 7:32-34.

APPENDIX D

Table 8. Correlation of mouthpieces for each player.

	Player 1	Player 2	Player 3
Mouthpiece 10½C			
Day 1	.8458	.8604	.8818
Day 2	.8983	.9006	.8975
Both Days	.8540	.8787	.8846
Mouthpiece 7C			
Day 1	.7722	.8975	.8246
Day 2	.8326	.8767	.7890
Both Days	.8022	.8796	.7751
Mouthpiece 7B			
Day 1	.7704	.8310	.8617
Day 2	.8873	.8758	.9071
Both Days	.8327	.8535	.8597
Mouthpiece 3C			
Day 1	.7631	.8821	.7942
Day 2	.5962	.9069	.8974
Both Days	.6712	.8970	.8446
Mouthpiece 1½C			
Day 1	.8129	.8688	.8866
Day 2	.8991	.8154	.8783
Both Days	.8615	.7915	.8956

Table 8 illustrates the ability of each individual player to match intonation patterns between the symphony and standard throat mouthpiece. The correlation figures for Day 1 and Day 2 are arrived at by comparing the readings of each individual day. The correlation figure for Both Days is arrived at by comparing the readings between days. A correlation which is smaller for the Both Days' comparison than the correlation for either Day 1 or Day 2, as for Player 2 on the 1¼C mouthpiece, probably means that from one day to the other the entire intonation pattern shifted one way or another, either flatter or sharper.

A large number tending toward 1., a perfect correlation, would seem to mean that the player using that mouthpiece was more consistent with that size of mouthpiece. This cannot be a definite statement because this measure of correlation is not between two mouthpieces whose dimensions are identical in all respects.

APPENDIX E

Table 9. Chromatic scale means in cents for mouthpiece M2(30).

*Note	Player 1	Player 2	Player 3
G3	52.25	47.50	51.00
G#3	28.50	25.25	15.75
A3	46.75	40.25	37.00
A#3	45.75	39.75	30.25
B3	30.25	26.25	13.75
C4	42.75	33.50	9.75
C#4	98.25	101.00	79.75
D4	75.25	79.50	62.00
D#4	50.00	48.75	46.50
E4	61.75	58.00	52.25
F4	71.75	46.75	48.50
F#4	51.00	45.25	30.25
G4	56.50	45.75	26.00
G#4	54.25	46.50	46.75
A4	56.75	64.25	58.00
A#4	51.50	53.25	41.25
B4	42.25	38.50	26.00
C5	51.75	46.50	30.25
C#5	50.75	47.25	63.00
D5	50.75	42.75	48.75
D#5	30.75	26.50	27.00
E5	33.50	32.00	37.00

*Pitches given are written pitches.

Table 9 (concl.)

*Note	Player 1	Player 2	Player 3
F5	59.25	55.00	74.75
F#5	50.50	48.00	60.25
G5	61.25	47.00	61.50
G#5	51.00	50.00	75.25
A5	62.75	65.50	92.25
A#5	58.50	48.50	76.50
B5	44.00	27.75	56.00
C6	48.75	38.50	62.75

*Pitches given are written pitches.

The means recorded in Table 9 are arrived at by adding the Stroboscope reading for the symphony and standard throat on both days and dividing the sum by 4--the number of readings recorded.

A STUDY OF BRASS MOUTHPIECE INTONATION

by

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B.S., Kansas State University, 1962

AN ABSTRACT OF A MASTER'S REPORT

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requirements for the degree

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The purpose of this report is to explore the intonation characteristics of different types of mouthpieces used upon the same trumpet by three individual players.

The equipment used in this research consisted of a Conn Chromatic Stroboscope and Fork Unit, which were used to measure the subjects' intonation; a Conn Dynalevel, which was used to show the subjects their dynamic levels; a Leblanc Sonic 707 trumpet with a medium-large bore; and five sets of trumpet mouthpieces. This equipment was used in a room where the temperature remained at a constant level.

During the tests the subjects were instructed not to compensate for faulty intonation. The player sat with the Stroboscope out of sight in order to avoid any tendency to observe the window patterns. The commonly accepted chromatic fingerings were used. The physical and acoustical relationship of all the equipment remained constant throughout the research.

Each mouthpiece set contained two mouthpieces which were identical in all dimensions, except that of the throat size. The throat sizes were designated by the manufacturer as standard throat and symphony throat, with the symphony throat being the larger. At each session all subjects played upon the same set.

Before each player began his series, a period of warm-up practice took place. This allowed the player to beoome accustomed to the mouthpiece being used at that time, to warm the trumpet to playing level, and to let the observer check the equipment.

The chromatic tones used in the test were called at random in order to isolate each tone and obliterate interval relationship in intonation as much as possible.

The players were subjected to two series of intonation readings for each set of mouthpieces, each on a separate day. The conclusions of the report were based upon the Statistics Laboratory analysis of the data collected.

The first conclusion of the report was that the tone production of individual players differs in intonation patterns when produced upon the same mouthpiece and instrument. Tendencies observed while organizing the data for this conclusion show that the symphony throat might actually promote an evening of these individual differences.

It was also concluded that mouthpieces with small cup diameters definitely play sharper than mouthpieces with larger cup diameters, and that mouthpieces with small cup depths and volumes play sharper than mouthpieces with large cup depths and volumes.

The data to be used for a third conclusion failed, by a very small margin, to reach a significant level, thereby making it impossible to come to any definite conclusions as to whether one throat size responds more accurately than the other in different registers of the trumpet.

It was established that when choosing between the symphony throat and the standard throat, the overall intonation pattern would not be altered sufficiently to warrant the choice of one over the other.

The author is certain that more research of this type should be attempted on all phases of brass mouthpiece intonation to help supply such information to music educators, for the final responsibility of selection rests with them.