INSTRUCTION TYPE: EFFECTS ON PITCH ACCURACY IN

FEMALE COLLEGIATE DECLARED VOICE MAJORS

by

Betty Melinda Damon

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

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ABSTRACT

In this quantitative study, the researcher examined differences in pitch accuracy scores of 59 female collegiate voice students (*N* = 59) at a large university in the mid-Atlantic United States to determine instruction type efficacy on pitch accuracy. In this double-blind, true-experimental posttest only control group design, the control group (*n* = 19) received traditional corrective verbal cues (TCVC) only. Treatment groups received TCVC with either real-time visual feedback (RTVF) (*n* = 20), or performed audio feedback (PAF) (*n* = 20). Data were collected via a demographics survey, audio-recorded vocal response, and visual-recorded vocal response using Sing and See software. Though assigned at random to the three instruction types, it was worthwhile to assess the comparability of the three groups in terms of the two factors that have been documented in literature as influencing pitch accuracy, the dependent variables, namely number of semesters of voice taken by the participants and menstrual status. Analyses demonstrated that groups did not differ in terms of these variables. Data was analyzed using a one-way analysis of variance (ANOVA), and results show that pitch accuracy scores differed according to instruction type. Post hoc tests revealed that the average gain in pitch scores of female students who received RTVF instruction was significantly better than female students who received TCVC and PAF instruction. The comparability of the three instructional groups in terms of the two factors that have been documented in the music education literature as influencing pitch accuracy, number of semesters of voice taken by the student and their menstrual status, was also assessed; they were found to be evenly distributed.

Keywords: real-time visual feedback (RTVF), performed audio feedback (PAF), traditional corrective verbal cues (TCVC), pitch-accuracy

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List of Abbreviations

Analysis of Variance – ANOVA

Cognitive Load Theory – CLT

Information Processing Theory – IPT

Internal Review Board – IRB

National Association for Music Education - NAfME

Music Education National Conference – MENC

National Association of Schools of Music – NASM

National Association of Teachers of Singing – NATS

Traditional Corrective Verbal Cues – TCVC

Performed Audio Feedback – PAF

Visual-Audio Feedback – VAF

CHAPTER ONE: INTRODUCTION

Most collegiate vocal music programs require eight semesters of private voice training, which occurs in the private vocal studio on a one-on-one basis between teacher and student. Mid-way through the collegiate program the student will have completed three to four of the eight semesters of private training and will then prepare to audition for formal acceptance as a voice major. A standard of competency is expected in order to pass from one level of voice instruction to the next. It is standard practice for all candidates in a school of music to pass this kind of a performance proficiency exam before being allowed to be an being allowed to be an officially declared voice major (National Association of Schools of Music Handbook, 2013). One of the criteria for passing performance proficiency exams is the ability to sing with pitch accuracy (Gavin, 2012), and this requires the ability to accurately "hear, differentiate, store, and reproduce pitch" (Estis, Dean-Caytor, Moore & Rowell, 2009, p. 173). Declared voice majors who pass performance proficiency exams are considered to sing in tune; however, research shows that even accurate singers on the professional level may occasionally deviate an average of 0.3 – 0.6 semitones, or 30 – 60 cents, from the center of the target pitch (Granot, Israel-Kolatt, Gilboa, & Kolatt, 2013). It is then reasonable to assume that collegiate voice majors, still non-professional, may still struggle with pitch accuracy.

Vocal struggles are addressed in the private studio and are of primary concern for the collegiate vocal professor entrusted with crafting the student's voice (Coffin, 2002). While the experiences of a quality teacher should be valued, more objective analysis is needed in the field to structure best practice for pitch instruction. Due to the one-to-one nature of the vocal training process, the role of instruction in the collegiate private voice studio is one of the most influential forces in undergraduate music education (Frederickson, Geringer & Pope, 2013). Lorrouy-Maestri and Moresomme (2012) state that research-based instruction is the expectation of current educational institutions wishing to compete for talented students and membership status in prestigious accreditation organizations such as National Association of Schools of Music (NASM).

The researcher explored the topic of vocal instruction research concerning pitch accuracy practices in an effort to examine efficacy of three instruction types on pitch accuracy. She examined how various methods of instruction influence the differences in pitch accuracy scores of 59 collegiate female declared voice students ($N = 59$) at a large university in the mid-Atlantic United States. In this blind true-experimental posttest only control group design, the control group ($n = 19$) received Traditional Corrective Verbal Cues (TCVC) only. Two treatment groups received either Performed Audio Feedback (PAF) with TCVC ($n = 20$), or Real-Time Visual Feedback (RTVF) with TCVC ($n = 20$). Data were collected via a demographic survey, and digitized vocal response identified in Hz and semitones using Sing and See software (Sing & See, Cantovation Ltd., Auckland, New Zealand) and converted into cents. The data were analyzed using a one-way analysis of variance (ANOVA). This author considered the background of what has come to be recognized as good singing, scientific approaches to vocal pedagogy, traditional methods, and relevant literature to examine the efficacy of visual-audio feedback and performed audio feedback instruction types, in comparison to traditional vocal instruction as measured by pitch accuracy improvement scores. Additionally, this author assessed the comparability of the three instructional groups in terms of the two factors that have been documented in the music education literature as influencing pitch accuracy, number of semesters of voice taken by the students (Conner, 2012; Collins, 2011; Estis, Dean-Clayot, Moore, & Rowell, 2011) and their menstrual status (Filipa, Sundberg, Howard, Saccuto, & Freitas, 2012; Van Houtte, Claeys, Wuyts, & Van Lierde, 2011).

Background of Topic

Vocal Pedagogy

One of the earliest schools of thought as to what constitutes good singing can be traced back to the Italian Bel Canto (i.e., beautiful singing) tradition of singing in the mid-1800s with the work of Nicola Vaccai, Francesco Lamperti, and Manuel Garcia who studied the voice scientifically and composed intricate vocalises for training in vocal agility and precision (Coffin, 2002). Because of the flexibility and difficult demands placed on the human voice in the repertoire from the Baroque and Classical periods (1600-1820), curiosity within the scientific community developed a desire to explain how such feats were achieved (Lamperti, 1980). During this time, the science of the voice, vocal pedagogy, was a newly budding field due to the invention of the laryngoscope by Garcia in 1854. The development of Gaspard de Prony's acoustic logarithm decimal system in 1830 established the use of 12 semitones in the western music scale as an algebraic representation. Building on de Prony's system, Alexander J. Ellis further quantified intervallic distance in music in terms of *cents* (Ellis & Chappell, 1877). Fundamental frequency (F_0), or the cycles of sound per second, was termed, *hertz* (Hz), named after 19th Century physicist, Heinrich Hertz. It was during the late 1800s that scientists attended concerts with an intent to analyze the performance in terms of the 1860 established acceptance of A_4 as 440 cycles of vibration (Ellis & Chappell, 1877). Before the acceptance of A-440, each composition and performance was based on the tuning fork held by the individual director; therefore, there was inconsistency in terms of which pitches were deemed *accurate*. The tines of the fork vibrated from an at-rest position to correspond with a vibration of sound, meaning that a tuning fork produces a F_0 of 440-Hz (Thurman & Welch, 2000). The ability to quantify sound in the 19th Century attracted curiosity from both the scientific and artistic community and initiated the budding science of acoustic physics due to the availability of an objective assessment of musical sound.

As the study of the human voice provided physical support for healthy singing, vocal limits were also stretched within the boundaries of what early vocal pedagogues such as Vaccai, Garcia, and Lamperti concluded from their vocal research (Bybee & Ford, 2004; Coffin, 2002; Stark, 2008). Virtuoso vocalists were set apart from amateur and choristers according to the level of difficulty of the material assigned by the teacher. Through the centuries, various interpretations have been argued concerning which elements constitute beautiful singing such as the presence of vibrato and clarity of tone (Bybee et al., 2004; Coffin, 2002; Stark, 2008), yet one of the requirements never debated is the consistent presence of accurate pitch.

Through the Baroque Period (1600-1750), student-singers were challenged with material written by composers such as George Frederick Handel and Henry Purcell, whose compositions stretched the human voice in terms of melismatic passages. Masterful teachers carefully guided students through the complex curriculum encountered (Stark, 2008). During the Classical Period (1750-1820), the vocally demanding compositions of Wolfgang Amadeus Mozart challenged the voice with extreme range requirements and intricate vocal patterns. Birthed within the Romantic Period (1820-1900), vocal contributions of Robert Schumann and Franz Schubert were examples of the curriculum of the accomplished vocal student. Until 1900, the presence of vibrato in the voice was demanded by teachers of singing and by the vocal literature of the day. However, the style of the negro-spiritual allowed the vocalist to stray from the typical demands of singing and eventually birthed early American jazz (Johnson, 2009) and ultimately musical theatre (Gurung, Chick, & Haynie, 2009). Each of these genres defied the previous traditions of vibrato, clear tone, and head-voice dominant techniques for the female vocalist. Vocal literature demanded belt voice, mixed voice, breathy tone, and ornaments unique to vocal jazz such as vocal shaking and fall-offs (Duvvuru, 2012). Therefore, the elements of vibrato and breathy tone were considered stylistic choices instead of intrinsic qualities of singing quality. Yet, through centuries of vocally demanding repertoire and diverse styles, pitch accuracy remains a staple as a necessary composite of good singing (Stark, 2008).

In the mid-1800s, music educators encountered many challenges of the scientific approach to vocal pedagogy emerged with Manuel Garcia's (Stark, 2008) invention of the laryngoscope. The instrument was an angled mirror used to view the vocal folds during singing. Aspects of bel canto techniques were both challenged and confirmed by scientific findings due to the ability to observe the larynx during phonation. Vocal educators**,** however, were resistant to trade traditional descriptions of healthy and beautiful singing for scientific terminology (Stark, 2008). Advances in technology allow for a scientific approach to vocal pedagogy and empirical research on teaching strategies in the vocal studio. Since pitch accuracy is an uncontested necessary element of good singing, the instruction given in the vocal studio for future music educators should be of utmost concern for collegiate music programs and music educators (Wilson, Lee, Callahan, & Thorpe, 2008) as the human voice is further explored.

Repertoire from the Baroque through the Romantic period is standard fare for collegiate vocal study, based on the use of Italian and English art songs during early study, followed by German literature, then French, as a means of building the singer's voice to maneuver artfully through challenges presented therein (Collins, 2011; Cowell, 2011). Constructs of bel canto hold that good singing requires a clear tone, even vibrato, and pitch accuracy in effort to produce an overall pleasing tone (Bybee & Ford, 2004; Coffin, 2002; Santo, 2012; Wilson et al., 2008). Vibrato was described by Thurman and Welch (2000) as a rapid and reoccurring fluctuation of sound within a quartertone or less (=/< 25 cents) and is considered to be a "normal and desirable feature of the artistic singing voice" (Stark, 2008, p. 26). Because most of the vocal programs of study, based on Western tonality in the United States and abroad, are traditional and train voice majors classically, vibrato is an integral part of the singing voice that yields a pleasant tone. Although singing with vibrato is a mark of proper performance in the bel canto tradition, vibrato can disguise some pitch inaccuracies that may enable the developing singer to avoid the achievement of a more accurate and consistent pitch (Marmel, Tillman, & Dowling, 2008) as the perceived pitch with vibrato averages the difference of two frequencies (Shipp, Doherty, & Hakes, 1989).

However, in modern schools of thought, there are differences from the bel canto tradition in sound production goals and in what is considered to be the essence of a *pleasing tone*. Commercial music, for example, requires some straight-tone phrases followed with a small amount of vibrato upon phrase end (Collins, 2011). Vocal jazz performance calls for some straight-tone and breathy tone production, which is in conflict with the bel canto tradition (Stark, 2008). Of concern is the role that stylistic demands, such as vibrato and breathy tone, may play in disguising existing vocal pitch inaccuracies (Gurung et al., 2009). Regardless of the voice major's particular preference of vocal style or genre demands, both commercial and classical performers can benefit from improved pitch accuracy navigation upon examination of straight tone singing, since straight tone singing exposes more pitch inaccuracy than production singing with vibrato (Collins, 2011; Garcia, 1984, Estill, 2012; Fraenkel & Wallen, 2006).

Without the development of a truly accurate sense of pitch navigation as a performer, many voice majors may be performing with disguised pitch inaccuracies, in which case the indiscriminant ear may be reinforced (Goller, Otten, & Ward, 2009; Hutchins et al., 2012;

Marmel et al., 2008; Tsang, Friendly, & Trainor, 2011). Pitch accuracy problems covered up with vibrato or breathy tone may further desensitize the aural ability to detect poor pitch in other singers. The result of this can contribute to an inability to detect and correct pitch errors in K-12 and collegiate vocal education upon entry to the profession of music education (Randall, 2012; Rickels, Councill, Fredrickson, Hairston, Porter, Schmidt, & Collins, 2010). Understanding the process of pitch perception and navigation from the student's vantage point is of paramount importance to the vocal educator as efforts are made to achieve accurate pitch perception and production.

Traditional collegiate instructional strategies for teaching pitch precision are supported by a generally agreed upon technique influenced greatly by the bel canto school of thought (Stark, 2008). Concepts of Bel Canto focus on the student's: (a) posture, (b) breathing, and (c) placement of sound. Instruction demands an upright singing posture insistent upon feet being shoulder width apart with the student's weight placed on the ball of the foot, unlocked knees, even hips, expanded rib cage, elongated spine, erect shoulders, relaxed arms and hands, and tension-free jaw and neck (Bybee, 2004; Coffin, 2002). This school of thought considers low diaphragmatic breathing and a raised soft palate essential to the basics of proper phonation and, specifically, accurate pitch. Apart from agreement upon the bel canto research-based technique, there lies conjecture and lack of research concerning best practices for teaching the most foundational of the elements of beautiful singing, that is, pitch precision.

Upper level collegiate voice instruction is taught with the assumption that the declared voice major sings with accurate pitch, since most programs do not consider the voice major to be *declared* until a proficiency hearing in vocal technique is successfully demonstrated, usually during the sophomore year (NASM Handbook, 2013), or after the third semester of voice training. As the voice major enters the vocal studio for the weekly private voice lesson, the master-apprentice model is engaged as the teacher expects the student to follow instructions in an effort to achieve a more pleasing, beautiful singing voice. The course of collegiate vocal instruction is expected to produce foundational to advanced concepts of correct posture, breathing, soft palate position, and placement, according to previous and current research (Estis, Dean-Claytor, Moore, & Rowell, 2009). When collectively employed, these concepts should produce a pleasing tone, which has been collectively held by centuries of professionals, as characterized the presence of: (a) a clear tone, (b) a natural vibrato, and most importantly, (c) pitch accuracy. Yet the literature shows that pitch inaccuracy is a widespread problem (Larrouy-Maestri et al., 2012; Pfordresher, Brown, Meier, Belyk, & Lotti, 2010).

The association of effective instruction to demonstrated learning outcomes places a focus on the strategies employed within the teaching and learning process, whether in the lecture hall or in the private studio. The skill of singing requires constant multi-tasking for production while simultaneously self-monitoring real-time production of sound. Traditional instruction methods concerning pitch precision are of particular interest since, in addition to the student singer's multi-tasking production, new information is introduced simultaneously via traditional corrective verbal cues (TCVC), which raised concerns about the overloaded working memory.

Due to the population of interest and the examination of three instruction types in the intervention, in this current study, the author uniquely extends the current literature due to the rarity of researched-based quantitative studies on pitch instruction method efficacy in the collegiate private vocal studio. Siegler's (1988) Information Processing Theory (IPT) points to the following four steps of processing new information: (a) perception, (b) encoding, (c) representation, (d) storage, and (e) retrieval (Aldalalah, 2010). Earlier researchers indicated a dependence on the working memory during the pitch retrieval process (Pechmann & Mohr, 1992); therefore, based upon the construct that the last stage (e.g., retrieval) is made more efficient by a lightened working-memory, perhaps it is possible that all stages of IPT can benefit from a lightened working-memory in regard to pitch perception, encoding, representation, storage, and retrieval.

Of interest to the music education community, this researcher examined traditional methods of pitch instruction, TCVC, and it's link to Sweller's (1970) Cognitive Load Theory (CLT). In this theory, it is held that if the working memory is lessened in pursuit of a task, deeper learning can occur. As applied to the current study, CLT supports lightened mental demand during the pitch perception and encoding stages, and efficient storage stages, so that retrieval may be facilitated (Aldalalah, 2010; Ayers & Paas, 2012; Paas et al., 2010; Sweller & Chandler, 1991).

Rooted in social cognitivism, the theory was developed by John Sweller (1970) and original from the solved-problem approach to learning with lessened mental load. By definition, CLT is "an instructional theory which enables the use of knowledge and human cognitive architecture to assist in the design of instruction" (Owens & Sweller, 2008, p. 40). While CLT has been applied to music learning in terms of music theory (Aldalalah, 2010), no studies were found in which this theory is linked to efficacy of pitch instruction in the private voice studio. It is anticipated that the findings from this study will inform voice educators and curriculum planners as to the efficacy of current methods and possibilities of innovative instructional strategies to accompany time proven techniques for collegiate voice pitch instruction. Through experimentation, which utilized TCVC with and without integrated visual and auditory sources, the current applications of CLT in regard to pitch instruction investigated the role of working-memory for pitch accuracy. Therefore, predominantly, the study was grounded in Sweller's (1970) Cognitive Load Theory, and also tied to Siegler's (1998) Information Processing Theory.

Problem Statement

The current instructional methods used in training the future music educator may not effectively address pitch issues (Lorrouy-Maestri, Leveque, Schon, Giovanni, & Moresome, 2013). The undergraduate's ability to navigate excellent pitch is considered foundational by experts in the field (Marmel et al., 2008; Stark, 2008). Collegiate music programs, which are concerned with academic reputation and membership of quality professional accreditation bodies, such as NASM, must produce quality future music educators, who understand pitch navigation (NASM Accreditation Handbook, 2013). Currently, females constitute approximately 73.2% of elementary and secondary vocal music educators in the U.S., and 80% of all music educators (National Center for Educational Statistics, 2012) are female; therefore, the focus of this study is on the female population currently enrolled as declared voice majors.

Traditionally, instructional strategies, which target pitch accuracy in vocal pedagogy, are reliant upon the singer's ability to perceive and produce center pitch, as demonstrated in several recent studies (Goller et al., 2009; Hutchins et al., 2012; Marmel et al., 2008; Tsang et al., 2011). Traditional methods in vocal pedagogy are based on these assumptions and include: (a) teacher-student modeling, (b) imitation, and (c) verbal corrective cues (Brown et al., 1999; Callaghan, 2000; Reifinger, 2013; Thorpe et al., 1999; Wilson et al., 2008; Wilson et al., 2007; Wilson et al., 2005).

Based on other studies, in which the researchers investigated CLT and the benefits of reduced working memory load (Aldalalah, 2010; Ayers & Paas, 2012; Paas, et al., 2010; Sweller & Chandler, 1991), the problem is informed by CLT as the demand for multi-tasking during singing may be more efficiently met if the cognitive load on the working memory is reduced by an integration of sources of information into one event or source. Pitch perception involves processing pitch and simultaneously assessing its accuracy as it is produced. Specifically applied to pitch instruction, CLT supports deeper learning by the singer visually seeing the sung attempt in real-time, hearing playback (Callaghan & Van Doorn, 1999; Macpherson, & Ward, 2011; Nix & Matthews-Mutwell, 2012; Wilson et al., 2008; Reifinger, 2013; Thorpe et a., 1999; Wilson et al., 2008; Wilson et al., 2007), or a combination of visual-audio feedback, as opposed to the traditional vocal cue method. The TCVC type is of particular interest, as in addition to the multi-tasking required for singing, new information is introduced simultaneously via verbal cues, drawing inquiry to the overloaded working memory.

Purpose Statement

The purpose of this quantitative true experimental, post-test only control group study was to test the applicability of the CLT (Sweller, 1970) and to compare the effect of instruction type on pitch precision according to pitch improvement scores of 59 female collegiate voice students ($N = 59$) at a large private university in the Mid-Atlantic United States. The independent variable, instruction type, is generally defined as the type of feedback offered to the participant in an effort to achieve center pitch of the stimuli.

