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The purpose of this study was twofold: first, to determine whether measurable and perceptible differences between American and British trombonists exist; second, to determine whether any of these measurable differences correlate in any way with established differences between American English and British English speech. The specific correlation between trombone sustain timbre and spoken vowels will be considered using American and British subjects in large groups, smaller dialect subgroups, and individually. In addition, the manufacturing origin of the trombone will be considered, to determine whether any differences are attributable to the instrument rather than the player.

Current research that specifically considers instrumental timbre as related to speech does not yet exist. However, the fields of acoustics, linguistics, and music cognition have produced studies that informed the background assumptions of this project. American and British trombone player participants were asked to complete a series of five tasks. These tasks included two playing conditions, two speaking conditions, and one listening test. Following the completion of the project, the data was organized and analyzed to address the two objectives of the study.

The first question, that of a perceptible difference, was tested by asking participants to identify whether recordings were performed by American artists or not. Subjects in this project were unable to do so, but did exhibit a preference for

those recordings that they believed were performed by artists from their own dialect group.

The second question, that of measurable differences relating to language, was addressed by creating a two formant spatial plot for each large dialect group, as well as dialect sub-groups and individuals. These showed that a measurable difference in timbre does exist, and that it can be related to the corresponding differences in speech. When considering whether the player or his/her choice of instrument produced this effect, recordings showed that both the player and the instrument impacted the timbre inventory, although the effect of the player was much stronger than that of the instrument.

CONNECTIONS BETWEEN LINGUISTIC AND MUSICAL SOUND SYSTEMS OF BRITISH AND AMERICAN TROMBONISTS

by

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APPROVAL PAGE

This dissertation written by KATIE A. COX has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

The idea that music and language can influence one another has been the subject of much qualitative and quantitative research since the latter half of the twentieth century. As a subfield of music cognition, connections between musical and spoken rhythms have been studied, and correlations between stress patterns in language and rhythmic compositional choices have been found (Patel & Daniele, 2003a). Music theorists borrowed principles from linguistic syntactic theories to describe harmonic development in a new way (Lerdahl & Jackendoff, 1983). Music therapists and speech pathologists use Melodic Intonation Therapy (MIT), treating linguistic deficiencies using musical tools (Norton, Zipse, Marchina & Schlaug, 2009).

Despite these areas of overlap between music and language that have been explored, one of the most obvious areas for comparison, the actual sounds that are produced in each area, has been largely overlooked in the existing research. Each sound system has been studied in isolation, but the connections between musical sounds and linguistic sounds have not been explored. Musical sound, or timbre, has been studied by organologists who examine how instrument structure affects an

instrument's sound, and by acousticians who examine the sound waves produced by that instrument's structure. Phoneticians study the phonemes, or minimal sound units of language, describing which sounds occur in a language, how those sounds interact or change over time. Although musical sound systems and linguistic sound systems had been richly explored independently of one another, the potential scholarship discussing overlap and relationships remained unrealized.

The differences in the playing style of instrumentalists from different regions are often discussed, but research has not been done to document these differences or to describe them with any precision. The anecdotal descriptions of these differences range from broad generalizations about the focus and pedagogical priorities of the British and the Americans to very specific statements about certain regions in each country that produce the most successful trombonists. The idea that language influences playing style is not a new one, but the idea is rarely explored in a data driven way.

Statement of Purpose

The purpose of this study was twofold: first, to determine whether measurable and perceptible differences between American and British trombonists exist and second, to determine whether any of these measurable differences correlate in any way with established differences between American English and British English speech. The specific correlation between spoken vowel and trombone sustain timbre was explored considering American and British subjects as

large groups, smaller dialect subgroups, and individuals. Additionally, the question of whether the instrument or the player is creating such differences was considered.

Participants in this project were asked to complete a series of five tasks. First was a listening test that demonstrates both whether listeners can perceive a difference between American and non-American performer, and whether listeners have a preference for one group over the other. Participants were also recorded both playing trombone and speaking, so that a comprehensive data set of speech and music was attained for each subject. This allows for subjects to be considered in large groups (American or British), as well as in smaller regional dialects within each group to establish how deeply, if at all, the correlations between language and music penetrate. The impact of training and equipment manufacture traditions will also be considered. The study was entirely synchronic, with a goal of showing correlations; causality was beyond the scope of this project. This project considered only the vowels in spoken language and the sustain timbre in playing. Other aspects of language such as consonants, rate of speech, syllable timing, or pitch variation, all of which could be related to music, are beyond the scope of the project. Similarly, discussions of instrumental articulation, rhythmic timing, and pitch variation will be excluded from this project.

Definition of Terms

Formants: concentrations of sound frequency energy above the sounding pitch. The sounding pitch is labeled F0; formants are labeled F1, F2, etc. in order from lowest to highest. Formants are measured in Hertz (Hz), cycles per second.

Phoneme: the elemental unit of language sound, broadly divisible into vowels and consonants

Phoneme Inventory: a comprehensive list of all phonemes present in a given speech set. A single speech sample, an individual speaker, a group of speakers, or an entire language can have a phoneme inventory.

Prosodic Contour: variation in pitch that is not tied to an individual word; for example, a rise in pitch at the end of a sentence indicates a question

Timbre: the aspect of musical sound not described by pitch, loudness, or duration

Timbre Inventory: a comprehensive list of all timbres produced by a given musical sample. This can be an inventory of an individual or a group.

Organization of the Document

Chapter II reviews the literature currently available on these topics. Although literature directly addressing the questions put forth by this study does not currently exist, scholarship from the fields of acoustics, music therapy, linguistics, and music cognition exhibits the fundamentals that informed the development of this project. The third chapter discusses the methods and materials used in this study, giving information about the participants and the five tasks they were asked

to complete. Chapter IV, Results, analyzes the data collected and identifies any trends that support or dispute the assumptions and purpose of this project. The final chapter summarizes the findings and draws some conclusions, as well as suggesting topics for future research.

CHAPTER II

REVIEW OF THE LITERATURE

Overview

The overlap between music and language has been explored from a number of perspectives, including rhythm in composition and speech, melody and speech therapy, harmonic development and syntactic theory, and shared cognitive resources. These studies have shortcomings when considering their relevance for this specific project: some projects compare differences between languages, rather than between dialects within a language; others relate only to vocal music or compositional trends, rather than focusing on instrumental music. There are no existing studies to address connections between phonology and timbre. To fill these gaps in the background for this specific project, anecdotal reports gathered during interviews were also considered in this chapter.

Rhythm and Melody in Speech and Music

Ani Patel, one of the foremost researchers in the field of language and music, has published a number of articles that focus on the overlap between rhythm in speech and in composition. Patel and his research partner Daniele (2003a) compared the speech rhythms of French and English, measuring the difference in syllable duration. They found that speakers of French tended to speak with

isochronous syllables, while English speakers exhibit isochronous stresses, but syllables of extremely variable length. Patel and Daniele also examined themes from major works by French and English composers and found a similar trend: the melodies written by French composers exhibited relatively little rhythmic variety; the English composers wrote more rhythmically variable and complex themes.

Patel and Daniele's study has some shortcomings: it only considers composition and not performance trends; they consider only composers' nationalities and not their language backgrounds or training; the selected composers reflect a narrow range of music history; and the study addresses only the difference between English and French. The last of these was addressed in a later study by Huron and Ollen (2003), in which composers from twelve nations and eleven languages were considered and found to reflect the same trend: the more isochronous languages correlate with less rhythmic variation in composed themes. In addition to these findings, Huron and Ollen made one further point: many of these themes included in their project were written to accommodate a specific text; these themes had been disregarded by Patel's study. Using broad criteria, rather than the restrictive measures set by Patel and Daniele earlier, demonstrated that this trend is more generalizable than Patel and Daniele's initial findings.

The reliance on compositional trends, rather than questions of performance or perception, was addressed in a later study by Hannon (2009). Hannon's project used a corpus of 150 songs, and asked subjects to categorize them as French or

English. The testing was done in three different conditions. The initial round of training included feedback; subjects were exposed to songs and their correct categorizations. The second round introduced novel songs and excluded feedback, testing whether subjects had accurately learned to categorize the melodies in the first round. A third round of testing eliminated pitch changes, so that listeners were making their classifications based on rhythm alone. In all conditions, subjects performed better than chance, indicating that the difference in rhythm of French and English melodies is a perceptible one, not just a compositional one.

In a later study, Patel and Daniele (2003b) address another of these concerns, developing a more diachronic approach to the study. Considering only those languages with high rates of rhythmic variability, Patel compared composers over a three-century span. He found that the later half of composers exhibit almost twice as much rhythmic complexity as the earlier half, an increase that exists independent of a corresponding increase in spoken syllable length variability. This data does not contradict his earlier research, but it does detract from the absolute nature of the earlier implication of spoken and musical rhythmic correspondence.

In a later study, Patel studied the connections between musical melodic contour and spoken prosodic contour. This study measured the prosodic contour of French speakers and English speakers and found that English has more sudden variation in spoken pitch than French does. In French, pitch changes more gradually and evenly, whereas in English these changes can be abrupt and wide. Sudden and

large pitch intervals in speech contour sound normal in English but sound out of place in French.

The researchers then evaluated melodies written by English composers and French composers; they tallied the interval motion of each note change to measure which composers chose which intervals with greater frequency. English composers as a group showed a higher proportion of wide intervals and a larger variety of intervals than French composers. They were able to draw a correlation between pitch variation in speech and pitch variation in composed music in addition to the earlier conclusion that speech rhythm and musical rhythm are similarly correlated (Patel, Iversen, & Rosenberg, 2006).

Melodic Intonation Therapy

The overlap between spoken and musical pitch change not only academically interesting, but also has a practical application. Melodic Intonation Therapy (MIT) is a technique used by music therapists and speech pathologists to help patients who have language production problems, particularly language fluency issues. MIT targets specific spoken words and phrases and assigns each one a "melody" made up of two pitches that mimic the pitch changes that would be heard in ordinary speech. Patients are asked to sing each target phrase, rather than speak it, and many experience less difficulty in producing a complete phrase while singing. Gradually the singing is reduced, but the language fluency and the natural intonation pattern in the speech both are retained (Norton, Zipse, Marchina & Schlaug, 2009).

The technique is used primarily with patients who have Broca's aphasia or non-fluent aphasia. Broca's aphasia often occurs in conjunction with some brain trauma, such as a stroke or traumatic brain injury. Non-fluent aphasiacs can produce the right words, or nearly right words, to convey their intent, but have difficulty forming larger utterances. The function words—articles, prepositions, conjunctions—are elusive, and the impact of word order becomes more meaningful to these patients than specific word forms, so passive constructions are especially confusing. The increased fluency that MIT can yield is helpful in countering these problems, even if traditional speech therapy has been ineffective (Schlaug, Marchina, & Norton, 2008).

Not limited to the effects of trauma, MIT has also been successfully applied to children with developmental language impairments, such as Developmental Apraxia of Speech (DAS) (LaGasse, 2012) and Autism Spectrum Disorders (ASD) (Duffy, 2000). In these cases, MIT helps children gain fluency, accuracy, and socially appropriate intonation changes in speech for the first time, as opposed to relearning these components of language that had been lost due to trauma as in the case of Broca's aphasia.

Overlaps in Cognitive Processing

In either scenario for applying MIT, the treatment is effective because it makes use of overlaps in neural resources between language and music. Speech prosody and rhythms are centered in the right brain; using therapies that engage these centers more are more effective. This has been demonstrated with different versions of MIT; for example, simple implementations, using only short phrases and two pitches separated by a small interval, have limited effectiveness for increasing subject's expressiveness. Modified Melodic Intonation Therapy (MMIT) is a more complex implementation of MIT that shows greater effects in this area (Conklyn, Novak, Boissy, Bethoux, Chemali, Smith & Zeigler, 2012). MMIT uses complete sentences or longer phrases and writes unique melodies for each that may contain more than two pitches and/or larger intervals. This more completely engages the areas of the right hemisphere related to language fluency and more effectively rehabilitates the patient's speech.

In addition to shared melodic resources that aid in MIT, Patel's research shows that there is a connection between the neural resources dedicated to processing harmonic progression in music and syntactic organization in speech. Because speech and music are both experienced linearly, there are neurological effects of expectation fulfillment or lack of fulfillment that can be observed. In speech, this is demonstrated by the difference between head elaborated sentences that progress as expected and fulfill expectations as compared with garden path

sentences that do not progress as expected, fail to fulfill expectations, and might require re-analysis after the first hearing. The musical analogue is the difference between a traditional tension-resolution cadence motion that fulfills musical expectations as compared with a deceptive cadence, which does not progress as expected and requires reanalysis after the first hearing (Patel, 1998). The fulfillment or lack thereof of expectation creates short-term neurological effects that can be observed using an fMRI; studies show that these effects are localized in the frontal or temporal lobes for both language and music.

Trombone Timbre and Spoken Dialects

Despite a lack of empirical research in the topic, the belief that a player's language has an impact on his/her playing is commonly held among trombonists. Such differences were the topic of a lecture given at the International Trombone Festival in Austin. Ian Bousfield presented a one-hour clinic on differences between American and European trombonists. The differences he cited were primarily cultural: European trombonists have a harder work ethic, they have more willing to take risks, and they consequently have more expressive playing. In a follow up email message, Bousfield addressed the impact of language specifically, saying that he hears a definite difference in the articulation styles of European players as compared with Americans that he feels is a direct result of differences in speech. He spoke particularly about the placement of consonants as more precise among

British English and German speakers than those speakers of American English (Bousfield, 2010).

