CASE STUDY: EFFECTIVE TEACHING METHODS FOR LEARNING STYLES IN PSYCHOACOUSTICS

by

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Thesis directed by Associate Professor Leslie Gaston-Bird

ABSTRACT

As audio professionals in the music industry, we must be sensitive to how our clients' music is perceived by the intended audience. Some audio education programs around the world teach psychoacoustics as part of their curriculum, but there is little documentation on effective teaching methods. I conducted a series of lessons that tested the effectiveness of different teaching methods for various learning styles in psychoacoustics utilizing enrolled undergraduate recording and music business students as my subjects. Students became more restless and inattentive as class went on but thrived in the reading and discussion lesson. The effects learning styles had on the lessons are explained in the conclusion. These findings will guide instructors to develop effective teaching methods for psychoacoustics.

The form and content of this abstract are approved. I recommend its publication.

Approved: Leslie Gaston-Bird

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CHAPTER I

INTRODUCTION

Psychology explains how humans interact with the world. Psychoacoustics is the study of sound perception. It covers how people perceive the audio around them, both commercially and environmentally (Fastl, 2013, p. 1). I have been interested in how we perceive sound and what our brains do to make sense of it.

Psychoacoustics is especially pertinent to recording arts, where we must deliver quality audio to our clients. Audio producers and engineers must be cognizant of how the intended audience will perceive the final product. “One needs to have ‘ears’…to critically evaluate sound fields” (Indelicato, Hochgraf, & Kim, 2014). Douglas Jones from Columbia College department of Audio Arts & Acoustics in Chicago, describes their program’s philosophy; "We want students to use their ears first…we want them to make audio decisions based, [sic] not on what they see in a software program but on what they hear"(Conte, 2004). Without the knowledge of how we hear, recording and mixing engineers alike could have a more difficult time delivering their clients’ content to the intended audience (Graham, 2015, p. 51).

Psychoacoustics combines music and human perception and allows me to research a side of recording arts that I have not experienced elsewhere. This made me question why it is not being taught and how that can be changed. Therefore, this case study tests the effectiveness of three different teaching methods for defined learning styles in psychoacoustics. Do students adapt to the teaching methods used, or do they struggle?

Research will focus on critical listening, hearing perception, and education practices related to audio.

For the sake of this case study, psychoacoustics is defined as the perception of sound, including "how we listen, our psychological responses, and the physiological impact of music and sound on the human nervous system" (Leeds, n.d.). It establishes a relationship between a sound stimulus and the auditory perception associated with it (Liebetrau et al., 2015, p. 1). This could easily be labeled as critical listening, but it is not. Critical listening encompasses the skills needed for students to make accurate judgment calls when working on audio projects based on what they hear and how the intended audience will hear it. Some instructors teach "the aural evaluation of sound, sound sources, sound reproduction devices and sound in spaces as opposed to the aural analysis of musical sources typical of many ear/aural training programmes [sic]" (Thompson, Mosley, & Ward, 2013, p. 1). It considers that "sound quality is related to the entire process, from performance to consumer playback, and that perspectives and perceptions vary greatly" (Reba, 2010). Considering these clarifications, psychoacoustics can either be taught as a separate course from critical listening, or within a critical listening class itself. This research will offer teaching methods for learning styles to instructors teaching psychoacoustic material.

Contemporary Applications of Psychoacoustics

To human ears, music at a louder volume tends to sound better (Vickers, 2011, p. 346). The ear's nonlinear frequency response "has played an important role in enabling the loudness war. If you play the same piece of music at two different volumes and ask people which sounds better, they will almost always choose the louder, partly because more of the frequencies are audible" (Milner, 2009). Loudness wars have stemmed from this innate tendency to prefer louder audio clips. It is "arguably the worst thing to happen to audio quality in decades…at the very least it is clear that while technological advances have greatly increased the available dynamic range, less and less of it is actually being used" (Vickers, 2011, p. 346). Performing artists want their audio to sound its best, and "feel deprived when they compare their own files against loud and distorted streams" (Katz, 2015, p. 940). The loudness wars are not a new concept, but have been slowly becoming more prevalent with the rise of technology. Dating back to the invention of the gramophone, generations have noted that music got 'louder and louder' (Devine, 2013, p. 173).

How do we know that consumers prefer louder recordings? Not only does the ear's nonlinear frequency response play a role, but other psychoacoustic attributes of sound and dynamic range compression complete the picture. Liebetrau et al. research the dimensions of pleasantness in music, using twenty-two listening samples and over fifteen listeners. Results show that a "link between psychoacoustic attributes and (un)pleasantness could be established" from their research (Liebetrau et al., 2015, p. 1). Ronan and colleagues explore

factors that influence listener preference for dynamic range compression (DRC). They identify:

> "four factors affecting preference judgments on DRC: prolonged exposure, musical genre preference, education and perceptual salience of sound quality attributes. The research suggests that objective measures mapping the degree of DRC to individual sound quality attributes may facilitate a greater awareness of how listeners make preference judgments of dynamic range compressed material" (Ronan, Sazdov, & Ward, 2014, p. 7).

Hjortkjær and Walther-Hansen refute these findings after conducting a study comparing original and remastered popular recordings. They "found no evidence of preference for the less compressed music…[and] failed to find differences in ratings of perceived "depth" between the original and more compressed audio" (Hjortkjær & Walther-Hansen, 2014, p. 1). They suspect that listeners are not as sensitive to dynamic range compression as previously believed. (Hjortkjær & Walther-Hansen, 2014, p. 1).

