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# The influence of performance background on instrumentalists' ability to discriminate and label cornet and trumpet timbre

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The Influence of Performance Background on Instrumentalists' Ability to Discriminate  
and Label Cornet and Trumpet Timbre

by

Gary Compton

A dissertation submitted in partial fulfillment  
of the requirements for the degree of  
Doctor of Philosophy  
School of Music  
College of Visual and Performing Arts  
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## Dedication

This project would not have been possible with the loving support and encouragement of my wife, Kim, and our daughters, Laura and Emily. I am also grateful to my parents, George and Melva Compton, my sisters, Gloria and Glenda, and my mother and father-in-law, Jim and Ivy Wasson for their advice and guidance, particularly over the last five years. Love and appreciation also go to my aunt, Dr. Renee M. Porter and my uncle, the late William H. Porter for being so supportive of me over the years.

Philippians 4:13.

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## Note to Reader

The original of this document contains color that is necessary for understanding the data. The original dissertation is on file with the USF library in Tampa, Florida.

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The Influence of Performance Background on Instrumentalists' Ability to Discriminate  
and Label Cornet and Trumpet Timbre

Gary Compton

ABSTRACT

This study was an examination of instrument timbre discrimination and labeling, with specific consideration of the soprano-brass timbres of cornets and trumpets. This study sought to determine whether instrumentalists differed in their ability to label and discriminate cornet and trumpet timbres, and whether these abilities were influenced by the instrumentalists' performing instrument and years of playing experience.

Wind, brass and percussion players ( $N=100$ ) from existing instrumental groups in the Tampa Bay area participated in the study. These groups were collegiate trumpet majors from a large public university school of music, a collegiate wind ensemble from a private university, and a brass band from an area Salvation Army church, composed primarily of adults and retirees. Participants from these intact ensembles were categorized by years of experience and instrument performance group.

Participants were administered a timbre discrimination and identification test consisting of twenty-five items. Each test item consisted of three short musical excerpts played on cornets and trumpets. The participants' task was two-fold: to indicate which item was played on the "different" instrument (either cornet or trumpet), and to label the items correctly.

Results of the study indicated that, in general, all participants were more successful at the discrimination task than the labeling task. Further analysis indicated that low brass and high brass players were better at the discrimination task than non-brass wind and percussion players. Performance experience was not a significant factor for either task. Since the instrumental performance background of the listener influenced outcomes on the discrimination task, further support was garnered for a constructionist model of auditory perception in which enculturation plays a role in development.

## Chapter One

### Introduction

Brass pedagogical practice has been devoted primarily to the role of the trumpet in the development of soprano-brass instrumentalists. The value of the cornet in modern wind bands has been either disregarded, misjudged, or both (Wallace, 1979). There has been some support, however, for a more visible role involving the cornet in the training of trumpet players from the early stages of musical development (Ognelia, 1971). This support is generally found among performers and teachers who received early training on the cornet, and then moved to the trumpet out of necessity in order to pursue professional careers.

Some research suggests that the cornet and the trumpet differ very little in terms of tone (Backus, 1969), with the fundamental issue being that of instrument design. In general, the Bb trumpet is designed in such a manner that the weight distribution is spread over its length. In contrast, the Bb cornet, while equal to the trumpet in terms of pitch, range, and length of tubing, is designed in a more compact fashion, with weight distribution towards the center.

Many younger students, due to limits of physical strength, arm length, and other factors related to posture, may find it difficult to maintain the trumpet in the ideal position required for tone production and breathing. In effect, the weight distribution of the trumpet may lead to a forward “dipping” of the instrument, with the bell directed downwards. This may be detrimental to proper embouchure development. Since the

cornet is more compact, weight distribution is much less a factor (Ognelia, 1971). The younger player is able to maintain the proper playing position, and concomitant embouchure issues are minimized.

While the cornet is considered a curiosity in the American school band program, this has not always been the case. Well into the twentieth century, the cornet was the primary solo and band instrument of choice for most performers. Wallace (1979) indicated that the cornet enjoyed extensive public attention in the latter half of the 19<sup>th</sup> century due to its role as the primary melody-carrying brass instrument among the town bands of the day.

From the standpoint of technical and musical craftsmanship, the cornet was often considered the predominant solo instrument, but Hickman (1992) reports that performers, teachers and manufacturers have argued about the respective advantages of cornets and trumpets for as long as the instruments have been in existence. Some were of the opinion that the cornet should be relegated to the variety stage and the street corner (perhaps a reference to Salvation Army bands, who often held religious services outside), and had no place in the classical concert hall.

Those who championed the cornet held to their views just as dogmatically. A letter to Eldon Benge from Herbert L. Clarke, noted cornet soloist with the John Philip Sousa Band, serves to illustrate the contempt for the trumpet as a solo instrument:

My dear (*sic*) Mr. Benge:

Replying to your letter of the 19<sup>th</sup> just received, would not advise you to change from cornet to trumpet, as the latter instrument is only a foreign fad for the time

present, and is only used properly in large orchestras of 60 or more, for dynamic effects, and was never intended as a solo instrument.

I have never heard of a real soloist playing before the public on trumpet. One cannot even play a decent song even, properly, on it, and it has sprung up in the last few years like “jaz” [*sic*] music, which is the nearest hell, or the devil in music. It polutes [*sic*] the art of music.

Am pleased that you are making improvements in your playing. Keep it up, and become a great cornet player. You have an equal chance with all the rest, but you must work for it yourself.

Sincerely Yours,

Herbert L. Clarke

January 13, 1921

Clarke’s missive serves to illustrate the contentious arguments on both sides of the cornet-trumpet debate at that time. The dominance of the cornet was waning, while the trumpet as a solo instrument was gaining popularity due to the growth of jazz.

Ironically, early jazz artists were still actively playing the cornet through the mid-1920’s. Louis Armstrong was a cornet player until he joined “King” Oliver’s band in 1925 (Ward & Burns, 2002), although his approach to the instrument may have offended cornet purists such as Clarke. Indeed, many Dixieland jazz artists still consider the cornet to be the definitive soprano-brass jazz voice.

Although there is some evidence to suggest the cornet may be a reasonable option in the early development of the soprano-brass instrumentalist, it is the trumpet that dominates from the commencement of instrumental music education (Jenkins, 1967).

Similarly, if the instruments differ in tone, this difference is not being utilized as all cornet-trumpet parts are played on trumpet in the band setting (Wallace, 1979). This indiscriminate use of the trumpet may not necessarily reflect the composer's intention.

### *Brass Bands*

From the perspective of cornet and trumpet historic praxis, it should be noted that many orchestral trumpeters began their careers as cornet players in amateur bands, having limited exposure to the orchestral repertoire in many cases. This is particularly evident in Great Britain, where the brass band movement is well established.

The brass band has a substantial history, dating back to the early nineteenth century with the town bands of Yorkshire in industrial northern England. These bands flourished by drawing upon working class coal miners and other laborers, and became popular largely due to the prevalent Victorian ethos that music was a force for moral and positive good among working people. As Herbert indicates, "The performance and, indeed, the reception of music was a 'rational recreation', a panacea for the many ills to which the working class were believed to be susceptible" (1991, p.21).

The brass band movement also stimulated the first mass involvement by the working classes as performers of instrumental art music. In open-air concerts, tens of thousands of working-class people had their first experience of 'serious' instrumental music through the medium of the brass band. Transcriptions of operatic overtures, symphonic works and solo repertoire gave audiences, regardless of their social standing or wealth, access to "high art music" (Herbert, pp.49-50). By the turn of the twentieth century, there were over 4,000 brass bands in Great Britain, and a flourishing contesting format had developed in which bands were grouped by level of skill and experience.

More recently, brass bands have become less of a working class recreation and more a professional enterprise, with considerable corporate sponsorship and hired players. While early repertoire for these groups consisted largely of transcriptions from opera and classical music, there are currently thousands of original works for brass band, many written mainly as commissions for contests, dedications to particular groups or individuals, or specific occasions.

Increasingly, brass bands enjoy widespread popularity. As performing media, they are prevalent not only in Great Britain but throughout Europe, as well as Canada, Scandinavia, Australia, New Zealand, and, more recently, the Far East. By the early 1980's, Japan boasted over 200 school brass bands, with students commencing their instrumental training in the primary grades (Taylor, 1983). Additionally, there are British national and European championships for all levels of bands, from youth organizations to semi-professional. The North American Brass Band Association lists over one hundred British-style brass bands in Canada and the United States, the vast majority of which are amateur or volunteer, with a selected number of professional bands in both countries (NABBA, 2002).

While there may be occasional variations in the format and instrumentation of these bands, the general standard scoring is as follows: one E-flat soprano Cornet, nine B-flat cornets, one B-flat flugelhorn, three E-flat alto horns, (also referred to as tenor horns) two B-flat baritones, three B-flat tenor trombones, one bass trombone, two B-flat euphoniums, two E-flat tubas, two B-flat tubas, and two or three percussion.

From an instrumental music education perspective, it is interesting to note that all instruments, with the exception of bass trombone and percussion, are scored in treble clef

and read transposed parts. This allows for movement from one instrument to another without the necessity of learning a new clef or fingerings. This tradition is one of practicality as the vast majority of brass band players were amateurs and not well versed in the skills of transposition. Parallels in wind bands and orchestras can be found with clarinets and saxophones, where switching is common without the necessity of learning new fingerings or reading in different clefs in most instances.

The popularity of brass bands in North America has had a particular impact among trumpet players who wish to perform on the cornet. Along with the E-flat alto horn, the cornet is unique to the brass band. In order for a trumpet player to perform in a traditional British-style brass band, the player must procure a cornet. Given this juxtaposition of trumpet players performing on the cornet, the current study grew out of a desire to quantify opinion as to what cornets and trumpets “sound like” in a musical environment.

No commentary on brass bands would be complete without reference to The Salvation Army. Initially named the Christian Mission, The Salvation Army commenced its missionary work in London’s east end by taking the Christian gospel out of the pews and into the streets. Led by a Methodist minister, William Booth, and his wife Catherine, the “Army” first used music to attract listeners out of the pubs and brothels. The first brass ensemble was formed in 1878, and used the secular tunes of the day (replaced with Christian lyrics) in an effort to entertain and hold the crowds long enough to hear Booth preach. Gradually, Salvation Army bands developed along the same format as the secular brass bands, though they remained separate entities tied to the mission and work of the Army. The instrumentation was roughly the same, although there were slight variations in

part assignments. Many Salvation Army churches (or “Corps” in Salvation Army terminology) had competent brass bands, and a handful of Staff Bands, attached to Salvation Army corporate headquarters throughout world, performed at an exceptional standard, especially given that these were volunteer aggregations.

From the standpoint of repertoire, the Salvation Army maintained its own publishing division, with thousands of titles of varying difficulty. As with the secular brass bands, transcriptions of classical works were prominent, but there were also hundreds of original works specifically written by Salvation Army composers. In recent years, The Salvation Army has allowed the sale of its music to secular bands, the result of which has led to recordings of Salvation Army repertoire by non-Salvation Army bands, and increased interest in this repertoire among brass bands around the world.

#### *Cornet-Trumpet Praxis*

British trumpeter Harry Mortimer, among the most respected of brass band-trained musicians, started his playing career as a cornet soloist, eventually joining the Halle orchestra as third trumpet in 1927. He relates a specific incident from his autobiography concerning the cornet-trumpet dichotomy in a practical application. Mortimer was summoned by Sir Hamilton Harty, the conductor of Halle, to a meeting in order to settle friendly argument concerning cornets and trumpets, and whether one can hear a difference. Mortimer continues:

Awaiting my arrival (at this meeting) was Sir Hamilton himself and a room full of other more or less important persons. “Now Harry”, was my greeting, “I want you to settle an argument for us. When we were in London, you as good as said that a cornet was equal to a trumpet, and, in fact, better for certain pieces, and that

nobody would know the difference anyway. Now I want you to go into that room and play the ‘Leonora Call’ six times, using both instruments, and we shall try to decide which was cornet and which was trumpet.” The ‘jury’ consisted of leading orchestral members and other knowledgeable experts.... None of them got it right all the time, and the majority was wrong every time.... It is all a question of how you blow and whether you blow down both sides of the instrument or use half the instrument’s capacity. (p.76)

One would surmise that “blowing down both sides” would indicate a trumpet approach, and “using half the instrument’s capacity” would suggest a cornet approach. Although the current study did not specifically address player effects in timbre discrimination and identification, there is general opinion among players that the role of the performer cannot be overlooked. Similarly, there is opinion among trumpet performers and pedagogues suggesting that the cornet is preferable to the trumpet for the beginning soprano brass instrumentalist. This is based on the belief that there is an audibly perceivable difference in the timbre of the two instruments. Scarlett submitted that, with the cornet, “The student focuses on the sound right way. The cornet is more forgiving when the inevitable “splats” occur. Also, although both instruments weight about the same, the length of the trumpet often makes it more difficult to hold up for younger players. The cornet is more compact” (Personal communication, June 2002).

Smith shared a similar view: “I grew up with the cornet tradition...kids should start off on cornet, which is easier to hold and play. It will form better tonal concepts for life. I think a revival of the *true cornet style* [italics added] should occur. Bugle corps and marching bands have made it nearly impossible for the cornet to survive in the public

schools” (Hickman, 1992, p.50). A newspaper feature reported that: “Smith grew up on the cornet, the traditional Salvation Army band instrument, which lacks the brilliance-or at worst, the “blatt” of the trumpet- giving Smith what he describes as a “restrained” style” (Olmstead, 1977).

Performers such as Mortimer, Scarlett and Smith represent a cornet-trumpet juxtaposition that is not uncommon. This is particularly true in the Salvation Army and British brass band traditions. Mortimer was a cornet player in British brass bands prior to his orchestral career, while Smith and Scarlett started playing cornet in Salvation Army bands, eventually becoming orchestral trumpet players. Scarlett is a retired trumpeter from the Chicago Symphony, and Smith is currently Principal Trumpet of the New York Philharmonic.