The three types of instruction considered in this study were: (a) Performed Auditory Feedback (PAF) with Traditional Corrective Verbal Cues (TCVC), (b) Real-TimeVisual Feedback (RTVF) with TCVC, and (c) TCVC only. The TCVC treatment included a series of two live correctional verbal cues to either Sing higher or Sing lower. Performed Audio Feedback treatment included TCVC followed by a sequence of recorded audio playback including: (a) target pitch, (b) the participant's initial attempt to sing as closely to the target pitch as possible, and (c) the post intervention repeated target pitch. Visual-Audio Feedback consists of TCVC followed by a sequence of visual and auditory playbacks including: (a) a visual template accompanied by the audio sample of the target pitch, (b) the visual display combined with performed audio feedback of the participant's initial attempt to sing as closely to the target pitch as possible, and (c) the post intervention repeated visual template accompanied by the audio sample of the target pitch. The dependent variable was the pitch accuracy improvement score as measured by the accuracy gains toward center pitch from the participant's first attempt to the second attempt post intervention as measured in units of cents deviated from target center.

Although the participants were assigned at random to the three type of instruction and some researchers say that group equivalence can be assumed (Campbell & Stanley, 1963), it is worthwhile to assess the comparability of the three groups in terms of the two factors that have been documented in the music education literature as influencing pitch accuracy. These variables served as dependent variables and were number of semesters of voice taken by the students (Conner, 2012; Collins, 2011; Estis, Dean-Clayot, Moore, & Rowell, 2011) and their menstrual status (Filipa, Sundberg, Howard, Saccuto, & Freitas, 2012; Van Houtte, Claeys, Wuyts, & Van Lierde, 2011).

Significance of the Study

In search of new methods to improve student learning, the significance of this research study lies in the examination of how integrated information sources lessens the demand on the working memory, thereby allowing for efficient, deep learning and independent pitch navigation. The population studied had not previously been the focus in experimental research on pitch accuracy according to instruction type in the collegiate private voice studio. Further, at the time of this study, no studies were found that challenged the efficacy of Traditional Corrective Verbal

Cues, Performed Audio Feedback, and Real-time Visual Feedback instruction types. Thus, findings that suggest efficacy of instruction type may be of significant value to music educators and collegiate music education programs because of the demand for research-based voice instruction.

Cognitive Load Theory (Sweller, 1970), as applied to the current study, suggests that as working memory is lightened and deeper learning occurs, the student is ultimately benefitted with improved pitch navigation, resulting in a more pleasant voice. Further, the student who truly learns to navigate toward pitch precision will develop a heightened sense of pitch discrepancy, which will enable the student to provide critical pitch guidance to his or her future students. Perhaps, more significantly, value lies in the exploration of not only how the singer perceives pitch, but in how the student learns most efficiently to navigate toward perceived pitch. The findings from this current study should add to the empirical body of knowledge about voice education in terms of the efficacy of instruction methods in the collegiate voice studio, as well as K-12 musical instruction.

In summation, the findings from this study:

1. should be significant to collegiate vocal music education programs, as the studied population constitutes 80% of the music education teaching force (NCES, 2012);
2. should contribute to the existing body of literature in vocal pedagogy and music education instruction as efforts are made to examine changes in pitch precision based on the instruction type received within a population that has not been previously examined in this type of research; and
3. could be used to inform more effective instructional practices within the vocal studio and other educational settings with the inclusion of the visual-auditory

integrated sources.

Research Questions

The purpose of this study was to understand the impact of instruction type (e.g., PAF with TCVC, RTVF with TCVC) on pitch accuracy among declared voice majors in comparison to TCVC in order to answer the following research questions:

RQ1: Is there a difference in pitch accuracy, as measured by pitch improvement scores, of collegiate female voice majors who receive either traditional corrective verbal cues, performed audio feedback, or real-time visual feedback?

Prior to examining the primary research question for this study, two additional questions were examined to determine if it was necessary to consider covariates as part of the primary analysis:

RQ2: Is there a difference in number of semesters of voice taken by the collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback)?

RQ3: Is there a difference in the proportion of menstruating collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback)?

Hypothesis

H_1: There will be a difference in pitch accuracy, as measured by pitch improvement scores in female vocal students who receive either traditional corrective verbal cues, performed audio feedback, or real-time visual feedback.

H_2: There will be a difference in number of semesters of voice taken by the collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback).

H_3 There will be a difference in the proportion of menstruating collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback).

H_{o1}: There will be no difference in pitch accuracy, as measured by pitch improvement scores in female vocal students who receive either traditional corrective verbal cues, performed audio feedback, and real-time visual feedback.

H_{o2}: There will be no difference in number of semesters of voice taken by the collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback).

H_{o3}: There will be no difference in the proportion of menstruating collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback).

Identification of Variables

The independent variable in this study was the type of instruction received, with three levels: (a) traditional corrective verbal cues (TCVC), (b) real-time visual feedback (RTVF) with TCVC, or (c) performed audio feedback (PAF) with TCVC. The dependent variable is pitch improvement scores, which would indicate gains toward the target frequency between the participant's initial attempt and the second attempt post-intervention. Pitch improvement scores indicate the proximity of the phonated sound to the intended frequency center (F0). Pitch discrepancies too abstract for practical measurement by human ear alone**,** a voice analysis device is used to operationally define the cent as the distance between the participant's first and second attempts toward the target, as influenced by the intervention. The number of semesters of voice taken by the students and their menstrual status were also considered. They were measured with the following self-report questions: "How many semesters of voice have you taken?" (Answer: number), and "Is menstruation present today?" (Answer: YES/ NO).

Definitions

Bel Canto: the traditional school of thought concerning voice training and widely accepted in conservatories and schools of music throughout the world (Stark, 2008) upon which traditional methods of singing are based.

Breathiness: a vocal quality produced when audible air is presented in tandem with the phonation of the sung tone (Hutchins & Peretz, 2013).

Cent: a logarithmic unit of measurement for musical intervals, specifically a ratio between two frequencies**,** wherein 1 cent represents 1/100 of a tone (Wilson et al., 2008.)

Collegiate voice training: one-on-one instruction received by the voice major while studying on a consistent basis, usually weekly (NASM Handbook, 2013), as an intended voice major.

Fall off: the descending of a defined pitch to another defined pitch (Clayton, 2001).

Frequency: A numeric identification and description of sound measured in Herz (Hz**;** Thurman & Welch, 2000).

Hertz (Hz): the measurement of vibration cycles of sound per second. 1Hz = 1 cycle per second (Thurman & Welch, 2000).

Long-Term Memory (LTM): "the central structure for human cognition, containing large amounts of knowledge that can be described as hierarchically organized schemas" (Paas et al., 2010, p. 116).

Performed auditory feedback (PAF): an intervention consisting of audio-recording of the participant's first attempt to match the target pitch (Boyd, 2012; Norris, 2013; Santo, 2012 Willis & Kenny, 2011).

Pitch accuracy: the ability to perceive and produce a sustained sung pitch to match a given pitch (Anderson, Himonides, Wise, & Pfordresher, 2010; Welch & Stewart, 2012; Wilson et al., 2008; Zarate, 2009).

Pitch precision: consistently singing a repeated in-tune pitch, but not necessarily the intended pitch (Pfordresher et al., 2010).

Proficiency hearing: an examination of vocal ability in which each student is evaluated on his or her performance in terms of pitch accuracy, clear tone, and expressiveness (NASM Handbook, 2013).

Ratio $f2/f1$: The division of one frequency by another in an effort to achieve the interval in **c**ents (Thurman & Welch, 2000).

Semitone: 1/12 of an octave (Thurman & Welch, 2000).

Sing and See: software that visually displays**,** audibly replays**,** and records sound (Hoppe, Sadakata, & Desain, 2006; Wilson et al., 2008).

Straight-tone singing: the absence of movement, or vibrato, in the produced vocal line of a steady sustained pitch (Marmel et al., 2008; Nix & Matthews-Muttwill, 2012; Wilson et al., 2008; Zarate, 2009).

Target pitch/Target Hz: the pitch selected that is set forth as the focus of production for the purpose of matching the pitch (Hsieh & Saberi, 2008; Willis & Kenny, 2011).

Real-Time Visual feedback (RTVF): the audio-recording of the participant's first attempt to match the target pitch and the visual template of the target accompanied by the visual pitch of the first attempt (Eldridge et al., 2010; Goller et al., 2009; Granot et al., 2013; Hutchins & Peretz, 2013).

Vocal shake: a trill between an established pitch and the minor third above (Clayton, 2001).

Working Memory (WM): the mind's limited capacity workspace that initially receives new information (Morrison & Chein, 2010).

Chapter Summary

As it is standard practice for all candidates in a school of music to pass three juried performances and a performance proficiency exam before being allowed to be an officially declared voice major (National Association of Schools of Music Handbook, 2013), examination of the learner's pitch accuracy is crucial (Gavin, 2012). Even though declared voice majors**,** who pass performance proficiency exams**,** are considered to sing in tune, there may still be pitch accuracy problems that are disguised by the use of vibrato (Marmel et al., 1989).

Granot et al (2013) found that even accurate singers on the professional level can occasionally deviate an average of 0.3 – 0.6 semitones, or 30 – 60 cents, from the center of the pitch. It is then reasonable to assume that collegiate voice majors, still non-professional, may still struggle with pitch accuracy. This author considered the background of what has come to be recognized as good singing, scientific approaches to vocal pedagogy, traditional methods, and relevant literature, to examine the efficacy of visual-audio feedback and performed audio feedback instruction types, in comparison to traditional vocal instruction as measured by pitch accuracy improvement scores.

CHAPTER TWO: REVIEW OF THE LITERATURE

This chapter reviews literature relevant to pitch instruction efficacy in voice training. Four sections are present in the literature review. The first section reviews literature pertaining to the theoretical framework that underpins the study. Specifically, Sweller's (1970) Cognitive Load Theory (CLT) is discussed and related to the efficacy of current teaching methods, as well as innovative teaching concepts that could result in improved pitch accuracy. This section also discusses Siegler's (1998) Information Processing Theory (IPT) as a secondary theory. The second section presents a review of the literature focused on pitch imprecision as a problem; specifically with regard to the collegiate female voice major. The third section discusses recent literature pertaining to the three pitch instruction methods: Traditional Corrective Verbal Cues (TCVC), Performed Audio Feedback (PAF), and Real-Time Visual Feedback (RTVF). The fourth section concludes this chapter, and summarizes current knowledge on instruction efficacy and pitch accuracy, discusses what knowledge is unknown, and identifies the gap in the literature; presenting a model that demonstrates a relationship between instruction types received and pitch accuracy.

Theoretical Framework

Cognitive Load Theory

According to instructional specialist and researcher, Ruiji (2012)**,** "learning is the basis for teaching, the rationality and validity of the teaching can be guaranteed only when the student's cognition law is understood" (p. 58). It would seem, then, that all instructional choices should take the learner's cognitive load capacity and limitations into account, and should be guided by principles of educational psychology. According to Leahy and Sweller (2011)**,** Cognitive Load Theory is "an instructional theory based on knowledge of human cognitive architecture” (p. 943). Grounded in Sweller’s (1970) Cognitive Load Theory (CLT), this study considers the cognitive load of the student while receiving TCVC while multi-tasking in the skill of singing. Specifically, the study will examine the process between working memory and long-term memory when the instructional design simplified in pitch instruction.

The theory holds that as new information is processed, it is moved from the working memory to long-term memory and stored. Sweller’s (1970) CLT provides theoretical support for the simplification of instruction as a means of navigation from one point to the next as the working memory load is lightened. According to Aldalalah (2010) if the center of the target pitch is not imagined, or internally heard by the singer, pitch inaccuracy occurs. Based on the CLT, if the working memory that initially receives the target pitch is lightened by the elimination of extraneous instruction processes, split attention should be reduced, allowing new information to be integrated into one focus point (Ayers & Paas, 2012).

Split attention occurs when the different sources of information are not integrated. As applied to singing instruction, the cognitive load of the student is fully engaged in the process of singing; therefore, verbal cues (TCVC) interjected which require the student to translate the meaning, or encode, while singing attributes to split attention. Upon visually seeing the pitch that was otherwise left to the imagination, the singer receives instruction from once source as the audio and visual feedback are integrated as opposed to TCVC, which give audible cues as to which direction to steer the voice. As real-time visual feedback is utilized in the vocal studio by such software as Sing and See, schema acquisition can be facilitated, allowing the student to build new information on processed and stored information. As the student watches the voice on the screen, however, she is also hearing herself as she sings, thus integrating the visual and audio sources into one experience (see Figure 1).

In an effort to guide the student toward development of navigation skills, instruction must go beyond landing the student at the right destination. Instruction must teach the student how to navigate precision independent of TCVC. Since singing is a complex neuro-motor multi-tasking process requiring engagement of correct posture, breathing, laryngeal muscle control, and raised soft pallet; while simultaneously expressing the meaning of the lyrics and delivering genre-specific vocal style, instruction given as the student is fully engaged in multi-tasking (Paas et al., 2010) may overload the student's cognitive capacity. The literature (Aldalalah, 2010; Ayers & Paas, 2012; Paas et al, 2010;) indicates that instruction void of extraneous information yields the best return in demonstrated learning outcomes; therefore, instruction concerning pitch precision should be most fruitful when the learner's mind is not overly taxed while juggling performance concepts.

According to Ayers and Paas (2012), split attention is reduced as visual patterns support learning. It seems reasonable that visual sources of information should guide the learner toward the center pitch. In other words, the use of visualization could simplify the information needed in the perception and encoding phases of information processing. Efforts to simplify instruction for pitch precision should enable to learner to navigate to the target pitch by lightening mental load required to receive initial information, allowing the working memory to solidify new information and then by deep practice, the ideas become second nature to the performer.

Researchers Ayers and Paas (2012) and Sweller, Ayers and Kalyua, (2011) have identified factors that undermine instructional effectiveness and have confirmed that when instruction is not simplified, an undue complication is weighted on the working memory (Ayers & Paas, 2013). The inhibition of learning occurs because "learners have to hold previously presented information in working memory while integrating it with other information which is presented later" (Ayers & Paas, 2013, p. 828). In this regard, the information processes stages are paused while meaning of the new information is being made. The theory supports the current study's focus on maximizing a learning experience by minimizing unnecessary storing of information as "wasted effort" (Ayers & Paas, 2013, 828).

Rooted in social cognitivism, the theory was fathered by John Sweller (1970) birthed out of the solved-problem approach to learning with lessened mental load. By definition, CLT is "an instructional theory which enables the use of knowledge and human cognitive architecture to assist in the design of instruction" (Owens & Sweller, 2008, p. 40). While CLT has been applied to music learning in terms of music theory (Aldalalah, 2010), no studies were found linking CLT to efficacy of instruction in the collegiate private voice studio. Centered in instructional design (Sweller & Chandler, 1991), CLT as applied to studio voice pitch instruction calls for a simplification of presented information on pitch perception and considers the rigor of the mind during the studio lesson. Before scaffolding of concepts can take place in order for the student to independently navigate toward center pitch, many tasks must be dedicated to long-term memory. These tasks include correct posture, breathing, pure vowel formation, and even vibrato (Stark, 2008).

The hypothesis that pitch accuracy scores will differ in the intervention group receiving RTVF and PAF with TCVC from the TCVC treatment group alone is based on the integrated nature of the visual-audio intervention. The study is advanced by CLT as the expected reduction in split-attention effects should allow the working memory to be lightened because the pitch no longer has to be imagined; it is simultaneously visualized and internally monitored as the student sings. The internal monitoring becomes the guiding force that follows the path to the visualized target, teaching the student true, independent pitch navigation skills instead of a means-end strategy. CLT advances the current study, as CLT is an instructional theory, and the current study examines the effects of pitch accuracy scores based on instruction type. The theory considers instruction futile that demand the learner "holds in working memory information from one source, while searching for associated referents from another source" (Owens & Sweller, 2008). Thus, the current study spatially integrates the visual and auditory sources into a single focus, as opposed to the split-attention possibly caused by TCVC, because according to findings in CLT research by several early CLT studies (Low & Sweller, 2005; Moreno & Mayer, 1999; Mousavi, Low & Sweller, 1995; Sweller & Sweller, 2006; Sweller, Van Merrienboer, & Paas, 1998; Tindall-Ford, Chandler, & Sweller, 1997; Todd & Mishra, 2012) integrated instruction lead the processing toward direct, simplified instruction and away from extraneous load.

The current study relates to the theory in terms of design, as the instructions for the actual true-experimental study are thoughtfully designed to facilitate a lightened working memory load for participants. Further, research in the current study relates to CLT as it is focused on the exploration of results stemming from unnecessary cognitive demands of the student singer. For example, the stimuli, or target pitch, is selected for the current study based on research, which shows that the tonic of the scale (DO) is the most stable and easily accessed (Stalinski & Schellenburg, 2010).

Although CLT has not been applied specifically to pitch instruction in research involving female declared voice majors, the theory may be expanded due to the expected instructional efficacy findings. The current study seeks to investigate pitch accuracy score differences according to instruction type, with the intervention instruction type being based on CLT, specifically in the intervention's effect on the split-attention effect. A study by Roodenrys, Agostinho, Roodenrys, and Chandler (2012) examined learning environments concerning the split-attention format of multiple and separate sources of information. Roodenrys et al (2012) study compared learning outcomes from a topic in Educational Psychology in which two groups received split-attention materials, and one group received the same material in an integrated format. Deeper learning in terms of transferring newly earned information to other tasks occurred in the integrated format group, suggesting that the integrated information format lightened the working memory effort in processing new information (Roodenrys et al., 2012). Split-attention effect is addressed in the theory's application to the current study, since the intervention is an integration of the visual and aural sources. Specifically, the intervention is the use real-time visual feedback in tandem with internal auditory monitoring on one screen (Sing and See Software) viewed as the student is singing. The focus is completely on singing toward, or navigating the voice to the target pitch center, which is also displayed on the screen.

CLT promotes acquired schema instead of means-end endeavors (Sweller & Chandler, 1991). Thus, the theory may be advanced by the current study because the focus of said study is centered on pitch instruction methods as an effort to teach true navigation to pitch center. This instructional focus differs from traditional instruction, which terminates TCVC once the student has reached an acceptable level of pitch accuracy in repertoire. That is to say, whether the student sings the right note by chance or by strategy, the schema is ignored in TCVC, as there is no pause in the lesson to allow the student to focus only on the pitch inaccuracy by filling the working memory with only pitch perception and production.

Even though neuroscience-focused studies (Bidelman et al., 2011; Boyd, 2012; Callaghan, Thorpe, & Van Doorn, 2004; Connell, Zhenguang, & Holler, 2013; Oxenham, 2012; Zarate, 2009; Zarate et al., 2010) support the multi-tasking demand of singing, it is unknown how Cognitive Load Theory, as applied to pitch instruction effects the lightened working memory (Moreno, Low, & Sweller, 1995; Mousavi, Low & Sweller, 1996; Owens & Sweller, 2008; Paas, Van Gog & Sweller, 2010; Sweller, 2010, Sweller & Chandler, 1991; Sweller, Merrienboer & Paas, 1998; Sweller & Sweller, 2006; Tindall-Ford et al., 1997).

Findings from a study by Tindall-Ford et al., (1997) suggest that dual-mode instruction that integrates the visual and audio sources into one format reduces the burden on the working memory that receives the initial information. Studies (Moreno et al., 1995; Mousavi et al., 1996; Owens & Sweller, 2008; Paas et al., 2010; Sweller, 2010, Sweller & Chandler, 1991; Sweller et al., 1998; Sweller & Sweller, 2006; Tindall-Ford et al., 1997) have shown that split-attention effects are reduced when learners can focus on one source of information. Even though is well established that singing is a multi-tasking skill, it is unknown how simplification of element interactivity will affect pitch precision. It is possible that the interactions of elements overcrowd the working memory, and the concepts that must be fully understood drain the working memory, and therefore, pitch is not tended to as needed in the voice studio.