Anecdotal reports of the impact of speech on articulation are not restricted to an American-European divide. Professor of Trombone at Truman State University Jay Bulen has taught trombone lessons in Ecuador as well as the United States, and claimed that his beginning Ecuadorian students had a predisposition for fast articulation that none of his beginning American students could match. He attributed that to the faster rate of speech in Central American Spanish, compared to American English. Faster articulations in speech were correlated with faster articulations on the instrument, in his view (Bulen, 2006).

Such relationships are not restricted to two separate languages. Dialect variation within a single language is also reported to have an impact on playing. Boston freelancer Gabe Langfur suggests that there is an audible difference in the playing of bass trombonists from various regions in the United States:

> I've long been interested in characteristic bass trombone sounds that seem to come from various parts of the US - the big, round sounds you tend to hear from the Southeast (Charlie V[ernon], Blair B[ollinger], Randy Campora, Steve Norrell), more focused, sometimes tending towards nasal from the northeast (Doug Yeo, Matt Guilford, me...and I think you could include Jim Markey now), and the balanced sounds from midwesterners (Randy Hawes is the best example and one of my very favorite players). They certainly appear to correspond with speech patterns (Langfur, 2010).

A similar trend is suggested to exist among British players by English trombonist Chris Fower. He notes that an unusual percentage of the successful players in the UK come from one specific dialect region in northern England (Fower, 2010).

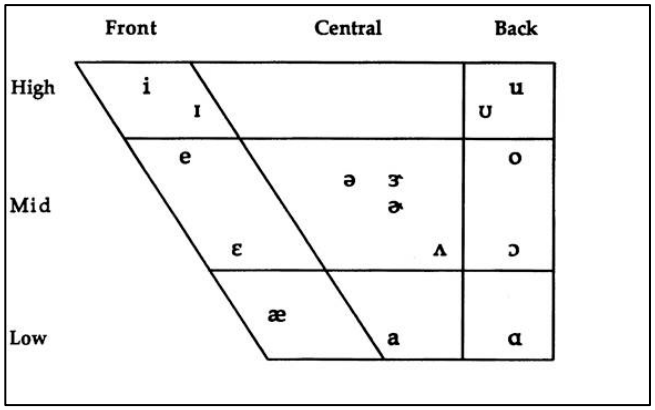
If a correlation between language variation and timbre variation exists, the questions of how to measure it must be addressed. Musical timbre is divided into two broad categories: the sustain and the articulation/release. Similarly, a language's phonetic inventory contains two main categories: vowel and consonant. Helmholtz (1887/2005) contains an early description of timbre as analogous to vowel and consonant sounds in the nineteenth century. He equated the attack or onset of a note with a consonant and its sustain with a vowel.

Backus (1977) uses formant analysis to identify an instrument's idealized playing range. This is an extension of earlier work by Jansson and Sundberg (1972); in their article, Jansson and Sundberg show the usefulness of Long-Time Average Spectra (LTAS) in describing instrumental sounds. They found that an LTAS measured consistent peaks in spectral energy for each instrument studied, regardless of variables such as acoustic environment, recording equipment, variations in performance, and, most importantly, fundamental pitch. Due to the high degree of reproducibility despite these variables, Jansson and Sundberg's study shows the effectiveness of describing instrumental timbre with peaks in spectral analysis, or formants.

Using formants to describe sustain timbre is a particularly effective method when considering relationships between sustain timbre and vowels. This is because vowels can also be described accurately using two formants. Vowels are often organized into a chart that plots each vowel's unique tongue on a two-dimensional field, where the vertical axis represents tongue height and the horizontal axis represents tongue placement front to back.

Figure 1

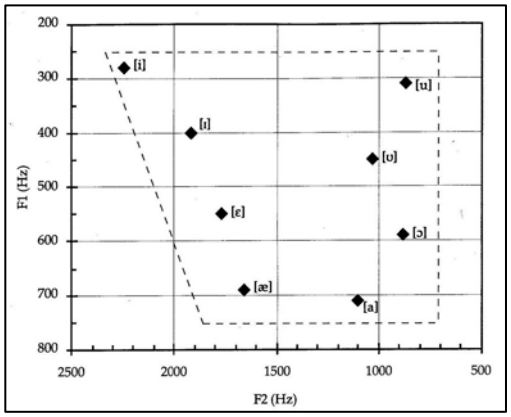
Vowel Chart by Tongue Placement



The same chart can be derived using formant readings. Here the vertical axis represents F1 and the horizontal represents F2.

Figure 2

Vowel Chart by Formant



If vowels and timbre can both be accurately described with two formants, then the two have a common point for comparison. McCarty (2003) developed a composition based on assigning each instrument of the orchestra a vowel correlate from its F1 and F2 readings.

A similar commonality can be found between articulations and consonant phonemes. Consonants are most often described by their amplitude envelope, or the specific shape they make on a waveform. Stop consonants (p, t, k, d, g, b) completely obstruct the airstream during speech, so the waveform demonstrates a brief silence followed by an abrupt increase in amplitude. Those consonants that partially obstruct the airstream (fricatives, nasals) show neither the silence nor abrupt motion of a stop consonant; instead, the change in the waveform is more gradual, and the consonant can be seen as having less amplitude than the adjacent vowel. Affricates have a blend of features from both stop consonants and fricatives, so the

waveform shows a corresponding blend of amplitude change. Liquids and semi-vowels (r, l, w, y) show the least change in amplitude when compared with vowels, and consequently have the most featureless waveforms.

Using waveforms and amplitude envelopes to describe articulations and consonants was an effective method for a 2011 study of the instruments of the Javanese Gamelan. In this project, complete syllables made up of "Consonant-Vowel-Consonant" were considered, and it was found that the most common syllable structure in the Javanese language ("Stop Consonant-Vowel-Nasal Consonant") corresponded with the noteshape produced by the most common instrument in the Javanese Gamelan ensemble.

Summary

Research in the specific topic of an instrument's sustain timbre relating to the spoken vowels of the people playing it or manufacturing the instrument is something that has not been explored. However, the fields of linguistics, acoustics, and music cognition have produced studies that show smaller aspects of this project. Music cognition has shown similarities and overlaps between music and language, both with regard to compositional practice and neural resources. Music therapy and speech therapy both make use of Melodic Intonation Therapy, which relies on music positively affecting language. Pedagogical trends in instrumental music, and the theories Helmholtz put forward, similarly rely on the idea that language impacts music with regard to articulations and note shapes. These points

put forth by previous scholarship suggest that the fundamental concepts of this project, the idea that linguistic and musical systems can influence one another, is a sound one.

CHAPTER III

METHODS AND MATERIALS

Overview

The purpose of this study was twofold: first to determine whether measurable and perceptible differences exist between American and British trombone players. The second purpose is to examine whether these differences, if present, are in any way correlated with the differences that are known to exist between British English and American English. As a result, data relating to each subject's playing, speech habits, listening preferences and listening identification was required. To accomplish this, selected participants were asked to complete a series of five tasks.

Subjects

A total of 18 British subjects and 12 American subjects were recruited. Criteria for participation were as follows:

- Over 18
- Native speaker of American English or British English
- Trombone player in an amateur status (unpaid) band. British subjects were recruited from brass bands; Americans were recruited from community bands. These band types in their respective countries have similar traditions

of community involvement and include similarly diverse ages and levels of education.

Task 1: Listening Test

The listening test subjects were given contains nine pairs of sound clips. These clips can be divided into three categories: unaccompanied solo works, accompanied solo works, and trombone section works. Each of the three categories contains three works, as shown in the table below.

Table 1

Listening Test Selections by Category

	Unaccompanied Solos	Accompanied Solos	Trombone Section
Title 1	Sequenza V - Berio	Solo from Bolero - Ravel	Chorale from Symphony No. 4 - Brahms
Title 2	Introduction to Ballade - Martin	Sonata Vox Gabrieli - Sulek	No More Blues -
Title 3	Cadenza from Blue Bells of Scotland - Pryor	Solo from Symphony No. 3 - Mahler	Chorale from Symphony No. 3 “Rhenish” - Schumann

Recordings were chosen to demonstrate a contrast of styles within the common trombone literature canon. Examples were drawn from standard solo works and standard orchestral works. A five to seven second clip was extracted from each track, and the American and European recordings were played in pairs, separated by three seconds of silence. A seven second gap of silence followed each pair, during which the subjects were asked to indicate which recording they preferred. On a

second listening of the entire test, subjects were asked to indicate which recording in each pair they thought was played by an American artist.

The test was arranged into three blocks that each contained one unaccompanied, one accompanied solo, and one section pair of recordings. The order of these three blocks was rotated, so that not all subjects heard the same version of the test. This creation of three test versions was done to counter any primacy or learning effects the results would otherwise indicate.

Task 2: Word List

Each subject was asked to read a list of 42 words. This word list was contained two examples of each standard vowel and diphthong in most dialects of English. One instance of each vowel was in a "bilabial stop consonant–vowel–alveolar stop consonant" combination (e.g. "bait," "put," "bird"), to provide a complete set of vowels for each speaker in the same phonetic context, eliminating as many variables as possible. The other instance of each vowel is less standardized, allowing for variety in pronunciation based on context to also be observed. In this way, the word list yields as comprehensive a vowel inventory as possible.

Reciting a word list is questionable practice among phoneticians who claim it yields "laboratory speech," where participants are more likely to speak with a more standard pronunciation than what might be present in their idiolect. For a project like this one, however, where standard pronunciations are as interesting as personal variation, the dangers of laboratory speech are less present.

The words were contained to a single syllable when possible. The exceptions to this standard are those words that required a second syllable to yield the "bilabial stop consonant–vowel–alveolar stop consonant" combination context for a specific vowel. The words lists also contained two words that were not used as data points. One of these words was placed as the final word on the list to counter any effects of List Intonation; a second word was placed elsewhere in the list so that the list contained an even number of items.

All spoken tasks were recorded using a digital recorder with internal microphone. Participants were not given specific direction about their proximity to the microphone, because the formant structure of speech is less easily affected by the room than the formant structure of instrumental timbre is. The recordings were processed using Audacity and Praat, two freely available audio programs. Audacity is most often used with musical recordings and Praat is intended for phonetic analysis of speech recordings.

Task 3: Etude Condition 1

Each subject was asked to play and record a prescribed etude. The selected etude was #3, *Allegretto* from the Bordogni/Rochut Melodious Etudes for trombone (Bordogni, 1813). This etude was selected for several reasons. The Bordogni/Rochut is a standard trombone studies book, so the etude might be familiar to subjects, thereby decreasing any anxiety they had about sightreading. Also, because the etudes in this book are derived from Italian vocalises, the style of

each etude is not inherently American or British; as a result the interpretation should be more idiomatic to each performer's playing style than it would be if the prescribed etude were in a jazz (American) or brass band (British) style.

This etude was also chosen for its key. G Major, is not a difficult key to sightread, and it minimizes the pitches used for which there are alternate positions. Because the recording was looking at the formant structure of selected pitches, those pitches must be played in the same position on the slide. A D4 (the D one step above middle C) that is played in first position will have different formant structure than the same pitch played in fourth position, because it is acting as a third in the fundamental's overtone series in the first case and a fifth in the other. These differences in formant structure would obscure the differences that this project is interested in, so those pitches with alternate position possibilities have to be disregarded from analysis. This etude has relatively few of those pitches.

All playing tasks were recorder with a digital recorder with internal microphone. Performers were asked to stand within 8 inches of the microphone to minimize the effect of the room on the recorded timbre (Carral, 2011). The playing recordings were processed using the same software as above, Audacity and Praat.

Task 4: Etude Conditions 2 and 3

To address the question of whether the player or the instrument yields an effect on timbre, subjects were also asked to play the same etude on two more trombones, provided by the researcher. One of these was a King, the other was a

Besson. Both instruments are as similar as possible while allowing for variation representative of the traditions of instrument manufacture in their respective countries.

Both instruments date from the mid-1980s and were manufactured in either the US or in England. Both are medium-small bore tenor trombones with F-attachment. Both F-attachments are in the closed wrap style, although the details of wrap shape differ. The English-made Besson is a silver plated instrument, while the King is lacquered brass. This represents the much higher rate of silver plated trombones in England and Europe when compared to those in the US, which are more often lacquered brass.

Task 5: Interview

The final task for participants was a brief interview. The purpose of this interview was to obtain background information about each subject's language background, musical interests, and level of education. Participants were asked the following series of questions:

- How long have you played the trombone?
- How long have you played in a brass band/community band? How long in this one specifically?
- Do you have any formal education in music?
- Have you ever studied any languages?
- What is your favorite kind of music to play?

- What is your favorite kind of music to listen to?
- Any favorite trombonists to listen to?
- Ignoring any financial restrictions, do you have a brand of trombone you would most like to own?

Participants were also invited to ask any questions of their own about the project and share any insights regarding differences in American and British trombone playing. In addition to providing necessary background information, this task also provided an unscripted speech sample for each subject, so that rate of speech, word choice, and non-laboratory pronunciations could be documented.

Summary

To determine whether a measurable and perceptible difference exists between American and British trombone players, and whether that difference is in any way correlated with existing differences in speech, participants were asked to complete a series of five tasks. These tasks yielded a data set for each subject including a complete vowel phoneme inventory, a prescribed playing sample, and an unscripted speech sample. Further background information and listening preferences were also ascertained, and the question of player or instrument having an effect on timbre was addressed. Following the completion of the project, the data was organized and analyzed to address the two objectives of the study.