It is also worthy to note that three consecutive principal trumpets in the London Symphony Orchestra, William Lang, Maurice Murphy, and Roderick Franks, also began their careers in British brass bands as cornet players. The oral tradition of master-apprentice is evident here in that Murphy was Franks’ mentor. This researcher had opportunity to study with Roderick Franks as an undergraduate, and the concept of cornet/trumpet transition and technical approach was a frequent topic of conversation during instruction. There is a belief that it is possible to make a cornet “sound like” a trumpet, but that the reverse was much more difficult. Whether this is due to a distinct timbre difference or listener perception experience remains to be studied.

Noted American trumpeter Carl “Doc” Severinsen suggests that the brass band movement needs to take hold in North America such as it exists in Britain. He also recommended a de-emphasis of the marching band in favor of the concert band in order

to help develop the correct tonal concepts with young players (Hickman, 1992). In this researcher's studio trumpet teaching, it has been observed that many players have serious embouchure and posture issues related to the demands of extreme volume and register from marching band and jazz band playing.

It is also evident that, although most of these younger players have adequate technique and range for their current level of development, they tend to lack the ability to play a melodic line as their playing experience has largely been devoid of such opportunities. The jazz, wind, and orchestral trumpet playing experience have been more of a supportive than melodic role, which is more often the domain of the woodwinds and/or strings. (The cornet parts in the wind band, however, often contain more involved technical and lyrical passages). The background role of the trumpet in orchestra and wind ensembles contrasts with the role of the cornet in the brass band, which is assigned the lead melodic voice. From the standpoint of lyrical/melodic playing, perhaps there is some justification for the introduction of the cornet as the instrument of choice for the beginner soprano-brass instrumentalist.

### *Problem*

While there is varying opinion as to whether the cornet and trumpet differ in terms of tone color, little research has been reported to verify or refute such views. This study, therefore, sought to address the following questions: Is there a difference among experienced listeners in their ability to discriminate and label soprano-brass timbres, specifically cornets and trumpets? Are these discrimination and labeling tasks influenced by listeners' years of instrumental playing experience and/or the type of instrument they play?

## *Theory*

This study was an evaluation of listener ability to discriminate and identify cornet and trumpet timbres, and whether these skills are influenced by the category of instrument the listener plays, and/or the listener's length of playing experience. There is a belief apparent in the brass instrument literature that, since there is an observable difference among cornet and trumpet timbres from spectrographic analyses (Wallace, 1979), then there must be a concomitant perceptual difference among experienced listeners when asked to discriminate cornet and trumpet timbres. From this point of departure, it is important to consider general theories of music perception.

Music listening and cognition theory can be organized into two categories, "copy paradigm" and "construction paradigm" (Fiske, 1996). These categorizations are grounded in two epistemologies: objectivism and constructivism. An epistemology is a theory of knowledge used to explain how we know what we know (Lorbasch and Tobin, 2001). The objectivist epistemology submits that knowledge is "out there", residing in books (or sound waves), independent of a thinking being and being separate from knowing and the knower. Constructivism asserts that knowledge resides with the individual, and that the only tools available to a knower are the senses. From a linguistic perspective, words are not "containers" whose meanings are in the word itself. They are based on the constructions of individuals.

The copy paradigm/objectivist model, most aptly demonstrable in the research of Carl Seashore (1967), suggests that music perception is a one-to-one translation between the sound object and the listener. By relying on the constituent elements of sound wave patterns; [frequency, intensity, duration, and waveform (p.5)] to predict listener

perception, copy paradigm suggests that music ability is a concrete, verifiable entity from which the listener extracts the necessary information for cognition: the music exists independently of the listener. Consequently, all listeners should be expected to extract the same acoustic information from a sound source given identical or similar conditions.

Fiske's analysis of Seashore's theory places doubt on the efficacy of the copy paradigm model, with particular emphasis on performer effects on listener perception. In reference to Seashore's performance scores (a series of studies based on measurements of fundamental frequency over time), Fiske observes:

One outcome of Seashore's performance analyses was the discovery of a frequent mismatch between what listeners say they hear versus what is actually happening acoustically. One example is vibrato. Seashore's performance scores showed that vibrato is primarily a rapid fluctuation in frequency. A strict reading of Seashore's theory predicts that vibrato will be perceived as a rapid fluctuation in pitch. But this rarely occurs. Instead, listeners usually report a *timbre* fluctuation [italics added]. Another example is the rapid intensity fluctuation found in the steady state portion of tones. This type of fluctuation is not perceived either, although it does have an effect *on the perception of timbre* [italics added].... So a one-to-one correspondence between acoustical events and perceptual events assumed by Seashore is not really the case. (p.7)

Essentially, Fiske asserted that player effects such as frequency, vibrato and intensity changes may influence timbre perception. These are variables that occur naturally in the performance of musical samples by players in a musical context. He also argued that these changes are not accounted for in Seashore's model, but are explained as

normal illusions, that is, some sound events are not perceived in the same way as they occur in sound waves, but may be explained by “faults and errors of hearing” (p.17) caused by the physical limit of the auditory mechanism. For Fiske, this reasoning was suspect as it ignored the role of listener perception.

In contrast to the objectivist copy paradigm model, construction paradigm postulates that musical sounds events are constructed in the mind of the listener through continual and reflexive hypothesis testing in the brain (Campbell & Heller, 1979). The listener constructs the meaning of a message according to his/her cultural background, previous musical experience and expectations. This cognitive process is a social/cultural contract that all members of a particular musical culture have in common, and is an implicit activity. The listener does not consciously decide to extract information from the acoustic signal, it simply occurs. As Fiske summarizes: “Construction paradigm entails the assumption that musical understanding is a product of pattern generating/reception processes rather than an aural copy of information contained in the sound object” (p.46).

A concomitant outcome of this process is the social-cultural contract (Campbell & Heller, 1982), in which the listener’s previous experience mediates the outcome of music identification processes. Musical comprehension, therefore, consists of pattern construction, listener expectation based on previous musical experience, and the listener’s facility in developing new patterns. Perception is constructed in the mind of the listener through implicit decision-making activity in the brain and is not merely a function of the sound wave pattern.

### *Purpose*

The purpose of this study was to determine whether experienced listeners differed in their ability to discriminate and identify modern cornet and trumpet timbre based on their category of instrument specialization and years of playing experience.

Timbre can be considered as the brightness (or lack of brightness) of a musical tone (Thayer, 1974). Factors that may influence timbre include the type of instrument (for the purposes of this study, cornets and trumpets), performer approach, and listener characteristics such as background and training. Matthews notes, “All quantifiable aspects of a sound go into making up its timbre, the most important being the final perception of the listener” (p.86). This study focused on listener discrimination and identification of cornet and trumpet timbre by groups of listeners based on general characteristics identified through a music background questionnaire, and a cornet-trumpet timbre discrimination and identification test.

### *Hypotheses*

The null hypotheses tested were that, as measured by the cornet-trumpet timbre discrimination and labeling test:

- I. There will be no difference among listeners in the ability to discriminate modern cornet and trumpet timbres based on their years of playing experience.
- II. There will be no difference among listeners in the ability to discriminate modern cornet and trumpet timbres based on the type of instrument performed by the listener.

- III. There will be no difference among listeners in the ability to label modern cornet and trumpet timbres based on their years of experience
- IV. There will be no difference among listeners in the ability to label modern cornet and trumpet timbres based on the type of instrument performed by the listener.

### *Definitions*

For the purposes of this study, cornet was defined as a soprano-brass instrument of 1/3 cylindrical and 2/3 conical bore, pitched in Bb, possessing the same range as the Bb trumpet. The cornet first appeared in Paris in *circa* 1828 with two valves and crooks (pipes) to put it in every key from low Db to C. It was added to the British wind band in place of the keyed bugle, and is now the primary melodic instrument in British brass and military bands (Newsome, 1998). Nineteenth century French composers such as Berlioz and Debussy favored the use of the cornet (*cornet a pistons*), mainly because of their ability to play chromatically since trumpets did not have valves at that time. For similar reasons, in England and the United States, trumpet parts were often played on cornet. Elgar and Stravinsky also employed the cornet in several of their orchestrations (Sadie, 1994). As previously discussed, the cornet is the predominant melody-carrying instrument of the brass band.

Trumpet was defined as a soprano-brass instrument of 2/3 cylindrical and 1/3 conical bore, pitched in Bb (Kennedy, 1980). Trumpet usage dates back to the ancient Egyptians, Greeks, and Romans, but it was not until the 17<sup>th</sup> century that it found a place in Western art music. Composers such as Purcell, Handel, and J.S. Bach, as well as their Italian contemporaries Torelli and Tartini, composed works for the high trumpet that are

staples of the modern repertoire. Keyed trumpets were created during the classical period, for which Haydn and Hummel composed their concertos. The addition of valves in the 1820's ushered in an increased use of the trumpet as a solo instrument as it was now capable of melodic content rather than rhythmic punctuation. The modern trumpet is the primary soprano-brass instrument used in orchestras, jazz bands, and wind bands.

Discrimination refers to listener ability to distinguish timbre among cornet or trumpet acoustic signals in a given listening task. For the purposes of this study, discrimination will involve selecting the different item from a group of three musical phrases. Labeling refers to the listener's ability to identify the instrument they hear as either cornet or trumpet.

Timbre is a multidimensional term. It can refer to tone color or sound color (Helmholz, 1862) or the number of harmonic partials and their relative strength in the sound spectrum (Seashore, 1942). Later researchers build on these definitions by suggesting those that focus on the attention and learning of the listener rather than the content of the sound wave exclusively (Pell, 1994, Handel, 1995). This may include performer factors that influence identification and discrimination tasks, such as the attack or initiation of the tone, what occurs between notes (transients), and the decay or release of the tone at its conclusion. A more thorough discussion of timbre theory is presented in the literature review portion of this study.

#### *Limitations and Delimitations*

This study, an examination of experienced listeners' ability to discriminate and identify modern cornet and trumpet timbres, was designed to consider differences in recorded musical examples when performed by professional players in a musically and

ecologically valid context. For this reason, the performers involved in the recording of the musical examples were free to choose instruments and mouthpieces used in a typical playing situation. Additionally, the musical examples were selected from standard study books often assigned at the high school or collegiate level. This contrasts with other studies that deal only with isolated tones or portions of tones.

No attempt was made to specifically address teaching methodology concerning embouchure, articulation or tone production, although these may be factors worthy of further consideration in future investigations. While further study using similar soprano-brass instruments such as flugelhorn or different-pitched trumpets would be of interest, this study dealt only with cornets and trumpets pitched in Bb.

Delimitations describe the population to which generalizations may be safely made (Locke, Spirduso, & Silverman, 2000), and deals with external validity. The generalizations made in this study are applicable to similar experienced musicians in comparable listening scenarios. No attempt has been made to generalize beyond the targeted population of wind, brass and percussion players. Studies of non-musicians, or participants who study other musical instruments, were also not a part of the current investigation.

## Chapter Two

### Review of Literature

In order to effectively address pertinent aspects of this study, several fields of inquiry were examined. Among these were research on cornet and trumpet perception; timbre as a variable in auditory discrimination and identification, including definitions and measurement of timbre; an overview of research in music perception; theoretical considerations from the fields of acoustics and psychoacoustics, and psychomusicological research concerning listener characteristics and performer effects. A comprehensive overview on these topics assisted in the understanding of issues relevant to the current study.

#### *Cornet and Trumpet Perception*

An impetus for the current study grew from Wallace's 1979 research on experienced listeners' perception of instrumental timbre, specifically band directors' ability to discriminate and identify modern cornet and trumpet timbres. Working from the premise that the practice of assigning wind band cornet and trumpet parts is done indiscriminately with a general preference for trumpets on all five parts (Cornet I, II, III/Trumpet I, II), Wallace designed a study to address band directors' ( $N=37$ ) ability to discriminate modern soprano-brass timbres, and also to find out whether performance specialization acted as a mediating variable.

Based on chi-square statistical statistics, Wallace found that subjects were able to discriminate cornet and trumpet timbres in both solo and ensemble contexts but were

unable to identify (label) cornets and trumpets under the same testing constraints, implying that labeling is a different type of task. The low correlations between subjects' scores on the discrimination and identification tasks further supported this view, implying that band directors may lack clear aural concepts of cornet and trumpet timbres. There was also no significant difference ( $p < .05$ ) between brass and non-brass playing band directors.

In his recommendations for further study, Wallace suggested that the use of instruments from different manufacturers introduces conflicting timbre interpretations. Such an approach may have addressed the restrictive and unrealistic nature of his study, however. A replication with a larger group of subjects comprised of college band directors and music faculty as well as college wind players from a wider geographic area was also recommended. The current study incorporated some of these recommendations through the use of a wider range of subjects with varying backgrounds and levels of performance experience.

Can experienced performers and listeners discern differences among various cornets and trumpets based on their monetary value? This area of inquiry goes to pre-conceived ideas about the quality of the instruments from auditory and tactile observations and experiences. Investigations by Kyme (1957) addressed whether expert listeners (music teachers,  $N=103$ ) could determine differences in the tone of various cornets and trumpets of different makes and price ranges when performed by a professional player. A second experiment, which ran concurrently, considered the performer's ability to distinguish cornets from trumpets, as well as the ability to assign a monetary value to each set of instruments.

Results indicated that expert listeners could differentiate among various cornets and trumpets of varying monetary value. The results of the performer identification task indicated a much higher correct response rate, although percentages are not supplied. The fact that the performer was playing the instrument and therefore receiving tactile in addition to auditory feedback may have aided in enhancing these results, even though the performer was blindfolded and wore gloves to provide some measure of control over these factors.