Recently, loudness normalization has become more popular in distribution methods. (Sylwesterzak, 2014, p. 9). Because of this, Sylwesterzak believes that the loudness wars are coming to an end. He argues that "the harder you work to turn up your master, the harder loudness normalization will work against you to turn you down" (Sylwesterzak, 2014, p. 9). Katz agrees, believing that it will only end after engineers spread the word and streaming providers and media players accept recommended loudness normalization (Katz, 2015, p. 940). Ultimately, Wilson and Fadenza point out that "while the perceived quality of popular music may have decreased over recent years," popular music is still well-received by the mainstream audience (Wilson & Fazenda, 2016, p. 23).

Genre classification of music utilizes psychoacoustic variables in its categorization processes. (Gouyon, Dixon, Pampalk, & Widmer, 2004, p. 1). "Musical genre classification

has received much attention from music record retailers and…from audio and music researchers" (Gouyon et al., 2004, p. 1). A structural identification method analyzes audio waveforms then places it into a predefined genre category. (Osmanovic, 2008, p. 4). Descriptors gathered for waveform classification include: ground-truth reference database selection, audio waveform feature definition, salient feature extraction, and decision boundary description (Osmanovic, 2008, p. 1). Other variables include emotion and musical features. Using the Short Time Fourier Transform, "new features [of genre classification] such as Spectral flatness and smoothness are added as they were seen to improve the clustering of different genres" (Radhakrishna, 2008, p. 10). Genres can also be classified by emotion. This is done by "generating music mood corpus and developing [a] novel classification scheme" that categorizes music into genres on a scale of four comprehensive emotions (J. Kim & Larsen, 2010, p. 6-7).

Psychoacoustics not only influences loudness and genres, but also speech and musical preferences in different cultures. This study of speech, in relation to psychoacoustics, is known as psycholinguistics. Languages place differing importance on pitch. Ebem et al. present research on speech quality algorithms, comparing American English to Igbo, an African tone language. They identify that "in English pitch only carries stress information whereas in Igbo the meaning of a word depends on the pitch, possibly leading to a difference in impact for different types of degradation when using degraded Igbo sentences as compared to using degraded English sentences" (Ebem et al., 2011, p. 647). Iversen and colleagues study the perception of rhythmic grouping of speech based on auditory experience. Subjects include Japanese and English speakers and discover that

"perception of basic grouping in nonlinguistic auditory sequences varies by culture, in contrast to long-held views about universal principles governing such grouping" (Iversen, Patel, & Ohgushi, 2008)

Olive et al. study headphone sound quality preferences on the basis of listening experience, age, and culture. They use a virtual headphone method, allowing subjects to switch between different headphones from a program, thus removing non-auditory bias, and testing the four headphones against three predefined tracks. However, a correlation between culture and headphone listening experience itself does not appear based on their results. "Listeners generally preferred the same headphones regardless of their listening experience, age or country of residence" (Olive, Welti, & McMullin, 2014, p. 10).

Musically, Kim and colleagues conduct a study about the cultural influence on listeners' timbre preferences. Subjects include Dutch, American, Korean, and Japanese adults tasked with adjusting a 3-band equalizer to their listening preference for five songs. Their findings "support the existence of a trend that each listener group had unique timbre preferences when listening to various types of music" (S. Kim, Bakker, & Ikeda, 2016). Lahdelma and Eerola study preferred emotions and psychoacoustic qualities in isolated chords. They measure all fifteen chords on the basis of valence, tension, energy, consonance, and preference (Lahdelma & Eerola, 2016, p. 1). Results suggest a "strong correlation between perceived dissonance and tension. The register and inversions contributed to the evaluations significantly, nonmusicians [sic] distinguishing between triadic inversions similarly to musicians." (Lahdelma & Eerola, 2016, p. 1).

Current Education in Psychoacoustics

Presently, a search of the Audio Engineering Society's Education Directory reveals fourteen educational programs offering psychoacoustics, spanning the North American, South American, and European continents (Audio Engineering Society, 2017). The list is as follows (Audio Engineering Society, 2017):

- "University of Sydney, Faculty of Architecture (Australia – Doctor of Philosophy
- Conservatoire National des Arts et Metieri (France) - Acoustical Engineering
- Conservatoire National des Arts et Metieri (France) - Acoustics (general)
- Estudio de Música Electroacústica (Argentina) - Electroacoustic and Computer Music Composition
- Estudio de Música Electroacústica (Argentina) - Music Technology
- OKTOPUS, School of Video and Audio Engineering (Hungary) - Audio Technician Course
- OKTOPUS, School of Video and Audio Engineering (Hungary) - Engineer Course
- University of Surrey (United Kingdom) - Audio Research
- University of Essex (United Kingdom) - Audio Systems Engineering
- University of Essex (United Kingdom) - Audio Systems Engineering [sic]
- Belmont University (United States) - Audio Engineering Technology
- Globe Institute of Recording and Production (United States) - PsychoAcoustics [sic] and Sound Healing Certificate Program
- Penn State University Graduate Program in Acoustics (United States) - Graduate Program in Acoustics
- University of Miami, Music (United States) - Music Engineering"

This is not an exhaustive list of programs, but rather a guide to show where universities around the world already advertise their instruction of psychoacoustics as part of an educational program. This only shows what is known by the Audio Engineering Society. Many of the programs advertised do not have information or translations available on their websites, and their directory information was last updated four to six years ago. More information about select North American courses is presented in Chapter II.