The first objective, determining whether a measurable and perceptible difference exists between the two groups, was addressed in two ways: the first, the

measurable component, considers the recordings from Task 3: Etude Condition 1; the second, the perceptible component, considers the listening test from Task 1. This objective will also consider Task 4: Etude Conditions 2 and 3, to determine whether the performer or their chosen equipment has more effect on the difference in sound. The second objective, whether those differences are in any way correlated with differences in language, considers the recordings from Task 3 in conjunction with Task 2: Spoken Word List and Task 5: Interview. These playing and speech samples will be examined for relationships between vowels in speech and sustain timbre in playing, considering American and British players as large groups, smaller subgroups by dialect, and individuals. The results are discussed in the following chapter.

CHAPTER IV

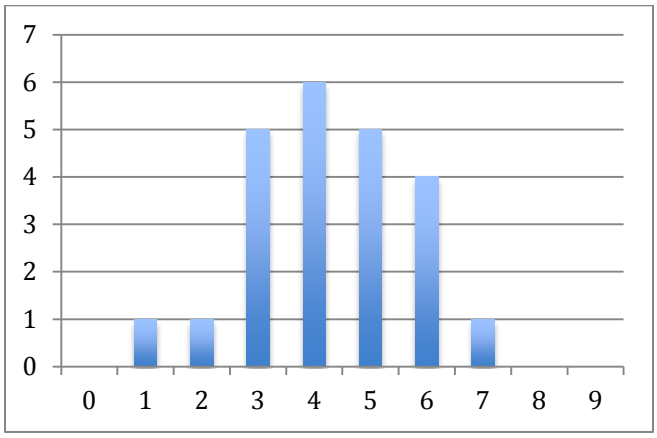
RESULTS

Perceptible Differences

The first question is whether the difference in timbre between British and American players is perceptible. Participants were asked to identify which recording in each pair was performed by an American artist or group. Their scores are presented in the following chart.

Figure 3

Number Correct in Nationality Identification



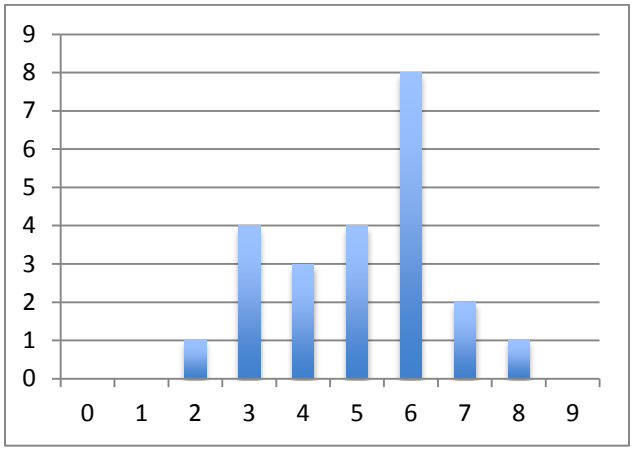
The charts in this section show the number of correct identifications on the horizontal axis, with the number of participants scoring at each level on the vertical

axis. For example, in the chart above, one participant scored only one correct answer and six participants scored four correct answers. The distribution of this specific chart shows that very few participants scored outside of chance, suggesting that the difference between American and British players is not overtly perceptible.

Participants were also asked to indicate which recordings they preferred. Their scores for preference of American artists or groups are presented in the following chart. The decision to score by American recording and preference was arbitrary; if the European recordings were scored instead, the distribution would simply be inverted left to right.

Figure 4

Number of Preferred Recordings Performed by Americans

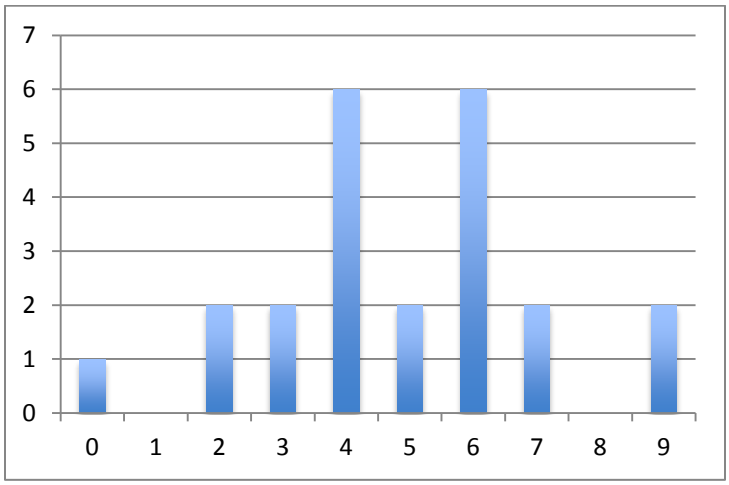


This chart shows a similar distribution, with only four participants scoring well outside of chance. This suggests that the difference between American and British performers is not perceptible in a way that influences preference.

One further question to address was whether the perception, correct or incorrect, of nationality impacts preference. Each subject's responses for identifying which recording featured an American player were compared with his/her selection of preference. Those results are shown in the following chart.

Figure 5

Scores for Preference Matching American Identification



As before, the possible scores for the test are found on the horizontal axis, and the number of participants attaining each score is shown on the vertical axis. This chart shows more subjects scoring outside of chance than the other results. When these results are broken down by nationality of subject, the results reveal a possible trend.

Figure 6a

Scores for Preference Matching American Identification (Americans Only)

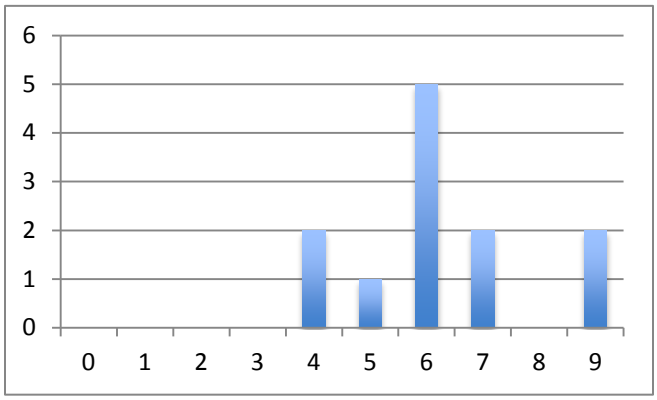
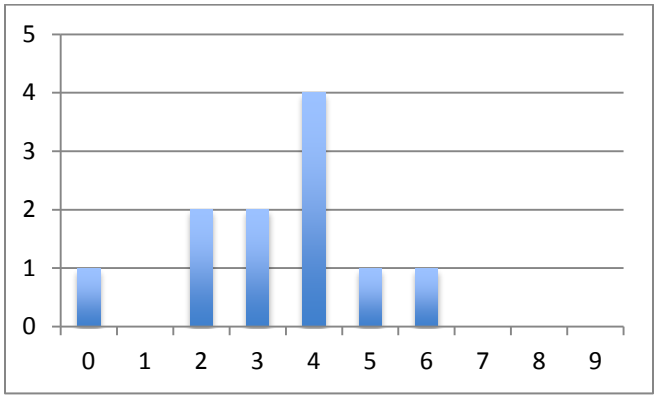


Figure 6b

Scores for Preference Matching American Identification (British Only)



These charts show that the subjects who scored well above chance, those whose preference best matched those recordings that they perceived as American, were all from the American subject pool. Those who scored well below chance, indicating

that the recordings they preferred were rarely the same ones they labeled as American, were all from the British group of subjects.

This indicates that, although the difference between Americans and British trombonists may not be overtly perceptible, subjects seem to believe that a difference exists and tend to prefer players from their native area, whether they are able to aurally identify those artists accurately or not. These conclusions agree with many subjects' responses during the interview portion of this project.

Measurable Differences: Speech

The use of formants to identify differences in vowel distribution is an established method; charts were created which orient F1 on the horizontal axis and F2 on the vertical axis, with both axes inverted. The vowel inventory from each subject was graphed using this method; the average of these inventories is seen below for each large subject group.

Figure 7a

Average American Vowel Inventory

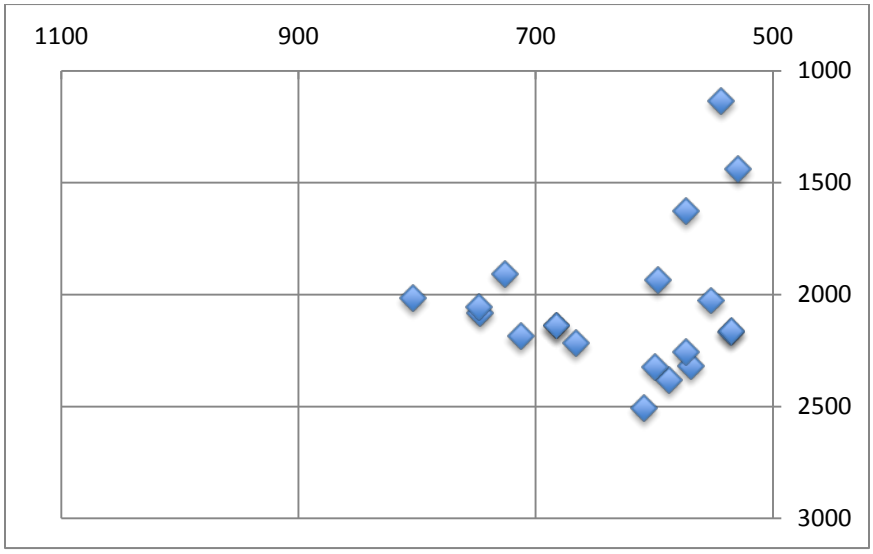
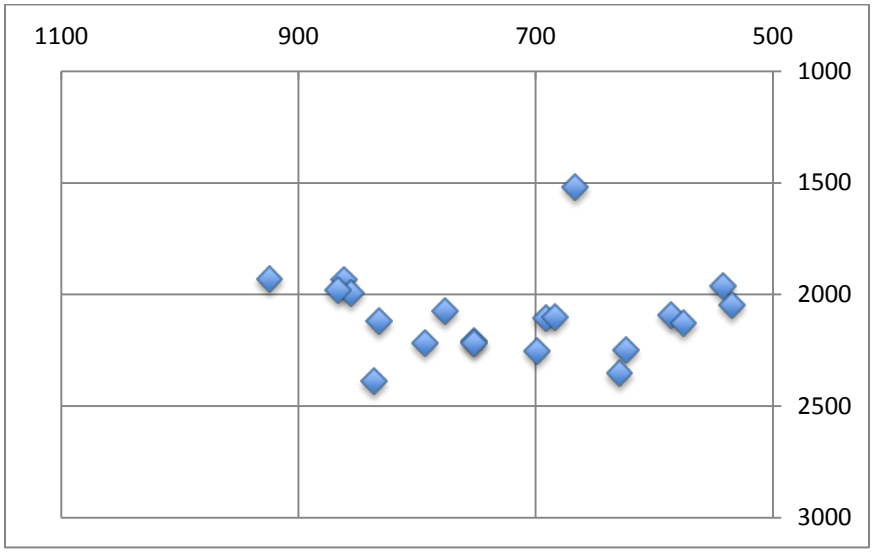


Figure 7b

Average British Vowel Inventory



These charts show that the American subjects in this study generally had more F2 variation than the British subjects did. This is demonstrated by the greater vertical distribution in the chart, which also represents greater variety in tongue height placement. The British subjects conversely showed greater F1 variation, shown in a greater horizontal distribution in the chart, also representing greater variety in tongue front-back placement.

Measureable Differences: Sustain Timbre

A similar chart was created for each large groups average timbre inventory. As with the vowel chart, F1 and F2 are plotted on inverted horizontal and vertical axes, respectively.

Figure 8a

Average American Timbre Inventory

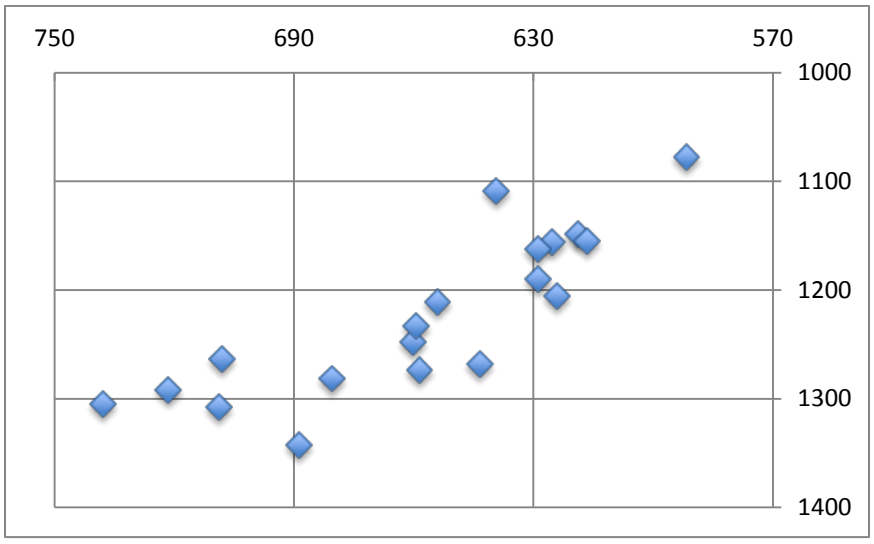
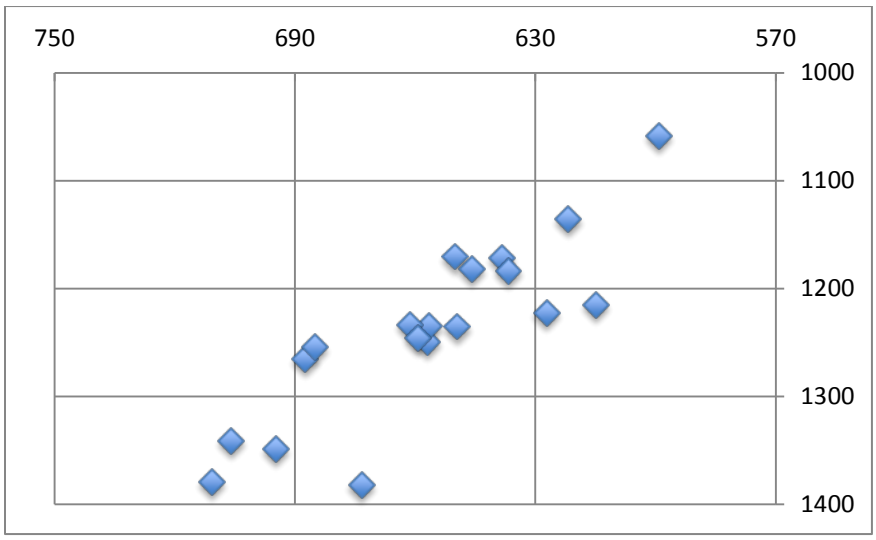


Figure 8b

Average British Timbre Inventory



These charts show that a measurable difference does exist between American and British trombone players. The American chart shows a larger horizontal distribution, while the British chart shows more vertical distribution. These trends are the opposite of the trends identified in the vowel inventory for each country. This suggests that, while there is a documentable difference between American and British trombone playing and American and British speech, the differences may exist in an inverted, rather than a direct relationship, or these variables may not be related at all.