There was the concern of ecological validity in this scenario, as the experiment did not reflect a real performing situation. In an effort to control factors by artificially imposing measures such as gloves and blindfolds, the researcher may have had results that were of little consequence beyond the scope of the experiment. Additionally, no formal statistical analysis was undertaken, making it impossible to generalize beyond this particular study concerning instrument identification and monetary value.

An interest in instrument quality and listener ability to distinguish differences among various instruments has been of interest to performers and researchers for several decades. In a study thirty-five years after Kyme's investigation, Hickman (1992) examined audible similarities and differences between the trumpet and the cornet. Participants (college brass majors,  $N=32$ ) listened to musical examples performed on a cornet manufactured in 1886, a modern cornet, and a modern trumpet. The task was to choose which instrument had a stronger attack and a darker sound. The researcher performed the musical excerpts behind a screen to prevent participants from visually identifying the sound source, and used three different mouthpieces on each instrument.

The results indicated that college brass majors perceived the sound of the old cornet as different from the modern trumpet. Given that mouthpieces were switched so that each instrument was heard on each mouthpiece and statistics were not utilized, it was difficult to generalize results beyond the scope of the study. The extremes in mouthpiece choice (the older mouthpiece from the 1886 instrument was much deeper than the other two) led the author to conclude that mouthpiece is the most important factor in the sound of the instruments, but these conclusions are suspect given the complete lack of statistical analysis addressing possible interactions among instruments and mouthpieces. Also, player effects were completely ignored, even though the research was attempting to address the attack portion of the tones presented.

#### *Sound Source Characteristics*

Researchers outside the field of music, specifically psychology, acoustics and psychoacoustics, have produced intricate psychological and mathematical models in an effort to isolate and describe harmonic partials and overtones. These models are then used to form theory regarding attributes of a musical tone that affect identification and perception. As a result, it is generally agreed that a musical tone consists of an attack transient, a steady state portion, and decay.

In tones produced by the continuous excitation of a vibrating source such as with a bowed string, a blown reed, mouthpiece (lip reed), or a vocal vibration, the onset/attack is followed by the steady state, in which the energy supplied and expended are roughly in balance. Instruments such the piano, plucked string (such as guitar or pizzicato string) and percussion have no steady state as the decay begins immediately following the onset phase. The descriptor legato transient (Campbell & Heller, 1979) characterizes what

occurs between notes of a musical phrase, while the decay or offset describes the point at which the energy expended exceeds the energy supplied. The decay concludes the tone.

With these terms in mind, Thayer (1974) developed a study that dealt specifically with instrument timbre perception, specifically the effect of the attack transient on aural recognition. The primary research questions concerned instrument identification: Does the start of a musical tone act as a determining factor in musical instrument identification? Thayer expanded the definition of timbre to include factors related to the interpretation of tone color by suggesting instrumental timbre may be perceived by the listener from the attack portion of the tone. This led to questions as to whether the attack portion is indeed a part of the overall tonal “fingerprint” of a given instrument. Limitations included the use of only three tones of no greater than two seconds duration, and an examination using four instruments: clarinet, oboe, flute, and trumpet. This allowed for wider generalization, as different means of attack are required for these instruments (single, double and lip reed for clarinet, oboe and trumpet respectively, with flute as a non-reed).

The procedure involved a listening test with three versions of a tone: unaltered, attack replaced with the attack of a different instrument (i.e. trumpet with clarinet attack), and attack eliminated. (As this experiment was conducted in the pre-digital era, some measurement error may be attributed to the recording process.) Results indicated that the greatest number of errors in instrument timbre identification (36.8%) were associated with the trumpet, which was the least identifiable to expert listeners when the attack portion was removed. This suggested that initial tone production (attack onsets) might

have acted as a determining factor in timbre identification among soprano-brass instruments.

What components of the acoustic signal are necessary and sufficient for the successful completion of selected listener tasks? To address this question, Campbell and Heller (1979) introduced a new construct, the legato transient, by testing listener identification of six instruments playing a two-note legato phrase. By means of a convergence procedure, the acoustic signal was partitioned into the attack transient (or onset, described previously), steady state portion, legato transient, and decay. The objective was to determine whether there were portions of an acoustic signal that contained descriptors of some sort that allow the listener to identify the instrument being performed. The authors pointed out that the partitions of the signal were arbitrary, but they were clearly defined in operational terms for the purposes under investigation.

Two experiments were undertaken: the interpretive matching of repeated phrases, and instrument identification. In the first study, repeated measures analysis of variance supported the hypothesis that loudness is not a factor in phrasing, and higher frequency spectra may contain more information than lower frequency spectra for identification decisions by the listener. The second experiment, also using segmentation of the acoustic sequence, supported the hypothesis that the legato transient portion (what occurs between notes) is necessary for instrument identification.

In general, this study was applicable to the current investigation in the use of musical samples rather than isolated tones of limited ecological validity. By addressing between note (legato) transients, this study placed perception and identification of

instruments in a musically valid context. The legato transient alone yielded better identification overall compared to the attack transient and steady state portions.

While Heller and Campbell were concerned with the transient, between-note portion of tones and their role in instrument identification, Elliot (1975) focused on attack and release portions of instrument tones and their role in instrument identification. For testing purposes, a two-part master tape was prepared. Part A contained eighteen randomized instrument tones with their attacks and releases spliced out, and Part B contained unaltered instrument tones. Fifty-seven graduate music students served as test subjects. Results indicated that only three instruments were correctly identified when attack portions were removed, but nearly all were identified in the unaltered form.

Elliot concluded that attacks and releases might be influential in differentiating between and identifying among specific instrumental tones. He also observed that, as musicians, most of our judgments concerning timbre are made on a comparative basis. Rather than listening to isolated tones in a contrived format, judgments are most often made in a musical context based on listeners' previous experience. This was further supported by Figgs' study (1981) concerning discrimination of tonal qualities among various types of trumpets, in which the hypothesis was that the impression of the listener is based on training and cultural indoctrination rather than the physical properties of the instruments themselves. This supposition that the listener determines or "constructs" the content and organization of a musical-acoustical event supports a construction paradigm model of musical perception (Fiske, 1996). These were of particular interest in relation to the current study in their focus on the role of the listener in timbre identification and labeling tasks.

Rather than focusing on individual portions of a tone in order to address issues of sound source identification, some research had focused on the role of listener experiences in the identification of specific timbres. Jones' study (1989) consisted of a series of four experiments related to the question of instrument identification, and the effect of general and specific experiences on auditory perception. The first study concerned adults and children, and their underlying perception of musical instrument "families". Study two hypothesized a taxonomy in which the perception of musical instrument families would function. The third study, a variation and extension of the second, addressed the effects of expertise and experience on listener instrument identification and labeling skills. The final study investigated the role of abstraction in musical instrument family identification tasks by introducing unfamiliar musical sounds (in this case, Chinese instruments).

In general, these studies supported the hypothesis that the level at which a musical instrument is well differentiated depends on the listener's prior knowledge and experience; the listeners' prior knowledge acted as a mediating variable. This raises further questions concerning listener perception and aural training. Does greater exposure to unfamiliar sounds increase recognition, and if so, is this due to listener characteristics and background? What role does the listener's learned experience play in timbre identification and discrimination tasks?

The juxtaposition of instrument quality and performer expertise and their effects on listener perception of sound events has been a catalyst for some research. Chen (2002) investigated musician and non-musician perception of instrumental performance with newly-made violins of different qualities played by violinists of varying skill and experience. This relates to the earlier work of Kyme (1957) and Hickman (1992). Three

new violins, priced from \$300.00 to \$20,000.00 were played by three violinists of varying skill; a college freshman, a performance doctoral student, and a violin professor. Listeners (musicians and non-musicians) responded to a researcher-designed Likert scale response task as to the quality of the instruments they were hearing.

Analysis of variance indicated that the playing experience of the performer contributed more than the choice of instrument to the perceived quality of the instrument, and that this varied for string and non-string playing listeners. Non-string players rated the least expensive violin as better in quality than the more expensive instruments. The author concluded that this may be due to the fact that the non-string players were the parents of children in a Suzuki strings program who mainly heard their children performing on less expensive instruments. This study placed both the listener and the performer variables as important considerations in instrument identification and discrimination. One caveat relating to the level of the performers concerns expertise. Chen did not address the issue of performer competence specifically, and it is possible that this may have had an effect on outcomes. It may be possible, for instance, that the doctoral student may have been a more accomplished player than the professor.

The current study utilized short musical phrases in the listening test portion. Similarly, Wang and Sogin's investigation (1990) examined listener ability to discriminate melodic fragments. The stated hypothesis was that listeners encode melodic segments (in this case, three-note groupings) as a tool in tonal memorization, and implicitly utilize this process in recalling melodic patterns. The execution of this process is aided by harmonic, rhythmic, and contour cues from the musical material and structure. In order to determine the effect of cues on tonal memorization, three types of interfering

stimuli, labeled “distractors” [*sic*], were introduced into a melodic sequence. These distractors consisted of foreign melodic patterns, tones in octaves, and a spoken number sequence. Each distractor was superimposed over the original melodic patterns at various times. Chi-square analysis supported the hypothesis that increased musical skill may be detrimental in perceptual accuracy. Musicians paid greater attention to the interfering stimuli than non-musicians, resulting in greater disruption to the previously stored information from the original, unaltered melodic patterns.

### *Perception Theory*

A review of literature addressing comprehensive texts revealed several important works on music perception theory and psychoacoustics that informed the current study. A cross section of these points of view will be considered.

Fiske (1996) examined models of music perception under two general constructs he coined “copy” paradigm (Seashore, 1938, 1967) and “construction” paradigm (Serafine, 1988, Kivy, 1989) with the implication that there has been a developmental progression in music cognition theory from the 1930’s through to the present. His argument was for a rejection of copy paradigmatic theory in which musical events occur as a result of the sound wave and the human brain merely “copies” what is heard. Fiske asserts: “...there is good reason to believe that variance in what is heard and comprehended musically is markedly extensive between many listeners, even those belonging to the same musical culture” (p. 143). This has direct import for the current study in that all listeners were drawn from a similar musical culture, specifically brass, wind and percussion players, even though there was variation in the nature of their individual experiences.

Physiological and psychological aspects of hearing and the implications on harmonic and melodic perception were investigated by Beament (2001). A wide range of topics in acoustics and psychoacoustics, from mathematical models of music including frequency and pitch, to a detailed analysis of human hearing were analyzed in this text. Many of these factors (melodic contouring in particular) were relevant to the current study, as listeners heard melodic samples performed by various players on cornet and trumpets. These performers brought their own implicit performance nuances to the process, which enhanced the current study, as musical phrases in a minimally contrived environment constituted the acoustic material used in examining timbre perception.

Earlier work along the same general research parameters (Backus 1969), presented an extended examination of acoustics, addressing wave patterns, musical perception, the musical environment (specifically, room acoustics), and the acoustics of musical instruments. In his analysis of brass instruments, Backus considered mouthpiece effects, instrument design, and materials used in construction, with specific reference to the trumpet. Of particular interest was the assertion that the cornet was very much like the trumpet in terms of tone. Researchers in the acoustic fields tend to group the cornet and trumpet together frequently, reinforcing the idea that little timbre difference exists. As a reference, this text supplied rudimentary acoustic terminology in a format that was consistently free of scientific jargon, making it more accessible to the general reader.

Orbach (1999) examined issues related less to acoustical factors and more with the dimensions of listener auditory perception, including musical pitch, timbre and tone color. This related directly with the current study concerning listener identification and discrimination of timbre from a musical phrase. Orbach's treatise involved the synthesis

and relationship among pitches, stylistic considerations, and possible performer effects, such as vibrato. Intensity (loudness) and interval discrimination were also considered, with the emphasis being on listener perception rather than measurement of the content of the acoustical sound wave. Similarly, Dowling (1993) presented numerous issues addressing melodic and tonal frameworks, integration of these factors by the listener, and the development of musical perception from infancy through childhood. The role of rhythm in perception is also addressed in some detail. In general, Orbach and Dowling add additional support to a construction paradigm model in that the focus is on how listeners interpret and evaluate what they are hearing rather than on the sound wave as an entity containing all the information necessary for cognition. This stands in contrast to Seashore's view on the autonomy of sound objects in auditory perception.

Further support for a constructionist model can be found in Kivy's theory of musical expressiveness (1989). He postulated that music no more contains emotion than a Saint Bernard is sad because it looks sad. It may depend on the listener's response and/or interpretation of the musical sound event. To some, Barber's *Adagio for Strings* is a melancholy work. Perhaps, but to those with no frame of reference or connotation, it may not be. As Fiske observed, "...listeners respond emotionally to music, but their responses, even to the same piece, are personal ones and may vary both in quality and degree" (p.128). One may extrapolate from this line of reasoning that musical examples, even those played by the same performer, may (or may not) sound different.

Additional work by Kendall (1984), Stewart (1992), and Brinckmeyer (1993) concerned instrument identification and preference, utilizing *post-hoc* analysis of experienced and inexperienced musicians, with age and length/type of musical

experience as moderator variables. These studies further supported a construction premise of auditory events as they attempt to evaluate listener characteristics as determinants of instrumental timbre discrimination and identification.

### *Computer Timbre Modeling*

Recognition of instrument tones has also served as an impetus for research in computer music modeling. Srinivasan, Sullivan, and Fujinaga (2002) investigated conservatory students' ( $N=88$ ) ability to recognize isolated instrument tones in order to measure the effect of ensemble experience and to help evaluate the performance of timbre recognition computer models. Using isolated tones played by specific instruments in random order, subjects were asked to identify which instrument had produced each tone. Results showed that subjects who played orchestral instruments had higher recognition rates than subjects who were pianists, guitarists, or singers. The authors concluded that this experiment presented new challenges to computer timbre recognition models by giving researchers better baseline data to rely on for human recognition rates. These results also suggest that previous exposure to instrument timbres has a positive effect on accurate identification.