One program type not represented in the directory search is the Tonmeister program, popular in Germany, which trains musicians in sound engineering (McGill

University, n.d.). Education in this program covers “the theory and practice of sound recording and audio engineering” (University of Surrey, n.d.). This research focuses on recording arts practices in North America and will not cover Tonemeister instruction. There are many classifications of audio education programs within the United States alone, including Music Production, Music Technology, and Recording Arts. While the goal of each program differs, my research can be applied regardless of the program title so long as instructors teach psychoacoustics as part of the program.

CHAPTER II

LITERATURE REVIEW

Research in psychoacoustics education can be divided into three different categories based on topic: undergraduate psychoacoustics education, psychoacoustics concept implementation, and teaching audio.

A search for psychoacoustics in the Audio Engineering Society's website under their Education search bar uncovers a handful of programs offering either degrees or courses in psychoacoustics (Audio Engineering Society, n.d.). This small number raises the questions of why it is not as popular and if there are any successful teaching methodologies used by these universities to foster success in this subject. Universities such as Belmont University and McGill University offer not only psychoacoustics as part of their courses, but as separate classes as well to better focus on the subject (Belmont University, 2016; Music Research, 2016; Music Technology, 2016). More undergraduate programs such as these should follow this standard being set to better prepare students for a job in the field.

Interviews with professors who teach psychoacoustics reveal the importance of its education. Oehlers states that "it is important for students to understand psychoacoustics in order to better understand how their brain is interpreting the audio it encounters" (2016). McAdams further stresses that "there are many aspects of audio engineering in which a better understanding of the quantitative and qualitative link between sound properties…and perceptual and affective properties of sound" will greatly benefit future audio engineers (2016).

Psychoacoustic education is not well-researched, even less so than audio education. There is little publicly formalized audio education curriculum before 2010 (Tough, 2010). Because of this, instructors had few resources to draw from to develop a well-rounded program. Furthermore, no audio accreditation standards existed as of 2010 (Tough, 2010, p. 152). Once professors built a program, there was no way to prove that the program teaches what is needed to succeed in the industry until the National Association of Schools of Music filled that gap. Current standards put forth by this association outline content for Music and Recording Technology programs in music programs (National Association of Schools of Music, 2016, p. viii). It does not, however, cover similar program in schools of film, engineering, or communication.

Christopher Reba authored a study on sound quality education, looking at pedagogical issues, concepts, and practices currently in place. He discovers that one thing students lacked were critical listening skills, which is imperative in the audio industry (Reba, 2010). Linking this to psychoacoustics, Jens Blauert looked to quantify this subject. Psychoacoustic sensations are understood as being subjective, so Blauert offers critical listening tests as a quantitative alternative (Blauert, 2012). Students will greatly benefit from a stronger unified curriculum (Tough, 2010, p. 149).

Lecture is widely used on college campuses, but it is not the most effective form of instruction (Tough, 2010, p. 158). ”On average [,] a student can recall 70% of the information presented in the first ten minutes of a lecture and only 20% of the information presented in the final ten minutes” (Tough, 2012, p. 213). If this is so detrimental to student learning, why is it in such wide practice? Case, Tough, and Vilão offer alternatives that have

proven successful in audio education and psychoacoustics. However, Reba urges that professors must not force their own creative ideas onto students, but instead give them the tools to form their own (2010). To be most effective when teaching psychoacoustics, instructors must be "able to explain what is happening acoustically and understanding how most listeners interpret the psychoacoustic material" (Oehlers, 2016).

Case draws from Kolb's Experiential Learning theory in his discussion about enriching the aural experience in audio education (2013). This theory helps professors plan a lesson that meets the needs of all students without pressure to understand it right away. Kolb's theory includes concrete experience, reflective observation, abstract conceptualization, and active experimentation. It allows students to enter at any of the four stages, placing no hierarchies on different stages (Case, 2013). Tough offers other alternatives, such as competency-based education and the use of Bloom's Taxonomy (2010, p. 152). He also goes into detail about Robert Gagne's instructional theories, including taxonomy of learning outcomes, conditions of learning, and nine events of instruction (Tough, 2012). Based on this, he recommends that professors "engage learners in a practical task rather than simply reading the task procedures. In this type of classroom, the instructor acts as a facilitator who increases student motivation and learning through sharing and self-development" to effectively teach audio (Tough, 2012, p. 213). Nelson recommends that "curriculum should provide opportunities for reflection, rather than be presented as discreet [sic] and separate parts" (2007, p. 30). Vilão and Melo offer a worldview of critical listening and psychoacoustics training. Their use of the berimbau-de-barriga, a gourd and string

instrument, has proven effective in teaching psychoacoustic elements due to its gourd body and string inharmonicity (Vilão & Melo, 2014, p. 1149).