An examination of individual subjects speech and timbre inventories suggests that the inverted relationship may be a good explanation. One American subject's inventories are presented below:

Figure 9a

American Subject 240761 Vowel Inventory

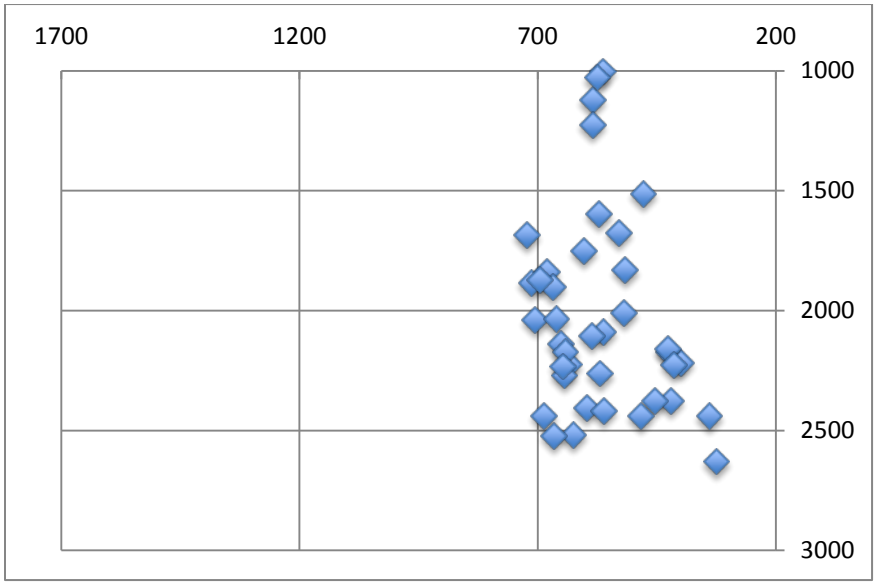
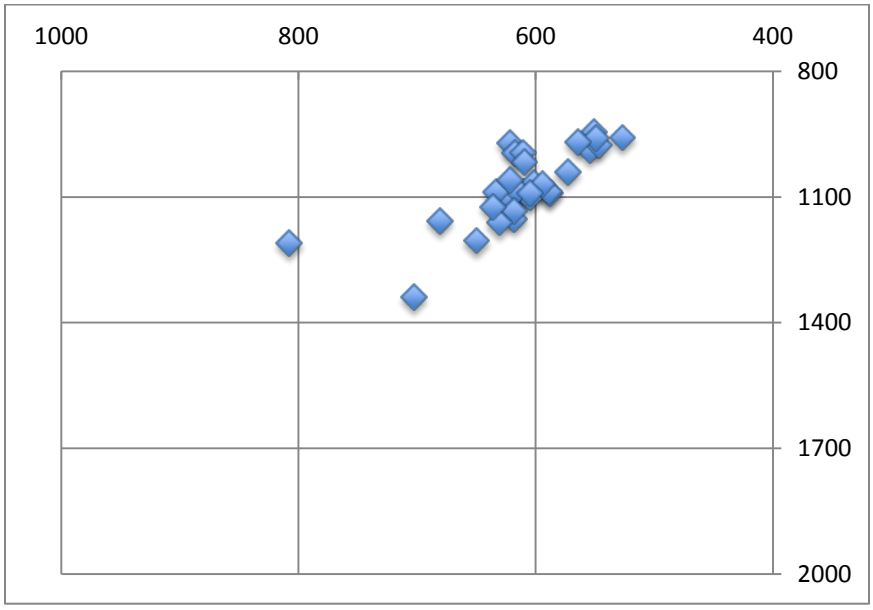


Figure 9b

American Subject 240761 Timbre Inventory



This subject's phoneme inventory is restricted to the rightmost third of the distribution area, while his timbre inventory is found exclusively in the upper half of the chart area. While these areas are not identical to those found in the large group average charts, the distribution pattern is characteristic of an American subject.

Similarly, a British subject's inventories are below:

Figure 10a

British Subject 926066 Vowel Inventory

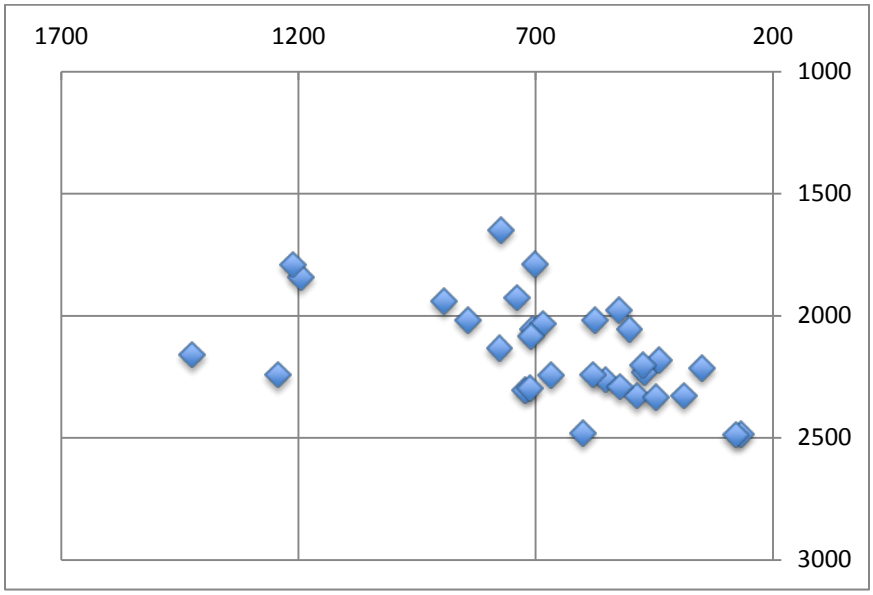
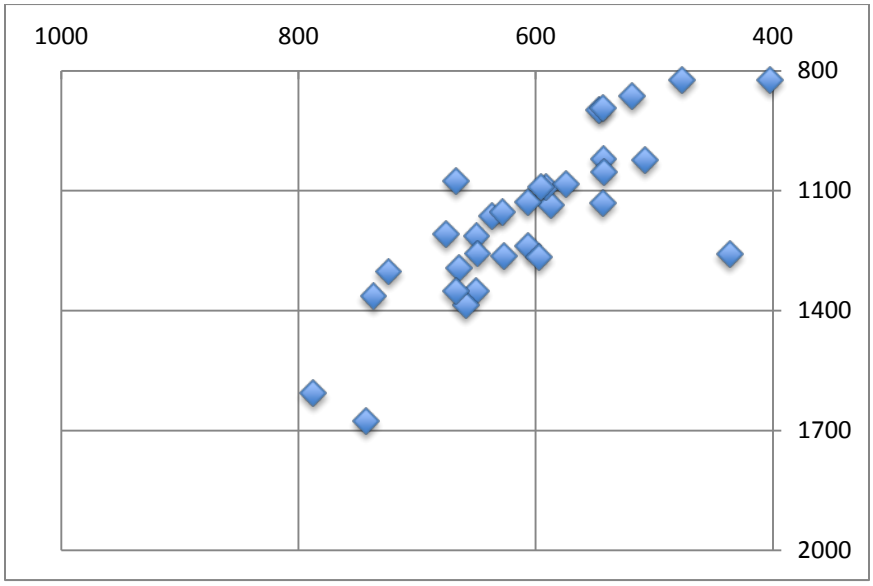


Figure 10b

British Subject 926066 Timbre Inventory



This example is more subtle, but does show that this subject's vowel inventory presents much more horizontally than his timbre inventory, which is more vertical. This is again indicative of the relationship identified in the average British charts. The relationships between individual subjects' vowel and timbre inventories, taken in conjunction with the average relationships, suggests that the amount F1 variation in speech may correspond with the amount F2 variation in trombone timbre.

Dialect Differences

If this inverted relationship between F1 and F2 variation is true, then it may also exist when considering dialect subgroups of British English or American English. Two British English dialect groups, one from the South and one from the North, show their averages in the charts below.

Figure 11a

South British Vowel Inventory

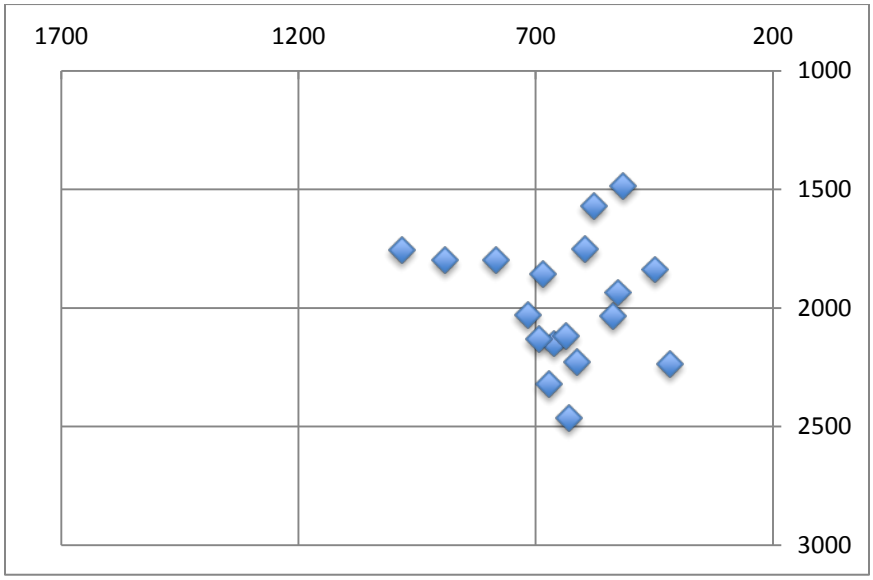
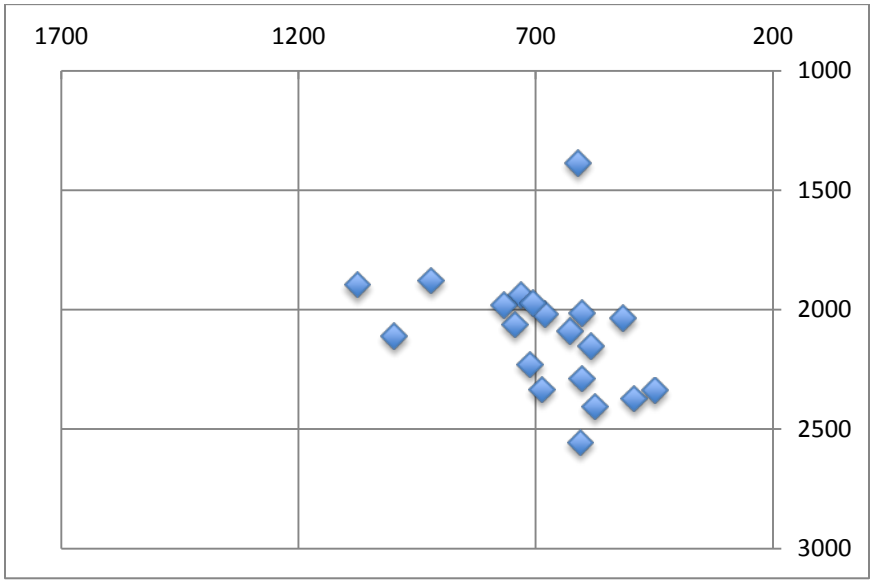


Figure 11b

North British Vowel Inventory



The distributions here are very similar: both contain a central cluster. The North British dialect chart shows a few points outlying to this cluster; these are both horizontally and vertically displaced. The prediction then is that the North British dialect timbre inventory will display a similar cluster, with a small number of outliers displaying vertical and horizontal displacement. The South British vowel chart shows a central cluster with only horizontally displaced outliers. If the established pattern continues here, this suggests that the South British timbre inventory will show a cluster with only vertically displaced outliers.