In another study addressing computer modeling of instrument timbre, Grey and Moorer (1977) utilized a discrimination procedure, directing subjects to listen for differences in the perceived quality of articulation and playing style among a group of instrumentalists performing a given musical task. This study suggested that alterations in timbre discrimination could result from playing the same note with slight variations in articulation and stylistic approach. The present study used different players who undoubtedly bring varying technique and approaches to the performance of the given

excerpts and these factors may have influenced outcomes. Although the research concerned timbre perception for computer synthesizing purposes, the use of a discrimination procedure, with emphasis on what the listener hears (subjective) rather than the physical attributes of the sound wave (objective) is reflective of a construction paradigm model.

### *Timbre as a Variable*

As early as the 1950's, researchers had conceded that, until careful study has been done, it could only be said that timbre is a multidimensional variable (Licklider, 1951). Working from that premise, Grey (1977) designed a multidimensional scaling procedure, subjecting trained musicians familiar with orchestral instruments to a listening test. Multidimensional scaling is a statistical procedure, used in this case to correlate listeners' ability to judge stimulus pairs (Grey, 1977, Freed, 1990). As with the previous study, the focus concerned computer applications in the creation of synthesized sounds.

Grey's test consisted of eighty trials in which listeners heard a single tone and were asked to identify it by choosing from sixteen proscribed instrument labels. His conclusions suggested that in-context studies may greatly expand the database relating to the phenomenon of timbre dominance in identification, and are therefore useful in computer applications. In selecting individual tones from extreme registers without any musical context or point of reference to other instruments, (bassoon was identified as brass 11% of the time), this study raises important validity issues. In order to address these concerns, the present study utilized musical excerpts from standard trumpet/cornet method books in a typical playing range for the respective instruments.

Freed (1990) investigated the correlation of perceived mallet hardness with listener identification accuracy, focusing on the attack-related dimensions of timbre. Building on Grey's earlier work, Freed centered on the need to provide psycho-acoustical data that could be helpful to users of digital sound processing techniques. In an effort to address ecological validity by using acoustic rather than synthetic stimuli, Freed's design yields insight into "everyday" auditory perception as well as music perception.

The stimuli consisted of metal cooking pots struck by percussion mallets, with a regression formula to predict the accuracy rating of perceived mallet hardness (PMH). Acoustical rather than mechanical properties (mallet hardness, striking velocity) were considered: the listeners did not know what type of mallet was used, or at what rate of attack. The focus was on listener perception rather than physical properties. Multiple regression analysis supported a four-predictor function, which is capable of predicting PMH ratings with sufficient accuracy (multiple R-Squared=0.725, F=1135, p<. 05). This function is suitable for predicting perceptual dimensions of mallet hardness, and may therefore be used as a reference in digital sound processing techniques. Freed concluded:

This study represents a first step towards building a set of rules evoking timbral percepts similar to that which is available in phonemic [language] percepts.

Unlike speech, music is unbounded: a given language has a finite number of phonemes [basic units of speech], but there may be no limit to the number of timbral percepts that could be manipulated for musical purposes. (p.321)

How early does the human brain begin to categorize and identify timbre? Lowther (2004) reported on the development of a discrimination task to investigate the sensitivity of children aged three to eight years to a range of timbre stimuli. The impetus for this

research was in response to the British National Curriculum in music education, which specifies timbre discrimination as one of the elements of music that children are instructed on from their earliest days at school. In order to encompass a wider definition of the term ‘timbre’, Lowther utilized both instrument and non-instrument tones, with the assumption that children would have previous experience with the environmental and vocal sounds, and that discrimination of these prompts would be easier than for the instrument sounds.

Children ( $N=40$ ) were asked to listen to twelve pairs of sounds, and respond to whether they thought the sounds were the same or different. Sounds were grouped in four categories, from ‘very easy’ (duck/dog, triangle/celeste) to ‘easy’ (tractor/car), ‘intermediate’ (flute/clarinet), and finally, ‘difficult’ (cello/violin, flute/clarinet). Results indicated that, as age increases, so does success in the timbre- labeling task, with scores ranging from 33% correct for three to four year-olds, up to 75% for the seven to eight year-olds. As labeling was not part of the task, this study highlights the difference between perception (by Lowther’s definition, being able to tell a difference), and categorization, or naming.

Qualitative data pertaining to the discrimination task were gathered through informal interviews with the children as they were carrying out the task. These data revealed that children carry out timbre discrimination of day-to-day sound objects (cars, trucks, doorbells, etc.) with high success, and that this activity occurs implicitly. While musical instrument labeling may develop later through instruction, children have a remarkable ability to absorb acoustic signals and incorporate them as part of their timbre

inventory. This skill acquisition seems to increase with the age of the participants in this study (maximum age, eight years).

Addressing the need for further studies that are ecologically valid employing some measure of qualitative data, Lowther comments:

Many of the previous research studies that have been commented upon in the preparation of this study frequently view timbre clinically as an acoustical signal devoid of meaning. This investigation finds this view potentially problematic for two reasons. Firstly, these studies, in their attempts to produce empirical data that is idealistically free from too many variables, begin to deny the way children develop timbre discrimination skills in the real world from experience that is without structure and [is] 'messy'. Secondly, this approach tends to propagate a view that this skill of 'timbre discrimination' can only be usefully examined in relation to specifically defined acoustic stimuli. (p.77)

By including both musical and non-musical timbres and juxtaposing qualitative data from the children themselves, Lowther provided a model that is easier to generalize beyond the confines of the experimental conditions. This approach was relevant to the current investigation in its use of musical examples in a reasonably typical playing and listening scenario.

An investigation into the perception of acoustic source characteristics (Li, Logan, & Pastore, 1991) examined the ability of listeners to perceive the source of a naturally occurring sound event. In this case, the researchers were interested in whether listeners could discriminate the gender of a human walker by listening to walking sounds. While not directly related to music perception, this study did focus on listener ability to

distinguish aspects of similar timbre events and reach some conclusions concerning identification of the sound source. The identification of sound source characteristics illustrated that humans use properties of sounds learned from experience to perceive important acoustic cues that aid in perception. This related to Lowther's (2004) model of perception as learned experience.

An examination of the Instrument Timbre Preference Test (Gordon, 1984) addressed the internal validity of this measure. Internal validity refers to the level of rigor and control in an investigation. A study is internally valid to the degree that the effect of influences beyond the experimental variable have been removed or minimized (Ary et al., 2002). The Gordon test uses synthesized rather than natural sounds of band instruments in order to assist beginning instrumentalists in choosing the "appropriate" instrument when commencing their study. Williams (1996) found that a number of the test timbres did not accurately represent actual instrument timbres, and this compromises the internal validity of the test. Experienced listeners could not identify the timbre of their own instrument 48% of the time. Other issues with the Gordon test include whether timbre preference is a reliable predictor of future success on a given instrument, although this is not examined in Williams' study. Recommendations to improve internal validity included modifications of the timbres used.

In general, the preceding studies and texts addressed timbre recognition in musical and non-musical contexts, as well as outlined theoretical models of music perception. This leads to the question of how the researcher defines timbre for the purpose of a study. Kim and Martin (1998) submit that arguments still abound over the definition of musical timbre, and over the relative importance of various acoustic features

of musical instrument sounds. Houtsma (1997) comments on the subjective nature of pitch and timbre, and how using these constructs as independent variables in an experiment is fraught with problems: “Because of their subjective nature, the parameters of pitch and timbre should never be presented as independent variables in perception studies. Doing so would amount to describing one unknown in terms of other unknowns” (p.115).

Krumhansl (1989) acknowledged that understanding timbre is a challenge to composers, music technologists, and perceptual psychologists. Studies in the measurement of timbre in the form of spectral energy distributions and amplitude envelopes have been highly informative in perception studies, but their complexity is often a challenge in isolating specific characteristics between and among various timbres (pp. 42-43). Within the realm of timbre studies involving orchestral instruments, performer effects must be considered an essential factor. As Krumhansl concluded, “The growing interest in expressive variations in music performance highlights the problem of what level of description is most useful for describing timbres” (p.45).

Slawson (1985) suggested that timbre encompasses an enormous variety of phenomena. Even the sounds of musical instruments, with various attacks, decays, and steady state portions present a wide array of disparate acoustic events (p.19). Sound color, according to Slawson, seems to be the clearest definition as it is a property or attribute of auditory sensation, not an acoustic property, much in the same way that visual color is a perceptual attribute, not a property of light. A sound may be heard to change from one color to another, but the change itself is not a sound color. Slawson concludes: “Sound color and visual color are multidimensional, both may be mixed, and both are

prominent, quite general properties of sensation” (p.20). In this model, timbre is not a property of the sound object, but a function of listener sensation and interpretation of the sound event.

As a multidimensional variable, timbre cannot be neatly placed into a discreet category. Unlike other musical variables such as loudness and tempo, an ordinal, ordered scale cannot be applied to timbre. A flute’s timbre is not greater or less than a clarinet’s, for example. The problem arises, therefore, as to how one defines timbre as a measurable variable, and what will serve as appropriate constitutive and operational definitions. (A constitutive definition describes a variable in terms of its relationship to other variables, while an operational definition is one used by the researcher in the context of a given study.)

In addressing the multidimensional nature of timbre, Butler (1992) admits that it is much more complex than many definitions would indicate. Similarly, Seashore observed that timbre is by far the most important and complex aspect of a tone, and introduces the greatest number of problems and variables (1938, 1967). In an effort to explain timbre’s multidimensional qualities and keep the integrity of his copy paradigm model intact, Seashore explained that timbre is only one element of tone quality, the other being sonance.

Seashore (1967) defined sonance as “the successive presence or fusion of changing timbre, pitch, and intensity in a tone as a whole” (p.95). Sonance is analogous to the frames of a motion picture. Although the observer is presented a series of discrete snapshots in each individual frame, the experience is one of actual motion as the successive snapshots fuse. Likewise, the timbre of a tone corresponds to the single

instantaneous picture, while sonance corresponds to the picture progression (pp. 103-104). What the listener hears in the course of a musical experience (as opposed to individual tones) may be more analogous to sonance than timbre in Seashore's explanation.

### *Definitions of Timbre*

As discussed previously, the multidimensionality of timbre makes it difficult to define and place into a discrete category. Research spanning well over a century indicates an array of theoretical modifications to the operational definition of timbre. Puterbaugh (2003) provides a comprehensive list of timbre definitions that serve to illustrate this progression:

- *Klangfarbe* (tone color, sound color, or timbre) depends primarily on the sound spectrum.
- The timbre of a tone depends upon: (i) the number of harmonic partials, (ii) their relative location in the sound spectrum from lowest to highest, and (iii) the relative strength of each partial.
- “Timbre: That attribute of auditory sensation in terms of which a listener can judge that two sounds similarly presented and having the same loudness and pitch are dissimilar.” (American National Standard (ANSI): Psycho-Acoustical Terminology, 1960, p.45)
- Timbre is the miscellaneous category for describing the psychological attributes of sound, gathering into one bundle whatever was left over after pitch, loudness, and duration have been accounted for.

- Timbre is an emergent property that is partly a function of the acoustic properties and partly a function of the perceptual process...the connection between the acoustic properties and object is learned by experience.
- Timbre is not a thing it is an abstraction. It does not exist in the real world as an object.
- Timbre is a grouping of the acoustic array influenced by acoustic content, and the attention and learning of the listener.

This historical perspective of timbre research supplies definitions that have progressed from a description of physical acoustic properties containing all the necessary information for cognition, to perceptual attributes that are multidimensional and context dependent. Of particular relevance to the current study was the focus on the attention and learning of the listener (Malloch & Bregman, 1997) and timbre perception as learned experience (Handel, 1995). Ward (1970) submits that the ANSI definition is problematic in that it defines timbre as the absence of a relationship with other variables, treating it as a ‘wastebasket’ category. Pratt and Doak (1976) expanded on the ANSI definition by postulating that timbre is the auditory sensation whereby listeners can judge that two sounds are dissimilar using any criteria other than pitch, loudness, or duration. This expanded definition is helpful in representing constructs of timbre perception. This improves generalization and reflects a typical musical situation, thereby enhancing ecological validity.

Sloboda (1992) utilized a meta-analysis approach of several measurement and statistical techniques in an attempt to compartmentalize and clarify timbre research over the last 3 decades. Among these approaches, studies involving discrimination were

relevant to the current investigation. This technique is defined as the subjective differentiation between stimuli or sets of stimuli, and focuses on listener perception rather than physical components of the sound object.

As a caveat, Sloboda points out that, although discrimination experimentation seems to work well in contrived environments with synthesized sounds, it is uncertain how they can be used effectively in musical situations. Musical signals are complex and time variant. The same tone performed by the same player in an immediate repetition can have timbre variation, especially in the “real world” context of musical performance. These tonal successions become increasingly confounded when different tones are used in the process of generating musical examples.

#### *Timbre Perception Theory*

Variability among listeners implies that all individuals may not perceive musical stimuli in the same manner, and the effects of musical context may confound timbre perception even further (Sloboda, 1992). Perception has been defined as the way in which an organism transforms, organizes, and structures information (Carterette & Friedman, 1974). Specifically, music perception involves both external/physical and internal/psychological stimuli, which relate to the brain’s decision making processes. With regards to studies in timbre perception specifically, Kendall (1986) observed: “questions concerning tone quality perception have received considerably less attention from researchers than questions concerning the perception of loudness and pitch” (p.186).