Tindall-Ford et al., (1997) examined learning outcomes of 30 electrician apprentices as measured by test scores and through completion of the practical task. All participants (N = 30) had at least high school education and were enrolled in trade-courses at technical college, and had participated in an apprenticeship. Participants were asked first, to identify which kind of testing various appliances should receive based on new instruction received, and second, to apply knowledge gained from new instruction to a practical task by physically conducting the test. This is important to the current study because common prior knowledge was noted as a guiding factor in the decisions made concerning the new information received. Participants were divided into three groups divided by the following instruction type: visual with a diagram only (n = 10), text explaining step-by-step directions (n = 10), and audio-visual format (n = 10). A 3 X 2 ANOVA showed no significant differences in the test scores on the written test of the three groups. There was however, a significant difference in the performance of the practical application of the knowledge between the groups. There was a significant main effect by group, demonstrating that the audio-visual group performed better on the practical task than the visual only group. Similar to the current study, Tindall-Ford et al., (1997) study tested groups that have similar subject-specific background knowledge, and considered the multi-tasking involved with making decisions concerning a practical task. Findings were consistent with a cognitive load framework, but while it is known that integration of information source formats yield deeper learning toward applied tasks, it is not known how this approach applies to musical instruction concerning pitch precision.

An interesting study by Leahy and Sweller (2011) explored the modality effect that occurs when integrated audio and visual instructions are more effective than visual instructions alone (Leahy & Sweller, 2011). In the study, two groups of twelve primary students ($N = 24$) were given instructions concerning how to read a temperature graph. One group received visual only instructions, and the other received integrated audio/visual instructions. Many studies have confirmed the superiority of an integrated format (Leahy, Chandler, & Sweller, 2003; Mousavi, Low, & Sweller, 1995; Tindall-Ford, Chandler & Sweller, 1997).

Leahy and Sweller (2011) based their hypothesized transient information effect on the belief that "if working memory can be divided into auditory and visual components, available capacity to deal with information may be increased by using both processors rather than a single processor" (Leahy & Sweller, 2011, p. 944). Participants were presented with auditory instructions in long phrases, when another group was given the same instructions, but in segments. Pertinent to the current study, the findings that spoken text, which is transitory, must be retained in the working memory. Likewise, it seems logical to associate Traditional Corrective Verbal Cues to the same kind of burden on the working memory. The dependent variable was the test scores based on correctly answered questions. Analysis with a 2 X 2 ANOVA showed a significant difference in test scores between the audio/ visual groups, and the visual only groups for audio visual groups, thus confirming the modality effect. The researchers state cognitive architecture suggest “making use of separate auditory and visual channels” (Leahy & Sweller, 2011, p. 949).

Of particular interest to the current study is the finding that complex statements do, indeed, overload the working memory and may actually not only slow learning, but rather prove to be counterproductive (Leahy & Sweller, 2011). As applied to pitch accuracy, these findings call into question the instructional techniques that upon receiving Traditional Corrective Verbal Cues, causing the learner to pause the process of singing, perceive what is being said through verbal cues, encode the verbal information, and then follow through the rest of the stages of information processing before applying the instruction to the problem of pitch correction.

Research by Wong, Leahy, Marcus, and Sweller (2012) has identified segmentation as a successful strategy in elimination cognitive overload for new information (Wong et al., 2012). The study found the working memory is lightened when large amounts of text are broken down into smaller sections. As applied to the current study, Wong et al’s (2012) findings may suggest that real-time visual tracking of pitch as it is being produced may actually inform the learner in a second-by-second navigation as the target pitch is approached.

Information Processing Theory

According to Sigler's (1998) Information Processing Theory (IPT) the first phase of information processing (e.g. perception) occurs as an initial information event. As applied to the current study, a target pitch is heard by the learner in the perception phase. IPT holds that during second phase, encoding, the event receives attention such as the listener focusing on the target pitch. The second phase (attention) continues into the third phase (memory) if, and only if, encoding occurs between the two phases. Without the encoding of the new information, the information is not learned, or is considered to be lost. With encoding, or making meaning of the information, memory continues into the fourth phase of thinking and ultimately to the final phase, response. As applied to the current study, the researcher seeks to inquire the simplest route to encoding the initial pitch information in an effort to maximize learning so that the process can be duplicated independently by the learner for future pitch matching, thus, achieving automaticity (Siegler, 2004). It is in the "making meaning" of the target pitch that a more direct path may be taken to propel the learner into the next phase of processing, thus, freeing up the working memory and solidifying the new information.

Pitch Imprecision as a Problem

The current instructional methods used in training the future music educator may not effectively address pitch issues (Lorrouy-Maestri, Leveque, Schon, Giovanni, & Moresome, 2013). The undergraduate's ability to navigate excellent pitch is considered foundational by experts in the field (Marmel et al., 2008; Stark, 2008). Collegiate music programs**,** which are concerned with academic reputation and membership of quality professional accreditation bodies**,** such as NASM**,** must produce quality future music educators, who understand pitch navigation (NASM Accreditation Handbook, 2013).

Although not abundant, a small body of current literature concerning singing pitch accuracy focuses on several groups, namely non-musicians and musicians (Devaney, 2011; Estis et al., 2009; Granot et al., 2013; Eldridge et al., 2010; Nix & Matthews-Mutwill, 2012; Pforderesher et al., 2010; Wilson et al., 2008), children (Hedden, 2012; Hopkins, 2009; Hutchins & Norris, 2013; Moorehouse, 2012; Roquet, & Peretz, 2012; Reifinger, 2012; Reifinger, 2013;), and non-singers with amusia (Hutchins & Peretz, 2013). No research focusing on pitch precision instruction and the female declared voice major was found at the time of this study.

Several studies and voice experts (Estis et al., 2009; Larrouy-Maestri et al., 2012; Pfordresher et al., 2010;) indicate pitch accuracy as paramount to any other quality necessary to deem a voice as "pleasing"; therefore, the ability to sing with precision is of optimal concern in the collegiate vocal studio. A foundational aspect of the building of a technically solid and pleasing singing voice, pitch accuracy may be considered to indicate different levels of precision.

In a study by Pfordresher et al., (2010), the problem of poor-pitch singing is shown to be a widespread issue among both occasional singers and non-singers due to poor pitch perception and production, which have gone undetected due to popular use of autocorrelation tools that correct the singing pitch by extracting the target pitch (F0) from recordings. According Pfordresdher et al's (2010) study, empirical analysis of pitch samples showed poor-pitch (inability to reach the target within one semitone) to be present in 10% to 20% of the population studied. Pfordresher et al's (2010) study focused on the measurement distinction between pitch accuracy and pitch precision, where accuracy refers to "the proximity of an estimate to the target population parameter…the average difference between the pitch one sings and the actual target pitch" (Pfordresher et al, 2010, p. 2182), while precision is defined as "the standard error of estimation…relating to the consistency of the pitch one sings on repeated occasions, irrespective of whether any sung pitch meets its target" (Pfordresher et al, 2010, p. 2183). This study concurs with other studies (Aldalah, 2010; Bidelman, Gandour, & Krishrab, 2011; Oxenham, 2012; Reifinger, 2013; Tomasi, Change, Caparelli & Ernst, 2008) that pitch imprecision occurs as a result of a disconnection between the singer's perception of F0 and the production of F0; therefore, attributing difficulties to a sensorimotor issue. From this approach, Pfordresher et al's (2010) study focused on the roles of imitation of unfamiliar song samples, and recall of familiar songs samples within the singer's skill set. Participants ($N = 45$) ranged in age from 17 to 31, and were self-identified as non-musicians, but occasional singers. Participants were asked to sing familiar tunes by either imitating a sample played, or from recalling the melody from prior learning. Results show that imprecision was present in 56% for correct notes, and 60% for correct intervals among participants, with the difference being attributed to the in the use of imitation and recall tasks; thus, motor control cannot be identified as the sole contributor to pitch inaccuracy as in Adalalah's (2010) previous study.

Findings in Pfordresher et al's (2010) study implicate a discrepancy within the music education community concerning differentiation between pitch precision and pitch accuracy, and implicates sensorimotor translation and the interplay between perception (imitating) and action (recall) as deficiencies related to musical structure in short and long-term memory. Findings also indicate that singers may be inaccurate in production of repeated pitches, but precise in that the repeated pitches are in the tonal center. Findings also indicate that singers may be accurate, singing closely to the center, but imprecise as the voice strays from center, returns, and strays again. These findings are significant to vocal instruction because imprecision indicates a problem in production, while inaccuracy implicates a problem in perception.

Larrouy-Maestri et al's. (2012) study considered the validation of pitch accuracy measures in terms of pitch interval deviation and tonal center deviation. Using a sample *(N* = 77) of occasional singers (*n* = 63) as singers without a given technique and trained singers (*n* = 14), the studied concluded that the vibrato present in the trained, or operatic style singing samples of the trained singers rendered the semi-automatic analytical measurements unreliable, as the pitch was varied greatly in the production of vibrato. Since classical technique, or the bel canto method, taught in collegiate traditional vocal programs insists on the presence of vibrato as a necessary component of vocal beauty, within the vocal studio it is possible that the human ear of the instructor may not be able to discriminate pitch imprecision due to presence of vibrato, just as the semi-analytical technology was unable to do in Larrouy-Maestri and Morsomme's (2012) study. Therefore, the use of the cent is valuable in this research, as this unit of measurement indicates distance and direction of pitch precision.

Since the birth of acoustical analysis in the late 19th Century, largely due to the invention of the laryngoscope by Manuel Garcia (1854) and the establishment of A-440 by acoustic scientists, vocal pedagogy has been considered to be a highly respected science by voice instructors, laryngologists, and scientists. Ongoing exploration of the singing mechanism continues with new technologies that enable the researcher and music educator to gain a deeper understanding of neural processes involved in the skill of singing. As functional imaging both confirms and challenges previous pedagogical findings, research in neuroscience has entered the discussion of what once was completely subjective: the accuracy of sung pitch. A study by Wilson, Abbott, Lusher, Gentle, and Jackson (2010) investigated the utilization of brain systems when singing in an effort to understand the neural networks involved with accurate singing. Through neuroimaging, Wilson et al. (2010) compared presence of cortical activity associated with the skill of singing. Research showed that trained singers used the right front lobe less than untrained singers, indicating the influence of neuroplasticity on pitch accuracy due to training (Wilson et al., 2010). Participants who were untrained showed a greater involvement of the bilateral frontal cortex, indicating the reception of new information.

In similar studies (Estis et al., 2009; Larrouy-Maestri et al, 2012; Pfhordresher et al, 2010; Wood, & Zatorre, 2010; Zarate, et al, 2010) the cent has been used to measure pitch distance from the center frequency (F0). The cent is calculated by dividing a known frequency (Hz) into another known frequency. Frequencies are labeled by numbers according to how many vibration cycles occur per second.

If the pitch is produced exactly in the center of the target, the standard deviation is “0”, meaning that the attempt was neither sharp (above the center), nor flat (below the center). The greater the distance from zero the pitch is measured, the farther away it is from the tonal center of “0”. From one tone to the nearest half step (semi-tone) 100 cents, or increments of pitch possibilities are present.

Research (Granot at al., 2013) indicates that professional singers deviate 30 – 60 cents, yet a gap in the literature remains since no research has been conducted focusing on the voice major in terms of standard deviation from the center pitch based on instruction type, and further, no research has focused specifically on the female declared voice major, a critical population that warrants research, as this population makes up 80% of the future music educators (NCES, 2012). How this population is instructed concerning the most foundational aspect of singing, pitch accuracy, is worthy of study since traditions in teaching are commonly passed down from teacher to student (Van Brumellen, 2002), and therefore warrants study.

A recent study by Hutchins and Peretz (2013) examined participants with and without amusia to examine vocal pitch shifts. Hutchins and Peretz’s (2013) study is relevant to the current study since the literature shows that the singer responds best to listening to his or her own voice to process pitch approximation instead of synthesized voice, piano, or the instructor's voice. Therefore, as the student hears his or her own voice and compares it to the target pitch, the student is presented with an audible signal and is informed of the distance from the destination, but is not shown how to reach the destination. Both groups were asked to match pitch with a recorded target tone selected by the researcher while being recorded. This newly recorded tone became the participant's new target. Data from Hutchins and Peretz's (2013) study was analyzed with a mixed-design 2 X (2 X 5) ANOVA, and showed a significant effect on the amusia group, and the target pitch. The difference in the pitch matching ability of hearing the pre-selected target and the participant's own voice showed that both groups matched pitch more accurately when hearing their personal voice as the recorded stimuli. Further, vocal responses, or sung attempts, were measured in terms of cents ranging from +200 to -200 cents, and results show that even the amusic group responded with more accuracy, even though the degree of accuracy ranged from +/-200 to +/-25 cents.

Granot, Israel-Kolatt, Golboa and Kolatt's (2013) study examined pitch accuracy differences in individuals based on their responses to live voice, recorded voice, sung full voice, sung breathy tone, and optimum singing tone. The sample (N = 18) was recruited through advertisements for adults who question their own ability to sing in tune. Granot et al's (2013) study found that participants matched pitch more accurately when responding to a voice stimulus, and that there was not marked difference between the responses of a live voice model and the recorded voice model. Pitch deviations when participants responded to a piano stimulus were higher and therefore were less accurate than those responding to live or recorded voice stimulus. Granot et al's (2013) study is relevant to the current study because the master-teacher apprentice uses the live voice model as the teacher demonstrates accurate pitch in the real classroom, and the tone variance from teacher to teacher can be great depending on weight and timbre. Therefore, the literature informs the current study of the likelihood that similar results can be expected from the experimental conditions and live classroom conditions pertaining to the use of recorded versus live voice model.

In an earlier study by Granot, Israel-Kolatt, Gilboa, and Kolatt (2012), the researchers explored pitch-matching improvement when responding to a live voice model with a focus on correlation between perception and production. Even the participants who sang out of tune were found to respond more accurately to a live voice model, since "sensitivity to the human voice seems to be hardwired" (Granot et al., 2012, p. 389). The 2012 study recruited participants (N= 18) from advertisements with no preliminary criteria, and the accuracy levels varied within the group from mean deviation of 16.6 – 451 cents from the target. Granot et al's (2012) study is relevant to the current study in terms of procedure and measurement choices. The literature informs the current study of the reliability of the recorded live voice model.

Existing research informs the current study of the most ideal conditions for the experiment to provide all participants with an equal chance of optimum performance during the test. Findings from Behlau and Oliveira's (2009) study suggest that for optimal singing, the voice should be hydrated with room temperature water. Therefore all participants are provided with room temperature bottles water and are asked to drink it at leisure during check-in. Further, Behlau and Oliviera (2009), Ferreira et al (2010) and Franca and Simpson (2013) suggests that at least two minutes of vocal warm ups is necessary to efficiently prepare the voice for focused singing. Accordingly, all participants will participate in two minutes of pre-recorded vocal exercises. Based on Thorton's (2005) recommendation for optimum room temperature for singing, the experiment labs will be set at 76 degrees Fahrenheit.

Literature states that 73% of all music majors will become music educators and 80% of all music educators are female (NCES, 2012) therefore, the current study focuses on the female voice student as the population of interest. In a recent study by Filipa, Sundberg, Howard, Saccuto and Freitas (2012), results showed an effect on pitch accuracy due to the menstrual cycle and oral contraception, and Willis and Kenny's (2011) study indicate swollen vocal cords at the time of menstruation. Therefore, on the day of the experiment, participants were asked to disclose as to whether or not the menstrual cycle was present.

Hutchins et al's (2012) study focused on vocal responses to pitch matching based on years of musical training. The (2012) study's sample ($N = 38$) included male and female participants with a mean age of 22.9 years for the musician group and 23.1 years for the non-musician group. The musician participants had at least seven years of private lessons ($M = 11.6$ yrs), and non-musician participants had less than a year of private lessons ($M = .2$ yrs). An interesting finding from this study, however, was that even poor singers improved most when using their own recorded voice as the target pitch, even though the non-musician group had a 40% error in vocal response and the musician group had only a 4% error. These findings are of importance to the current study because findings point to the need for a similar experience in training in order to minimize the chance of the results being due to lack of vocal training.

Untrained singers constituted the sample ($N = 20$) in Marmel, Tillman, and Dowling's (2008) study in which pitch perception was studied in relation to tonal expectations. Marmel et al's (2008) study asked participants to press a computer key to indicate the played pitch as being in or out of tune. Further, participants were asked to gauge how out of tune the pitches were on a scale of 0-3 with higher number indicating detection of being very out of tune. None of the participants were professional musicians, although the years of private instruction ranged from 0-11 years with a mean of 4 years, and median of 3 years. While the study supports the idea that the expectancy of pitch and musical training experience are influential factors in the accuracy of perceived pitch, it also points to the influence of the perceived pitch on the response. Therefore, findings encourage the current study to base each pitch improvement score on how much closer the participant moves toward the center pitch, instead of a comparison across the sample since natural talent and musical instruction experience are shown in the literature to influence pitch accuracy. The focus of the current study is on pitch accuracy improvement instead of just pitch accuracy.

Pitch Instruction Methods

According to current literature, modern higher education has the following three chief characteristics: (a) modernization of teaching methods, (b) innovation of teaching expressions, and (c) management reformation (Ruiji, 2012). Existing research in the field of private voice instruction is limited, likely due to a stigma that was attached to studio instruction by early researchers, as it was declared to be a “deviant educational tradition” (Schön, 1983, p. 56). According to Schön, “Human phenomena that could not be observed or measured were not worth pursuing” (p. 2143). Studio instruction research has since earned a place in research as an excellent laboratory for the study of the voice, likely due to Bloom (1985), Madsen (1985), and Yarborough’s (1996) literature refuting Schön’s view of the worthiness of the field of research. Early studies by Grant and Drafall (1991) drew attention to the need for research to support systematic instruction methods in the voice studio.

Since this time, many studies have been conducted on voice instruction and methods in the vocal studio (Matthis, Traser, Markl & Richter, (2011); Erickson-Levendoski & Sivasanker, 2011; Morrow & Connor, 2011); Patel, Bless & Thibeault, 2011); Staes, Jansen, Vilette, Coveliers, Daniels & Decoster, 2011; Van Houtte, Claeys, Wuyts & Van Lierde, 2011; Zimmer-Nowicka & Henryka, 2011). While there is a growing body of literature concerning pitch instruction within the context of the private voice studio (Connell, Zhenguang, & Holler, 2013; Duvvuru, 2012; Estis, Dean-Claytor, Moore, & Rowell, 2011; Filipa, Sundberg, Howard, Saccuto, & Freitas, 2012; Hutchins, Roquet, & Peretz, 2012; Hutchins, Roquet, & Peretz, 2012; Larrouy-Maestri, Leveque, Schon, Giovanni, & Moresomme, 2013; Nikjeh, Lister, & Fritsch, 2009; Oxenham, 2012; Pfordresher, Brown, Meier, Belyk, & Lotti, 2010; Reifinger, 2013; Thorpe, Callaghan, & Van Doorn, 1999; Wilson, Lee, Callahan, & Thorpe, 2008; Wilson, Lee, Callaghan & Thorpe, 2007)**,** no studies were found at the time of the present study that focused on the application of Cognitive Load Theory to pitch instruction methods within the targeted population of female declared voice majors. In this literature review, literature pertaining to pitch instruction is discussed in light of the need for more research in the field of collegiate private voice pitch instruction.

Although a small body of literature suggests the need for systematic research in studio vocal instruction, (Grant & Drafall, 1991; Kennel, 2002) there remains a tendency for one to teach as one was taught (Campbell, 1991; Van Brummellen, 2002). While this school of thought is also present in other disciplines, vocal instruction differs in the fact that the instrument being shaped is internal, meaning that the voice is inside the student as opposed to a musical instrument held in the hands. The learning that occurs during voice training is ingrained because of the neuroplasticity engagement required to demonstrate proficiency. As muscle memory facilitates deep learning, technical methods become a kind of second nature for the singer after dedicated practice in a technique (Tsang et al., 2011). Further, the one-on-one relationship between the teacher and student is extremely personal and is recognized as musically and personally influential in the life of the student, “only duplicated in one’s life by the kinship of parent and child” (Jones, 1975, p. 46). Therefore, the influence of private instruction must be heavily considered in selection of best practice.