Figure 12a

South British Timbre Inventory

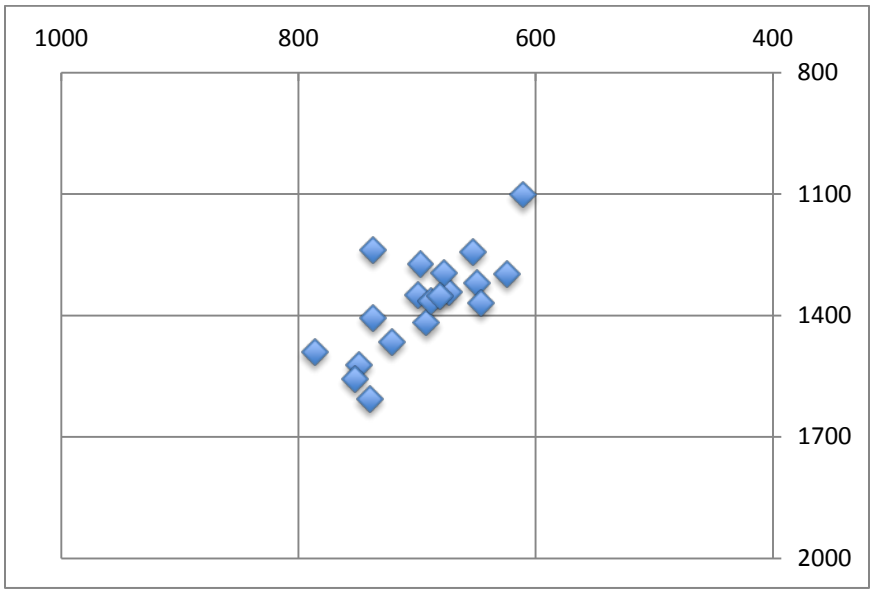
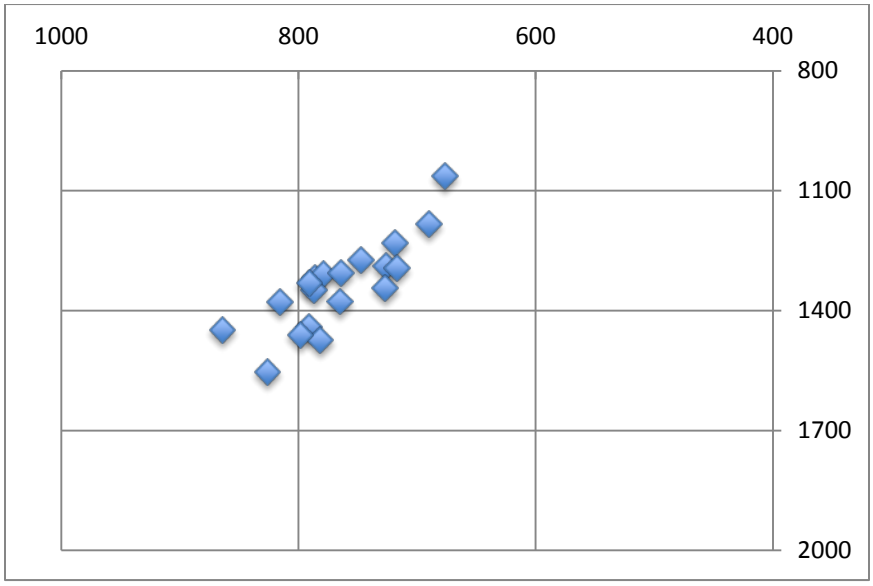


Figure 12b

North British Timbre Inventory



The predictions regarding these timbre charts were relatively accurate. The South British timbre chart is overall more widely distributed than the North British chart, and it contains a single outlying point that is vertically separate from the rest of the data points.

Impact of Instrument vs Player

The question of whether the player or their choice of instrument is creating these differences must also be addressed. Two participants, one British and one American, have their performances with their own instrument plotted alongside their performances with a provided American trombone and a provided British trombone. The British charts are presented first.

Figure 13a

British Subject 480218 Timbre Inventory (His Own Trombone)

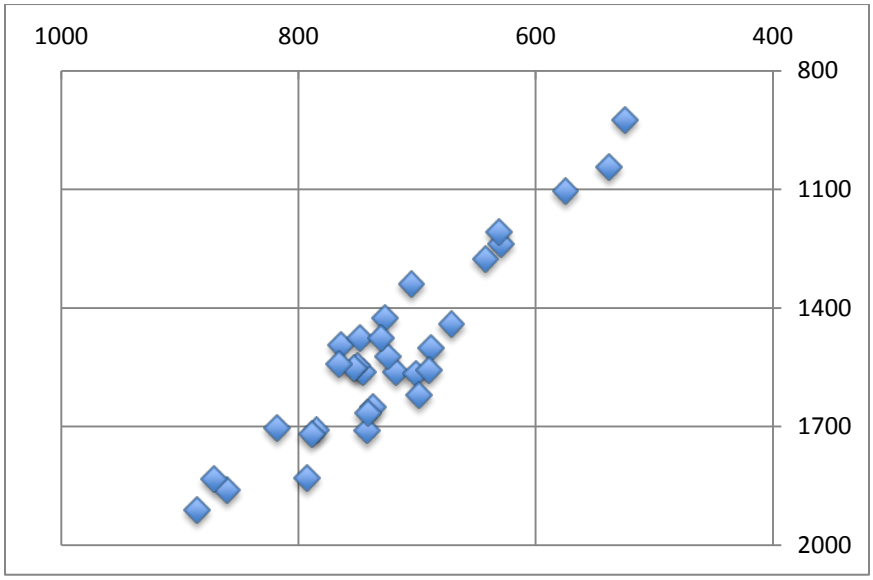


Figure 13b

British Subject 480218 Timbre Inventory (American Trombone)

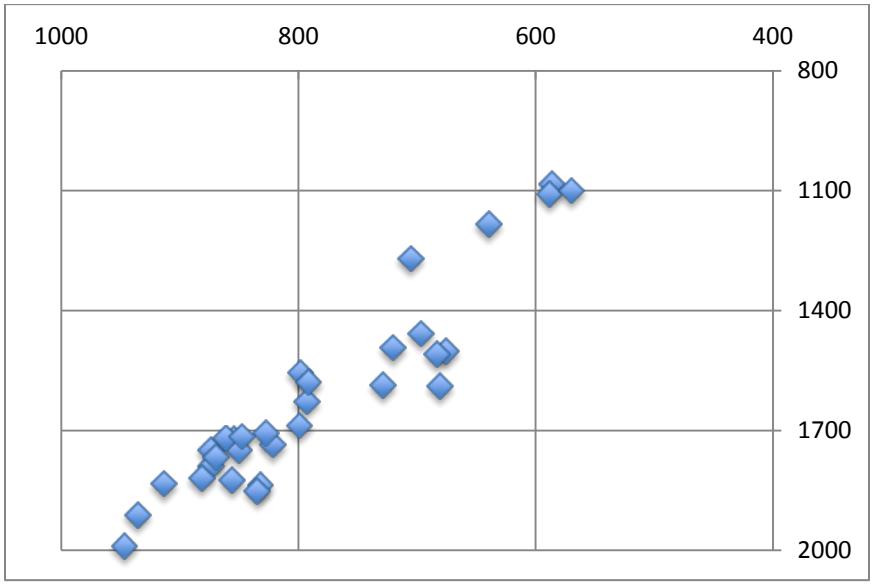
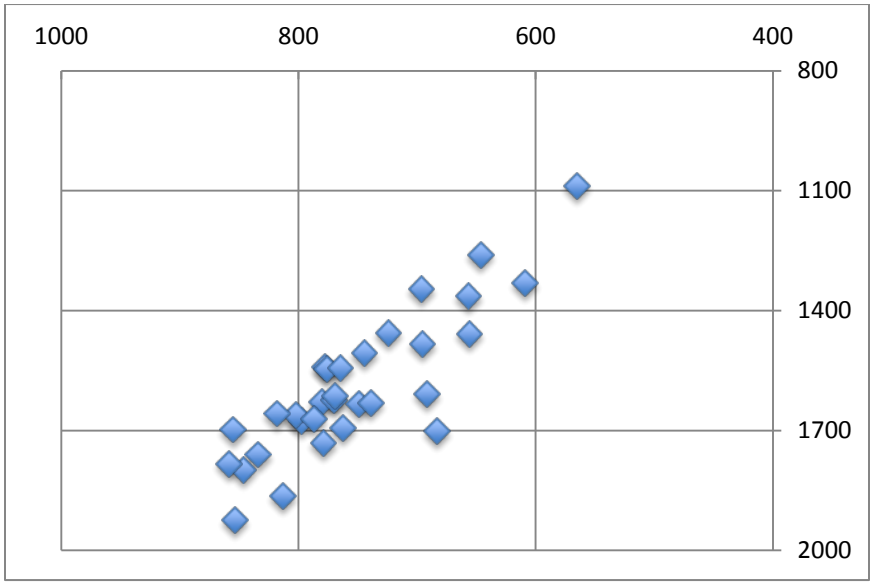


Figure 13c

British Subject 480218 Timbre Inventory (British Trombone)



Each of these charts shows a similar distribution, a generally diagonal line that has no strong characteristics identifying it as British or American. Although the distributions are all similar, the British trombone produced the most similar results to the player's chosen instrument, suggesting an affinity of the British player for the British instrument. Additionally, the American trombone plot is wider than the British trombone plot, suggesting the same horizontal orientation of the average American timbre inventory. These results suggest that the instrument may have some impact on whether a player's sound is characterized as British or American.

An American subject's charts follow.

Figure 14a

American Subject 434275 Timbre Inventory (His Own Trombone)

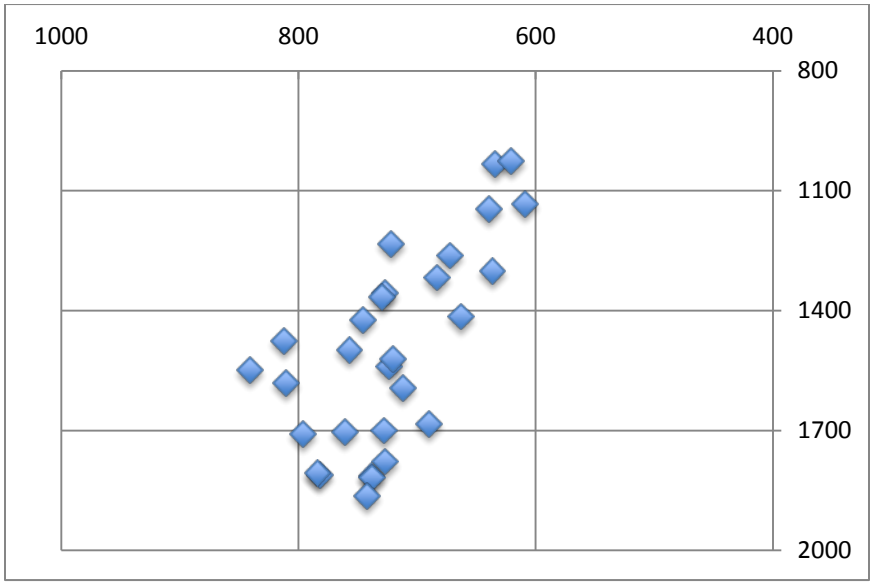


Figure 14b

American Subject 434275 Timbre Inventory (American Trombone)

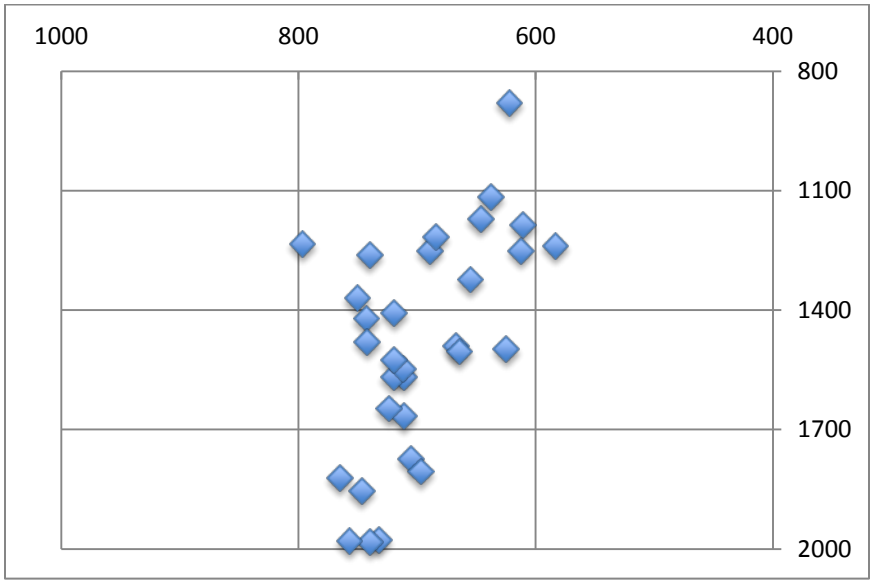
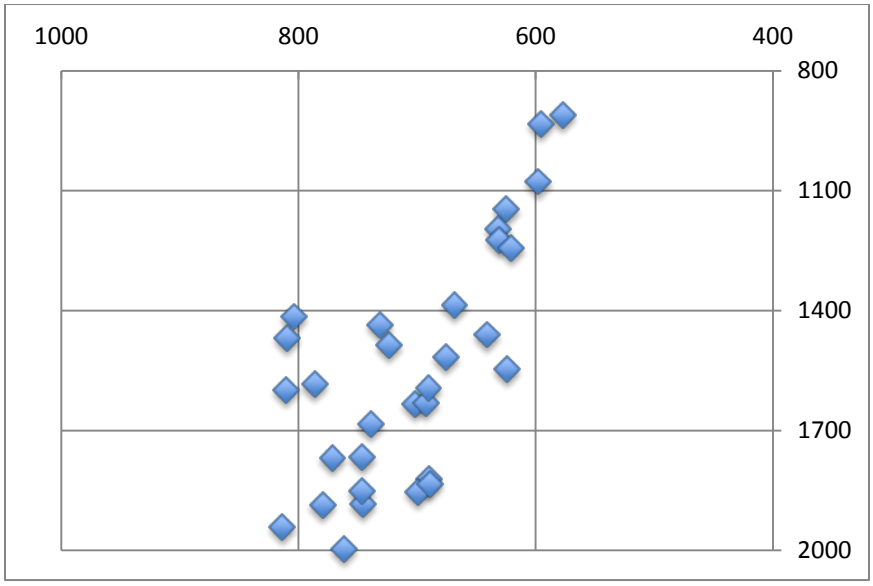


Figure 14c

American Subject 434275 Timbre Inventory (British Trombone)



These charts show similar findings with the above. Each plot is similar, and each can be categorized as primarily vertical, which is in accordance with the American timbre averages. The American trombone produces the most vertical, and therefore most American, plot; the British trombone produces the least vertical, and therefore more British, plot. This again suggests that the instrument has some impact on the sound, although less of an effect than the player does.