Roederer (1975) provided an extensive definition and scenario for how timbre perception operates, suggesting it is a first stage in tone source recognition. In this model,

there were two means by which information is extracted from an auditory signal. The first was storage in memory, with an adequate label for identification. This requires learning or conditioning. A child hears a signal, and is told: “This is a trumpet”, and, after adequate repetition and repeated experience, labels the stimulus ‘trumpet’. The second was comparison. The child hears a different sound and creates a new memory ‘file’ which may be labeled ‘clarinet’, or whatever label is given to them through the learning experience. This new ‘file’ is then compared to other labels that have been learned as to whether the stimulus is the same or different. When the sounds are mixed (as with synthesized manipulations) or closely related (as with cornet and trumpets), the labeling and discrimination skills become more difficult, and new ‘files’ are needed.

Heller (1981) presented a model of music communication that postulates a transition from a performer coding process to a listener decoding process. Commencing with a performer coding process, the model addressed the performer’s intended message, inclusive of instrument and performance components such as musical examples and performer variables. The intended message then travels through the acoustic medium, such as a concert hall or other area, to the listener through the auditory mechanism. Decoding then occurs, in which the listener implicitly partitions the sound event by instrument, styles and musical context, based on previous experience. Categorization of features then takes place, including characteristics preserved from one player to another, as well as unique features of each performance and/or performer. All of this information is then reconstructed by the listener and subjected to implicit hypothesis testing based on cultural and contextual factors to produce an effective message in the form of a musical sound event.

While this model did not address timbre identification and discrimination specifically, it was suited to the current study in terms of performer, instrument, and listener considerations. The model posited a theory of a shared social-cultural contract that exists implicitly between and among performers and listeners. Characteristics of listeners may influence outcomes, as music communication is a result of implicit hypothesis testing based on shared cultural expectations and contexts. As Heller submits, “Listener response is only partly determined by the signal transmitted by the acoustic medium. Communication thus depends upon the extent to which performer and listener share...an implicit rule structure for relating gestures of performance” (p.268).

Kendall expressed concern regarding the number of studies in timbre discrimination that focus solely on components of the sound wave pattern, while seemingly ignoring listener factors. He asserted: “The psycho-acoustic approach to the study of timbre suffers from the fallacy of reification of concepts- that a single noun or word will correspond to something unique and unchanging” (p.187). In order to achieve control of various factors, experimenters end up with stimuli that have little resemblance to those normally heard by musicians. In an effort to obtain acceptable levels of internal validity, external validity may be compromised. The experiments may be well designed and scientifically sound, but may lack any relevance beyond the scope of the study, and have little consequence in a musical context. Kendall notes that the privileged status accorded to the acoustical frame of reference is the product of a Cartesian mentality (p.188). This approach assumes objectivity of measurements taken with acoustic instruments, with the implication being that they are trustworthy since they are free from

observer bias. In contrast, a Humean approach acknowledges the essentiality of observer perception in the examination of acoustic phenomena.

Handel and Erickson (2001) addressed the need for timbre research not based solely on sound wave or acoustic characteristics. In order to reconcile the use of the word timbre, "... there must be some form of acoustic transformation *perceived by the listener* [italics added] that provides a way to predict the quality of one note on the basis of the quality of another note played (or sung) by the same instrument (or singer)" (p.121). Following this premise, they conducted two experiments, the first of which was to determine how well experienced listeners ( $N=22$ ) could determine whether two instrumental tones at different pitches were played on identical or different instruments. The second experiment examined experienced ( $n=12$ ) and inexperienced listeners' ( $n=19$ ) ability to identify classically trained singers performing different pitches. Results from both studies suggest experienced and inexperienced listeners cannot accurately judge or extrapolate the timbre of instruments and voices when there is greater than an octave displacement among pitches. The researchers conclude that a one-octave timbre window is probably an upper bound in vocal and instrumental timbre perception. Choosing typical rather than extreme ranges in a discrimination and identification task therefore seemed reasonable.

In a later related study, Handel & Erickson (2004) addressed research questions concerning how timbre across a sound-producing object's playing range contributes to the identification of that object. As in previous research, the authors cited concerns about the ANSI (American National Standards, Incorporated) 1973 definition of timbre as a perceptual quality, which states that timbre can be defined only at a single pitch and

loudness. Often, however, timbre is used to describe overall sound quality of one instrument, or a class of instruments (e.g., woodwinds or brass). There is also the added confusion of contradictory definitions of timbre within the same instrument.

The study consisted of stimuli produced across the playing ranges of two woodwind instruments (oboe and clarinet) and one brass instrument (trumpet). Listener judgments of instrumental timbre across pitch were measured using a three-note sequence in a dissimilarity task, with instrument identification measured as same/different using what the researchers describe as a three-note oddball task. Results indicated that even experienced listeners could not disassociate timbre from pitch, suggesting that listeners did not judge timbre difference solely on the basis of sound source. The authors concluded that the ability of listeners to judge what instrument(s) they are hearing in an identification (labeling) task is more difficult than indicating which source is more or less dissimilar in a three-note oddball set of stimuli. In essence, labeling appears to be a more exacting task than discrimination.

In summing up, the researchers challenged the usefulness of questions concerning the independence of timbre and pitch, and argue that experimental outcomes are a function of the particular stimuli used:

For any source, the sound timbre will change across pitch because of different excitations (resonance and/or *performer's intentions* [italics added]). The listener's ability to determine whether the two sounds came from one object or from two objects or judge source timbre differences across pitch will depend on many factors, including the *listener's knowledge* [italics added] of the source of

timbre transformations and the differences in the sound timbres themselves.

(p.606)

In general, there are still many unknowns concerning the multidimensional attributes of timbre from a measurement standpoint, and researchers should be willing to adopt a convergence of methods in order to address questions arising from studies. When examining subtle timbre difference such as those among instruments of the same family (in this study, soprano-brass) understanding of various approaches is considered useful.

### *Summary*

The preceding literature review addressed issues concerning cornet and trumpet timbre perception, timbre as a variable, and the challenges of defining it as a construct in music perception. Contrasting theories of music perception, from a copy paradigm model that emphasizes the measurable content of the sound wave as the primary determinant in identification of sound objects, to the construction paradigm model, with its emphasis on listener determination in the interpretation of sound events, were also considered. Overviews of acoustic and psycho-acoustic theories were similarly addressed, with implications for the current study in terms of player effects and instrument types. A major challenge when undertaking a review of research in acoustic phenomena and timbre perception was that much of the material in academic acoustic journals assumes an in-depth knowledge of physics, calculus, and acoustical engineering.

## Chapter Three

### Method

The purpose of this study was to determine whether listeners differed in their ability to discriminate and label modern cornet and trumpet timbres when considering their category of instrument specialization and years of playing experience. The following is a detailed presentation of methodology under the general categories listening test instrument development and procedural methods.

#### *Performers*

Three professional performers were invited to perform the musical excerpts that composed the discrimination and identification test. Player A was a professional performer and associate professor at a large public research university, and held the terminal degree in trumpet performance. This performer had approximately 37 years of playing experience and a varied background in jazz, commercial, and classical trumpet playing. Player B had approximately 28 years of playing experience, with a foundation in the brass band and cornet tradition, and served as an adjunct professor of trumpet at an area two-year college and private university. This player was also an active professional performer, and held the master's degree in trumpet performance. Player C was a professional performer with approximately 15 years of experience in jazz, commercial and classical trumpet playing. This performer also held the master's degree in trumpet performance.

### *Music Items and Recording*

Ten music items were selected for the listening test, chosen from standard intermediate study books for trumpet and cornet. Specifically, music was selected from the study books of Skornicka (1937), Glowaty (1989), and Getchell (1948). Studies of varying styles, dynamic range, and tempi were selected to provide a variety of listening scenarios reflective of a typical musical situation. The selected studies utilized major and minor tonalities. As these were intermediate study books, no extreme registers were included. (The selected music items are found in Appendix A).

The musical samples were digitally recorded in a music recital hall on the campus of an area university using a Sony ECMM907 electronic condenser microphone, Cool Edit Pro music software and a Memorex CD-RW compact disc. For each performance of the music selections, performers were positioned center stage to represent the location if presenting a solo recital.

Performers were asked to provide two versions of each of the ten musical samples on each instrument; two for cornet and two for trumpet, with the second iteration for each instrument played in an interpretive manner. For example, player A played the first musical item on trumpet and, after a short pause, repeated the same item, allowing latitude for the individual performer's interpretive discretion. The performer then switched to cornet and repeated the process with the same musical example. The reasoning behind this approach was an effort to provide more samples from which to extract listening test items, and to enhance interpretive variety in the items selected.

Prior to the commencement of each recorded musical sample, the items were identified by a verbal cue as to instrument and sample number. Player A playing the first

iteration of item one on trumpet would be verbally cued as “number one, trumpet one”, and for the second iteration as “number two, trumpet two”. This procedure produced four phrases per item and forty phrases per player, for a total of one hundred and twenty phrases.

From this process, two matrices of musical samples were generated, which were coded for selection in the listening test. The first group of samples was labeled alpha, while the second, interpretive iteration was labeled beta. Each item was identified by a 3-character code. For example, player A performing item 1 on cornet was labeled “AC1” for “A Cornet 1”, and when playing the same item on trumpet, the code is “AT1” for “A Trumpet 1”. For matrix beta (the interpretive phrases), the same coding was used, but marked with an asterisk, such as “AC1\*” or “AT1\*”, and so on.

#### *Editing and Selection*

After the completion of recording the musical examples and codification as outlined above, the samples were edited for content. While the majority of the recorded samples were relatively error-free and most of the remaining errors were corrected through immediate retakes during the recoding session based on performer feedback and researcher consultation, some minor editing was necessary, which led to the elimination of eight of the one hundred and twenty samples. These edits were generally spread across the entire range of samples, and had only minor implications in the overall item selection as only seventy-five samples were needed.

Following the editing process, the remaining one hundred and twelve coded samples were randomly selected for inclusion in the listening test, with the stipulation being that two of the samples must have been played on one instrument (cornet or

trumpet), and the third sample played on a different instrument. This was done manually by writing each coded sample on an individual index card and categorizing them into six groupings based on interpretive approach: AC/AC\*, BC/BC\*, CC/CC\*, AT/AT\*, BT/BT\*, and CC/CC\*. The interpretive approach used by the performers involved playing more “trumpet-like” or “cornet-like” on the respective phrases. The degree of interpretation of these phrases was left to the performer; there was no other direction given by the researcher. When selecting the items for inclusion in the listening test, no consideration was given as to which player was performing which excerpt. The primary interest was to ensure that two of the samples were played on the same instrument (cornet or trumpet), and one was played on a different instrument.

#### *Pilot Studies*

After the development of the listening test was completed, it was necessary to perform some preliminary investigation on the efficacy of this measurement instrument. This was achieved through the implementation of pilot studies. The purpose of a pilot study is to assess the practicality and appropriateness of the methodology and to permit preliminary testing of the hypothesis (Ary 2002). The pilot study can also be used to address issues of test length and administration. For the current study, two pilot studies were undertaken.

Pilot study 1 was administered to trumpet majors ( $N=6$ ) from the researcher’s trumpet studio at two different area colleges. Students were tested individually during studio regular lesson times and were asked to evaluate the test in terms of length, clarity of instructions, and timing of prompts. There was general agreement among all

participants that the format and timing was satisfactory, so no adjustments were deemed necessary.

Pilot study 2 was used to assess reliability of the testing instrument. Reliability is defined as the degree of consistency with which a measuring instrument measures whatever it is measuring (Ary et. al., 2002). A test-retest approach using the collegiate trumpet group ( $n=21$ ) yielded Pearson's Product-Moment correlations of .74 for the discrimination task, and .88 for the labeling task. Kubiszyn & Borich (2000) submit that the longer the interval between test administrations, the lower the correlation. The time interval of approximately ten days between administrations may have had an effect on these correlations. In general, these coefficients were in the acceptable range for test-retest reliability.

#### *Test Format and Scoring*

The listening test format was modeled after Wallace's study (1979) of band directors' ability to discriminate between and identify modern cornet and trumpet timbre, and was comprised of twenty-five items for the discrimination and identification tasks. For each item, listeners heard three similar musical examples, two of which were played on the same instrument, and the other on a different instrument (either cornet or trumpet). The rationale for the use of three rather than two examples per item was to decrease the error rate associated with guessing from 50% (one chance in two), to 33% (one chance in three). The use of a greater number of prompts per item (e.g., five, thus reducing the guessing factor from 33% to 20%) was considered, but given the increased time required for test administration and construction, this was not practical.

This decision is supported in the research literature. Asmus (1981) found that the three-choice exam prompt appears to be more efficient in the ability to sample examinee knowledge on a given task than the five-choice prompt, and also has a number of other potential advantages including reduced time in test construction and administration, as mentioned above. A trend towards higher means, item discrimination, item difficulty indices and reliability was also found with the three-part versus the five-part item.

Choice of the three-part item contrasts Wallace's approach in which listeners were given only two choices (cornet or trumpet) and were asked to circle one or the other in response to the musical phrases provided. For the current study, listeners were instructed to circle either cornet or trumpet in response to each of three similar musical samples per test item. A time interval of four to five seconds was inserted between each prompt. Each set of three musical samples was repeated once, with two practice items given prior to the commencement of the test. The practice items allowed the participants an opportunity to adjust to the timing of the test items and to gain a better understanding of the tasks required. (A sample of the listening test is provided in appendix B).

In order to receive a point on the discrimination task, the listener needed to accurately discriminate among the three phrases by indicating which phrase was the different instrument. Indicating "cornet-trumpet-cornet" on an item that was "trumpet-cornet-trumpet", for instance, would be a correct response as the listener recognized the second item as different than the other two, even though the label was incorrect. For the labeling task, the listener had to correctly label the instruments they heard as either "cornet" or "trumpet", and did not receive a point unless all three prompts were circled

correctly. These scores were based on a total of twenty-five possible correct responses and were converted to percentages for evaluation and analysis purposes.