To further complicate the matter, no two students approach learning the same way. Some students prefer active lessons, while others prefer to be told the information (Felder, 2010). “Awareness of learning style differences can help instructors teach in a manner that effectively reaches most students rather than putting a large subset of them at a disadvantage” (Felder, 2010). However, this is a controversial subject in educational psychology. “Most learning styles debunkers base their arguments on the meshing hypothesis. They claim they have found no credible evidence that matching teaching to students’ learning style preferences leads to improved learning, so there is no reason to take learning styles into account when designing instruction” (Felder, 2010). Despite this there is still much research supporting it. From a skeptic’s point of view, learning styles research in “pedagogical literature demonstrates that an educator, attempting to take an evidence-based approach to education, would be presented with a strong yet misleading message that the use of Learning Styles is endorsed by the current research literature” (Newton, 2015) However, Felder’s work in learning styles has been proven valid for assessing learning styles as opposed to an evaluation tool. According to Zywno, “test-retest analysis of the ILS scores suggested a strong to moderate reliability of all scales” (2003).

The pedagogy of psychoacoustics is not well-documented and needs some direction. Only a handful of universities advertise expertise on the subject (Audio Engineering Society, n.d.). Current professors stress the importance of psychoacoustics, but there is little evidence of its teaching at the university level. Research by Tough, Blauert, and Reba offer

benefits for students such as a unified curriculum and critical listening skills. Case and Vilão add their opinions by offering suggestions to improve not only audio education through the use of Kolb's Experiential Learning theory and competency-based education, but also of psychoacoustics through use of the berimbau-de-barriga to demonstrate concepts. Felder offers a measurement of learning styles to help guide professors to successful teaching methods for psychoacoustics. Research presented in the following chapters will fill in gaps and offer professors teaching methods proven useful the field.

CHAPTER III

METHODS

My target population included undergraduate students in Audio Production II at University of Colorado Denver who have basic knowledge of audio and the human auditory system. My subjects came from various sections of the Audio Production II course with the professor's approval. One student from each section chose not to participate in the study. They participated in the lesson but no data was collected from their assignments.

Three groups of mixed learners participated in a lesson in psychoacoustics. Each group was taught the same content using a different teaching method. These included lecture, activity and discussion, and reading and discussion. All three styles were chosen to evaluate Tough's research in audio education (Tough, 2012). Specifically, the lecture method was chosen to evaluate Tough's findings on lecture-based learning while activity and reading were chosen based on Kolb's learning theories (Case, 2013; Tough, 2012).

In this study, the lecture method was used by describing the topics to students with the use of visual aids in the form of outlines and graphs. Activity and discussion utilized a description of the topic, an audio example, then a discussion of what was heard. Reading and discussion was used by dividing students into groups and having student-led learning with articles and an outline of key points to cover on the whiteboard. Activity and reading differ in a few areas. First, the activity was largely guided by me and consisted of an explanation of the topic, audio examples, and then a discussion of what students heard. In comparison, reading was student-led. I divided students into three groups, having them number off by threes. Then, I passed out an article on a different topic to each group and

had an outline on the whiteboard of important points to cover. Students decided on their own how to organize and present the material. All three groups chose to divide the article into sections and read it, then come together in their group to discuss the important points. They then verbally presented it to their peers. One group requested a visual aid in the form of a graph.

I covered the same topics in all three class sessions: Weber's Law, Fletcher-Munson Curves, the ear's bias, and how to overcome this when mixing. Instruction on Weber's Law included its definition, how it relates to audio, just noticeable difference, absolute threshold, and why it is not always true. Fletcher-Munson Curves included the definition, unit of measurement, and how high and low frequencies are effected by the curves. Instruction on the ear's bias included what kind of transducers are in the ear, how many equalizers and compressors are in the ear, and how equalization in the ear differs from a standard plug-in compressor. Then, the students came up with ways to overcome these biases when mixing. Some examples include listening at different volumes and walking around the room. An outline of my lecture notes can be found in Appendix D.

I conducted the study in Arts 285H, commonly known as Studio H. It was the classroom most familiar to students and gave me the technology I needed to complete my lesson. This ensured that everyone felt comfortable in the environment and helped the case study go smoothly. I gave a quiz at the end of the period as a check for understanding as well as a survey of learning styles so I could identify their preferences. This quiz can be found in Appendix B.

An assistant surveyed the engagement of each class at 5, 15, 20, 30, and 45 minute intervals as well as any noticeable distractions that may be present in the room at any given time during the lesson. They also noted general observations about the lesson and anything I should be aware of while reviewing the data collected. This gave me another perspective on the lesson and helped me focus on instruction during each period. It also gave data from another viewpoint in the classroom, as they could sit with the students and more accurately notice when they were restless or inattentive. Their note sheets can be found in Appendix C.

I measured students' learning styles from a questionnaire entitled *Index of Learning Styles*, as defined by Richard M. Felder and Linda K. Silverman. It "is a self-scoring web-based instrument that assesses preferences on the Sensing/Intuitive, Visual/Verbal, Active/Reflective, and Sequential/Global dimensions" (Felder, 2002). "Active learners tend to retain and understand information best by doing something active with it—discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly first." (Felder & Celanese, n.d.). "Sensing learners tend to like learning facts, intuitive learners often prefer discovering possibilities and relationships." (Felder & Celanese, n.d.). Visual learners best remember what they see, while verbal learners remember words, whether spoken or seen. "Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly 'getting it.'" (Felder & Celanese, n.d.). This type of questionnaire did not force

students into a singular category, but instead demonstrated where they are on four spectrums of learning (Felder & Spurlin, 2005, p. 104).

CHAPTER IV

RESULTS

The results section included all data collected throughout the case study. The mean score and standard deviation of the quiz were presented by each group as well as by type of learner. Individual scores appear in Appendix E. The engagement of each group at predetermined intervals was also presented. Choice of research time played a role in data collection and is introduced. Further exploration and interpretation of these results are presented in Chapter V.