Summary

The objectives of this project were twofold: first, to determine whether a perceptible and measureable difference exists between American and British trombone players; second, to determine whether these differences, if present, can be related in any way to the differences between American English and British

English dialects. The first of these questions, that of a perceptible difference, was tested by asking participants to identify whether recordings were performed by American artists or not. Subjects in this project were unable to do so, but did exhibit a preference for those recordings that they believed were performed by artists from their own dialect group.

The second question, that of measurable differences, was addressed by analyzing recordings performed by American and British trombonists. Using a two formant spatial plot, timbre inventories for each large dialect group, as well as dialect sub-groups and individuals, showed that a measurable difference in timbre does exist. When considering whether the player or his/her choice of instrument produced this effect, recordings showed that both the player and the instrument impacted the timbre inventory, although the effect of the player was much stronger than that of the instrument.

CHAPTER V

CONCLUSIONS

Summary

The purposes of this study were twofold: first, to determine whether measurable and perceptible differences between American and British trombonists exist and second, to determine whether any of these measurable differences correlate in any way with established differences between American English and British English speech. The specific correlation between trombone sustain timbre and spoken vowels will be considered using American and British subjects in large groups, smaller dialect subgroups, and individually. In addition, the manufacturing origin of the trombone will be considered, to determine whether any differences are attributable to the instrument rather than the player.

Specifically considering instrumental timbre as related to speech is minimally explored in existing research. However, the fields of acoustics, linguistics, and music cognition have produced studies that informed the background assumptions of this project. Similarities and overlaps between music and language, specifically with regard to compositional practice and neural resources, have been studied in music cognition. Music directly affecting language is the foundation of

Melodic Intonation Therapy, which is in use by both music therapists and speech therapists. The inverse trend, that of language affecting music, is found in instrumental pedagogy and the theories Helmholtz put forward, particularly with regard to articulations and note shapes.

To determine whether a measurable and perceptible difference exists between American and British trombone players, and whether that difference is in any way correlated with existing differences in speech, participants were asked to complete a series of five tasks. These tasks included two playing conditions, two speaking conditions, and one listening test that explored both preferences and ability to distinguish between American and non-American player recordings. Following the completion of the project, the data was organized and analyzed to address the two objectives of the study.

The first objective, determining whether a measurable and perceptible difference exists between the two groups, was addressed in two ways: the first, the perceptible component, relies on the listening test; the second, the measurable component, considers the recordings made of each subject playing. The second objective, whether those differences are in any way correlated with differences in language, considers those playing recordings in conjunction with the two speaking tasks. The playing and speech samples were examined for relationships between vowels in speech and sustain timbre in playing, considering American and British players as large groups, smaller subgroups by dialect, and individuals.

Conclusions

A perceptible difference between American and British performers as tested by the listening portion of this project was not found. The majority of participants scored at or close to chance levels, indicating that they could not correctly distinguish between or identify trombonists of one nationality over another. However, the listening portion did suggest a bias: trombonists seem to want to prefer players of their own nationality. This was suggested by a higher rate of preference for those recordings that subjects had identified as belonging to their own national dialect group, regardless of the accuracy of that identification.

A measurable difference between American and British players was uncovered. Timbre plots, created by measuring the first two formants, showed that a different distribution pattern existed for American trombonists and British trombonists. These differences exist at the large group, dialect subgroup, and individual levels.

The differences in timbre inventory could be related consistently to the differences in vowel inventory. However, this relationship was not directly relating F1 to F1 and F2 to F2. An inverse relationship was found, where F1 for each group's speech correlated with F2 for each group's timbre, and vice versa. The relationship is consistent at all three levels of analysis.

The question of player versus instrument effect was also considered. Analysis showed that the national origins of the instrument did have an effect on the

timbre inventory that a player produced, although it was generally a weaker influence than the nationality of the player himself.

Suggestions for Further Study

Potential for further study in this area is extensive. The project could easily be expanded to other instruments that have similar anecdotal relationships between their British and American players. The clarinet is one such example. The same project could also examine differences across languages, rather than looking at dialects within English.

The data gathered for this project alone has the potential for further analysis. In addition to considering relationships between sustain timbre and spoken vowel, the connection between musical articulations/releases and spoken consonants can also be explored. The amplitude envelopes that characterize each type of consonant can also be used to describe noteshapes. Each subject's rate of speech can be determined from the interview portion of this project, and that natural rate of speech compared to metric hierarchy emphasis, as well as tempo selection and the use of expressive timing.

This same project could be done again with a different group of participants. Using professional musicians rather than amateurs, or focusing on the level of education or training for subject recruitment could produce different results. In that case, the effect of different educational and training paradigms could also be explored, lending a more diachronic approach to the project.

Previous research shows connections between music and language in those topics where a simple measurement method is possible, but timbre is a less well-defined concept, and it has therefore been largely overlooked in any data-driven analysis. This study shows that borrowing methodologies from linguistics and phonetic analysis is useful for analyzing and measuring musical timbre. This method can help to fill an existing gap in the literature, not just relating trombone timbres of different dialects to each other, but considering different instruments, different languages, and more aspects of each than the sustain timbre and the vowel content respectively. The impact of further study in these areas would be widespread, helping music teachers, instrument manufacturers, linguists, organologists, and music and speech therapists, all of whom can benefit from further elucidating connections between music and language.

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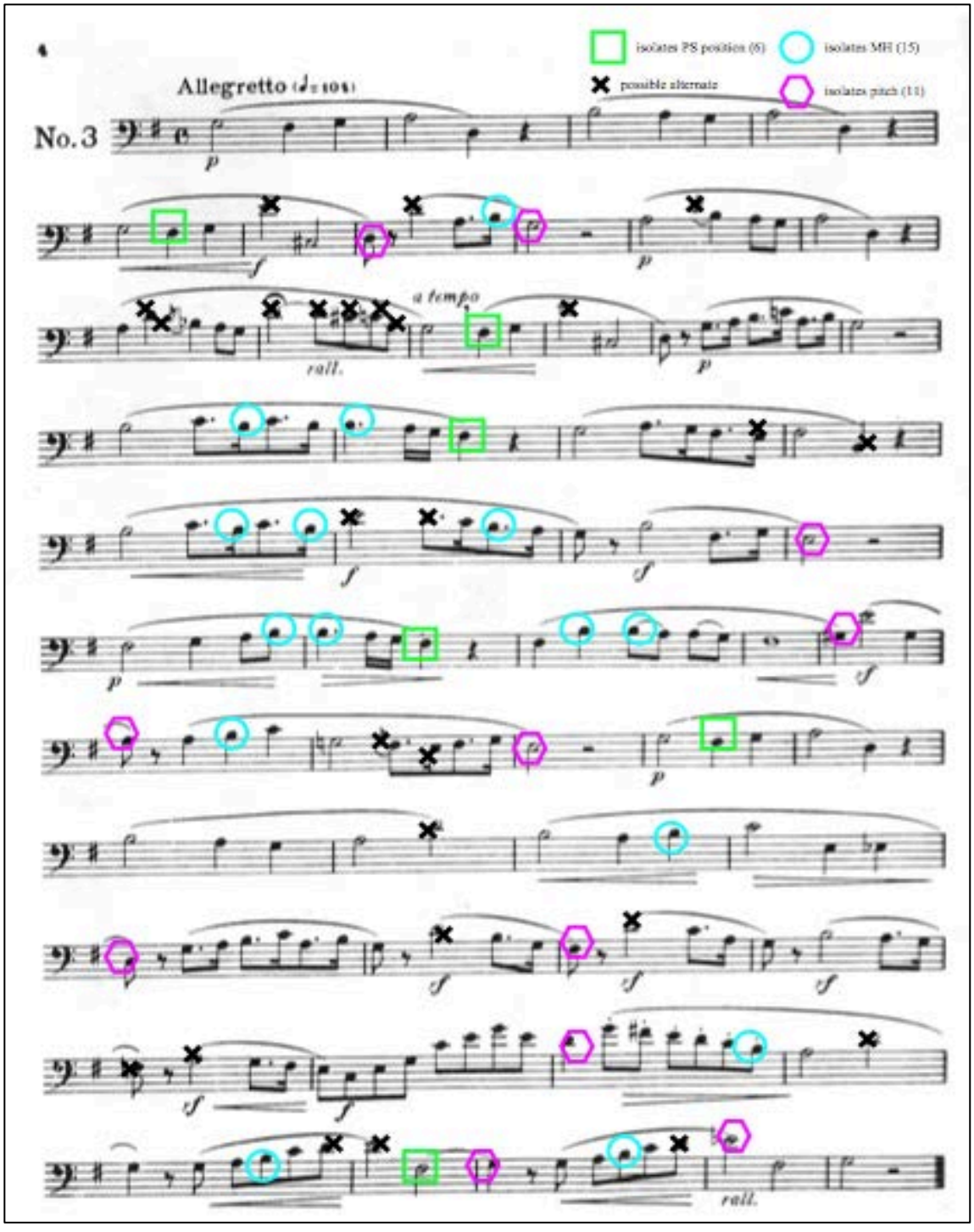
APPENDIX A

WORD LIST

ABOUT	TURN
BAIT	BOISE
CALM	BOOT
BAT	POOR
CARE	POT
BEAR	TIME
CORD	BOT
BEER	WAIST
DOG	PUT
BEET	BOUGHT
FOUND	ROAD
BET	BOUT
HEAD	SAT
PORT	BOY
BIRD	SOUP
HERE	BUT
BIT	SUN
HIM	BUTT
BITE	SEEP
LURE	BUTCHER
BOAT	BLANK

APPENDIX B

ANNOTATED ETUDE


isolates PS position (8)
isolates MH (15)
possible alternate
isolates pitch (11)
Allegretto
No. 3
a tempo
rall.
rall.

APPENDIX C

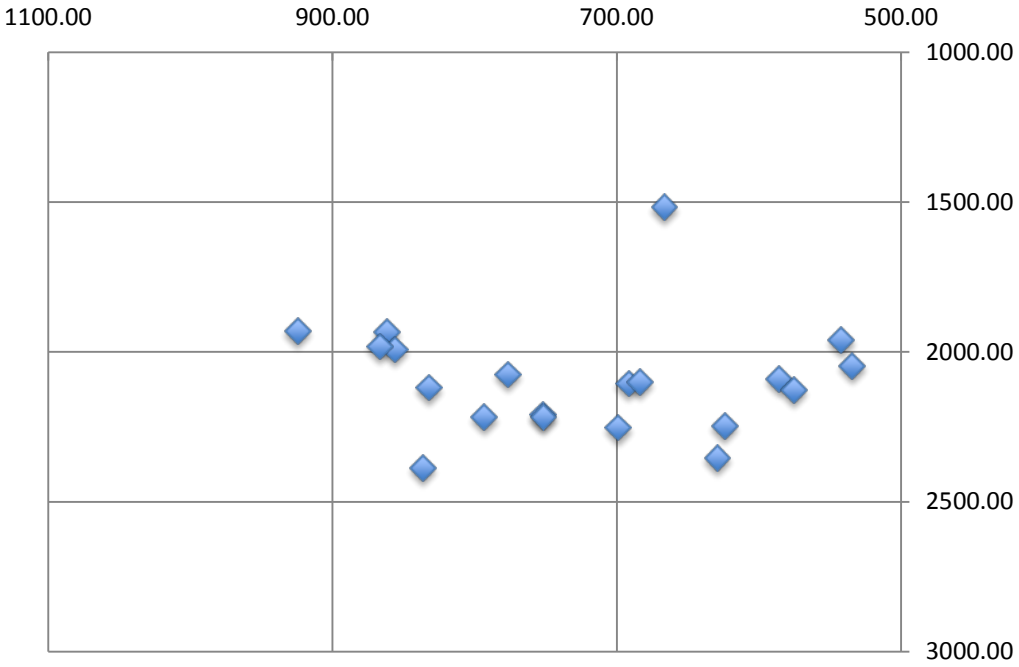
SUMMARIZED DATA SETS

British Average Summaries

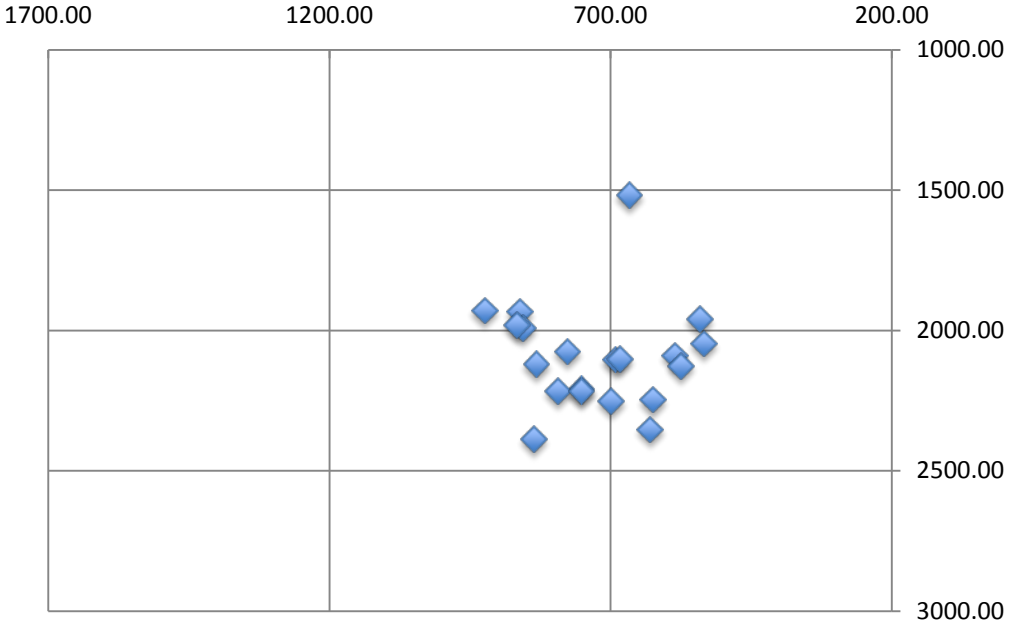
Average British Vowel Inventory Data Points