Instruction is**,** by nature, a process of communicating a systematic approach to construct a path to a predetermined destination. In an earlier study by Rosenthal (1984)**,** the author portrayed voice instruction as either: (a) instructor model guide, (b) instructor verbal guide, or (c) a combination of the two. Based on Rosenthal’s study of voice instruction, the role of instruction can be compared to the role of a Global Positioning System (GPS). A GPS is used to direct the automobile driver to a predetermined destination, just as pitch instruction is used to direct the student singer to arrive at a target pitch with precision. The three instruction types discussed in this study **(**e.g., TCVC, PAF, and VAF**)** can be respectively related to three GPS modes of navigation: auditory, visual grid, and full visual-audio. These GPS modes**,** as well as instruction types**,** are differentiated by the delivery method of instruction

Traditional Corrective Verbal Cues TCVC) As GPS Auditory Navigation

Traditional Corrective Verbal Cues (TCVC) are based on the master-apprentice model in which the teacher gives verbal cues to either “singer higher” if the sung attempt is flat or beneath the target pitch; or to “sing lower” if the sung attempt is sharp or above the target pitch (Stark, 2008). This method relies on the teacher’s ability to detect pitch imprecision and to draw the student singer’s attention to the issue. Typically, the student assumes that they have reached the precise pitch when the verbal cues cease and the teacher allows the student to continue singing on to the next musical passage (Howard, 2005). The role of TCVC to the student singer can be likened to the role of the audible command GPS mode to the automobile driver’s efforts to arrive at an unfamiliar destination in the dark with no visual contact. Audible instructions are given in real-time that direct the driver to make turns, reroute, or remain on the current course. The driver's sole reliance of reaching their destination is dependent upon the auditory cues, as the GPS does the navigating. In many cases, however, the driver will not be able to find the unfamiliar destination at a later date, even with visual contact, without the help of audible cues. In this regard, the driver has not learned to independently navigate to the destination. Such could be the case with TCVC. The student may follow the instructions of the teacher to arrive at the target pitch, and then proceed to the next passage in the piece, but whether or not the student has learned to independently navigate pitch from "point A" to "point B" is not clear; this is to say that the student singer may not truly be learning precise pitch accuracy in singing apart from instructor cues.

According to Hsieh and Saberi (2008) TCVC instruction directs the student to translate the heard and perceived pitch, and produce it vocally as close to the center of the pitch as possible. At this point, the instruction varies greatly from studio to studio, as educators tend to teach the way they were taught (Campbell, 1991; Van Brummellen, 2002). Upon the student's failed attempt to precisely sing an acceptably accurate pitch as deemed by the instructor, the student is often instructed to try again, although repetition and redundancy yield no difference in results if the instruction is not differed (Sweller & Chandler, 1991). Further, negative effects of redundancy without corrective instruction may develop as inaccurate perception is reinforced in the muscle memory and pitch discrimination is further desensitized. Therefore, there is practical implication that warrants investigation into the effectiveness of TCVC and the need for a more direct route for navigation for voice majors as future educators.

TCVC often results a means-end strategy, as the student may focus the voice higher or lower as directed by the teacher in an effort to satisfy a level of accuracy for a specific note in a song or vocal exercise, but it is unclear whether or not the student has truly learned to navigate that pitch with the processes of hearing, perceiving, and production, apart from the presence of TCVC. Within the traditional method of pitch instruction, the instructor guides the student by producing "psychological hooks", which according to Howard (2005) are gestures and analogies which "have been used and passed down over many teacher-pupil generations, and they do indeed appear to work for many students in terms of enabling them to produce an appropriate vocal output" (Howard, 2005, p. 41).

Indications that a more effective instruction strategy may be necessary upon investigation that reveals a lack of precision in detecting and/or producing accurate pitch. Research suggests that the sound the singer hears internally is not exactly the same sound that is heard by another person listening (Oxenham, 2012). It is often difficult then, for the student to accept the fact that pitch precision is a problem on specific notes if the ability to detect is underdeveloped or dulled. Apart from perception of the tone, imprecise singing ability may lie in vocal motor control issues, or perhaps the student cannot hear the true tone produced because of vibrato (Hutchins et al., 2012).

Performed Audio Feedback (PAF) As GPS Visual Grid

In GPS visual grid, the driver sees the distance from current location to the desired destination represented by two pins indicating current position and destination, but navigation instructions are not given toward the destination. Such is the case with PAF instruction, which involves the student listening to recordings of her initial attempt at the pitch and then to the target pitch, or vice versa. As the student compares the two pitches, comparison may show the student how far they are to center pitch. GPA grid mode indicates exactly how far the destination is from current position, but this mode offers no navigation instructions toward the destination. Concerning the skill of singing, then, the student receiving PAF may or may not detect the distance from the target, but is no better equipped to reach the target pitch as this instruction mode exposes the distance, but does not offer navigation.

Hanrahan's (2012) study on the effects of auditory feedback on singing examined changes in pitch accuracy, among other factors, upon the participant's hearing their own voice. Participants ($N = 8$) were all voice students in various levels of collegiate and graduate school programs with an age range of 24-30 years of age. The auditory feedback in Hanrahan's (2012) study was delivered through Room feedback, with no altered or enhanced acoustics, and through Headphone feedback with enhanced acoustics such as a mix of high and low frequencies. The study found measureable changes in pitch accuracy, among other qualities in the singing voice, when using the enhanced/ Headphone feedback. However, the study states that further research is needed to determine if the changes found are attributed to the altered feedback and the sounds made by participants.

Pitch matching improvement attributed to participants matching their own voice has been examined in several studies (Bella et al., 2009; Hutchins et al., 2010). Hutchins and Peretz (2013) studied pitch shift in congenital amusia, or pitch deafness. As referenced earlier, participants with tone deafness and those without tone deafness both showed pitch improvement when matching their own voice. These studies are important to the current study because of the inclusion of the Performed Audio Feedback intervention. However, the current study differs from the referenced auditory feedback interventions in that the feedback is performed by the participant (thus, titled "Performed Audio Feedback"). This kind of feedback is worthy of study since the playback of the sung tone reveals the true sound of the singer, since the singer is able to hear only 60% of her own voice inside her head (Jahn, 2013).

Real-Time Visual Feedback (RTVF) As Full GPS Real-Time Navigation

In full GPS real-time navigation mode, the driver sees the road, the grid, and receives verbal navigation cues. In this respect, the driver personally experiences the navigation at each turn and landmark and is likely to find the destination at another time independent of technology. With RTVF the student visually recognizes the distance from the target, audibly engages with production of sung pitch, and navigates in real-time toward the target. In this uncommon instruction mode, the student simultaneously sees and hears the target pitch, and sings toward the pitch while her voice is visually tracked in real-time. Concerning the skill of singing, then, the student receiving RTVF is likely to reach the destination again at a later date without assistance. Not only is the student likely to independently find that particular pitch again, but due to visual-audio cuing and experienced navigation, the student's sung pitch in general is likely to improve.

While existing research exists in support of the benefits of visualization in learning (Brown et al., 1999; Feng, Zheng, Zhang, Song, Luo & Li, 2011; Macpherson, & Ward, 2011; Nix et al., 2012; Reifinger, 2013; Thorpe et al., 1999; Van Gog, Paas, Marcus, Ayers, & Sweller, 2009), few studies have been conducted on the value of visualization in the vocal instruction concerning pitch accuracy pertaining to technical studio instruction. An earlier study (Howard, 2005) investigated the efficacy of real-time visual feedback in singing lessons with a focus on the reduced amount of time between the learner's attempts toward singing the center of the pitch. In other words, Howard (2005) found that stopping the student to digest the teacher's comments slowed down the learner's response, whereas, visual feedback allowed for a more immediate attempt. Howard (2005) is careful to emphasize the need for the human instructor in the studio, since many training aspects require human judgment such as stagecraft, communication, and ornamentation. Howard (2005) consulted a panel of voice professionals, linguists, and psychologists, known as the Liaison Panel, to identify specific vocal issues that had potential to benefit most from real-time visual feedback within the context of the vocal studio. Pitch accuracy was identified as one such aspect (Howard, 2005).

A small body of work (Wilson et al., 2008; Wilson et al., 2007; Wilson et al., 2005) by researchers and specialists in voice training points to the superior benefits of "continuous, contextual feedback with information about degree of accuracy, and continuous but categorical (right/wrong) feedback" (Wilson et al, 2008, p. 157). Wilson et al's (2008, 2007, 2005) research is important to the current study as the study seeks to extend the previous findings and test the Cognitive Load Theory. The current study differs from Wilson et al's previous studies due to the theoretical framework, and also in terms of the separation of the feedback types during the study.

In Wilson et al's (2008) study, a sample consisting of 45 participants ($N = 45$) received either no visual feedback, grid, or keyboard visual displays in real-time feedback during the study. The control group, receiving no real-time visual feedback, pitch improvement improved by less than 1 Hz (SD=8.1). However, the two intervention groups showed significant change in pitch accuracy improvement. The grid screen released real-time tracking of the participant's singing and followed the slight changes in pitch.

Participants receiving the Grid display feedback had a mean improvement in pitch accuracy of 8.1 Hz (SD=5.2). As shown in the figure above, the pitch is traced in real-time and is related to the Hz to the right of the screen. The participant was able to see their slight pitch inaccuracies and movements during Wilson et al's (2008) study, while participants in the other intervention group, the Keyboard Display group, received real-time feedback of their sung pitch in terms of a "right/ wrong" response.

In the figure above, the pitch sung by the participant is marked in red. It is worthy of note note that this feedback display does not offer a degree of accuracy. Instead, this mode offers an identification of the pitch in terms of correct/ incorrect. Participants receiving Keyboard display feedback had a mean improvement in pitch accuracy of 7.9 Hz (SD=8.4). It is noted in the study that a history of musical experience in participants may have attributed to a difference using the keyboard display. Further, the keyboard display does not indicate changes in pitch less than one-half step. In other words, after the pitch is sung, no information was displayed between the next attempt, therefore, no tracing of the pitch is available in this mode of visual feedback.

Wilson et al's (2008) study shows a difference between changes in pitch accuracy between the groups between baseline and post-test ($F_{2, 42}$=5.909 p = 0.005), indicating a significant improvement in pitch accuracy after the visual feedback intervention. This study is of particular interest to the current study because of Wilson et al's (2008) suggest that future research examine visual feedback and the interaction with singing and musical background.

Real-Time Visual Feedback (RTVF) software available for studio use include Sing and See (Cantovation, Ltd., Aukland, New Zealand) (Thorpe, Callaghan & Van Doorn, 1999), VocaVista (Nair, 1999), and WinSingad (Howard, 2004), and VoicePrint (Estill, 2009). RTVF was explored in relationship to airflow using an airflow interrupter, which measured change in breath pressure during singing (Hoffman, Rieves, Surender, Devine, & Jianj, 2012). In Hoffman et al's (2012) study, the RTVF integrated real-time displays of airflow, sound pressure, and fundamental frequency. The sample consisted of eleven participants (N = 11), six females, and five males. Participants performed a sustained tone for 5-7 seconds, during which time the participant's breath pressure was measured with the following feedback types: no feedback, auditory feedback, visual feedback, and combined audio-visual feedback. The feedback types were evaluated in an effort to assist singers maintain a constant airflow and sound consistency. The participants, however received each feedback, and the researchers identified no optimal feedback method as superior to the other. Hoffman et al's (2012) study is important to the current research, as the suggestion was made for future research to separate the feedback methods.

Chapter Summary

A large body of early and recent literature explains traditional voice training principles as influenced by the Bel Canto school of thought supports what is aesthetically considered beautiful in the singing voice (Baker, 1940; Bybee & Ford, 2004; Coffin, 2002; Stark, 2008). Through centuries of writings and studies, it is commonly accepted that a beautiful singing voice must have excellent pitch, even vibrato, and expressive tone (Stark, 2008). Yet, current research indicates that pitch imprecision among singers may still be an issue, despite vocal training (Bonner, 2012; Estis et al., 2011; Pfordresher et al., 2010).

A growing body of research (Aldalalah, 2010; Ayers, 2012; Paas et al., 2010; Sweller & Chandler, 1991) that attributes the lightened working memory to visualization, resulting in deeper learning. Hence, the current study is grounded in Sweller's (1970) Cognitive Load Theory. The theory has evolved in spite of conjecture and doubt due to confirmation of hypothesis, and slight modifications upon new research findings.

Current literature informs the current study of many factors for design and procedural decisions. The vowel chosen for such experimentation is of key importance. The vowel chosen for the experiment is the [a] vowel (as in "pot") vowel, which is also commonly used in the medical field when examining the pharynx and throat (Thurman & Welch, 2000). Earlier research (Sundburg, 1987; Thurman & Welch, 2000; Vennard, 1967) indicates that the production of round vowels afford stability in the pitch and lessens the chance of the tongue interfering with the vowel consistency. Specific literature supports the current study in terms of design and methodology. A study by Hutchins et al (2012) suggests that 2-4 years of vocal training is necessary in order for solid production technique to occur. Therefore, the participants in the current study are upper classmen who have completed at least three semesters of training and further, to demonstrate ability in proper production, have passed a junior proficiency exam or three successful juried examinations declaring that these abilities are evident.

A study by Rosenthal (1984) suggests that vocal students are best guided by a live-voice model instead of a synthesized tone. Therefore, the target stimuli will be recorded using a female voice. Further, research shows that A-440 (A4) is generally easy tone for the female voice to sing (Stark, 2008; Nikjeh et al., 2009). As many studies have cited vibrato as a cause for unusable samples in past studies (Callaghan et al., 2004; Duvvuru, 2012; Granot et al, 2013; Hoppe et al., 2006) participants will receive a two-minute training session on correct production of straight tone singing for the purpose of the test.

Current literature (Brown, Macpherson & Ward, 2011; Callaghan et al., 2004; Connell et al., 2013; Bella, Giguere & Peretz, 2009; Doing & Miller, 1998; Eldridge et al., 2010; Platz et al, 2012; Thorpe et al., 1999; Wilson et al., 2010; Wilson et al., 2008; Wilson et al., 2007; Wilson et al., 2005) points to the need for the choice for instruction type to include a dual sensory mode. Although concepts for proper singing technique currently taught in collegiate vocal studios have been studied and examined in several areas of vocal pedagogy (Behlau et al., 2009; Bhavsar, 2009; Ferreira, Latorre, Pinto, Ghirardi, Karmann, Silva & Fugueira, 2010; Gurung et al., 2009); the efficacy of instruction types toward pitch precision in not known. Further, objective analysis of vocal progress is generally undefined within the context of the voice studio as subjective assessment continues as a norm in the field (Loarrouy-Maestri & Morsomme, 2013; Larrouy-Maestri, Leveque, Schon, Giovanni, & Morsomme, 2013). Also undefined in the literature is how the Cognitive Load Theory is tested in terms of pitch accuracy improvement based on instructional techniques used, specifically with the perception and encoding stages of new information.

The referenced studies contribute to a body of literature in the field of private voice instruction and pitch accuracy; however, a gap in the literature remains in terms of the pitch improvement scores after the three instruction methods examined in the current study. Further, pitch-matching instruction types have not been examined within the population in the current study. Aspects of the current study are combined based upon suggestions made by researchers for future research. Specifically, the current study is informed by the literature as studies suggest further research for separated intervention types (Hohhman et al., 2012), influence of intervention on response (Hanrahan, 2012), the influence of musical background (Wilson et al., 2008), and testing with straight-tone samples (Larrouy-Maestri & Morsomme, 2013).

CHAPTER THREE: METHODOLOGY

Because "program adoption decisions increasingly are made on the basis of evidence from experiments" (Gall, Gall & Borg, 2010, p. 305) and research-based instruction is required by such organizations as the National Association of Schools of Music (NASM) (NASM Handbook, 2012), it is crucial to understand how pitch instruction effects pitch precision in the collegiate voice student. The purpose of this quantitative true-experimental, post-test only control group study was to examine the differences between pitch accuracy scores in three groups of female vocal students receiving Traditional Corrective Verb Cues (TCVC) only, Performed Audio Feedback (PAF) with Traditional Corrective Verbal Cues, or Real-time Visual Feedback (RTVF) with Traditional Corrective Verbal Cues. The study was driven by Sweller's (1970) Cognitive Load Theory (CLT) in an effort to reduce the load on the working memory and simplify the pitch perception and encoding stages of Siegler's (1998) Information Processing Theory (IPT). The purpose of this chapter is to explain the methodology used to conduct this quantitative true-experimental study. This chapter discusses the research design, research setting, participants, instrumentation, procedures, and methods for data analysis in an effort to answer the research question.

Research Design

A true-experimental post-test only control group design was used to determine if student's pitch accuracy scores differ according to instruction type received. This rigorous research design is appropriate due to the presence of random assignment, the manipulated variable, the presence of a control group, and because the groups are being compared after an intervention (Gall, Gall & Borg, 2010). Further, this design has been utilized in similar studies in the field of music education research (Platz & Koplez, 2012; Tindall-Ford et al., 1997; Reifinger, 2013; Wilson et al., 2008). A post-test only design was used to eliminate most threats to internal validity (Gall et al., 2010, p. 304). Participants were randomly assigned to one of three groups, a control group receiving TCVC only, or treatment groups receiving TCVC and either PAF or RTVF; thus assumed to be equivalent. Randomization assignment of participants was based on a random numbers program, www.random.org.

Additionally, a causal- comparative design, which is used to examine a phenomenon after the fact (Gall et al., 2010, a was used to examine the comparability of the three instructional groups in terms of the two factors that have been documented in the music education literature as influencing pitch accuracy, number of semesters of voice taken by the students (Conner, 2012; Collins, 2011; Estis, Dean-Clayot, Moore, & Rowell, 2011) and their menstrual status (Filipa, Sundberg, Howard, Saccuto, & Freitas, 2012; Van Houtte, Claeys, Wuyts, & Van Lierde, 2011).

Research Questions and Hypotheses

The research questions for this study are:

RQ1: Is there a difference in pitch accuracy, as measured by pitch improvement scores in female vocal students who receive either traditional corrective verbal cues, performed audio feedback, or real-time visual feedback?

Prior to examining the primary research question for this study, two additional questions were examined to determine if it was necessary to consider covariates as part of the primary analysis:

RQ2: Is there a difference in number of semesters of voice taken by the collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback)?

RQ3: Is there a difference in the proportion of menstruating collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback)?

Hypotheses

$H_{1:}$ There will be a difference in pitch precision, as measured by pitch improvement scores in female vocal students who receive either traditional corrective verbal cues, performed audio feedback, or real-time visual feedback.

$H_{2:}$ There will be a difference in number of semesters of voice taken by the collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback).

H_3 There will be a difference in the proportion of menstruating collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback).

The following is the null hypotheses:

$H_{o1:}$ There will be no difference in pitch precision, as measured by pitch improvement scores in female vocal students who receive either traditional corrective verbal cues, performed audio feedback, and real-time visual feedback.

$H_{o2:}$ There will be no difference in number of semesters of voice taken by the collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback).

$H_{o3:}$ There will be no difference in the proportion of menstruating collegiate female participants across group assignments (traditional corrective verbal cues, performed audio feedback, or real-time visual feedback).

Participants

Due to the accessibility of participants, a convenience sample was used (Fraenkel & Wallen, 2006). Participants (*N* = 59) in this study were female voice students at a mid-Atlantic university, who had taken between three and seven semesters of collegiate voice training, and had performed at least five times in either a solo recital for final semester juried examination. Participant's training was built on similar foundational basics as grounded in the Bel Canto method pertaining to breath control and the raised soft pallet. Additionally, all participants had experience singing repertoire in English, Italian, and German, and vocalized regularly in private lessons utilizing an [a] "ah" vowel. Although there were many types of performance degrees represented by the participants, all voice and theatre programs the university require private studio voice lessons for degree completion. Each semester of voice training culminates in a final vocal juried exam in which each voice student's vocal technique is examined by a panel of voice faculty. In the jury, aspects of the student's voice are assessed in terms of accuracy in pitch, rhythmic, intonation, diction, stylistic interpretation/ performance, phrasing, and overall pleasing tone, for a total of 250 points (see Appendix A). The student must score at least 200 points, a "C", to be allowed to count the semester toward their major and register for the next semester of voice lessons.