Research was conducted directly after a week-long break from classes. This introduced problems in attendance and attention, as some students were still gone on extended trips or re-adjusting their sleep schedules. However, it also offered benefits. The first classes after a break did not continue a topic discussed in a previous class. It offered me a place to guest lecture without interrupting the course schedule.

Participation went as well as I expected it to. Class attendance for my lectures were just above 50%, which still gave me an even number of participants across all sections. One student left early from the first section, so no data was collected for that person. No students arrived late enough to be removed from research in the second section. One student arrived too late for their quiz score to accurately reflect learning in the lesson and one student opted out of participation in the third section. This gave me 11 students in the first section, 12 from the second, and 13 from the third section. I had 10 female and 26 male students, with a total of 36 students participating in my case study.

I expected my findings to be very similar to previous research on teaching methods. I did not expect lecture scores to turn out as well as reading and discussion or activity and discussion, based on previous research gathered. Tough states that lecture has been proven ineffective, as students find it difficult to pay attention in this setting (2010, p. 158). However, the lecture section in my case study had the second highest average score. This raises the question of if students adapt to different teaching methods at the college level. I expected reflective students to have a more difficult time in the activity class, but perform well in lecture. This turned out to be true. I did not anticipate seeing much difference between verbal and visual learners because I used visual aids and verbal elements for all lessons. I could not gather accurate data from this group of learners because only five out of 36 participants were verbal learners. No verbal learners were in section three.

Table 1 outlines the average and standard deviation of quiz scores for each class section, as well as the total average and standard deviation for all participants combined. There is a downward trend of scores throughout the research mainly caused by outliers in sections 2 and 3 who did not score as well, although everyone learned the same material and was given the same quiz. This is reflected in a wider standard deviation for these sections.

Table 1: Section Results

	Section 1	Section 2	Section 3	Total
Average of Participants' Scores	98.8%	92.75%	86.23%	89.81%
Standard Deviation	7.98%	9.49%	11.81%	10.12%
Incorrect Answers	1.14	1.36	1.69	1.45

Table 2 outlines the average by percentage out of 100 and the standard deviation of quiz scores for each learning style. Note that each student is placed into four sections, meaning that each score is reflected in the table four times. Reflective students had the lowest average with the widest standard deviation, while active students had the highest average with the lowest standard deviation. All other scores were within one percent of each other.

Table 2: Learning Style Scores

	Reflective	Active	Intuitive	Sensing	Verbal	Visual	Global	Sequential
Average	84.85%	92.95%	90.00%	89.42%	90.60%	89.68%	90.14%	89.33%
Standard Deviation	12.46%	6.92%	10.43%	9.90%	7.50%	10.58%	9.89%	10.77%
Incorrect Answers	1.78	0.99	1.49	1.41	1.07	1.51	1.41	1.54

Student engagement was recorded through a video camera in the first two sections and a research assistant in the third section. The number of students not paying attention and those who were restless were noted in observations, as shown in the following tables. Restlessness was measured by how much the student was moving at their seat. This could have also been because of an uncomfortable chair, fatigue, or boredom. Inattention was measured by the research assistant's judgement on if the student was not paying attention or doing something else entirely.

Table 3 outlines the number of students from each section who were inattentive at the designated intervals, as well as a total for each minute marker. Trends indicated more

students restless at the beginning of class and past the 30-minute mark. Within the first 5 minutes of class, students were arriving late and getting settled. This was the largest contributor to inattention in the first minutes of class. By the last 15 minutes of recorded observation, students had been in class and participating in the lesson. Many inattentive students were simply done with the activity by that time.

Table 3: Inattentive Students

	Section 1	Section 2	Section 3	Total
5 minutes	1	1	1	3
15 minutes	0	0	1	1
20 minutes	1	0	1	2
30 minutes	0	0	3	3
45 minutes	2	3	1	6

Table 4 outlines the number of students from each section who were restless at the designated intervals, as well as a total for each minute marker. Trends indicated that as class went on, students got more restless. An increasing number of students were restless at each marker. By 45 minutes, a total of 8 students were restless. Just like with inattentive students, most restless students were done with the activity by 45 minutes.

Table 4: Restless Students

	Section 1	Section 2	Section 3	Total
5 minutes	0	0	0	0
15 minutes	1	1	0	2
20 minutes	1	0	1	2
30 minutes	0	0	3	3
45 minutes	2	3	3	8

The case studies went well. Students were eager to learn new information and responded well to my instruction. Attendance was poor, as explained, and some variables

were out of my control, to be discussed in Chapter V. Reviewing the results, there appears to be a significance to teaching reflective and active learners, but most quiz scores stayed within normal bounds. Further analysis of these results will occur in Chapter V. A table containing all test scores is accessible in Appendix E.

CHAPTER V

DISCUSSION

I assigned teaching methods to sections based on the amount of preparation I had ahead of time. Section 1 was first, and gave me over an hour of time to prepare the room and materials for the reading and discussion teaching method. Section 2 was directly after section 1, giving me no preparation time. The lecture teaching method required the least preparation time and was a natural transition from an activity-heavy class. Section 3 had little preparation time the day of the study, but I had preparation time the night before and simply checked everything when I entered the classroom the day of that lesson. This worked well for the activity and discussion lesson.