The purpose of the listening test was to evaluate experienced listeners' ability to (a) discriminate cornet and trumpet timbres using musical excerpts in a solo context, and (b) identify (label) what instrument they are hearing as either "cornet" or trumpet" under the same listening scenario. The format of the devised test allowed both tasks to be completed concurrently. As previously mentioned, the listener heard three similar musical excerpts played on cornets and trumpets, with the indication that two of the excerpts were played on the same instrument and one was played on a different instrument. The listener circled either "cornet" or "trumpet" in response to each musical prompt. In addition to the discrimination and identification listening test, participants were asked to complete an anonymous background profile, outlining years of experience, performing ensembles and major/secondary instruments. These categorical data were utilized in the analysis in addressing factors that may influence outcomes.

#### *Item Analysis*

Item analysis refers to the evaluation individual objective test items for their difficulty and their ability to discriminate among the examinees (Boyle & Radocy, 1987). The possible range for the ease or difficulty of a test item is from 0.00 (an item which no participants answer correctly) to 1.00 (an item which all participants answer correctly). Extremes in either direction indicate the items are non-discriminating and may not be valid measures of the constructs under investigation.

This is a concern for a norm-referenced test because individuals are not separated by the item, but less a factor for a criterion-referenced test such as the test that was given

in connection with the current study because the goal was to determine whether specific construct criteria (musical instrument timbre discrimination and labeling) were being met. Bachman (1990) indicated that criterion-referenced tests are designed to enable the test user to interpret a test score with reference to a criterion level of ability or domain content. The emphasis here was on a specific skill (or skills) rather than whether the participants fit under a normal distribution of scores, which is paramount in a norm-referenced test.

Hughes (2003) expanded further on this matter: “The purpose of criterion-referenced tests is to classify people according to whether or not they are able to perform some task or sets of tasks successfully. It does not matter in principle whether all the candidates are successful, or none of the candidates successful. The tasks are set, and those who perform them satisfactorily ‘pass’; and those who don’t ‘fail’” (p.21). Boyle and Radocy (1987) submit that “...there is no universal rule regarding optimal item difficulty or the optimal mix of difficulties within a test. The test writer must consider the particular advantages of hard or difficult items in the context of the test’s purpose(s)” (p.127). With these views in mind, and given the criterion-based nature of the current test, an item analysis was not practical or useful. Manipulation of the musical phrases chosen to fit some type of normal distribution may have satisfied the item analysis criteria for a norm-referenced test, but would have made the current test somewhat artificial and contrived.

#### *Procedural Considerations*

Each performer was instructed to choose instruments and mouthpieces used for typical playing. This related to providing a musically valid scenario rather than a

contrived format in which the researcher controls instrument and equipment selection. For practical purposes, all instruments were pitched in B-flat, as cornets pitched in C are not common, nor were they easily accessible. It should be noted that, for practical considerations, the researcher provided two cornets and a selection of typical cornet mouthpieces, as the performers did not possess these instruments. This was done for logistical reasons and was not an attempt to influence outcomes. As with the trumpets, mouthpieces selected were typical for the instruments.

A brass mouthpiece consists of the rim, throat, back-bore, and cup. The rim is the rounded edge that is placed against the lips, and can vary by width and shape. Since every player has individual characteristics of lip shape and size, a wide variety of rim contours are available from numerous mouthpiece manufacturers. Since the performers used in this study were directed to choose their own mouthpiece, rim characteristics were considered typical.

The throat of the mouthpiece is the opening leading out of the cup. Generally, there may be some variability in throat size, as this area controls the amount of air passing into the instrument. This goes to player comfort and ease of blowing, and, as with rim size, was not considered as a variable in the current study. Similarly, the back bore, or tubing that leads from the mouthpiece to the instrument, was not considered a factor in this study, although there is opinion among manufacturers that timbre can be affected by bore size (Giardinelli, 2004).

Mouthpiece cup depth is noted by the letter indication. Generally, B cups are of medium depth, with C being slightly shallower. It is a commonly held belief among trumpet players that the shallow cup aids in making the higher range easier to produce,

and generally makes the timbre “brighter”. This belief is echoed in mouthpiece and brass instrument manufacturer publications as well. The numbering system (in this case, 1 ½ and 3) refers to the width of the rim as it makes contact with the performers embouchure: the higher the number, the narrower the rim. In this researcher’s experience, and from informal discussions with numerous players over many years, most professional players use the #3 rim or wider, with a B or C depth cup for typical Bb or C trumpet playing. Higher-pitched trumpets such as the E-flat or A/Bb piccolo usually require a narrow rim (5 or 7) and shallow cup (D or E). The mouthpieces utilized in this study were typical of those used in standard professional performance practice (1½ and 3 rims, with B and C-depth cups).

It should be re-emphasized that no attempt was made to intentionally select specific instruments or performers in order to influence outcomes. The performers selected were of professional level, playing instruments typically used in a normal playing situation given the parameters of the recording procedures. This addresses ecological validity issues concerning a musically varied scenario from which to extract the samples used for the listening test. While it may be of further interest to select players of widely varying ability (perhaps a beginner and professional performer on the same task), or to use instruments and mouthpieces identical or of vastly different configuration, this was not the purpose of the current study.

A purposive sampling method was utilized in determining the participants examined in this study. This involved the selection of participants who are judged to be representative of a chosen population as dictated by established criteria. For this study, the criteria for inclusion were defined by instrument families, specifically, high brass

players (cornet, trumpet, F horn and E-Flat alto horn), low-brass players (trombone, baritone/euphonium, tuba), and non-brass wind/percussion players (piccolo/flute, oboe, clarinet, alto, tenor and baritone saxophone, bassoon, and percussion). While there is a risk that the results of purposive sampling methodology may be misleading (Ary et. al, 2002), the sample sizes were large enough to address this concern.

The intact ensembles from which the participants were extracted for analysis purposes were collegiate-level and professional trumpet players, collegiate-level wind and percussion players, and British-style amateur brass band players. The collegiate trumpet majors group consisted of the trumpet studio of a large public university, with the addition of professional players from the immediate area. The collegiate wind and percussion players group was an existing ensemble from a local private university. The British-style brass band was an area Salvation Army band, composed of high and low brass players, as well as percussion.

By definition, the trumpet group ( $n=23$ ) was comprised entirely of those whose primary instrument was trumpet. Some members of this group also had experience with cornet playing, but indications from the background questionnaire suggested this exposure was limited, even for the more experienced players. The range of years playing experience for this group was from 9 to 52 years, with a mean of 35 years. (It should be noted that, although this group consisted mainly of collegiate undergraduate and graduate trumpet players, the presence of two professional players skewed the mean of years playing experience. This effect on the mean is to be expected given the relatively small sample size.) Testing took place in the fall of 2004.

The wind group ( $n=41$ ) was heterogeneous, comprised of wind, brass and percussion players reflective of a typical collegiate wind ensemble formation. This was an existing ensemble that rehearses and performs regularly throughout the academic year. The range of playing years playing experience of this group was approximately 9 to 30 years, with a mean of 9.4 years. Testing took place in December 2004.

The brass band group ( $n=36$ ) was an existing ensemble from a local Salvation Army congregation, where they perform for weekly church services and other special events. The range of years playing experience for this group was approximately 10 to 70 years, with a mean of 50 years. During the winter months, the band increases in membership due to the influx of retirees from northern states (New England and the Midwest) as well as Canada. Testing took place in February 2005, and thus reflects the group's enhanced membership due to the presence of these winter residents. In contrast to the other intact performing ensembles, the high players in this group were primarily cornet players who had limited or no performing experience with the trumpet.

#### *Addressing the Research Questions*

By stratifying instrumental families across groups, the research questions concerning instrument played as a function of timbre discrimination and labeling tasks success could be more readily addressed. As mentioned previously, this process was undertaken by targeting three categories: high brass players, low brass players, and non-brass players (winds and percussion), and extracting the data generated from these groups.

The high brass players included trumpet, cornet, alto horn, and French horn. These instruments were grouped as high brass as they all play and sound primarily in the

treble clef (with the exception of the French horn, which sometimes reads in bass clef).

Low brass was all other brass, specifically, baritone, euphonium, trombone, and tuba.

These instrumental parts read and sound in the bass clef, although brass band players read in treble clef from transposed parts. Non-brass included all winds and percussion.

Categorization of participants based on these criteria yielded thirty-seven high brass players, thirty-six low brass players, and twenty-seven wind and percussions players.

#### *Institutional Review Board*

Prior to the administration of any pilot- testing instrument, it was necessary to obtain University Institutional Review Board approval. This body evaluates whether there is more than minimal risk to the subjects, and also determines if the study is exempt from oversight based on that criterion. The researcher was required to complete a Human Participant Protections in Educational Research course, and was granted a completion certificate on April 29, 2004. Since the present study satisfied the IRB requirements of minimal risk, confidentiality, and anonymity of subjects, a waiver was granted and the study could proceed.

## Chapter Four

### Results

The purpose of this study was to determine the influence of performance background on listener ability to discriminate and label modern cornet and trumpet timbres. For analysis purposes, listeners from three pre-existing, intact ensembles (a brass band, a collegiate wind ensemble, and a collegiate trumpet studio) were categorized based on their years of performing experience (high or low), and their major instrument (low brass, high brass, non-brass). This information was gleaned from a background questionnaire administered to the participants immediately prior to the administration of the listening test.

The null hypotheses tested were that, as measured by the cornet-trumpet timbre discrimination and labeling test:

- I. There will be no difference among listeners in the ability to discriminate modern cornet and trumpet timbres based on the type of instrument performed by the listeners.
- II. There will be no difference among listeners in the ability to discriminate modern cornet and trumpet timbres based on their years of performance experience.
- III. There will be no difference among listeners in the ability to label modern cornet and trumpet timbres based on the type of instrument performed by the listeners.

- IV. There will be no difference among listeners in the ability to label modern cornet and trumpet timbres based on their years of performance experience.

*Preliminary Descriptive Statistics*

The initial data collection was performed on intact music groups. Table 1 presents data related to these intact ensembles and suggests that the trumpet group was more successful at discriminating among cornets and trumpets. Table 2 indicates that brass band players appeared to be more successful at *labeling* cornets and trumpets. The wind band was the least successful ensemble on either task.

Table 1. Discrimination Means (SD) by Intact Ensemble

Group	<i>n</i>	Means ( <i>SD</i> )
Brass Band	36	62% (8.5)
Wind Band	41	60% (7.3)
Trumpet	23	65% (10.3)

Table 2. Labeling Means (SD) by Intact Ensemble

Group	<i>n</i>	Means ( <i>SD</i> )
Brass Band	36	40% (10.4)
Wind band	41	34% (11.8)
Trumpets	23	37% (10.5)

Data from tables 1 and 2 were for informational purposes only and not subject to inferential analyses.

Table 3 and figure 1 present data concerning years of performance experience, without consideration of any other factor. As can be seen, the higher-experienced group was slightly more successful on the discrimination task, but there was little difference on the labeling task.

Table 3. Discrimination and Labeling Means (*SD*) by Experience

Experience	<i>n</i>	Discrimination Means ( <i>SD</i> )	Labeling Means ( <i>SD</i> )
Low (< 10 Years)	43	62% (9.1)	37% (11.0)
High (10= Years)	57	65% (8.6)	36% (11.3)

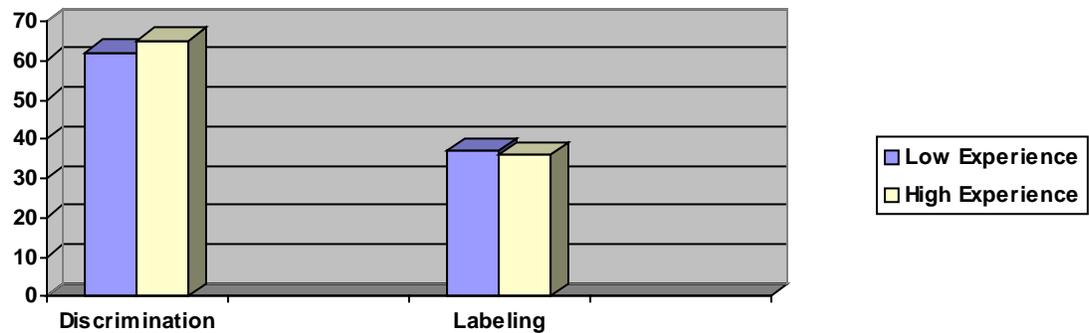


Figure 1. Discrimination and Labeling Means (%) by Experience

Data from table 3 and figure 1 were for informational purposes only and not subject to inferential analysis.

The research questions dealt primarily with differences based on instrument performance background. Table 4 and figure 2 present means on the discrimination and labeling tasks based on the instrument family of the listener. As previously discussed, high brass refers to cornets, trumpets and horns pitched in E-flat and F. Low brass refers to all other brass (trombone, baritone, euphonium, and tuba). These instruments were common to both the wind ensemble and brass band groups. The non-brass group

consisted of all woodwinds (flute, oboe, clarinet, saxophone, bassoon) and percussion. The woodwinds were unique to the wind ensemble group, and percussion was present in both the brass band and the wind ensemble. The percussion group was included with the wind group under the category of non-brass because the number of participants ( $n=4$ ) was too small to warrant a separate analysis. As can be seen, low and high brass players differed little from each other on either the labeling or discrimination tasks, but the non-brass group appeared to be less successful. For all groups, labeling appears to have been a more difficult task.