Using an effect size of .5, a statistical power of .80, and an alpha level of .05, the calculated ideal, target sample size was 64. However, because there are two treatment groups with a combined number of participants twice as large as the control group, and given that equal groups are assumed, the sample size of 60 was sufficient (Field, 2009). Further, according to Gall, Gall and Borg (2010) each experimental condition group should be comprised of at least 15 participants; therefore, the sample size is exceeded this criteria as recommended for this design.

All 88 female voice students with at least three consecutive semesters of vocal training at the university were invited to participate via a University email account through the music department (see Appendix B); thus, the volunteer rate was 67%. Announcements (see Appendix C) were made in classes as well as in a music department meeting, which required music student's attendance. In an effort to encourage participation, participants were remunerated in the form of voice training software valued at $49.00.

Setting

The site for this study was a large university located in the mid-Atlantic United States. Upon entrance to the music building, participants were greeted by check-in personnel, showed university identification, and were escorted by a liaison to the appropriate tutorial room. The testing for this study was conducted in six music department classrooms including: three tutorial rooms that also served as a waiting area for each treatment groups, and a testing room for each group. The test site was familiar to the participants, as each frequents the area for vocal training or musical events on a weekly basis. The windows of the testing rooms were covered and the walls were bare to avoid distraction.

In the waiting room, participants were grouped according to their randomly assigned treatment method. A multimedia presentation specifically designed to explain the nature of the particular treatment group was shown (see Appendices D1-D3) that included vocal warm-up exercises (see Appendix E). Each test room was partitioned by a black stage curtain; installed to keep the participant from seeing the researcher and technician, and vice versa. This was crucial since there was a chance that the participant would know the researcher or technician, or that the researcher was the private teacher of the participant. Each test room had a clearly marked "X" on the floor indicating where the participant should stand during the test. This mark was three feet away from the laptop used to record the vocal sample on the other side of the curtain. Each room was equipped with intervention specific recordings (see Appendix F1-F3) and identical recorded instructions and equipment. The testing occurred on a Saturday morning when no other classes or meetings were held in the building.

The temperature was set for 72-74 degrees Fahrenheit, as this is a temperature known to not interfere with vocal production (Platz & Koplez, 2012; Reifinger, 2012). Since proper hydration is required for an optimized vocal response (Bhavsar, 2009; Franca & Simpson, 2011; Franca & Simpson, 2013; Morrissey, 2003; Thorton, 2005), room temperature bottled water was provided in the waiting room for each participant. Each setting is explained in the procedures section.

Instrumentation

The dependent variable was the pitch improvement score computed by digital measurement of sound in Hz and semitones with Sing and See software, as this is a widely accepted instrument in similar studies in the field (Craven, 2012; Duvvuru, 2012; Goller, et al., 2009; Granot, et al., 2013; Wilson, et al., 2008). This instrument measured the participant's sung attempt before and after the intervention in terms of Hz and semitones and recorded the test with visual and audio data.

Each lab was equipped with two Macintosh Pro laptop computers, power cords, and two sets of Sennheisser HD 203 headphones. The participants and researcher heard the test tracks and participant samples through headphones ran through Belkin RockStar five-way splitters. The internal microphones in the laptops were set to a level of 75%.

The digital measurement in Hz and semitones of participant attempts was analyzed with Sing and See software (Sing & See, Cantovation Ltd., Auckland, New Zealand), a product that shows visual precision of sound in relationship to the target frequency. The software instantly records the audio response and analyzes the voice in an excel spreadsheet. A five-second vocal sample can yield as much as 250 data lines representing tiny variance of pitch within the sample. Therefore, the last twenty lines of data were averaged to constitute the participant's pitch response for the initial score, and the first twenty lines of data were averaged for the participant's pitch after the intervention. The decision to select this method for averaging the participant's score was guided by the Cognitive Load Theory, which supports minimal lapses of time between instruction and effort (Sweller, 1970) in an effort to attribute the learning outcome to the instruction received. The average became the participant's cents away from the target frequency.

The target frequency ($f1$) was 440 Hz, indicating that the target pitch was A4 (see Figure 2). The distance between the target Hz, and the participant's attempt ($f2$) to match the target was initially measured in semitones by the software, and then converted to cents. One cent (c) is 1/100 of a semitone, or 1/12 of an octave. One semitone = 1.05946, therefore, any distance >100c was considered an outlier, as this indicated more than a ½ step distance from the target pitch. The formula used to support the calculation of the software is $n = 1200 \bullet \log_2 (b/a) \approx 3986 \bullet \log_{10} (b/a)$ since f2/ f1 = cents. This formula used a logarithm base 2 function and was based on the Pythagorean comma as the frequency ratio $(3/2)^{12}/ 2^7 = 3^{12}/ 2^{19} = 531441/ 524288 = 1.0136432647705078125$. On a scientific calculator, using the log button, the formula calculated as: c = 1200 X 3.322038403 log 10 (f2/f1). The participant's second attempt, post-intervention was calculated in the same manner.

The pitch accuracy scores were attained by subtracting the cents from the tonal center, from 100 possible cents within the semitone. For example, if the participant measured ten cents from the center, the score was 90, since there is a total of 100 possible cents within the semitone.

Initial raw scores were measured in units ± cents, depending on the direction of the distance from the target (sharp or flat). A $+c$ value indicates a sharp pitch that registered above 440 Hz, and likewise, $(c)\ -c$ value indicates a flat pitch that registered below 440 Hz. The distance between the first and second attempt indicated the pitch precision gains toward the 440 Hz (A4) target, and thus, provided the pitch improvement score.

The identification of the numbers of semesters of voice taken by the students was measured using numerical data in the form of a question followed by five options from which one was to be selected and circled. Students were asked in a survey question, "How many semesters of voice have you taken?" Students selected and circled either: 3, 4, 5, 6, or 7. Therefore, the number selected by the student represented the one of five categories of numbers of semesters of voice taken.

The identification of the student's presence of menses on the morning of the experiment was measured using categorical data in the form of a question followed by two options to be selected and circled. Students were asked in a survey question, "Is menstruation present today?" Students selected and circled either "YES" or "NO" as a response. The "YES" response was assigned the numerical value of 1, and the "NO" response was assigned the numerical value of 2.

Procedure

Before data collection, university permission was secured and classroom reservations were made through the music department. Institution Review Board (IRB) approval was obtained (see Appendix G), and with the permission of the dissertation chair, experiment materials were audio recorded for the test tracks to be used during the experiment (see Appendices F1-F3). On the morning of the test participants completed a demographics survey (see Appendix H). The completed survey indicated the participant's specific major, length of private voice study, and whether or not menstruation was present on the test day.

Recruitment

Students who had three or more semesters of voice training were eligible to participate. An email promoting the study was sent to 88 eligible voice students through the music department office. Participants emailed the researcher to reserve a place in the experiment. Reminders about the study were emailed to participants at four weeks prior, two weeks, and also one day prior to the day of the experiment (see Appendix I). The initial email included a consent form, a link to a digital informant consent, and compensation information for participation in the study. Each participant received free voice-training product download of the Sing and See software (Sing & See, Cantovation Ltd., Auckland, New Zealand) upon completion of participation. The first 60 potential participants to respond to the digital letter of official invitation and informed consent constituted the sample, and a list of additional responders were kept as replacement in the event of loss of participant. Participants completed a survey on the morning of the study. Completed surveys indicated the number of semesters of voice the participant had completed, the specific performance major, and whether or not menstruation was present on the day of the cycle.

Testing Materials

Six weeks before the experiment day, audio recordings used during the examination were recorded on a Macintosh Pro laptop computer. The recordings included a welcome message and instructions via a multimedia presentation (see Appendices D1-D3), pitch targets, and warm-up exercises (see Appendix E). Warm-up exercises were included to provide all participants the same opportunity to clear the cords of phlegm and engage proper breathing (Sundberg, 1987). Three test tracks to be used in the experiment were recorded as well (see Appendices F1-F3).

The target was recorded with the sung human voice, as research indicates the best response from the learner is found in imitation on human voice instead of a synthesized voice or instrument (Granot et al., 2013). When recorded, the vocalist was guided by digital and visual feedback to insure an accurate straight tone pitch sample. The target sample was sung at tone center, A440.

The pitch selected for the current study was A4 as this is within easy range of the female voice whether soprano or alto (Sundberg, 1987; Nikjeh et al., 2009). Recorded sung samples were produced with an [a] “ah” vowel, as the literature (Sundberg, 1987; Thurman & Welch, 2000) indicates the articulatory system affords the voice the most stability in the vocal tract upon production of the [a] vowel. As pertinent to the current study, the selection of the [a] “ah” vowel was crucial, as the sung response was taken from a five-second attempt and stability of the voice was necessary for accurate measurement.

Testing supplies were secured, including six Macintosh Pro laptop computers, six power cords, nine sets of Sennheisser HD 203 headphones, and three Belkin RockStar five-way splitters. 65 download codes for Sing and See software (Sing & See, Cantovation Ltd., Auckland, New Zealand) were secured and the software was downloaded on all testing laptops. Upon the researcher’s email request, the software company (Sing & See, Cantovation Ltd., Auckland, New Zealand) graciously donated 65 downloads of the software. This provided enough downloads for each testing laptop and each participant. Each download code was inserted into an individual letter with download instructions and the manufacturer’s contact information, and placed in an envelope for each participant.

Research Team Training

A month prior to the study, the research assistants and research technicians received a multimedia presentation indicating the specific needs for the three treatment groups (see Appendices K1-K3). The principle researcher, four research assistants, four liaisons, and four check-in personnel met to cover the purpose of the study and the protocols involved. The research assistants and the research technicians were informed of the anonymity of the experiment provided by a data card that contained an identification code only, and further secured by the presence of the partition drapes hung between the research assistant and the participant. Each aspect of the study was covered in great detail to support randomized assignment, anonymous data collection, and consistency throughout the testing process for each group.

Check-in

All three check-in personnel received one-on-one training from the researcher, as well as an instructional multimedia presentation (see Appendices K1-K3) that covered check-in procedure. As indicated in the reminder emails, all participants reported to a check-in table staffed with three check-in assistants who verified the participant's identity by the data card and student university photo ID. Participants had previous access to the informed consent form (see Appendix J) however, another copy was provided at the check-in table. IRB qualified the current study for exemption of the signed consent form, since the data was collected anonymously. Check-in personnel informed participants as to which liaison would walk them to the waiting room that corresponded to the treatment group randomly assigned on the data card. Random assignment was derived through the use of a random numbers, www.random.org. The participants were not aware that they were divided into three groups that would receive different treatment, and the researcher did not know who was in each group. These procedures facilitate a random assignment from a convenience sample and further, allow for a double-blind study.

Waiting Room

Each treatment group had its own waiting area and testing room. Participants watched the welcome and instructional multimedia presentation, and warmed up their voices in a series of vocal exercises included in the presentation (see Appendices D1-D3). After the power point presentation was viewed, the check-in personnel remained in the waiting room. All participants remained in the waiting room until their name was called, at which time the liaison escorted the participant to the test room. The check-in personnel gave the data card to the liaison, and the participant and liaison left the waiting room to check-in to the test room, which was conveniently located approximately 60 feet away from the waiting room.

Test Room

In each test room, the participant, research assistant, and research technician are unable to visibly see each other due to an installed black stage curtain that served as a partition. The inability of the participant to see the research assistant, although less natural than voice lessons, benefitted the study in terms of ruling out emotional response/ nonresponse that otherwise could possibly have been attributed to personality interactions between participant and research assistant. Further, participants were familiar with recording studio practice and were accustomed to being unable to see the engineer or director giving verbal cues. Each test room was equipped with recording equipment as previously described.

Liaisons

All three liaisons received one-on-one training from the researcher, as well as an instructional multimedia presentation (see Appendices K1-K3) that covered the waiting room procedure. Liaisons were instructed to not share any information about the study, especially in regards to pre-informing the participant about the intended intervention type while in the hallway or on the way to the lab. Upon arrival at the test room, the liaison took the belongings of the participants and placed them on a table outside of the test room, then showed the participant where to stand (on the marked “X”) and placed the headphones on the participant. The liaison then walked behind the partition curtain and handed the data card to the research technician who used the ID code as the file name under which the data was to be saved. The liaison left the room and closed the door. The sound of the closed door was the cue for the research assistant to begin the test with test track 1.

Research Assistants

The three research assistants received one-on-one training from the researcher, as well as an instructional multimedia presentation (see Appendices K1-K3) that covered the specific intervention procedures. Although only three were needed for the study, a fourth assistant was trained in the event of an unforeseen circumstance that would preclude one assistant from participating on the day of the study. All research assistants were voice educators holding a doctoral degree in music or music education, with no less than 10 years of collegiate voice teaching. All research assistants were trained on the software used in their test rooms, and were given guidelines (see Appendix L) as to judging the participant’s first attempt as either sharp or flat according to the visual feedback seen on the screen. Each research assistant selected either track 2 or track 3, depending on whether the initial sung pitch was deemed sharp or flat. The tracks contained a recorded voice informing the participant that their pitch was either sharp or flat, and instructed the student to either sing higher or lower toward the target pitch center. This instruction was considered to be Traditional Corrective Verbal Cues, which is commonly used in the vocal studio. The research assistant's duties varied according to assignment of treatment group. Each assistant was trained in only one type of treatment to be administered to avoid diffusion of treatment. The fourth assistant, available to replace an assistant in case of an emergency, was trained in all three treatments.

Research Technicians

Three research assistants received one-on-one training from the researcher, as well as an instructional multimedia presentation (see Appendix L) that covered the specific technical procedures. While the research assistant served as the musical expert, deeming the pitch as sharp or flat according to the visual graph, the technician was responsible to record the participant response, and to quietly speak the words "second attempt" right before the participant sang the second attempt. The technicians emailed all data csv files to the researcher's chairperson and a third-party analysis personnel to determine the average pitch score in an effort to keep the researcher unaware of which raw scores belonged to which treatment group. The specific duties of the research assistants varied according to the intervention type.

Group Procedures

Group I Procedures: Traditional Corrective Verbal Cues. Participants heard a target pitch through headphones and were instructed to sing the same pitch using a straight tone with a [a] "ah" vowel and hold it for five seconds. The recorded prompts informed the participant to "begin singing" and "stop singing". The research assistant behind the partition curtain was able to see the participant's pitch on the laptop with Sing and See software. Based on the proximity of the participant's first sung attempt, the research assistant selected the appropriate test track to instruct the participant to either "sing higher" if the initial attempt was below the target center, or to "sing lower" if the initial attempt was above the target center. The participant then heard the target again and sang attempt #2, with straight tone on an [a] "ah" vowel, based on the direction of the recorded tracks. It was imperative that pre-recorded tracks be used in case the participant recognized the speaking voice of the researcher.

Group II Procedure: Performed Audio Feedback. The same initial procedure was followed as that of the TCVC group. Participants heard a target pitch through headphones and were instructed to sing the same pitch using a straight tone with a [a] "ah" vowel and hold it for five seconds. The recorded prompts informed the participant to "begin singing" and "stop singing". The research assistant behind the partition curtain was able to see the participant's pitch on the laptop with Sing and See software. Based on the proximity of the participant's first sung attempt, the research assistant selected the appropriate test track to instruct the participant to either "sing higher" if the initial attempt was below the target center, or to "sing lower" if the initial attempt was above the target center.

At this point in the process, however, PAF and TCVC procedure differed to include an audible comparison of the sung attempt and the target pitch, as the PAF group listened to the playback of their first sung attempt followed by the target pitch. The participant then heard the target again and sang attempt #2, with straight tone on an [a] "ah" vowel, based on the direction of the recorded tracks and the influence of hearing their own voice recorded as compared to the target pitch.

Group III Procedure: Real-time Visual Feedback. The same initial procedure was followed as that of the TCVC group. Participants heard a target pitch through headphones and were instructed to sing the same pitch using a straight tone with a [a] “ah” vowel and hold it for five seconds. The recorded prompts informed the participant to “begin singing” and “stop singing”. The research assistant behind the partition curtain was able to see the participant’s pitch on the laptop with Sing and See software. Based on the proximity of the participant’s first sung attempt, the research assistant selected the appropriate test track to instruct the participant to either “sing higher” if the initial attempt was below the target center, or to “sing lower” if the initial attempt was above the target center.

The RTVF group procedure differed, however, to include a visual comparison of the sung attempt and the target pitch. After the participant sang attempt #1, she was instructed to view the white board displaying the pitch attempt and the target pitch (see Figure 1). Based on the proximity of the participant’s first sung attempt, the research assistant selected the test track to instruct the participant to either “sing higher” if the initial attempt was below the target center, or to “sing lower” if the initial attempt was above the target center. The participant sang attempt #2 while watching the pitch trace in real-time as it approached the target pitch as marked on the screen.

Data Analysis

Data was stored on a laptop with a secure password and was submitted regularly to university secured Share Point site for easy access and updates. Statistics were computed through Statistical Package for Social Sciences (SPSS, version 22). Participant information was collected through a demographics survey concerning semesters of private instruction received, the participant’s major, and presents of menstruation. Neither participants nor researchers were aware as to which group participants had been assigned to the three groups through the random number program rwww.random.org. Participant the raw scores were pitch error (the cents away from the tonal center). These were numerically coded to provide for a double-blind study. Data was collected via digital measurement as measured in Hz and semitones and converted into and cents. The mean standard deviation between the two pitches will demonstrate the difference attributed to the intervention and will be analyzed. The pitch scores indicate how close the participant was to the center in terms of cents. For example, a pitch score of 90 is achieved if the participant sang either 10 cents below or 10 cents above the target pitch. Each of the two sung attempts serve as the pitch accuracy scores, and the two pitch accuracy scores are compared to see how the scores differed post intervention.

A one-way analysis of variance (ANOVA) was used to test the null hypothesis that there is no difference in pitch accuracy, as measured by pitch improvement scores in female vocal students who receive either traditional corrective verbal cues, performed audio feed-back, and real-time visual feedback. The statistical tool of choice for the comparison of average gain in the pitch score between two groups is independent *t*-test and across more than two groups is ANOVA, provided the data meets the underlying assumptions (Warner, 2012). Per the literature, the ANOVA was chosen due to the fact that the study involved the examination of an independent variable with three levels and one dependent variable (Warner, 2012). Post hoc tests were conducted in an effort to determine between groups differences exist. The null hypothesis was tested with alpha level .05, which is standard in similar studies (Anderson et al., 2012; Wilson, et al., 2008). Eta squared was reported and interpreted using Cohen's conventions (1988).

Underlying assumptions were checked prior to conducting the ANOVA. Responses were independent in each sample by nature of the study design. Homogeneity was examined with Levene's Test for homogeneity of variance (Larson, 2012). Assumption testing for normality was conducted with Shapiro-Wilk's tests and histograms. Outliers in the gain in pitch accuracy scores were assessed using boxplots. Some assumptions were violated. As some statistics text suggest that the ANOVA is robust even when the assumption of violations of homogeneity of variance is violated, the conventional ANOVA was carried out (Field, 2009; Gall, Gall, & Borg, 2010; Larson, 2012). To confirm these results, since the assumption of homogeneity of variances was violated and the data was non-normally distributed across some groups, Warner (2012) recommendation to report Welch's ANOVA and Brown-Forsyth, was also carried out.

Additionally, the number of semesters of voice training was assessed across groups, and the proportion of menstruating participants was also assessed across the three groups. An ANOVA and Chi-square test of independence was carried out to determine whether the two variables, menstruation status and semesters of voice taken, were similar across groups and needed to be considered in the primary analysis.