Section Discussion

Section 1 was taught using the reading and discussion teaching method. They responded well and their test scores reflected this. Students with visual preferences, preferring to see pictures, tended to struggle in this lesson. Three out of the five total verbal learners participating in the study were also in this section. Students had visual references in the given articles, but mainly chose to discuss the contained information with their peers. This may have greatly benefitted verbal students, who prefer to hear or see words, while slightly hindering their visual peers.

This section also contained largely active learners, pairing well with a student-led class. Only three out of the 11 students participating were reflective learners. Reflective learners, who prefer time to quietly think about the material, still had time to read through and process the article on their own before the groups discussed how to share this information

with the class. The class was uniquely compatible with this teaching method, and the amount of effort given was positively correlated with their quiz scores. The standard deviation of 7.98% reflects a deviation of roughly one question.

Six total outliers appeared in this section. Three students' quiz scores were significantly lower than the average, at 80% each. All students were active learners, who prefer to engage with the material rather than sit and reflect on it, but no other similarities appear in their learning styles. Each student incorrectly answered questions from material presented 10 minutes or more after the start of class. They may have responded better to hands-on application than reading material in order to explore the concepts for themselves. In contrast, three students also received perfect scores on their quizzes. All three of these students were intuitive learners, who prefer discovering possibilities and connections themselves. This area fits well with the lesson, where students were randomly assigned groups and given articles to discern important information and make connections to prior knowledge.

Section 2 was taught using the lecture method. Students did well, but their average was lower than section 1 at 92.75% with a wider standard deviation of 9.49%. Reflective learners tended to struggle on the quiz. None of these learners received a perfect score on it, but a few of them only missed one question. The other two verbal learners were in this section. This lesson was beneficial for the few verbal learners in the class, but I also used visual examples to help offset this verbal-focused lesson.

This section had the most variety in learning styles between all three sections. Five students were reflective learners, while seven were active. Six students were intuitive and

the other six were sensing learners. Global and sequential learners were represented in equal numbers. The only underrepresented group was verbal, with two students. The other 10 students were all visual learners. Test scores were lower on average with a higher standard deviation, which could be easily representative of the wide range of learning styles among these students.

Five total outliers appeared in this section. Four students received perfect scores on the quiz. These students all had one learning style in common: active. The rest of their styles vary, notably including both verbal and visual learners. One student received 67% on the quiz, missing five questions. Student R was a reflective, sensing, visual, and global learner. She missed questions in the beginning and middle of the quiz, all questions that were not represented by pictures. This student may have relied heavily on visual affirmation of the text presented in the article.

Section 3 was taught using the activity and discussion teaching method. This entailed a short description about the topic in question and then how to apply it. I pulled volunteers to do one activity that would have been difficult to replicate with the entire class, but for all audio examples every student was engaged and participating. Quiz scores averaged at 86.23%, equating to two questions missed. The standard deviation was wide at 11.81% and represented nearly two questions.

This section had little variance in learning styles. No students were verbal learners in this section, and only two were sensing. Students were equally spread between active and reflective learning with one more student in the active category. Five participants were sequential and eight were global learners. Reflective students tended to do worse in this

section, possibly because students were encouraged to act right after learning the material rather than contemplating the given information.

There were also five outliers in this section. Two students received perfect scores. Both participants are global learners, able to understand the whole idea before comprehending the parts. Three students received 67% on the quiz. All of them are reflective, intuitive, and visual learners. This aligns with the more active pace of this class, as these students did not have much time to think about the information presented before being expected to apply it in the example and discussion. These students were also the least interested in the material from my perspective as the instructor. All three students incorrectly answered a question on the equal loudness curves and a question on pitch that I had verbally iterated multiple times and had on the lesson outline on the whiteboard. These students may have responded better to the reading and discussion teaching method, which would allow them to reflect on the information before sharing it with their peers.

Learning Styles

Learning styles offer subjective measurements of students' learning preferences. They "suggest behavioral tendencies rather than being infallible predictors of behavior." (Felder, 104.) The basis of collecting learning style data was to find correlation between these variables and possible teaching methods to best meet the needs of student tendencies. Every student is different, and it is ultimately up to the instructor to decide what will work best for the class or student in question.

Participants in this study represented a multitude of learning styles overall. I had close to equal representation on all categories except for verbal vs. visual. Very few verbal

learners participated, which I find interesting in an audio-focused class. The course my participants came from enrolls both recording arts and music business students, which could explain part of this visual trend.

Audio professionals stress the need for aural training in audio programs, and this may prove challenging for the participants in this study (Tough, 2010, p. 159). Guzman defines audio perception as "the ability to systematically and expertly control how sounds are perceived" (2013, p. 1). Thompson argues that as audio programs are becoming more prevalent, we must identify "some of the ways that critical listening skills can be developed and integrated more effectively in more formal educational settings" (2013, p. 1). Conte points out that students tend to use what they see when manipulating plug-ins, rather than what they hear it doing to the mix (2004).

Gender did not seem to play a role in learning styles or comprehension of psychoacoustics. Female participants in this study were mostly reflective learners, however all other ranges are equally represented. All scores were represented by both genders. Only two male participants were verbal learners, but this is not statistically significant due to its low overall representation among participants.

Active learners tended to do better than their reflective peers. This could be because two out of the three teaching methods involved active lessons. Intuitive learners had a wider standard deviation, considering its equal representation among participants. Most other categories stayed within the average and does not seem to play a large role in comprehension for psychoacoustics. Active students adapted to the lecture section while reflective students adapted to the other two sections.