Point	F1	F2
1	836.29	2386.63
2	751.96	2208.11
3	793.23	2216.77
4	776.69	2074.35
5	924.38	1929.29
6	624.09	2247.20
7	698.80	2251.74
8	832.12	2118.99
9	534.30	2046.06
10	585.76	2090.17
11	629.21	2352.55
12	666.42	1516.77
13	691.60	2104.98
14	861.75	1933.29
15	856.01	1992.05
16	541.95	1959.81
17	866.54	1981.41
18	575.20	2126.05
19	683.52	2100.95
20	751.66	2216.52

Average British Vowel Inventory – Scaled for Comparison of Averages



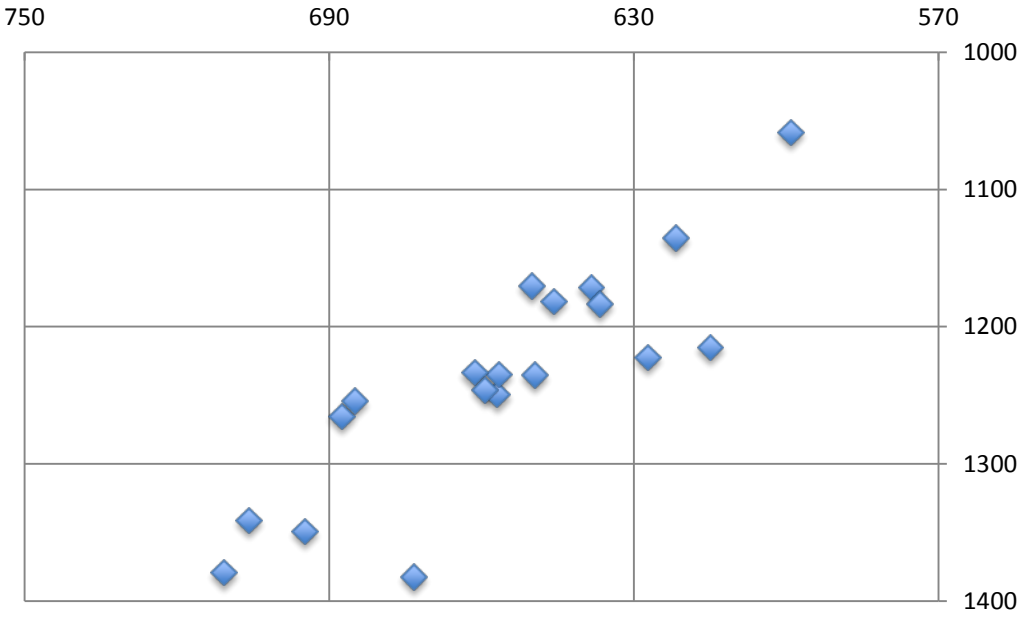
Average British Vowel Inventory – Scaled for Comparison of Individuals



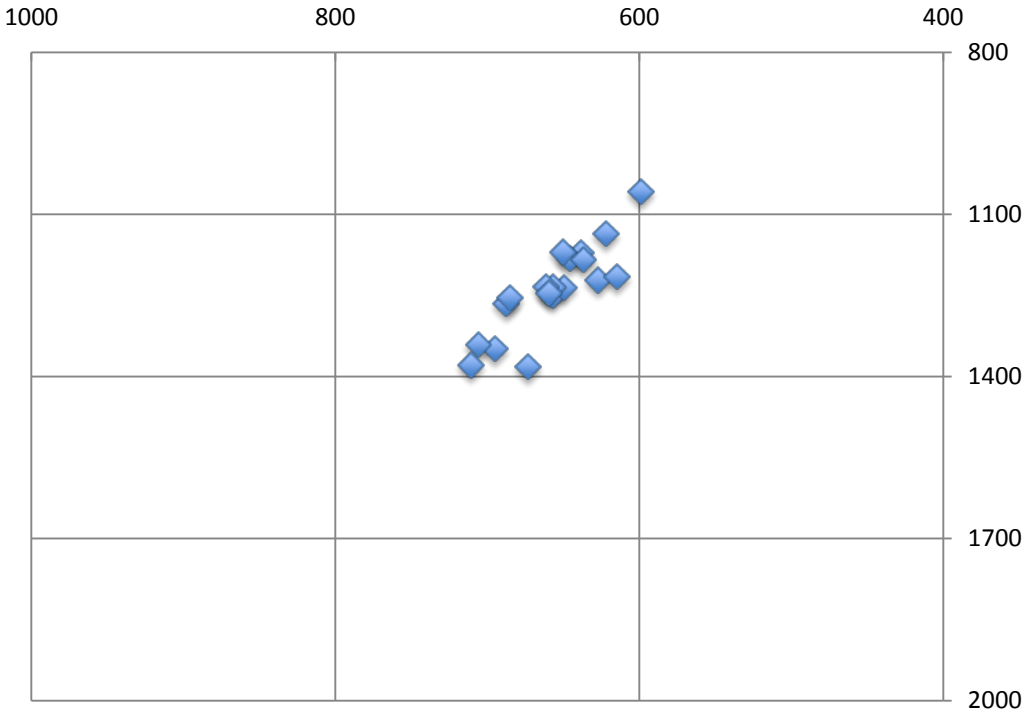
Average British Timbre Inventory Data Points

Label1	Label2	F1mean	F2mean
MH	1	656.89	1249.41
MH	2	638.32	1171.38
MH	3	687.41	1265.23
MH	3.5	649.50	1235.26
MH	3.75	645.80	1181.65
MH	4	694.77	1349.00
MH	4.5	656.53	1234.72
MH	4.75	661.33	1233.42
P	1	627.19	1222.34
P	3	650.09	1170.28
P	5	636.68	1183.48
P	6	614.90	1214.93
P	7	705.86	1341.05
P	8	684.98	1254.16
P	13	673.34	1382.22
P	14	710.74	1379.17
PS	1	659.32	1245.95
PS	2	621.77	1135.44
PS	3	599.05	1058.21

Average British Timbre Inventory – Scaled for Comparison of Averages



Average British Timbre Inventory – Scaled for Comparison of Individuals

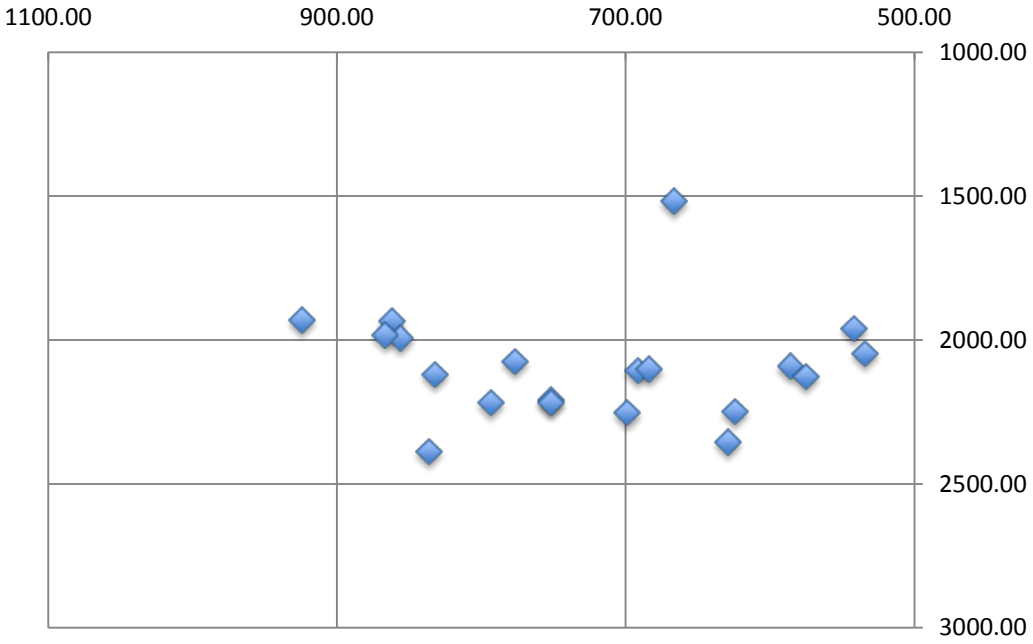


British Sub-Dialect 1 ("South") Summaries

Average Sub-Dialect 1 Vowel Inventory Data Points

Label	F1	F2
1	836.29	2386.63
2	751.96	2208.11
3	793.23	2216.77
4	776.69	2074.35
5	924.38	1929.29
6	624.09	2247.20
7	698.80	2251.74
8	832.12	2118.99
9	534.30	2046.06
10	585.76	2090.17
11	629.21	2352.55
12	666.42	1516.77
13	691.60	2104.98
14	861.75	1933.29
15	856.01	1992.05
16	541.95	1959.81
17	866.54	1981.41
18	575.20	2126.05
19	683.52	2100.95
20	751.66	2216.52

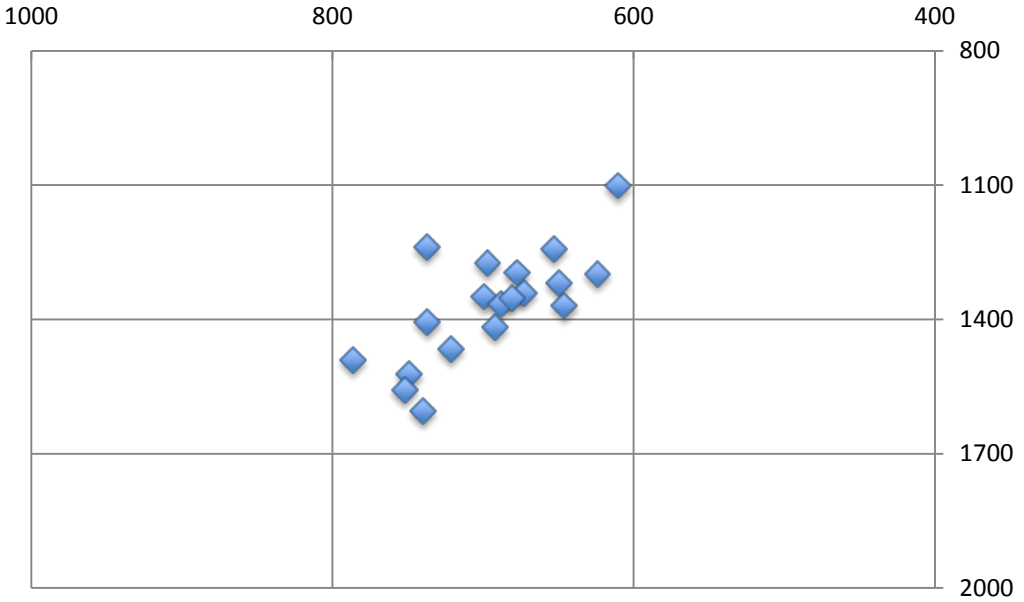
Average Sub-Dialect 1 Vowel Inventory – Scaled for Comparison of Individuals



Average Sub-Dialect 1 Timbre Inventory Data Points

Label1	Label2	F1mean	F2mean
MH	1	656.89	1249.41
MH	2	638.32	1171.38
MH	3	687.41	1265.23
MH	3.5	649.50	1235.26
MH	3.75	645.80	1181.65
MH	4	694.77	1349.00
MH	4.5	656.53	1234.72
MH	4.75	661.33	1233.42
P	1	627.19	1222.34
P	3	650.09	1170.28
P	5	636.68	1183.48
P	6	614.90	1214.93
P	7	705.86	1341.05
P	8	684.98	1254.16
P	13	673.34	1382.22
P	14	710.74	1379.17
PS	1	659.32	1245.95
PS	2	621.77	1135.44
PS	3	599.05	1058.21