CHAPTER FOUR: RESULTS

This chapter describes the analysis conducted to test the null hypothesis that there is no difference in pitch accuracy scores according to instruction type received by collegiate female voice students. Also, described are the analyses conducted to test the null hypotheses that there is no difference in number of semesters of voice taken by the collegiate female participants across group assignments (Traditional Corrective Verbal Cues, Performed Audio Feedback, or Real-Time Visual Feedback); and that there is no difference in the proportion of menstruating collegiate female participants across group assignments (Traditional Corrective Verbal Cues, Performed Audio Feedback, or Real-Time Visual Feedback). This chapter outlines the hypotheses of this study that there is a significant difference pitch accuracy scores according to instruction type; there is a significant difference in number of semesters of voice taken by the collegiate female participants across group assignments; and there is a significant difference in the proportion of menstruating collegiate female participants across group assignments This chapter describes the sample and reports the descriptive statistics for the variables included in the study. The findings are presented and results of the analysis are discussed.

Sample and Analyses for Hypotheses Two and Three

A convenience sample ($N = 59$) of collegiate female voice students who had completed at least three semesters of voice training at a mid-Atlantic university, and who responded to an email invitation from the university music department participated in this study. The sample included 59 out of 81 eligible female students, which provided a response rate of 72.8%. Seven students (8.4%) responded that they would be out of town on the morning of the study, and 15 students (18.5%) did not respond. All 59 participants were randomly assigned to the following three types of instructions: Traditional Corrective Verbal Cues (TCVC) control group ($n = 19$), Performed Audio Feedback (PAF; *n* = 20) group, and the Real-Time Visual Feedback (RTVF; *n* = 20) group.

Though participants were assigned at random to the three type of instruction, it is worthwhile to assess the comparability of the three groups in terms of the two factors that have been documented in the literature as influencing the dependent variable, namely number of semesters of voice taken by the students (Conner, 2012; Collins, 2011; Estis, Dean-Clayot, Moore, & Rowell, 2011). and their menstrual status (Filipa, Sundberg, Howard, Saccuto, & Freitas, 2012; Van Houtte, Claeys, Wuyts, & Van Lierde, 2011).

The mean number of semesters across the three groups was assessed using an ANOVA. The number of semesters of voice taken by the participants ranged from three to seven. The number of females who took different number of semesters was as follows: 12 females took three semesters, 18 females took four semesters, 13 females took five semesters, 13 females took six semesters, and 3 females took seven semesters. The mean and standard deviation for the number of semesters of voice taken for TCVC, PAF and RTVF were *M* 4.63 (*SD* = 10), *M* 4.80 (*SD* = 10) and *M* 4.40 (*SD* = 10), respectively. Preliminary assumption testing demonstrated that no major violations existed. A one-way ANOVA, indicated that the number of voice semesters did not differ among groups, $F(3,55) = 0.81$, $p = .49$. There was not sufficient evidence to reject the null hypothesis that there is no difference in the number of semesters of voice taken by the participants. This demonstrated the effectiveness of random assignment. Additionally, the descriptives for the gain in pitch accuracy score from the first vocal response to the second vocal response among participants based on the number of semesters of voice taken are reported in Table 1. The non-significant results of an additional one-way ANOVA, indicated that the number of voice semesters taken did not have an effect on the gain in pitch score, $F(3, 55) = .15$,

$p = .93$.

Table 1

Gain in Pitch Accuracy Score from the First to the Second Vocal Response among Participants who took Different Number of Semesters

Number of semesters of voice taken	*n*	Range	*M*	*SD*
3	12	-22.4 - 28.2	6.62	12.33
4	18	-9.8 - 18.1	5.53	7.812
5	13	-23.5 - 24.2	7.34	10.82
6 or 7	16	-36.8 - 34.9	4.61	15.93
Total	59	-36.8 - 34.9	5.90	11.70

Participants were also asked to report whether or not their menstrual cycle was present on the morning on testing. Thirty-nine (66%) participants reported that their cycle was not present, and 20 (34%) participants reported that their cycle was present. The proportion of girls who were not menstruating in the morning of the vocal test in the three instruction groups of TCVC, PAF and RTVF were 52.6% ($n = 10$), 70% (n = 14) and 75% ($n = 15$), respectively (see Table 2).

Table 2

Menstrual Status and Type of Instruction

Menstruation	Type of instruction			Total
	Traditional Corrective Verbal Cues	Performed Audio Feedback	Real-Time Visual Feedback	
Absent	10 (52.6%)	14 (70%)	15 (75%)	39 (66.1%)
Present	9 (47.4%)	6 (30%)	5 (25%)	20 (33.9%)
Total	19 (100%)	20 (100%)	20 (100%)	59 (100%)

Assumptions were assessed, and assumptions for the analysis were met. A chi-square test for independence performed suggested that menstruating and non-menstruating participants were evenly distributed in all the three groups, $\chi^2(2, N = 59) = 2.38$, $p = .354$, showing again the effectiveness of random allocation. Since the number per group did not differ, it was assumed that this variable influenced the participants similarly across groups. The variance of gain in pitch accuracy score was higher among menstruating participants compared to non-menstruating participants, $t(58) = 3.92$, $p < .001$ (see Table 3). Because pitch accuracy scores of non-menstruating participants were better as compared to the scores of menstruating participants, findings concerning the influence of menstruation on pitch accuracy suggests that future studies consider this as a focus in future studies.

Table 3

Change in Pitch Accuracy Score from the First Vocal Response to the Second Vocal Response and Menstrual status

Menstruation	*n*	Range	*M*	*SD*
Absent	39	-9.8 - 34.9	10.10	8.42
Present	20	-36.8 - 12.5	-2.41	12.92

Results

The descriptive statistics for the gain in pitch accuracy score among the three types of instructions is presented in Table 4.

Table 4

Change in Pitch Accuracy Score From the First Vocal Response to the Second Vocal Response in the Three Instruction Groups (N = 59).

Type of instruction	*N*	Range	*Mdn*	*M*	*SD*
Traditional Corrective Verbal Cues	19	-5.8 - 12.5	5.74	5.34	4.62
Performed Audio Feedback	20	-36.8 - 16.4	6.81	0.61	15.53
Real-Time Visual Feedback	20	0.7 - 34.9	10.40	11.72	9.64

Normality tests using histograms (see Figure 1) and Shapiro-Wilk's tests suggested that the gain in pitch score followed normal distribution among participants who were assigned to TCVC (p = .458) and RTVF (p = .057). Gain in pitch accuracy scores were not normal among participants who were put assigned to PAF (p = .007).

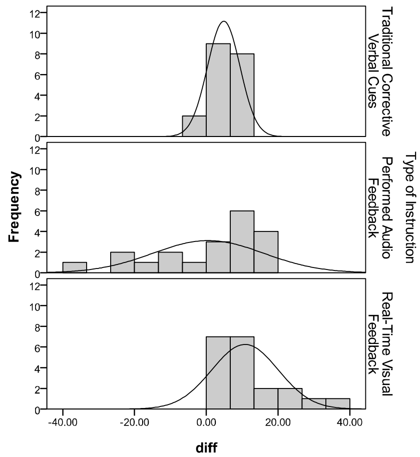

Figure 1. Gain in pitch score following normal distribution

Levene's test (*Levene* $F(2,56)$ 10.8, $p < .001$) suggested that the variation in gain in pitch accuracy scores among participants who were assigned to the three types of instructions were not similar. As some statistics text suggest that the ANOVA is robust even when the assumption of violations of homogeneity of variance is violated, the conventional ANOVA was carried out. (Field, 2009; Gall, Gall, & Borg, 2010; Larson, 2012).

To confirm these results, since the assumption of homogeneity of variances was violated, robust ANOVA tests, Welch's ANOVA and Brown Forsyth, were also reported and used to confirm the results. The results of the ANOVA suggested that the type of instruction effected the gain in pitch accuracy scores, $F(2,56) = 5.26$, $p = .008$, $\eta^2 = .158$. The strength of relationship between independent variable and dependent variable score was moderate, accounting for 15.8% of the variance of the dependent variable. The power was strong at .814, which indicates that a study such as this with 59 participants would detect a significant effect of the type of instructions on gain in pitch accuracy score on 81.4% of the occasions.

Both tests (*Welch* $F(2,31.6) = 4.89$, $p = .014$; *Brown-Forsythe* $F(2,35.8) = 5.38$, $p = .009$) confirmed these results and indicated that the mean gain in pitch accuracy scores were not similar in the three groups. Consequently, there is significant evidence to reject the null hypothesis and conclude there is a difference in the improvement of scores from first to second vocal response by type of instruction. Thus, follow-up post hoc tests were conducted to evaluate pairwise differences among group means to provide comparisons of differences in mean gain between groups. Dunnett's test that assumes no equality of variance was used for post hoc analyses. Post hoc tests suggested that the average gain in vocal scores of participants who received RTVF instruction was significantly better than participants who received TCVC instruction (difference in mean gain = 6.5, $p = .035$) and PAF instruction (difference in mean gain = 11.2, $p = .029$). Post hoc tests indicated not significant difference, but inspection of the descriptives revealed that participants who received TCVC instruction improved more than participants who received PAF instruction (difference in mean gain = 4.71, $p = .487$).

CHAPTER FIVE: DISCUSSION

This chapter will present a brief summary of the study, purpose, and procedure. Findings are discussed and are related to prior research. This chapter describes the limitations of the study, and offers recommendations for possible directions in future research. Finally, Chapter 5 concludes with implications the current study may have for both private voice instruction practices and K-12 curriculum.

Summary of the Study

Pitch improvement scores as measured through semi-analytic software (Sing & See, Cantovation Ltd., Auckland, New Zealand) were compared between three groups each receiving different types of instructions: Traditional Corrective Verbal Cues (TCVC)), Performed Audio Feedback (PAF), and Real-Time Visual Feedback (RTVF). The researcher used a quantitative, post-test only control group design. The difference in the two attempts was sought in an effort to determine the effects of the interventions of RTVF and PAF with TCVC as compared to TCVC alone. Using a one-way, between groups ANOVA, the dependent variable, pitch accuracy improvement scores, were compared to examine the effects of the three groups.

Because participants were randomly assigned to treatment groups through a number randomization program (www.random.org), they were assumed to be equivalent. However, numbers of semesters of voice taken by participants and participant's menstrual status were considered influential per the literature (Gackle, 1991; Gackle, 2009; Filipa et al., 2012) and examined in all three groups. An ANOVA and Chi-square test of independence were carried out to determine whether the two variables, menstruation status and semesters of voice taken, were similar across groups.

Summary of Findings and Prior Research

Instructional Type

Results show that the average change in pitch accuracy scores were different according to instruction type. Participants were instructed to listen to a target pitch and match the target as closely as possible, singing a five-second straight-tone sample. The vocal responses were recorded and calculated into semitones by Sing and See software (Cantovation, New Zealand). Each group received a different intervention, after which, the participant sang a second attempt. The difference between the fist and second attempt was the pitch change, converted into cents to yield a pitch accuracy score. The average gain in vocal scores of participants who received RTVF instruction was statistically significantly better than participants who received TCVC instruction and PAF instruction. While analyses indicated no significant difference among other groups, an inspection of the descriptives revealed that participants who received TCVC instruction improved more than participants who received PAF instruction. Further, upon examining improvement descriptives, it is interesting to note that consistent with results the most significant improvement in the difference between the first vocal response and the second vocal response was shown in RTVF group, which improved an average of 11.72 cents (*SD* 9.64). This sizable improvement is indeed significant in light of the smaller improvements made by the other instruction types, as TCVC improved an average of 5.34 cents (*SD* 4.62), and PAF improved only 0.61 cents (*SD* 15.53).

An explanation of how RTVF improves learning can be understood in light of Siegler's (1998) Information Processing Theory (IPT) and research that suggests that visualization is important to learning. IPT holds that during second phase of processing the event (e.g. the listener focusing on the target pitch) receives attention. The second phase (attention) continues into the third phase (memory) if, and only if, encoding occurs between the two phases. Without the encoding of the new information, the information is not learned, or is considered to be lost. With encoding, or making meaning of the information, memory continues into the fourth phase of thinking, and ultimately, to the final phase, response. Results of several studies (Bernardi et al., 2013; Howard, 2005) support visualization's role in learning by bridging the gap between the encoding phase and the attention phase, as was provided to the RTVF treatment group, especially when verbal feedback is present.

When students have to stop to digest the teacher's comments, such as is necessary in TCVC, their response is slowed down, whereas visual feedback enables the learner to more quickly process what is said verbally and respond more immediately (Howard, 2005). The significantly better improvement by the RTVF group may also be due to the superior benefits of "continuous, contextual feedback with information about degree of accuracy, and continuous but categorical (right/wrong) feedback" (Wilson et al, 2008, p.157).

The significant improvement in the difference between the first vocal response and the second vocal response in RTVF group is consistent with other studies (Brown et al., 1999; Feng, Zheng, Zhang, Song, Luo & Li, 2011; Macpherson, & Ward, 2011; Nix et al., 2012; Reifinger, 2013; Thorpe et al., 1999; Van Gog, Paas, Marcus, Ayers, & Sweller, 2009) that suggest visualization can improve learning, that according to (Bernardi et al, 2013) is afforded by imagery and mental practice. Bernardi et al's (2013) findings suggest that visualization improves learning due to quicker responses from the neural pathway to the pianist's hands. As applied to this study, pitch accuracy improvement through visualization can be attributed to the quicker response time of the larynx to the command of the frenetic nerve. Therefore, RTVF provides a constant feedback as to "right/ wrong" singing, and allows the learner to immediately correct pitch attempts. These findings in light of both theory and additional empirical research are discussed further in this chapter.

Semesters of Vocal Training

Prior to examining the primary research question, preliminary analyses were conducted to investigate the differences in participants' semesters of vocal training across groups. A one-way ANOVA showed that there was no statistically significant difference in numbers of semesters of voice taken by female participants across group assignments. The average number of semesters of voice taken in each group was 4.61 (*SD* 1.18). Further, results from the current study show that there is not a significant difference in the pitch accuracy scores of the participants based on the number of semesters of voice taken. Hence, numbers of semesters of voice taken was not considered to be an attributing factor in the change of pitch accuracy improvement scores that were relatively close in the mean change of scores ranging from 4.6 – 6.6 cents across the three groups. These findings are surprising in light of research (Estis, Dean-Claytor, Moore, & Rowell, 2011; Estis, J. M., Coblentz, J. K., & Moore, R. E. ,2009) that suggests vocal training and length of training are influential factors in pitch-matching accuracy. An explanation for the results in the current study could be found in the small intervals of time, a fifteen-week semester that divided the students into different categories of training.

Menstrual Status

Preliminary analyses were conducted to examine the differences in proportion of menstrual participants across groups. A one-way ANOVA showed that there was no significant different in the proportion of menstruating female participants across group assignments. Based on existing research (Gackle, 1991; Gackle, 2009; Filipa, Sundberg, Howard, Saccuto, & Freitas, 2012; Willis & Kenny, 2011) the current study considered menstruation as a factor that could influence the vocal responses of participants. A chi-square test for independence performed suggested that menstruating and non-menstruating participants were evenly distributed in all the three groups, showing the effectiveness of random allocation. Since the number per group did not differ, it was assumed that this variable influenced the participants similarly across groups. However, further analysis, consistent with previous research (Gackle, 1991; Gackle, 2009; Filipa et al., 2012; Willis & Kenny, 2011), did reveal that menstruation is an important factor to consider when studying pitch. Results showed a significantly better pitch improvement in non-menstruating participants, as compared to pitch improvement in menstruating participants.

Findings reveal a difference in pitch score improvement based on menstrual status reported on the morning of the experiment. Thirty-nine non-menstruating participants improved an average of 10.10 cents (*SD* 8.41), indicating that this group moved closer toward the target pitch after the intervention. The twenty menstruating participants, however, actually strayed farther from the target pitch an average of -2.40 (*SD* 12.92). It is also worthy of note that all non-menstrual participants improved more than the menstrual participants, regardless of treatment. RTVF non-menstruation participants improved an average of 14.81 cents (*SD* 9.12), as compared to the menstrual participants in the same treatment with an average of 2.71 cents (*SD* 3.73). TCVC non-menstruating participants improved an average of 7.34 cents (*SD* 2.32), which is more than twice the improvement made by the menstruating participants with an average of 3.1 cents (*SD* 5.53). PAF non- menstrual participants improved an average of 7.21 cents (*SD* 8.5), as compared to menstrual participants in the same treatment with an average of -14.83 (*SD* 9.1), indicating a regression away from the target pitch.

The consideration of menstruation's influence on the pitch accuracy is seen in the gain in pitch score among non-menstruating participants, which ranged from -9.8 to 34.9, and it ranged from -36.8 to 12.5 among menstruating participants. These findings can be explained by the fact that vocal folds are swollen at the time of menstruation (Gackle, 1991; Gackle, 2009; Filipa et al., 2012; Willis & Kenny, 2011).

Findings as an Extension of Previous Empirical and Theoretical Research

The current study was crafted from recommendations made in existing literature, and the results were found similar to what has been previously found and are supported by theory. Larrouy-Maestri and Morsome's (2012) study is the most similar to the current study in terms of focus on pitch accuracy measurement, however; the current study differs from Larrouy-Maestri and Morsome's (2012) study in terms of the population studied and in the testing requirement of the use of straight-tone sample. Larrouy-Maestri and Morsomme (2012) recommended that trained singers be the focus of research to determine pitch accuracy; thus, this study considered only this unstudied population. Further, Larrouy-Maestri and Moresomme (2012) also recommended the use of straight tone, since many of the samples in the (2012) study were not usable for analysis due to the presence of vibrato. The current study, therefore, responded to these recommendations by choice of unstudied population of only trained singers and in the requirement of straight-tone singing in the experiment and, thus, added to the current body of knowledge in terms of efficacy pitch accuracy instruction methods as measured by pitch improvement scores in female collegiate voice majors.

Unlike Larrouy-Maestri and Morsome's (2012) study that focused on traditional corrective cues (Larrouy-Maestri & Morsome, 2012), the current study focused on methods using integrated instruction sources in an effort to remove extraneous mental load during the pitch perception and production process. Since singing requires the student to self-monitor output and simultaneously compare the produced tone with internal memory of accurate pitch (Tsang et al., 2011), the current study focused on the effect of reduced cognitive load. Therefore, this study was driven by Cognitive Load Theory, and not only were the results are supported by the theory, but the study also applied the theory into a new area of study.

Cognitive Load Theory (Moreno et al., 1995; Mousavi et al., 1996; Owens & Sweller, 2008; Paas et al., 2010; Sweller, 2010, Sweller & Chandler, 1991; Sweller et al., 1998; Sweller & Sweller, 2006; Tindall-Ford et al., 1997) suggests that deeper learning in terms of transferring newly learned information to other tasks occurs in an integrated format, suggesting that the integrated information format lightens the working memory effort in processing new information and reduces split-attention effect. Studies (Moreno et al., 1995; Mousavi et al., 1996; Owens & Sweller, 2008; Paas et al., 2010; Sweller, 2010, Sweller & Chandler, 1991; Sweller et al., 1998; Sweller & Sweller, 2006; Tindall-Ford et al., 1997) have shown that split-attention effects are reduced when learners can focus on one source of information. Due to the reduction of split-attention effect in the integrated instruction source, students, like those in previous studies applying this theory to other disciplines (Roodenrys, Agostinho, Roodenrys, & Chandler, 2012; Tindall-Ford et al., 1997), who received dual-mode instruction integrating visual and audio sources into one format, had a reduction of burden on their working memory. These study's (Roodenrys, Agostinho, Roodenrys, & Chandler, 2012; Tindall-Ford et al., 1997) findings showed improved learning outcomes in groups that received integrated dual mode instruction. These results, as well as the results in the current study show the benefits of lightened cognitive load. The lightened load within the context of singing, which requires retaining previously introduced information and interpreting new information, yields faster communication from the brain's frenetic nerve to the laryngeal processes; thus, producing more accurate pitch in singing

(McCoy, 2004).