Comparison to Research

Some results came out as I expected. Learning styles did not seem to play a large role in comprehension of psychoacoustics. I anticipated noting tendencies, such as active learners thriving in an active lesson as was the case in section 1. However, students seem flexible and can adapt to whichever teaching method is used, as shown with active learners in section 2. “To function effectively as professionals, students will need skills associated with both categories of each learning style dimension; if they are never given practice in their less preferred categories, they will not develop the skills that correspond to those categories” (Felder & Spurlin, 2005, p. 105). These learning style tendencies can be best used when a student or class is stuck on a particular problem or subject, allowing them to understand it easier in their more preferred categories.

I did not expect lecture to turn out as well as it did in section 2. The lecture itself was short for a 75-minute class period, only a half hour, but I still noticed students’ attention slipping as time went on. This correlates with research describing how information recall drops the longer a lecture continues (Tough, 2012, p. 213). However, quiz scores still reflect an average of only one incorrect question. Students seemed comfortable with this amount of lecture in a class period as long as there was an alternative activity for the remainder of the time.

I was surprised by the low average of section 3. The class was mostly engaged during the lesson and responsive to the activities. Background noise may have played a role in making the activity examples more difficult to follow from a student’s perspective. The projector’s fan was pointing back toward the students’ desks, directing the sound toward their part of

the room. There was also a clock near the door of the room, by desks on the right side. Furthermore, floor vents were located on the back wall of the room directly behind the back row of desks. All of this noise combined would make it difficult for students to discern small changes in an audio sample.

An alternative method to the one utilized in my lesson encourages students to listen in their own environments with less background noise, such as with headphones. A description is as follows:

> "the audio can be reproduced – to multiple students via one-at-a-time presentation in their own studios – in a lower sensory noise floor environment. The educator can have a good sense of what they might hear, while controlling what they see. Low noise floor – visually – presentation of audio via prepared multimedia experiences have the chance to be more effective as a way to communicate versus the attention-getting production experience of competitive digital audio" (Case, 2013, p. 5).

Potential Biases

The case study introduced a few biases, including my participation pool, me teaching the lessons and using a camera for the first two sections. My sample size was heavily reliant on participation. In order to get the most participants, I utilized Audio Production II classes at the permission of their professors. This limited my participant pool to mostly students with only basic knowledge of audio.

I also planned and taught each lesson. I hold an education degree and am comfortable in the classroom, but I am not a seasoned educator. I tried to use similar words and phrases throughout all three classes to offer the same knowledge to all students in the study, but this could still introduce a bias into my study.

I planned on utilizing the help of research assistants so that I could focus on teaching an effective lesson, rather than try to collect data at the same time. However, one assistant

could not attend sections 1 and 2 and I could not find a replacement in time. I decided to use a video camera to record the students during my lesson so that I could go back and analyze their behavior after. This was nice in that I could replay any events in question as many times as I felt needed. However, students did notice the camera in the room. Section 1 caught it before the lesson started while section 2 noticed it 10 minutes into the lesson. I assured them that the video would remain private, but it still could have influenced their behavior. The camera also made it impossible for me to see students' computer screens to ensure that they were taking notes or engaged in the questionnaire. It was placed in the front of the room facing the students, so all I could see was the back of their laptops and not their screens. My assistant for section 3 sat in the back corner of the classroom, with easy sight to most students' computer screens. This allowed him to observe in greater detail than I could from a recorded video.

I limited my environment to one classroom in order to avoid the risk of room or equipment bias. This gave me more control over my teaching environment and helped students feel comfortable during the lesson. Room noise still had an effect on hearing activities, especially for students in the back of the classroom. Students heard room noise before the music sample I played, and this background noise made it more difficult to hear what I described of the music at quieter volumes. This was more prevalent while I used a frequency generator. 1,000 Hz is easily recognizable in many situations, but tended to blend in with the room as volume decreased. In section 3, the activity group, students still claimed to hear the tone after I turned it off and I momentarily agreed with them until I had visual confirmation from the monitor level on the SSL AWS 924. This was caused by a

psychoacoustic trick known to come from a 1,000 Hz tone. Human ears tend to discern high frequencies by volume level in each ear and low frequencies by arrival time of the sound to each ear (Goodman, 2006). In actuality, “human ears do not do a good job finding the source of sounds around 1,000 hertz using either method” (Goodman, 2006). This, combined with the same 1 kHz tone present within the projector’s hum, tricked our perception of the noise. Thus, we believed the frequency generator was still playing the tone when it in fact was not.

CHAPTER VI

CONCLUSION

The education of psychoacoustics is not well-researched even though audio engineers stress the need for instruction on hearing and the impact of sound on the human body. Furthermore, the necessity of learning style consideration is widely debated. I recommend using multiple teaching methods, combining student and teacher-led instruction, to help both active and reflective learners while effectively teaching psychoacoustics.

These results will help professors decide how to best teach psychoacoustic principles to different types of learners. The case study yielded little statistical significance toward learning styles as a factor for psychoacoustic instruction. The only group that showed significance was the active/reflective learning group. Active and reflective learners prefer to interact with and think about new information, respectively. This difference in learning should be considered in the classroom. Students adapted to whatever teaching style was used. My recommendations will be most effective to assist students who do not understand the material and need to be taught using the strengths of their learning styles. However, instructors can also use learning styles to survey the preferences of the class and adapt instruction to fit the unique preferences of the class All teaching suggestions made are based on success for various learning styles, therefore they offer advice based on tendencies rather than predictors or facts.