Table 4. Discrimination and Labeling Means (*SD*) by Instrument Family

Group	<i>n</i>	Discrimination Means ( <i>SD</i> )	Labeling Means ( <i>SD</i> )
Low Brass	27	66% (7.4)	40% (9.5)
High Brass	45	67% (9.9)	39% (11.3)
Non-Brass	28	58% (9.4)	31% (12.8)

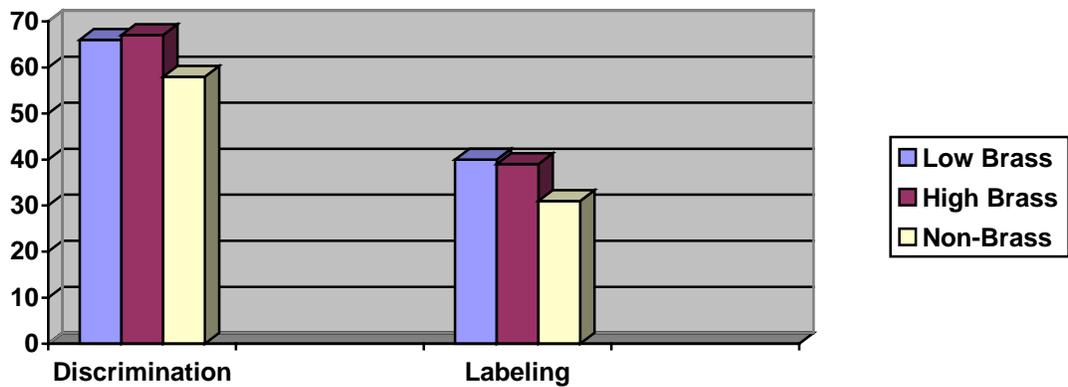


Figure 2. Discrimination and Labeling Task Means (%) by Instrument Family  
Data from table 4 and figure 2 were for informational purposes only and not subject to inferential analysis.

### *Analysis of Variance*

While there were differences among means for both the discrimination and labeling tasks, further analysis was needed to determine whether these means differed enough to be statistically significant. For the current data, the appropriate procedure was the two-way, between-groups analysis of variance (ANOVA).

The advantage of the two-way design is that it allows for the testing of main effects for each independent variable as well as the possibility of an interaction effect. Pallant (2005) states: “An interaction effect occurs when the effect of one independent variable on the dependent variable depends on the level of a second independent variable” (p.209). As an example, the influence of experience on discrimination may be different for low and high brass players. For the purposes of this study, there were two dependent variables, discrimination and labeling. A two-way ANOVA for each dependent variable (discrimination and labeling) was therefore necessary.

Before proceeding with the two-way analysis of variance, it was necessary to address assumptions that would permit the proper utilization of this statistical test. The first assumption was that of independence. Because participants did not interact and the test was monitored to insure individual responses, the assumption of independence was met.

The second assumption was that scores were normally distributed, which can be addressed by examining the skewness and kurtosis values of the sample scores. On the discrimination task, the skewness and kurtosis values were both  $-.510$ . The labeling task revealed a skewness value of  $-.165$ , and a kurtosis value of  $-.732$ . These values revealed

only slight platykurtic or flat distributions across the entire sample on both tasks. Given the sample size, the ANOVA was robust to violations of the assumption of normality.

The third assumption was that of the homogeneity of population variance, or the average variation of scores about the grand mean. This assumed equal variation of scores across groups. Levene’s test of equality of variance was not significant for the labeling task [F (5,94)=.904, p=.482], or the discrimination task, [F(5,94)=1.513, p=.193]. Since there were no violations of the statistical assumptions, it was appropriate to proceed with the ANOVA.

Tables 5 and 7 present means and standard deviations for the discrimination and labeling tasks, based on instrument groups and years of experience. The results indicate that the non-brass group was less successful on either task than the low or high brass groups. This is consistent with the previous results. Tables 6 and 8 summarize the ANOVA data for the discrimination and labeling tasks respectively. Since two ANOVA’s were utilized, the probability value was adjusted using the Bonferroni procedure to control the type I error rate ( $\alpha = .025$ ).

Table 5. Discrimination Means (*SD*) by Experience and Instrument Family

Experience Level	High Brass	Low-Brass	Non-Brass
High (10+ Years)	68% (10.9)	68% (7.0)	58% (7.1)
Low (<10 years)	65% (8.9)	64% (6.9)	59% (11.6)

Table 6. 3x2 Factorial Analysis of Variance Investigating the Relationship Between Instrumental Group and Prior Experience on the Ability to Discriminate Cornet and Trumpet Timbre

Source	<i>df</i>	<i>F</i>	<i>p</i>	$\eta^2$
Group (G)	2	6.795	0.002*	.126
Experience (E)	1	1.227	0.271	.013
G x E	2	0.442	0.644	.009

\*Significant at  $\alpha = .025$

#### *Discrimination*

The analysis of variance for the discrimination task (table 6) indicated a statistically significant main effect for group [ $F(2,98)=6.795, p<.002$ ]. All other main effects and interactions were not significant. This suggested that the type of instrument played by the listener (either low brass, high brass, or non-brass) was a significant factor in outcomes on the discrimination task.

Table 7. Labeling Means (*SD*) by Experience and Instrument Family

Experience Level	High Brass	Low Brass	Non-Brass
High (10+ Years)	39% (11.4)	37% (11.1)	32% (11.5)
Low (<10 Years)	39% (11.1)	42% (7.8)	31% (13.1)

Table 8. 3x2 Factorial Analysis of Variance Investigating the Relationship Between Instrumental Group and Prior Experience on the Ability to Label Cornet and Trumpet Timbre

Source	<i>df</i>	<i>F</i>	<i>p</i>	$\eta^2$
Group (G)	2	3.261	0.043	.065
Experience (E)	1	0.511	0.477	.005
G x E	2	0.558	0.574	.012

### *Labeling*

The analysis of variance for the labeling task (table 8) indicated no significant differences among groups or experience levels ( $p = .025$ ). This suggested that listeners did not differ significantly in their ability to label cornet and trumpet timbre when years of playing experience or the type of instrument played were considered.

Means for the labeling task (table 7) were close to the chance level. A chi-square statistic was calculated by comparing the means of each group to chance, which in this case was 33.33%. The analysis revealed that means on the labeling task were not significantly different from chance,  $\chi^2 (2, N=100) = 1.39, p = .05$ . This indicated that participants might have been guessing on this task.

### *Effect Size*

The partial eta squared ( $\eta^2$ ) value is shown in the far right hand column of tables 6 and 8, and was used to indicate the effect size, strength of association, or practical significance of outcomes.  $\eta^2$  represents the proportion of variance in the dependent

variable, in this case instrumental group, and ranges from 0 to 1. Table 6 indicated that the ability to discriminate cornet and trumpet timbre depended on what category of instrumental group (low brass, high brass, non-brass) the listener belonged to. The strength of this association is small however, given the effect size of .126. Only 12.6% of the variability among participants is attributed to their instrumental grouping.

### *Post-Hoc Testing*

Since there was a significant main effect for group on the discrimination task, it was necessary to investigate where the differences among the means were located. The two most commonly used *post-hoc* or *a posteriori* significance tests are Tukey's HSD (Honest Significant Different) test, and the Scheffé test. The Scheffé test is the more cautious method for reducing the Type 1 error rate (that is, stating there is a difference among group means when there is not), and was deemed appropriate for the current study, even though statistical power was reduced.

The Scheffé procedure revealed that there were no statistically significant differences in the means between low brass players ( $M=66$ ,  $SD=7.4$ ) and high brass players ( $M=66.5$ ,  $SD=9.9$ ) on the discrimination task. There was a statistically significant difference between low brass players and non-brass players ( $M=58.5$ ,  $SD=9.35$ ), and high brass players and non-brass players. Non-brass wind and percussion players scored lower than either brass group, and this difference was statistically significant. We could expect that the population of non-brass players would be less successful than either high brass players or low brass players on the task of discriminating cornet and trumpet timbre under similar testing situations.

## Chapter Five

### Discussion

This study was an examination of the influence of years of experience and instrument performance background on listeners' ability to discriminate and label modern cornet and trumpet timbres. Utilizing a timbre discrimination and labeling test, participants were evaluated on their ability to hear differences among cornet and trumpet timbres when listening to musical phrases performed by professional players. Participants were also evaluated on their ability to label these timbres as being played on either cornets or trumpets.

Three intact, existing ensembles were evaluated during the data collection phase: trumpet majors from a large research university ( $n=23$ ), a wind ensemble from a private university ( $n=41$ ), and a brass band from an area Salvation Army church ( $n=36$ ). The participants from these groups also responded to a questionnaire to gather information concerning their years of playing experience and instrument performance background. The data gleaned from the questionnaire and listening test allowed for examination by three instrument categories (high brass, low brass, and non brass winds and percussion) and years of experience (less than ten years, and ten or more years) to examine the effect of these factors on the ability to discriminate and label cornet and trumpet timbres.

Inferential statistical analysis supported the null hypothesis for the labeling task: years of experience and the major of instrument of the listener were not significant factors in the labeling of cornet and trumpet timbre. Participants did not differ

significantly in their ability to label (identify) cornet and trumpets when their years of experience or major instrument were considered.

On the task of discriminating cornet and trumpet timbre (that is, selecting the different item from a group of three prompts), the null hypothesis for years of experience was also supported: there were no significant differences among participants based on their years of performing experience. The null hypothesis for type of instrument played (low brass, high brass, non-brass) was rejected, however: There were differences among means based on instrument background for the discrimination task, and these differences were statistically significant. *Post hoc* analysis revealed that non-brass players were less successful than either high or low brass players at discriminating cornet and trumpet timbre. The effect size of this association was .12, which is a small effect. Only 12% of the variability in discrimination could be explained by instrumental group membership.

#### *Epistemological Paradigms Revisited*

Given the stated results, it was necessary to reflect on theories of music listening presented earlier in this study, specifically constructivist and objectivist epistemological paradigms. The constructivist or construction paradigmatic epistemology states that knowledge is a process of human intellect: the role of the participant in the cognition process of acoustic sound events is essential. Additionally, musical communication is the result of a shared social-cultural contract.

The objectivist epistemology asserts that all of the necessary information needed for cognition (in the case of this study, labeling and discrimination) is contained in the acoustic object. Acoustical sound events are independent of the listener and not open for interpretation. To extrapolate, a cornet “sounds like” a cornet, and a trumpet “sounds

like” a trumpet, and this experience should be the same for all listeners if the sound wave pattern is the sole determinant of timbre content.

The current study did not add currency to objectivist theory, however. Regardless of their experience or instrument performance background, listeners did not differ significantly in their ability to label cornet and trumpet timbres. Given the low mean correct response rate (37.6%), it also appeared that they were not particularly successful on this task. Chi-square analysis indicated that participants did not differ statistically from chance on this task, and were therefore most likely guessing in their responses. One would surmise that, if objectivist “copy” theory could be validated, then the cornet and trumpet would sound different because they are physically different instruments. The role of the listener would be removed from this equation.

The inability to label timbre differences may be due to a lack of enculturation as to the differences between cornet and trumpet based on prior experience. For example, the high-experienced high brass group, with a mean response rate on the labeling task of 39%, contained all of the brass band cornet players, yet they were no more successful than the non-brass, low experienced group, who scored 31% on average. As previously stated, these mean differences were not statistically significant from each other. Each group, however, may have been hampered by their respective lack of exposure to one or both of the instruments. The brass band cornet players may have had very little exposure to the trumpet, and the college groups little exposure to the cornet.

On the discrimination task, there was a significant main effect when instrument performance background was considered: brass players were more successful than non-brass players in discriminating cornets from trumpets. It may be possible to attribute the

advantage of brass players on this task to greater enculturation to the sound of brass in general, although this did not seem to be a factor for labeling.

Heller (1982) points out that listener response is only partly determined by the signal transmitted by the acoustic medium, and that a shared social-cultural contract is needed to provide a context in which the acoustic signal is decoded. Gamon and Gamon (1991) agree: “The brain is no naive organ. Musical perception is the result of a complex process of musical enculturation: the assimilation of the norms and conventions of a particular style or styles. The degree to which individuals ‘master’ these norms and conventions conditions the degree to which we respond to and are able to understand differences within a particular musical style” (p.125).

The current study adds support to this premise by supplying evidence that listener performance background was a significant factor in timbre discrimination. Success in timbre discrimination appeared to be moderated by the listeners’ instrumental performance background. The caveat here, however, was the small effect size. While there were statistically significant differences between groups on this task (non-brass players were less successful at discrimination than brass players), the practical application of these differences is questionable.

#### *Perpetuating Differences*

Although there has been a growing body of research in timbre perception that supports the role of listener construction of sound events, instrument and mouthpiece manufacturers, in an effort to differentiate their products from the competition, continue to emphasize physical aspects of sound wave patterns. By utilizing intricate acoustical models and soliciting opinion from professional performers, numerous manufacturers

offer a wide range of products for every player demand. The British manufacturer Smith-Watkins, for instance, offers “a wide choice of bells, bores and interchangeable lead pipes, which can be calibrated to the player’s individual needs” (Smith-Watkins, 2005). Further references from this manufacturer point to an overriding emphasis on sound wave characteristics and instrument design as the primary indicator of timbre differences:

The *ideal instrument* [italics added] is produced by combining a particular shape of bell and lead pipe. A range of quality sounds can be produced from these instruments, as lead pipes are interchangeable. Some players buy more than one, enabling them to vary the sound of their instrument for different types of work. (Smith-Watkins promotional brochure, p.2)

Geringer and Madsen (2005) point out that this type of opinion among manufacturers and performers is an example of “folk wisdom” that is passed on within various music cultures, including the sub-cultures of trumpeters:

Not only are various instrument brands identified as being superior, but lively debates proceed concerning the superiority/inferiority of mouthpieces, materials, different bores, back bores, bell flares and so on. The epistemological basis for much of this is often an “appeal to authority” wherein the receiving person is expected to just accept something as true, or the method of a priori, where one is first told that there will be a difference between examples, a “demonstration” is given and the person/student for whom the demonstration is made is then expected to concur with the initial premise. Of course, most of this information is not subjected to any scientific methodology by which an outcome can possibly be falsified. (p.13)

Further evidence of this epistemological “folk wisdom” can be found among performers, who have their own set opinions about the perceived and, in their view, obvious differences between cornets and trumpets, to the extent that switching from one to the other should only be undertaken with great preparation and careful consideration. Cornet virtuoso Leonard Smith, former soloist with the United States Navy Band, founder of the Detroit Concert Band, and former Principal Trumpet of the Detroit Symphony, expresses strong opinions concerning the dual role of the cornet/trumpet player. When asked which instrument he preferred, Smith states: “...the two instruments have different “feels” because of the differing lengths of conical and cylindrical bores...I would never play the cornet and the trumpet on the same day. You have to take some time to get used to the different instruments...usually about two weeks. Many players today try to make them interchangeable when they’re not.” Asked if he would play cornet and trumpet on the same concert, Smith responds, “No, never. I took the time to change” (Bowman, 2002, p.36).