The findings of the current study were in alignment with the Cognitive Load Theory. The theory considers instruction futile that demand the learner “holds in working memory information from one source, while searching for associated referents from another source” (Owens & Sweller, 2008). However, the RTVF treatment spatially integrated the visual and auditory sources into a single focus by the constant corrective measures seen on the projected voice tracing of the student’s sung attempts (Tsang, et al., 2011). As the student sang, she was able to see and hear her voice in relationship to the target pitch. Therefore, the target pitch was actually visualized instead of imagined, as both proximity and direction are afforded through this integrated feedback.

The results support what CLT holds concerning the integration of instruction sources, as seen in the mean change in scores of 11.7 from first to second vocal response among girls in the RTVF group, as compared to the mean change in scores of 5.7 in the TCVC group, and .6 in the PAF group. These results provide further evidence to suggest that the simplified and integrated instruction does indeed, reduce the split-attention effects, and allow the working memory to be lightened. Since the major difference in the instruction types centers on the navigation model previously discussed, it is clear that when the pitch is seen instead of imagined, the working load is lightened and the navigation toward the target pitch is more accurately attained.

Many researchers (Low & Sweller, 2005; Moreno & Mayer, 1999; Mousavi, Low & Sweller, 1995; Sweller & Sweller, 2006; Sweller, Van Merrienboer, & Paas, 1998; Tindall-Ford, Chandler, & Sweller, 1997; Todd & Mishra, 2012) agree upon characteristics that qualify methods as those capable of reducing split-attention effect. Specifically, Owens and Sweller’s (2008) state “spatially integrating or simultaneously delivering sources of information are two of the methods of lowering extraneous cognitive load associated with the split-attention effect" (Owens & Sweller, 2008, p. 32). As applied to this study, RTVF meets both of these criteria in that the visual feedback is integrated with the audible, and both sources are delivered in one place simultaneously, on the screen showing the voice in real-time; thus the theory explains why the gains in pitch scores were highest in this group.

The transferring of newly learned information (pitch target) to other tasks (vocal response) was made simpler by removing any pauses the learner must experience within the transfer process, which as applied to this study, meant taking out the stalled time the learner needed to interpret what verbal instruction (TCVC). The learner was able to skip the interpretation process, which holds the same function as the encoding process in Seigler's (1998) Information Processing Theory. Since this study employed TCVC immediately followed by the intervention (RTVF) improvement in pitch accuracy scores is attributed to the instruction intervention of RTVC, that yielded the largest score improvement of 11.7 cents as compared to TCVC (5.7 cents) and PAF (0.6 cents).

Cognitive Load Theory and TCVC Results

Unlike the RTVF, gaining 11.72 cents (*SD* 9.64) group, the TCVC group, gaining 5.34 (SD 4.62) did not experience as high gains in the pitch scores, which can be understood in light of the findings from existing research (Leahy & Sweller, 2011) that focus on the negative impacts of pauses on the learning process. As applied to this study, Leahy and Sweller's (2011) findings support the premise that the pauses in TCVC divert attention away from the target pitch in order to interpret meaning of the teacher's instruction. It is in the making meaning of the instruction that the pause occurs (Leahy & Sweller, 2011), and this likely explains the lower TCVC pitch accuracy scores in the current study; which is unfortunate, as TCVC is currently the primary and normally, exclusive leans of pitch instruction in the private voice studio (Reifinger, 2013).

Specifically, TCVC does not integrate information sources, but rather interrupts the student's attempt. In this treatment, the student is a given command such as "that note was a little flat", or "that note was a little sharp," and the student is expected to understand the implication of what is being said as well as the degree to which she is erring. It is clear that TCVC alone does not meet the standards for methods that reduce split-attention effect (Leahy & Sweller, 2011), and therefore explains why pitch accuracy gains in this group were not as high as those in the RTVF group.

Cognitive Load Theory and PAV Results

PAF group scored the lowest of the three groups. This may be explained by considering Leahy and Sweller's (2011) study, which showed that overloading the working memory not only slows learning, but is also be counterproductive. This theory holds true to the fact that seven of the twenty PAF participants actually regressed in their pitch accuracy; meaning that their first attempt before hearing themselves in playback was actually better than after the intervention. Not only did this group experienced the pause in learning to interpret meaning from the TCVC as described above, the PAF had a second pause that diverted attention from the target (Granot et al., 2005; Leahy & Sweller, 2011); namely, the playback of the student's own voice. The PAF participant heard her initial attempt, through headphones followed by the target pitch. PAF group showed a mean change in pitch score of only .61 cents (*SD* 15.53). Based on Leahy and Sweller's (2011) study the extra mental load slowed learning in PAF because the participant had to compare her own recorded response to the target pitch, and basically choose which one to esteem as the model (Granot et al., 2005). The lack of improvement with PAF is further supported by Granot et al's (2012) work that supports the individual's sympathy toward personal voice. The participants' confrontation with two pitches partially explains why PAF group did not successfully sing toward the target pitch.

Further, research (Tsang, Friendly, & Trainor, 2011) suggests that the delay, or pause between the target pitch and participant's production, is a contributing factor towards pitch inaccuracy. Trainor et al's (2011) findings support the lack of improvement in the PAF group due to the delay between the playback of participant's own voice and the target pitch.

Implications for Practice

K-12 and collegiate programs alike are continuously faced with accountability and measureable learning outcomes. The results of this research study have implications for those at the K-12 and collegiate level in both teaching and curriculum planning, since singing proficiency is most often measured in terms of pitch accuracy (Tsang et al., 2011). Although most voice programs rely solely on the ear of the teacher to make pitch judgments (Matthis, Traser, Markl & Richter, (2011); Erickson-Levendoski & Sivasanker, 2011; Morrow & Connor, 2011), integration of semi-analytic voice training software into the traditional lesson offers the student an integrated source of feedback (Wilson, Abbott, Lusher, Gentle, & Jackson, 2010) and a more objective measurement of pitch. Therefore, the findings of this study suggest the addition of real-time visual feedback as a weekly component of the studio voice lesson.

The adoption of real-time visualized feedback will effect the studio's physical arrangement to some degree. These physical changes in the voice studio can be minimal or elaborate to accommodate integrated instruction methods for pitch accuracy. Visualization of the student's voice can be shown on a laptop computer or by use of a projector and a large white board on the wall.

Further, offering a week-by-week check-up in which the student is tested for pitch accuracy would serve as documented history of progress, which would be useful to accrediting associations calling for measureable learning outcomes (NASM, 2014). As the software records the student's sung attempts, it also has the option to generate a hard copy of what has been recorded. This would serve as a historical hard copy of student pitch accuracy progress. The print out is basically a hard copy of the student's pitch attempts and shows the distance from the target pitch in the form of a grid.

The weekly pitch progress print-out would also be helpful for the female student, as it would provide a way to look back and trace pitch accuracy when menses was/ was not present as a means of vocal care during menstruation, as vocal folds are swollen during menses (Gackle, 1991; Gackle, 2009; Filipa et al., 2012). Further, the results of this study concerning the lack of pitch accuracy attributed to the presence of menstruation regardless of instructional method may influence the expectations teachers have of their female students in the studio when menstruation is present. Thus, the teacher needs to sensitive to the swelling of the vocal folds by making wise choices as to the rigor of the repertoire of that particular lesson. Extra care and attention may be warranted concerning the extremes of the range being worked in the presence of menstruation as well (Filipa et al., 2012).

As pitch accuracy navigation improves as measured by print-outs, it is recommended that the teacher move toward a recorded lesson as the practice material for the upcoming week in an effort to encourage mental practice, which has shown to be effective in music studies (Bernardi et al., 2013). If the student records the lesson and sings through it during the week for practice, the personal voice is recognized, and due to improved pitch navigation, according to research (Granot et al., 2012) the student should detect the pitch errors in the voice.

The theoretical underpinnings of this study lend credibility to the results as applied to instructional reform as it is commonly accepted that a reduction in split-attention lightens to working memory and yields efficient learning. While choosing an instructional method should be based on data-driven research and theory (NASM, 2013), the individual needs and tendencies of students also must be considered (Hedden, 2012). The student's propensity towards visual and aural learning should be considered in curriculum and instruction choices (Eldridge, Saltzman, & Lahav, 2010). Further, the individual's resistance to a change in instructional methods must be considered to gauge the timing of any changes during the training process, especially when one method has been considered the norm, and another is introduced.

As noted above, it is crucial that the adoption of pitch accuracy software is not considered to be a replacement for the presence of a live voice professional with the capability to combine many factors when adjudicating the student's performance such as tone, timbre, and expression (Eldgridge, et al., 2010; Goller, Otten, & Ward, 2009; Nix, Matthews-Muttwill, 2012). Above all, the instructor must keep the focus on independent navigation abilities instead of focusing on new methods, or else the student may start to doubt their own abilities once the technology is not present when actually performing (Eldridge, et al., 2010).

Limitations

While this study used a rigorous design, limitations still existed. Caution should be used when making generalizations based on the presented research findings alone, due in part to the following possible factors:

1. the study was open to all female voice students, who had studied voice for three consecutive semesters and were enrolled in this University. This means that the male population was not included, which opens an obvious area for future

research;

2. the vocal responses of the participants were drawn from a 5 second sample, in which time it is possible that the participant performed much better or much worse than was typical; and,

3. the data were collected in a single day within a 2 hour time frame in the month of January, when many of the participants could have been suffering from winter colds or respiratory infections, as these were common within the University at the time of testing. This means if the data had been collected at a different time of the year when colds were not typical, results may have been different.

These findings do not account for the participant's personal effort to give the best attempt to sing center pitch since personal effort cannot be measured. These limitations provide insight into areas in which further research can be done.

Recommendations for Future Research

The following recommendations for further study are made based on the procedures, limits, and findings from this study:

1. the study was open to female voice students only. Perhaps the inclusion of the male population would allow the researcher to gain insight as to gender differences and similarities regarding instruction type efficacy. Of special interest in this type of study might be the assumption that males tends to be more visual in their learning than females (Whitmir & Bailey, 2010; Coddington & Guthries, 2009);
2. the vocal responses of the participants were drawn from a 5 second sample, in which time it is possible that the participant performed much better or much worse than was typical. Perhaps a longer sample, or an average of several vocal responses would yield a different vocal response. This would allow the researcher to take several samples and would be

able to ascertain the students' typical pitch production;

3. the data were collected in a single day within a 2 hour time frame in the month of January, when many of the participants could have been suffering from winter colds or respiratory infections, as these were common within the University at the time of testing; meaning that if the data had been collected at a different time of the year when colds were not typical, results may have been different. Perhaps if the study was replicated during a different season, results would be different due to clearer tones produced when allergy counts are lower, or sinus and cold mucus is minimized; thus, allowing for freer vocal production;
4. further, since it is impossible for the vocalist to be constantly guided by RTVF in real-life performance situations, it is clear that internal, independent pitch navigation must be the goal of the implementation of any instruction type. Therefore, it is recommended that future research expand the current study by a focus on the pitch navigation skills of learners trained weekly with these three instruction types in a situation where the instruction type is removed, and the learner's pitch accuracy is simply measured by the vocal response. This would allow the researcher to determine if the instruction type truly produces a long-term independent navigation toward center pitch in the absence of the instruction itself; and lastly,
5. since the current study recorded vocal responses from the sample on 1 day, the participants who reported the presence of menstruation, were not measured for pitch accuracy on another day when menstruation was not present. Therefore, replication of this study followed by a repeat study with the same participants 2 weeks later would allow the researcher to see all individuals' pitch accuracy performance both with and

without menstruation.

Conclusions

To some extent, the use of increased data-driven instruction methods and measurable learning outcomes have not been embraced by the vocal teaching profession at large. The study of vocal pedagogy is still a young science, which has only in the last 15 years been able to benefit from examination of the intricacies of the immediate vocal production process, allowed by technologies such as the distal-chip camera for aerodigestive endoscopy. Clinical application of developing technology and tools for laryngologists and voice specialists has opened the door for the marriage of a quantitative science and what was once considered a qualitative art. The findings of this study speak to the quantitative effects of instruction methods and embrace an objective adjudication of pitch accuracy. Specifically, the findings show that real-time visual feedback is significantly more effective in pitch guidance as compared to traditional corrective verbal cues alone and performed audio feedback in improved pitch accuracy scores in female collegiate voice students. Findings also show that traditional corrective verbal instruction is only slightly more effective than performed audio instruction.

These findings also indicate that menstruation plays a role in the accuracy of produced pitch regardless of instruction type, and it is suggested that pedagogy within the private vocal studio consider these findings in terms of expectations for menstrual female students during the private lesson. In the spirit of adopting more consistent, research-driven, and systematic voice teaching methods, the insights gained from this study will provide educational leaders with quantitative data concerning efficacy of three pitch instruction methods.

The RTVF treatment with an integrated source of instruction, shown in research to reduce the working memory load (Aldalalah, 2010), and reduce split-attention effect (Owens & Sweller,

2009) made this type of instruction the most useful in improving pitch accuracy. The presence of menstruation was shown to be a factor that needs to be considered when studying pitch accuracy; however, it was not considered in this study as this variable was distributed equally across the groups under study. Results of this study call into question the efficacy of the most common pitch instruction method, TCVC, and recommend the addition of real-time visual feedback within the weekly studio lesson.

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APPENDIX A: JURY SHEET AND VOCAL STANDARDS

	Rhythmic Accuracy	Pitch Accuracy	Intonation	Phrasing	Diction	Tone Quality	Dynamics	Breathing Technique	Performance	Posture / Alignment
Excellent 25 pts	Rhythms are consistently accurate as notated enhancing the overall performance. Professional level rhythmic accuracy.	Pitches are consistently accurate as notated enhancing the overall performance. Professional level pitch accuracy.	Intonation is consistently accurate performance. Professional level intonation.	Phrasing is consistently accurate as notated enhancing the overall performance. Professional level phrasing.	Vowels are stable and consistent; consonants are clean, crisp and appropriate to the language being sung enhancing the overall performance. Professional level diction.	Tone is consistently focused, clear, centered, and ringing tone throughout the dynamic range enhancing the overall performance. Professional tone quality.	Dynamics are consistently accurate enhancing the overall performance. Professional level dynamics.	Breath mechanics are consistently employed enhancing the overall performance. Professional level technique.	Performer sings from memory, communicating the emotional sense of the piece at all times. Professional level performance.	Student exhibits a balanced, free, and flexible posture throughout the performance.
Good 20 pts	Incorrect rhythms rarely occur without detracting from the overall performance.	Incorrect pitches rarely occur without detracting from the overall performance.	Intonation is usually accurate without detracting from the overall performance.	Incorrect phrasing rarely occurs without detracting from the overall performance.	Vowels are rarely inaccurate, consonants are rarely unclear without detracting from the overall performance.	Tone is usually focused, clear, centered, and ringing tone throughout the dynamic range without detracting from the overall performance.	Dynamics are usually accurate without detracting from the overall performance.	Breath mechanics are usually employed, without detracting from the overall performance.	Performer sings from memory, usually communicating the emotional sense of the piece without detracting from the overall performance.	Student exhibits a balanced, free, and flexible posture throughout most of the performance.
Fair 15 pts	Incorrect rhythms occasionally occur detracting from the overall performance.	Incorrect pitches occasionally occur detracting from the overall performance.	Intonation is usually accurate, but detracting from the overall performance.	Incorrect phrasing occasionally occur detracting from the performance.	Vowels are occasionally inaccurate, consonants are occasionally unclear, detracting from the performance.	Tone is mostly focused, clear, centered throughout the dynamic range, detracting from the overall performance.	Dynamics are sometimes accurate detracting from the overall performance.	Breath mechanics are often employed, but detract from the overall performance.	Performer sings from memory, occasionally communicating the emotional sense of the piece, detracting from the overall performance.	Student exhibits a balanced, free, and flexible posture throughout some of the performance. At times posture becomes rigid.
Poor 10 pts	Incorrect rhythms frequently occur detracting from the overall performance.	Incorrect pitches frequently occur detracting from the overall performance.	Intonation is rarely accurate, detracting from the overall performance.	Incorrect phrasing frequently occur which detracting from the performance.	Vowels are frequently inaccurate, consonants are frequently unclear, detracting from the performance.	Tone is rarely focused, clear, centered throughout the dynamic range, detracting from the overall performance.	Dynamics are rarely accurate within the ensemble, detracting from the overall performance.	Breath mechanics are rarely employed, detracting from the overall performance.	Performer occasionally sings from memory and occasionally communicates the emotion of the piece detracting from the overall performance.	Student exhibits a unbalanced, rigid, and inflexible posture throughout some of the performance.
Unacceptable 0 pts	Incorrect rhythms consistently occur significantly detracting from the overall performance. Rhythms generally unrecognizable.	Incorrect pitches consistently occur significantly detracting from the overall performance. Pitches generally unrecognizable.	Intonation is never accurate, significantly detracting from the overall performance.	Incorrect phrasing significantly detracting from the overall performance.	Vowels are consistently inaccurate, consonants are consistently unclear, significantly detracting from the overall performance.	Tone is never focused, clear, centered throughout the dynamic range, significantly detracting from the overall performance.	Dynamics are never accurate significantly detracting from the overall performance.	Breath mechanics are never employed, significantly detracting from the overall performance.	Performer does not sing from memory and does not communicate the emotion of the piece significantly detracting from the overall performance.	Student exhibits a unbalanced, rigid, and inflexible posture throughout all of the performance.

Ratings ________ ________ ________ ________ ________ ________ ________ ________ ________ ________

APPENDIX B: LETTER OF INVITATION

Dear Voice Student,

You are invited to participate in a research study of pitch accuracy instruction methods. You were selected as a possible participant because you are a female voice student who has had at least three semesters of vocal training. Participation in this study is completely voluntary and has no bearing on any academic standing whatsoever. I ask that you read this form and ask any questions you may have before agreeing to be in the study.

In an effort to obtain my doctoral degree, I am conducting this study in conjunction with the School of Education .The purpose of this study is to explore pitch accuracy based on instruction type. If you agree to be in this study, I would ask you to do the following things:

Please arrive at the test site (SOR 119) on Saturday, January 25, 2014 at 10:15 AM. At this time you will be given a brief vocal warm-up to prepare you for the testing which will require you to sing two pitches. Your attempts to match the target pitch will be digitally recorded for analysis in the study.

Your involvement time including check-in, wait time, to completion of testing will be between 45 minutes – 2 hours, although the time you will actually be test will only last for three minutes.

Upon completion of your participation, you will receive compensation in the form of a download of a voice training software valued at $49.99. This download code will be given to you by the liaison as you exit the test center upon completion of your participation in the study.

The records of this study will be kept private. In any sort of report I might publish, I will not include any information that will make it possible to identify a subject. Research records will be stored securely and only the researcher will have access to the records. Audio records are stored on a password secure computer. Your name will not be linked to the test sample. Instead a numeric code will serve as the link to the data.

The researcher conducting this study is Mindy Damon. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact Mrs. Damon at bmdamon@liberty.edu.

Thank you for your participation,

Mindy Damon

APPENDIX C: RECRUITING ANNOUNCEMENTS MADE IN CLASS

If you are a female voice student who has completed at least three semesters of voice, you are eligible to participate in a study on pitch accuracy instruction methods on Saturday, January 25 at 10:15 a.m. in SOR. Please email Mrs. Damon (bmdamon@liberty.edu) if you are willing to participate in this study. All participants will receive free voice training software valued at $49.99 for participation.

APPENDIX D-1: **TCVC WELCOME AND INSTRUCTIONS SCRIPT**

Slide 1

“Welcome. Thank you for your participation in this study. Please do not talk while waiting in the waiting room. Please drink the bottled water as you wait. Feel free to read or work quietly in your seat until a liaison calls your name and escorts you to the test lab.

Slide 2

Your time requirement will be anywhere from 30 minutes to 2 hours depending on when your name is called to go to the test room.

Slide 3

When your name is called, please take all of your belongings with you. You will not return to the waiting room. Please give your data card to the Liaison. Follow the liaison to the lab. Please do not talk to the liaison on the way to the room. Your belongings will remain in the hall with the liaison while you are testing. The liaison will show you where to stand and will give you the provided headphones. The liaison will leave, and an assistant researcher will be present during your test in an adjoining area, although you will not see them.