Average Sub-Dialect 1 Timbre Inventory – Scaled for Comparison of Individuals

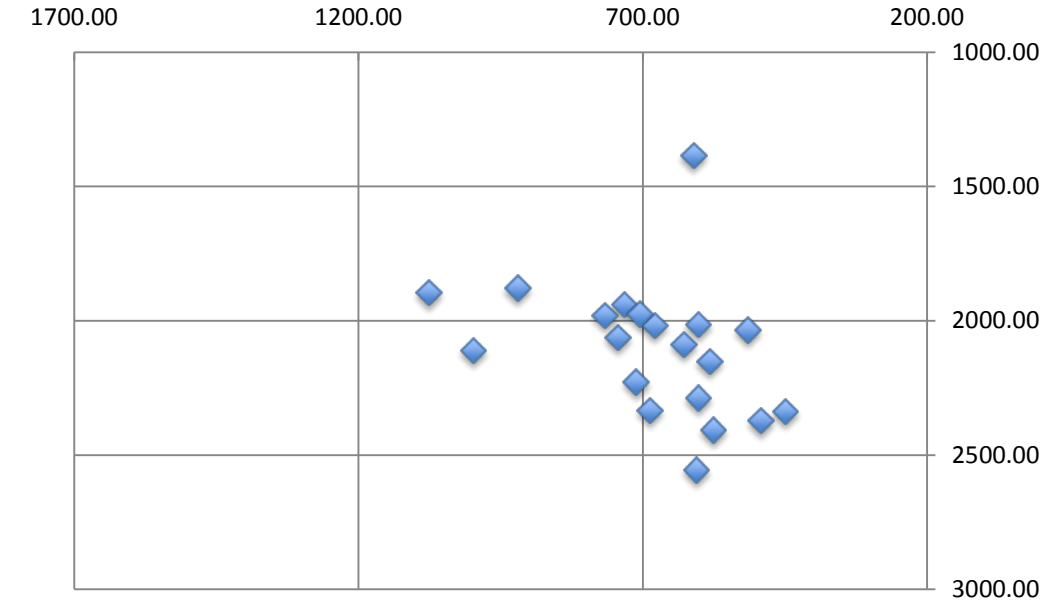


British Sub-Dialect 2 ("North") Summaries

Average Sub-Dialect 2 Vowel Inventory Data Points

Label	F1	F2
1	711.12	2228.50
2	743.87	2060.77
3	997.89	2110.59
4	731.92	1938.69
5	765.85	1978.77
6	605.35	2554.86
7	687.45	2333.20
8	1076.03	1894.25
9	448.98	2336.80
10	491.94	2370.86
11	602.09	2286.54
12	610.66	1383.54
13	601.87	2012.89
14	679.45	2016.32
15	705.30	1972.70
16	515.08	2033.24
17	919.99	1877.58
18	575.46	2405.38
19	627.68	2087.06
20	582.50	2150.33

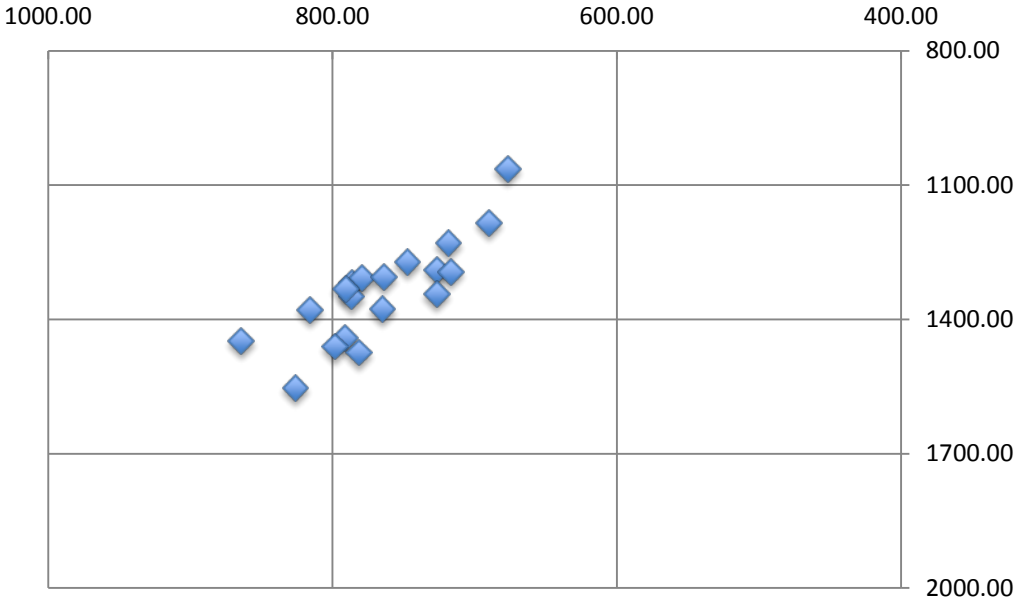
Average Sub-Dialect 2 Vowel Inventory – Scaled for Comparison of Individuals



Average Sub-Dialect 2 Timbre Inventory Data Points

Label1	Label2	F1mean	F2mean
MH	1	786.34	1318.49
MH	2	718.42	1230.04
MH	3	815.66	1378.40
MH	3.5	747.31	1272.19
MH	3.75	778.98	1307.47
MH	4	826.11	1552.36
MH	4.5	786.64	1349.01
MH	4.75	790.77	1331.41
P	1	726.30	1288.56
P	3	690.03	1183.67
P	5	764.82	1377.27
P	6	716.90	1293.77
P	7	791.43	1440.67
P	8	726.86	1343.32
P	13	864.14	1447.84
P	14	781.52	1473.94
PS	1	798.36	1460.09
PS	2	763.92	1305.46
PS	3	676.70	1063.29

Average Sub-Dialect 2 Timbre Inventory – Scaled for Comparison of Individuals

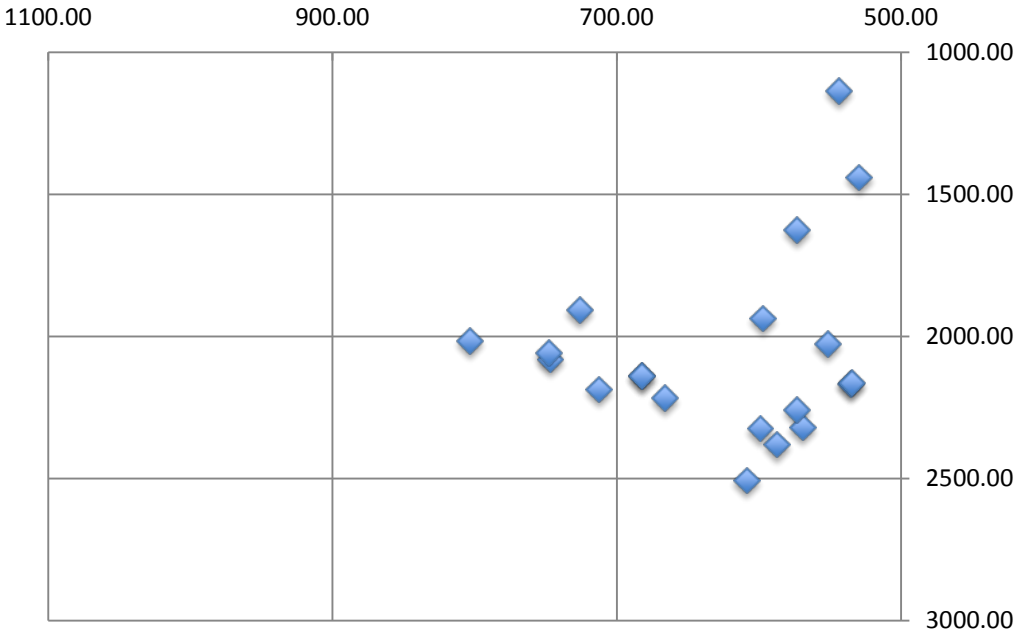


American Average Summaries

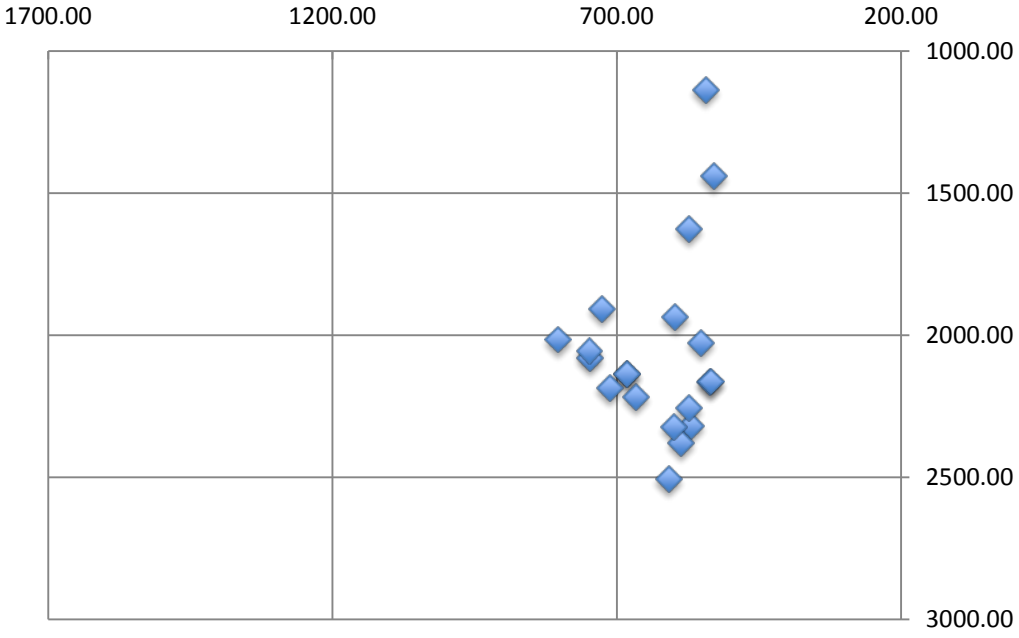
Average American Vowel Inventory Data Points

Label	F1	F2
1	608.72	2505.93
2	569.28	2318.62
3	587.34	2380.19
4	598.96	2323.54
5	682.31	2137.83
6	682.31	2137.83
7	712.55	2184.56
8	535.50	2165.67
9	573.16	2256.81
10	551.69	2026.43
11	726.11	1906.72
12	803.44	2015.13
13	597.04	1935.75
14	746.58	2080.43
15	747.92	2056.64
16	529.48	1439.89
17	573.06	1625.25
18	543.56	1135.88
19	534.73	2162.13
20	666.35	2216.97

Average American Vowel Inventory – Scaled for Comparison of Averages



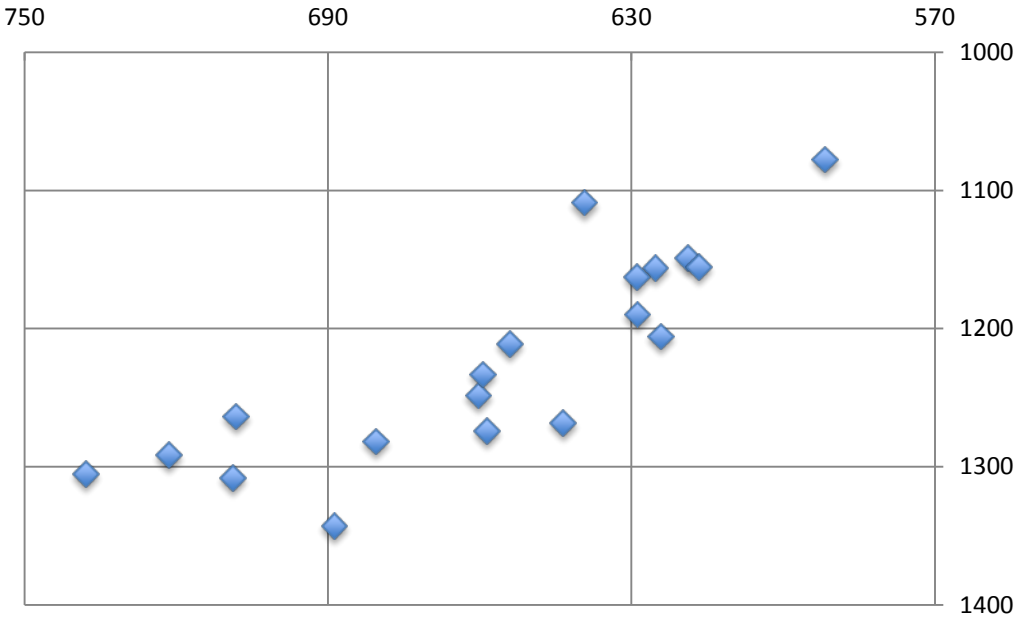
Average American Vowel Inventory – Scaled for Comparison of Individuals



Average American Timbre Inventory Data Points

Label1	Label2	F1mean	F2mean
MH	1	658.56	1273.80
MH	2	708.12	1263.46
MH	3	708.77	1307.88
MH	3.5	680.51	1281.49
MH	3.75	660.24	1248.23
MH	4	688.74	1342.73
MH	4.5	659.34	1233.07
MH	4.75	654.05	1210.85
P	1	625.26	1155.97
P	3	639.31	1108.68
P	5	624.13	1205.67
P	6	618.88	1148.54
P	7	643.48	1267.99
P	8	628.92	1162.52
P	13	721.46	1291.56
P	14	737.83	1305.03
PS	1	628.82	1189.66
PS	2	616.63	1155.21
PS	3	591.64	1077.61

Average American Timbre Inventory – Scaled for Comparison of Averages



Average American Timbre Inventory – Scaled for Comparison of Individuals