This echoes some of Mortimer’s earlier statements concerning performer approach to either instrument. As discussed previously, many composers score specifically for cornet, but these parts are most often played on trumpet, with the underlying assumption that, at least in practice, there is no discernable timbre difference. This may not be in keeping with the composer’s intentions, otherwise the specific scoring would have indicated trumpet.

From the perspective of Leonard Smith and instrument manufacturers such as Smith-Watkins, the timbre difference between cornets and trumpets are widely disparate. The current study indicated that listeners do not differ significantly in their ability to

discriminate and label cornet and trumpet timbres when years of experience is considered as a determining factor, and only differ slightly in discriminating cornets and trumpet when their instrument playing background is considered. This calls into question the common-held view that these differences are obvious.

Geringer and Madsen (2005) found that experienced musicians could not differentiate between Bb, C, and Eb trumpets in musical contexts. This adds further support to the results of the current study in that the cornet and trumpet are closely related in much the same way as different-pitched trumpets. The authors comment that there appears to be a strong belief that these instruments actually sound quite different, but this is not supported with scientific evidence. It was also suggested that further study should be undertaken using different performers and instruments.

#### *Performer Effects*

The current study utilized three performers using cornets and trumpets to play similar musical excerpts. Even exact repetitions of the same musical examples would never produce an identical interpretation, as the performers were free to make their own interpretive decisions.

Although the current study did not specifically address player effects, the requisite experience that each player brought to the performance of the musical excerpts may be worthy of further consideration. As previously stated, one of the performers (labeled as ‘Player B’) had enculturation in the brass band and cornet style of playing from an early age. Indeed, this performer did not commence trumpet studies until the age of seventeen. Perhaps this player’s approach reflected a more ‘cornet-like’ acoustic signature that was perceived by the listener as cornet, even when playing trumpet on the musical excerpts.

While these excerpts were randomly selected for inclusion in the listening test, player interpretation may have acted as a confounding variable from a scientific measurement standpoint.

Those who engage in scientific inquiry would argue that, in experimental research, confounding variables must be controlled as they are considered extraneous, and may have an effect on the dependent variable (Ary, Jacobs, and Razavieh, p.278). By not having strict controls over the parameters of player effects, instruments and mouthpieces used, or even the location of the listening tests (in this study's data collection phase, different test locations were used for each group), it could be argued that the results are compromised. Differences in timbre perception may have little to do with listener response, and more to do with the lack of control over key variables.

This is exactly what occurs, however, when listeners are engaged in the task of music listening. In the 'real' world context of the concert hall or the rehearsal, musicians implicitly interpret what they hear based on previous experience. Performers can and do vary the timbre of the instrument through various techniques. As Fiske points out: "Perception is dependent upon a cognitive context created by the listener" (p.153). The role of listener experience cannot be ignored in the cognition of timbre.

In spite of this evidence, which supported the role of listener background in the construction of timbre sound events, manufacturers and pedagogues continue to insist that significant timbre differences are based on the physical characteristics of the instrument (bore size, metals used in construction, mouthpiece used, etc.), and evidence from acoustical measuring devices that can verify these differences empirically.

## *Pedagogy*

Cavitt (1996) points out that teaching students to develop tone quality is one of the most important goals of instrumental music teachers, but describing tone quality or timbre is often problematic. Tone color is often an abstract, subjective, and somewhat illusive characteristic of playing a musical instrument (Johnson, 1981). The term tone quality has been used for the purposes of describing; first, the tone production of an instrument and its nature or function; second, methods and mannerisms of individual performance and the control of the instrument by the player, and third, certain conceptual values associated with musical expression (Stubbins, 1954).

With these factors in juxtaposition, music teachers have attempted to verbalize to their students about tone quality. The use of words to describe the quality of a particular tone is common in music pedagogy books, journal articles, and studies related to tone quality, but there is little research on the adjectives used to describe the qualities of musical tones (Malave, 1990). Verbal descriptors are often vague, but musicians have relied on these terms to label these qualities. These codified conventions are the language of musical pedagogy: they are learned and re-learned as part of the “language” or terminology of the particular instrument. Trumpet players may have a “dark” sound, or a “bright” sound, and this may be a function of the player, the instrument, room acoustics, or the background and experience of the receptor (the listener).

Texts in brass pedagogy for music education majors also codify sound characteristics of brass instrument based on actual or perceived sound differences. Whitener (1997) points out that trumpet players, when performing on cornet, often use the same mouthpiece with the smaller cornet shank, thereby losing much of the *inherent*

[italics added] contrast between the two instruments. Adding to the mix of fact and opinion, Whitener asserts that, “The only true cornet mouthpieces available are the Denis Wick models, particularly numbers 4 and 5” ( p.32). Is it possible to achieve a “true” cornet sound by any other means? These particular mouthpieces were not included when the musical samples used in this study were recorded. Could it have been that the mouthpieces alone determined outcomes?

### *Informal Observations*

During the course of the current investigation, some informal observations were noted. First, the collegiate level trumpet players sometimes reported that they were unsure what differences they needed to listen for. General comments after the listening test indicated that these participants, having generally little exposure to the cornet, were confused by the labeling task, but seemed to be more at ease with selecting the ‘different’ sounding instrument out of a group of three. Test scores appear to bear this out, as all three groups demonstrated a higher level of success at discrimination rather than labeling.

Secondly, with the brass band group, there were comments concerning the various levels of player ability, with one participant, a retired music teacher, making the observation that one of the players was a noticeably weaker performer than the other two. Although this was not a variable under consideration, it is interesting to note that this comment came from a performer who is steeped in the cornet and brass band tradition. Perhaps this person’s concept of a ‘good’ sound had to do with the attack portion of the tone, which was audibly different with one player than those of the other two performers.

### *Implications*

Given that experienced instrumentalists do not differ significantly in their ability to identify (label) cornet and trumpet timbres, and only differ slightly in their ability to discriminate these timbres, what practical conclusions can be drawn that would have impact for instrumental music teachers as they introduce the trumpet to the beginning band student?

This study commenced by presenting the notion that the cornet was a much-neglected instrument in the modern American wind band tradition, but this has not always been the case. Results suggested that, as far as the listener was concerned, very little difference in the sound characteristics of these instruments exists. This is counter to what many teachers and expert performers strongly believe. Indeed, if there is a difference between cornets and trumpets (other than the obvious physical look of the instruments), then it may have less to do with sound and more with the ease of playing and holding the cornet as opposed to the trumpet for the younger and physically smaller player. The supposition of this study must be reconsidered in some respects, therefore. Sound differences seem to be less the issue than practical reasons related to ease of sound production and manipulation of the instrument. These results may still support a more viable role for the cornet as a choice for the beginning instrumentalist, however.

The challenge may lie in the fact that, while young violinists can commence their study on a  $\frac{1}{4}$  size instrument and still maintain proper pitch, this is not the case for winds and brass, with the possible exception of the tuba, which is available in a variety of sizes adaptable to the younger player. A smaller clarinet, for instance, is by definition higher pitched, and involves specialized skills. Similarly, a smaller trumpet, which might be a

better physical fit for a 5 or 6-year-old student, is also in a different key due to the reduction of tubing. It is impractical to start a student on an E-flat trumpet, for instance, as this is a highly specialized instrument, and is usually not introduced until the college level. The dilemma, then, is how to find a soprano-brass instrument that maintains the proper pitch (B-flat), but alleviates the concomitant embouchure and posture challenges of a full-size trumpet for the younger player (see page 1 of this study).

The solution may be in the adoption of the cornet as the instrument of choice for the younger brass player. As previously stated, the cornet is more compact, with a more centered weight distribution, making it easier to hold for the younger player. There is also support among professional performers that an enhanced role for the cornet may be warranted, leading to the development of better sound concepts that can be applied to the trumpet later. Other performers have suggested that the cornet is somewhat easier to control from a sound production standpoint. Given that experienced listeners had a difficult time articulating what timbre differences they were hearing, perhaps cornets and trumpets are more homogeneous in terms of sound color than previously believed, especially when factors such as player, instrument choice, and mouthpiece are not strictly controlled.

#### *Further Research*

Future research may focus on the role the cornet in the teaching of the beginning instrumentalist. Since the cornet is all but ignored in brass pedagogy at the school level, it would be of interest to utilize the cornet in a school band setting in longitudinal study of first year trumpet players, with one group playing cornet and the other playing trumpet. At the end of a designated time frame, the students could be rated by an expert panel of

brass teachers and performers as to their tone and general facility on their chosen instrument. This could be done in much the same way as an orchestral audition, with the students playing a few short musical items they have studied in their band class. If results seem to suggest a preference for cornets, then the inclusion of this instrument might be a viable option for future band programs.

Currently, there is a beginner band program in the Pinellas County, Florida, school district that is introducing band instruments at the third grade level, a full three years ahead of the standard practice in Florida. Equipping these young players with cornets instead of trumpets would make for an interesting study, particularly given that they are being taught with a rote method concentrating on proper posture, breathing and sound production rather than note reading. Also, given that these students are generally smaller physically than middle school-aged students, it would be of interest to observe whether the cornet is easier to hold and play, as is the opinion of many teachers and professional performers.

Interest in musical instrument timbre is a varied and rich field of research in the field of acoustics and psychology. The value of such investigations for instrumental music researchers presents challenges in terms of musical validity. Do we control all aspects of the acoustical and testing environment in order to have a scientifically reliable study, or should the emphasis be on a more musically valid approach that speaks to pedagogical and practical issues for band directors and instrumental teachers? The current study was designed to quantify opinion on the matter of listener construction of auditory sound events in a musically valid context. Further research in this area may help bridge the perceived gap between “pure” scientific investigations and more practical

solutions for brass music educators as they consider the value and future role of the cornet in the training of brass students.

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## Appendices

Appendix A: Musical Items

22. 15. D Minor  
Moderato ♩ = 92 - 108

1

*f* staccato

6. 1. C Major  
Allegro ♩ = 120 - 132

2

*f*

3

Moderato

**STACCATO TONGUING ETUDE**

3

*f* simile

4

*f*

Appendix A (Continued)

5 67

The image shows a handwritten musical score on three staves. The first staff begins with a circled number '5' and the number '67' above it. The music is written in a treble clef with a 3/4 time signature and a key signature of one flat (B-flat). The first staff contains a single line of music with several measures of eighth and sixteenth notes. The second and third staves continue the piece with more complex melodic lines, including slurs and ties. The paper appears to be a page from a notebook or manuscript, with some visible creases and a slightly aged appearance.

Appendix A (Continued)

**ETUDE EXPRESSIVO**

7) **Moderato**

*p* *mf* *mp* *f* *mf* *f* *mf*

*mp* *p* *p* *mf* *mp* *mf* *p*

**ACCENT ETUDE**

3) **Moderato**

*mf*

9)

*p*

rit. ....

4. Eb Major \* 9.

**Allegro** ♩ = 120 - 132

*mp*

Appendix B: Participant Background Questionnaire

Thank you for participating in this research project concerning listener perception of cornet and trumpet timbre. Please complete the following.

Performance Category: \_\_\_\_\_Brass \_\_\_\_\_Wind/Percussion

Major Instrument (s): \_\_\_\_\_

Secondary Instruments (s): \_\_\_\_\_

Number of Years Playing Major Instrument: \_\_\_\_\_

Instrumental Performing Ensembles of Which You Are Currently a Member  
(check all that apply):

\_\_\_\_\_ Brass Band

\_\_\_\_\_ Jazz Ensemble

\_\_\_\_\_ Wind Ensemble

\_\_\_\_\_ Symphony Orchestra

\_\_\_\_\_ Marching Band

\_\_\_\_\_ Chamber Ensemble

Appendix C: Timbre Discrimination and Labeling Test

**Directions:** For each of the following items, a group of three musical phrases, A, B, and C, will be played on cornets and trumpets. Two of the phrases will be played on the same instrument, and the other will be played on a different instrument. For each phrase, indicate which instrument is being played by circling Cornet or Trumpet. Each group of three phrases will be repeated once. There will be two practice items prior to the commencement of the test.

Item #	A		B		C	
<i>P1</i>	<i>Cornet</i>	<i>Trumpet</i>	<i>Cornet</i>	<i>Trumpet</i>	<i>Cornet</i>	<i>Trumpet</i>
<i>P2</i>	<i>Cornet</i>	<i>Trumpet</i>	<i>Cornet</i>	<i>Trumpet</i>	<i>Cornet</i>	<i>Trumpet</i>
1	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
2	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
3	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
4	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
5	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
6	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
7	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
8	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
9	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
10	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
11	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
12	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
13	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
14	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
15	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
16	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
17	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
18	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
19	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
20	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
21	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
22	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
23	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
24	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet
25	Cornet	Trumpet	Cornet	Trumpet	Cornet	Trumpet

## About the Author

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