Slide 4

Try to do the following things:

Match the target pitch, use an “ah” vowel, sing with a straight tone, and hold the tone for three seconds. You will be told when to stop singing.

Please do not do the following things:

Do not speak at all. Do not ask to try again. Do not sing with vibrato for the test. Your time in the lab will be approximately three minutes. Upon completion of the test your liaison will give you the voice training software code for your complimentary download as a token of thanks for your participation. As soon as you receive the gift from the liaison, please exit the building and do not return during testing hours.

Slide 5

Let's warm up your voice now. Please stand and sing the following exercises with lower abdominal support and a raised soft pallet. Sing the exercise on an "ah" vowel. Here is an example of the exercise: _________________ (sung and played)

Please sing the exercises now: ________________ (played only)

You are asked to use no vibrato during the test, and to sustain the pitch for three seconds. You will be told you when to stop singing. Now let's discuss straight tone singing.

Slide 6

Please listen to the sample of straight-tone singing as compared to singing with vibrato.

This is a tone with vibrato ____________

This is a straight tone (with no vibrato) ___________

Now, using a [a] ("ah") vowel, please sing a straight-tone note on the following target pitch and sustain it for three seconds.

Stand by for the target pitch ___________

Match the target pitch now ___________

Slide 7

After your first attempt, you will be told to either “sing higher” if your pitch is flat, or “sing lower” if your pitch is sharp.

Slide 8

You will then hear the target pitch again. Your goal is to sing the center of the pitch matching your pitch to the target pitch following the directions to either sing higher or lower. Now try to match the pitch again.

Stand by for the target pitch ___________

Match the target pitch now ___________

Stop.

Slide 9

Please wait quietly for your name to be called. Thank you for being a part of this study today.”

APPENDIX D-2: PAF WELCOME AND INSTRUCTIONS SCRIPT

Slide 1

“Welcome. Thank you for your participation in this study. Please do not talk while waiting in the waiting room. Please drink the bottled water as you wait. Feel free to read or work quietly in your seat until a liaison calls your name and escorts you to the test lab.

Slide 2

Your time requirement will be anywhere from 30 minutes to 2 hours depending on when your name is called to go to the test room.

Slide 3

When your name is called, please take all of your belongings with you. You will not return to the waiting room. Please give your data card to the Liaison. Follow the liaison to the lab. Please do not talk to the liaison on the way to the room. Your belongings will remain in the hall with the liaison while you are testing. The liaison will show you where to stand and will give you the provided headphones. The liaison will leave, and an assistant researcher will be present during your test in an adjoining area, although you will not see them.

Slide 4

Try to do the following things:

Match the target pitch, use an “ah” vowel, sing with a straight tone, and hold the tone for three seconds. You will be told when to stop singing.

Please do not do the following things:

Do not speak at all. Do not ask to try again. Do not sing with vibrato for the test. Your time in the lab will be approximately three minutes. Upon completion of the test your liaison will give you the voice training software code for your complimentary download as a token of thanks for your participation. As soon as you receive the gift from the liaison, please exit the building and do not return during testing hours.

Slide 5

Let's warm up your voice now. Please stand and sing the following exercises with lower abdominal support and a raised soft pallet. Sing the exercise on an "ah" vowel. Here is an example of the exercise: _________________ (sung and played)

Please sing the exercises now: ________________ (played only)

You are asked to use no vibrato during the test, and to sustain the pitch for three seconds. You will be told you when to stop singing. Now let's discuss straight tone singing.

Slide 6

Please listen to the sample of straight-tone singing as compared to singing with vibrato.

This is a tone with vibrato ____________

This is a straight tone (with no vibrato) ___________

Now, using a [a] ("ah") vowel, please sing a straight-tone note on the following target pitch and sustain it for three seconds.

Stand by for the target pitch ___________

Match the target pitch now ___________

Slide 7

After your first attempt, you will be told to either “sing higher” if your pitch is flat, or “sing lower” if your pitch is sharp.

Slide 8

You will then hear your recorded voice and the target pitch played back. Your goal is to match your sung pitch to the target pitch.. Now try to match the pitch again.

Stand by for the target pitch ___________

Match the target pitch now ___________

Stop.

Slide 9

Please wait quietly for your name to be called. Thank you for being a part of this study today.”

APPENDIX D-3: RTVF WELCOME AND INSTRUCTIONS SCRIPT

Slide 1

"Welcome. Thank you for your participation in this study. Please do not talk while waiting in the waiting room. Please drink the bottled water as you wait. Feel free to read or work quietly in your seat until a liaison calls your name and escorts you to the test lab.

Slide 2

Your time requirement will be anywhere from 30 minutes to 2 hours depending on when your name is called to go to the test room.

Slide 3

When your name is called, please take all of your belongings with you. You will not return to the waiting room. Please give your data card to the Liaison. Follow the liaison to the lab. Please do not talk to the liaison on the way to the room. Your belongings will remain in the hall with the liaison while you are testing. The liaison will show you where to stand and will give you the provided headphones. The liaison will leave, and an assistant researcher will be present during your test in an adjoining area, although you will not see them.

Slide 4

Try to do the following things:

Match the target pitch, use an "ah" vowel, sing with a straight tone, and hold the tone for three seconds. You will be told when to stop singing.

Please do not do the following things:

Do not speak at all. Do not ask to try again. Do not sing with vibrato for the test. Your time in the lab will be approximately three minutes. Upon completion of the test your liaison will give you the voice training software code for your complimentary download as a token of thanks for your participation. As soon as you receive the gift from the liaison, please exit the building and do not return during testing hours.

Slide 5

Let's warm up your voice now. Please stand and sing the following exercises with lower abdominal support and a raised soft pallet. Sing the exercise on an "ah" vowel. Here is an example of the exercise: _________________ (sung and played)

Please sing the exercises now: ________________ (played only)

You are asked to use no vibrato during the test, and to sustain the pitch for three seconds. You will be told you when to stop singing. Now let's discuss straight tone singing.

Slide 6

Please listen to the sample of straight-tone singing as compared to singing with vibrato.

This is a tone with vibrato ____________

This is a straight tone (with no vibrato) ___________

Now, using a [a] ("ah") vowel, please sing a straight-tone note on the following target pitch and sustain it for three seconds.

Stand by for the target pitch ___________

Match the target pitch now ___________

Slide 7

After your first attempt, you will be told to either “sing higher” if your pitch is flat, or “sing lower” if your pitch is sharp.

Slide 8

Face the board and this time, and watch your voice (the red dot) that moves when you sing as you are attempt to match the target pitch. The blue line shown here is a sung attempt.

Slide 9

Your goal is to sing the center of the pitch, which is shown as the faint yellow line beside A4. Now try to match the pitch again by lining up your voice with the faint yellow line.

Stand by for the target pitch ___________

Match the target pitch now ___________

Stop.

Slide 10

Please wait quietly for your name to be called. Thank you for being a part of this study today.”

APPENDIX E-1: TRADITIONAL CORRECTIVE VERBAL CUES TEST SCRIPT

Track #1

“You will be asked to match a target pitch. Please match the target pitch as precisely as you can using a straight tone, and sustain the pitch for five seconds on an “ah” vowel. You will be told when to stop singing. You will be instructed to either “sing higher” or “sing lower” to match the center of the target pitch. Following these directions attempt the pitch again. After you have sung the pitch you will exit the room and the building. Now let’s begin the test.

Please standby for target pitch. _________This is the pitch you are asked to match using a straight-tone [a] vowel.

Listen to the target pitch again. ____________

Sing the pitch now (pause)

Stop.”

END TRACK 1

Track #2

“The pitch you sang was flat. You need to sing higher.

Listen to the pitch again __________

Please sing the pitch now (pause)

Thank you for your participation. You may now collect your belongings from the hall, receive your gift and exit the building. Goodbye.”

Track # 3

“The pitch you sang was sharp. You need to sing lower.

Listen to the pitch again _________

Please sing the pitch now (pause)

Thank you for your participation. You may now collect your belongings from the hall, receive your gift and exit the building. Goodbye.”

END TRACK 3

APPENDIX E-2: PERFORMED AUDIO FEEDBACK TEST SCRIPT

Track #1

“You will be asked to match a target pitch. Please match the target pitch as precisely as you can using a straight tone, and sustain the pitch for five seconds on an “ah” vowel. You will be told when to stop singing. You will be instructed to either “sing higher” or “sing lower” to match the center of the target pitch. Your sung attempt will be played back as well as the target pitch. After you have sung a second pitch you will exit the room and the building. Now let’s begin the test.

Please standby for target pitch. _________This is the pitch you are asked to match using a straight-tone [a] vowel.

Listen to the target pitch again. ____________

Sing the pitch now (pause)

Stop.”

END TRACK 1

Track #2

“The pitch you sang was flat. Please sing higher.

Listen to what you sang _________

Now listen to the target pitch again ________

Please sing the pitch now (pause)

Stop.

Thank you for your participation. You may now collect your belongings from the hall, receive your gift and exit the building. Goodbye."

END TRACK 2

Track # 3

"The pitch you sang was sharp. You need to sing lower.

Listen to the pitch again _________

Please sing the pitch now (pause)

Stop.

Thank you for your participation. You may now collect your belongings from the hall, receive your gift and exit the building. Goodbye."

END TRACK 3

APPENDIX E-3: REAL-TIME VISUAL TEST SCRIPT

Track #1

“You will be asked to match a target pitch. Please match the target pitch as precisely as you can using a straight tone, and sustain the pitch for five seconds on an “ah” vowel. You will be told when to stop singing. You will be instructed to either “sing higher” or “sing lower” to match the center of the target pitch. Your sung attempt will be played back as well as the target pitch. After you have sung a second pitch you will exit the room and the building. Now let’s begin the test.

Please standby for target pitch. _________This is the pitch you are asked to match using a straight-tone [a] vowel.

Listen to the target pitch again. ____________

Sing the pitch now (pause)

Stop.”

END TRACK 1

Track #2

“The pitch you sang was flat. Please sing higher.

This time, turn around and face the board and watch your voice as your sing.

Listen to the target pitch again ________

Please sing the pitch now (pause)

Stop.

Thank you for your participation. You may now collect your belongings from the hall, receive your gift and exit the building. Goodbye."

END TRACK 2

Track # 3

"The pitch you sang was sharp. You need to sing lower.

This time, turn around and face the board and watch your voice as your sing.

Listen to the pitch again _________

Please sing the pitch now (pause)

Stop.

Thank you for your participation. You may now collect your belongings from the hall, receive your gift and exit the building. Goodbye."

END TRACK 3

APPENDIX F: IRB APPROVAL LETTER

December 11, 2013

Betty Damon

IRB Exemption 1741.121113: Instruction Type: Effects on Pitch Accuracy in Female Collegiate Declared Voice Majors

Dear Betty,

The Liberty University Institutional Review Board has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and that no further IRB oversight is required.

Your study falls under exemption category 46.101 (b)(1), which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:

> (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Please note that this exemption only applies to your current research application, and that any changes to your protocol must be reported to the Liberty IRB for verification of continued exemption status. You may report these changes by submitting a change in protocol form or a new application to the IRB and referencing the above IRB Exemption number.

APPENDIX G: DEMOGRAPHICS SURVEY

Pitch Accuracy Instruction Methods Survey

ID Checked __________ Student Name: ____________________________________

Major: Music/ Theatre/ Worship

How many semesters of voice have you taken? (Circle one) 3 4 5 6 7 8

Is Menstruation Present today? (Circle one) Yes/ No

Random Assigned Group ______________ **Participant #_______________**

____

Participant Signature

RESEARCH ASSISTANT:

1. **Use Firefox ONLY**
2. **Name the file exactly as the Participant #**
3. **Save this participants files as a wav file**
4. **Email the files to:** quansah@liberty.edu AND cc: aszapkiw@liberty.edu
5. **Place all data cards in the envelope, seal it, and give to Mrs. Damon/ Ernest Quansah at the end of your morning.**

APPENDIX H: EMAIL REMINDERS

Dear Female School of Music students,

This is a reminder of the **Pitch Accuracy Study** that Mrs. Damon is conducting for her doctoral degree. Thank you to many who have already committed to participate.

Any female student who has completed *at least three semesters* of private voice lessons is invited to participate in this study. Please take time to read the attached document (informed consent) for details and more information on this exciting opportunity.

Please be in Religion Hall 119 promptly at 10:15a.m. on Saturday morning, January 25 to check in.

If you have any questions, please contact Mrs. Mindy Damon at bmdamon@liberty.edu.

Thank you for your help in this study.

APPENDIX I: CONSENT FORM

Instruction Type: Effects on Pitch Accuracy in

Female Collegiate Declared Voice Majors

Betty M. Damon

Liberty University

School of Education

You are invited to be in a research study of pitch accuracy. You were selected as a possible participant because you are a female music major who has had at least four semesters of vocal training. I ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by Mindy Damon in the School of Education at Liberty University.

Background Information:

The purpose of this study is to explore pitch accuracy based on instruction type.

Procedures:

If you agree to be in this study, I would ask you to do the following things:

Please arrive at the test site (SOR 119) on Saturday, January 25, 2014 at 10:15 AM. At this time you will be given a brief vocal warm-up to prepare you for the testing which will require you to sing two pitches. Your attempts to match the target pitch will be audio recorded for analysis in the study. Your involvement time including check-in, wait time, to completion of testing will be between 30-90 minutes, although the time you will actually be test will only last for three minutes.

Risks and Benefits of being in the Study:

The study has minimal risks that are no more than you would encounter in everyday life.

There are no direct benefits to participation in the study. The music education community will benefit from the study in terms of gained knowledge about efficacy of pitch instruction methods. Findings could alter the way private voice instruction is taught, and well as classroom music for

K-12 education. Findings could serve the medical community that deals with cochlear implants as patients are trained to speak and guide the voice after newly gained hearing.

Compensation:

You will receive compensation in the form of a download of a voice training software valued at $49.99. This download code will be given to you by the liaison as you exit the test center upon completion of your participation in the study.

Confidentiality:

The records of this study will be kept private. In any sort of report I might publish, I will not include any information that will make it possible to identify a subject. Research records will be stored securely and only the researcher will have access to the records. Audio records are stored on a password secure computer. Your name will not be linked to the test sample. Instead a numeric code will serve as the link to the data.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Liberty University. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:

The researcher conducting this study is Mindy Damon. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact Mrs. Damon at bmdamon@liberty.edu. You may also contact Mrs. Mindy Damon's advisor, Dr. Amanda Rockinson-Szapkiw at aszapkiw@liberty.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd, Suite 1837, Lynchburg, VA 24502 or email at irb@liberty.edu.

You will be given a copy of this information to keep for your records.

Statement of Consent:

I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

IRB Code Numbers: [Risk] *(After a study is approved, the IRB code number pertaining to the study should be added here.)*

IRB Expiration Date: [Risk] *(After a study is approved, the expiration date (one year from date of approval) assigned to a study at initial or continuing review should be added. Periodic checks* *on the current status of consent forms may occur as part of continuing review mandates from the federal regulators.)*

Statement of Consent:

I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study. I understand that my participation in the study will be audio and video taped.

IRB Code Numbers:

IRB Expiration Date:

APPENDIX J-1: TCVC RESEARCH ASSISTANT INSTRUCTIONS

Pre-Experimental Needs:

1. Set up individual meeting with the principle researcher for a tutoring session on procedure.

2. Download itunes to the computer provided for you for the test.

3. Download the test tracks that have been emailed to you.

4. Please contact principle researcher if you have technical difficulties running the test tracks.

During the Test:

1. Stay behind the privacy curtain in your test lab.

2. Avoid speaking to the participant (let the recorded instructions guide the participant).

Test Tracks:

1. Target pitch (A-440)

2. Instructs student to “sing higher” (indicating flat pitch)

3. Instructs student to “sing lower” (indicating sharp pitch)

TCVC Procedure:

1. Play track #1

2. Judge the pitch according to the computer monitor (by what you SEE)

3. Select track #2 if the pitch is flat, or track #3 if the pitch is sharp

APPENDIX J-2: PAV RESEARCH ASSISTANT INSTRUCTIONS

Pre-Experimental Needs:

1. Set up individual meeting with the principle researcher for a tutoring session on procedure.
2. Download itunes to the computer provided for you for the test.
3. Download the test tracks that have been emailed to you.
4. Please contact principle researcher if you have technical difficulties running the test tracks.

During the Test:

1. Stay behind the privacy curtain in your test lab.
2. Avoid speaking to the participant (let the recorded instructions guide the participant).

Test Tracks:

1. Target pitch (A-440)
2. Instructs student to “sing higher” (indicating flat pitch)
3. Instructs student to “sing lower” (indicating sharp pitch)

PAV Procedure:

1. Play track #1
2. Judge the pitch according to the computer monitor (by what you SEE)
3. Select track #2 if the pitch is flat, or track #3 if the pitch is sharp
4. Play the participant’s first sung attempt back in participant’s headphone

APPENDIX J-3: RTVF RESEARCH ASSISTANT INSTRUCTIONS

Pre-Experimental Needs:

1. Set up individual meeting with the principle researcher for a tutoring session on procedure.
2. Download itunes to the computer provided for you for the test.
3. Download the test tracks that have been emailed to you.
4. Please contact principle researcher if you have technical difficulties running the test tracks.

During the Test:

1. Stay behind the privacy curtain in your test lab.
2. Avoid speaking to the participant (let the recorded instructions guide the participant).

Test Tracks:

1. Target pitch (A-440)
2. Instructs student to "sing higher" (indicating flat pitch)
3. Instructs student to "sing lower" (indicating sharp pitch)

PAV Procedure:

1. Play track #1
2. Judge the pitch according to the computer monitor (by what you SEE)
3. Select track #2 if the pitch is flat, or track #3 if the pitch is sharp

APPENDIX K: RESEARCH ASSISTANT PITCH JUDGING GUIDELINES

In the test lab, you may have several pitches that are harder to declare as “sharp” or “flat” for a variety of reasons. Since all decisions should be made by what is seen on the monitor, and not by what is heard, this presentation will show examples of visual displays of vocal attempts to sing the center of the target pitch with guidelines to help judge with consistency.

You are judging the accuracy of the pitch by determining where the sung pitch spent most of its time (above or below the red line)

Example : Sharp Pitch

The reason this sample is considered “Sharp” is because there are more peeks

above the red line than there are below the red line.

Example: Flat Pitch

This sample is considered “Flat” because there are more peeks below the

red line than there are above the red line.

APPENDIX L: TCVC TECHNICIAN INSTRUCTIONS

1. Using "Sing and See", you will press "Record" a soon as the assistant researcher begins the test. This will occur after the test lab door is closed.

2. After the participant sings the first pitch, say "Second attempt" into the laptop.

3. After the participant sings the second pitch, press "Stop".

4. Name and save the file according to the code on the data card.

5. At the end of ALL TESTS for the day, immediately send an email to the researcher's chairperson containing the wav file and the csv file.

PAF Technician Instructions

1. Using "Sing and See", you will press "Record" as soon as the assistant researcher begins the test. This will occur after the test lab door is closed.

2. After the participant sings the first pitch, say "Second attempt" into the laptop.

3. At the cue, playback the participant's sung attempt and target pitch.

4. After the participant sings the second pitch, press "Stop".

5. Name and save the file according to the code on the data card.

6. At the end of ALL TESTS for the day, immediately send an email to the researcher's chairperson containing the wav file and the csv file.

RTVF Instructions

1. Using "Sing and See", you will press "Record" as soon as the assistant researcher begins the test. This is occur after the test lab door is closed.

2. After the participant sings the first pitch, say "Second attempt" into the laptop.

3. At the cue, show the Visual feedback screen on the screen as the participant sings second attempt (press screen "on" for display).

4. After the participant sings the second pitch, press "Stop"

5. Name and save the file according to the code on the data card.

6. At the end of ALL TESTS for the day, immediately send an email to the researcher's chairperson containing the wav file and the csv file.