A balance must be achieved when teaching psychoacoustics in order to teach to the significant learning styles, active and reflective. Therefore, my recommendation is to use multiple teaching methods whenever possible. Give active learners the opportunity to

interact with the material and give reflective students the opportunity to think about what they have been taught. This will give students the best chance for success when learning psychoacoustics.

All teaching methods used in this case study can be implemented with psychoacoustics, if done in a logical order. First, students should learn about the material through a lecture supplemented with audio examples to reinforce the concepts being taught. Then, the reading and discussion teaching method should be used as a reinforcement of knowledge after students have learned the material. It will allow instructors to clear up any misunderstandings before students synthesize similar information for themselves. Finally, allowing students to plan an activity based on the learned vocabulary will further reinforce and show competency in the knowledge learned during that unit.

This case study had a limited participation pool. It was conducted at one university in one state of the United States. Results may vary in different regions of the country or in different countries. More research must be done in order to sort out whether the results presented here accurately reflect those of the country. Programs other than recording arts should also be explored, as results may prove different in Music Technology or Tonmeister programs. Where psychoacoustics fits within a curriculum should also be addressed. There is still much to learn about the education of psychoacoustics, and more research must be done to help guide the industry toward good teaching practices for psychoacoustics.

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APPENDIX A

INTERVIEWS

Paul Oehlers

How long have you been teaching at American University?

13 years

What is your official title?

Associate Professor of Audio Technology

What role does psychoacoustics play in your program?

We offer several courses that incorporate psychoacoustics.

How important do you feel it is for audio engineering students to understand psychoacoustics and why?

It is important for students to understand psychoacoustics in order to better understanding [sic] how their brain is interpreting the audio it encounters.

Within your program, is it taught as a separate course or within other courses? If so, what courses cover this content?

ATEC-101 Fundamentals of Audio Technology

ATEC-403 Advanced Mixing and Mastering

ATEC-652 Critical Listening

How do you or faculty members within your program teach psychoacoustics?

In ATEC-101, students encounter the material initially by experiencing audio perception examples on their own. Students also read articles by Daniel Levitin and Diana Deutsch. In ATEC-403, students read books by Levitin and Deutsch and learn about phenomena such as masking using sessions that present the audio engineer with certain audio challenges. In ATEC-652, graduate students practice listening to audio examples, many of which contain audio anomalies which are difficult to hear.

What material aids are used?

Books and examples by Levitin and Deutsch, binaural recordings, Critical Listening by Jason Corey, and audio examples unique to AU

Have any teaching methods proven more effective than others regarding psychoacoustic principles?

Students understand acoustic phenomena best by hearing them then reading about the scientific/mathematical principle.

How can professors be better prepared to tackle the subjective nature of psychoacoustic content?

By being able to explain what is happening acoustically and understanding how most listeners interpret the psychoacoustic material.

What is the biggest challenge encountered when introducing psychoacoustics to young audio engineers? How do you overcome this?

Students first need to listen to audio examples. The more familiar the student is with critical listening skills, the better able they are to listen to specific elements of an audio example.

How has the treatment of psychoacoustics in audio education changed since you began teaching?

There has been a much better and clearer understanding of the brain and how it interprets music and sound.

Stephen McAdams

How long have you been teaching at your current university?

12 years

What is your official title?

Full Professor and Canada Research Chair (Tier I) in Music Perception and Cognition

What role does psychoacoustics play in your program?

It is taught within the Music perception and cognition class, which is a requirement for students in two Music Technology minors and the Sound Recording qualifying year.

How important do you feel it is for audio engineering students to understand psychoacoustics and why?

Extremely important, because there are many aspects of audio engineering in which a better understanding of the quantitative and qualitative link between sound properties (as created by various audio engineering devices such as equalizers, compressors, etc.) and perceptual and affective properties of sound.

Within your program, is it taught as a separate course or within other courses? If so, what courses cover this content?

see question 3.

How do you or faculty members within your program teach psychoacoustics? What material aids are used?

There is one lecture on acoustic properties of sound, one on the biophysics and neurophysiology of hearing, two covering pitch, timbre, loudness and space perception as well as masking, two on auditory scene analysis, one on how timbre perception and scene analysis play a role in orchestration practice, and one on time and rhythm perception. The rest get into more cognitive issues of music psychology. I use graphs, sound examples, and students do small demonstration lab experiments to get a sense of how psychoacoustics research is conducted.

Have any teaching methods proven more effective than others regarding psychoacoustic principles?

Not sure what you mean. I've always done it as described above.

How can professors be better prepared to tackle the subjective nature of psychoacoustic content?

Sound examples and demonstration experiments are the best, so it is more concrete.

What is the biggest challenge encountered when introducing psychoacoustics to young audio engineers? How do you overcome this?

It is critical to get the acoustic notions mastered and how the ears and auditory system process sound in order to get the main idea that perception is constrained by these processes.

How has the treatment of psychoacoustics in audio education changed since you began teaching?

I began teaching psychoacoustics in the early 80s and the technological advances with personal computers and real-time signal processing now make it possible to set up demonstration experiments that the students can do on their own time on their on [sic] laptops.

APPENDIX B

QUIZ

Hearing Biases

Answer the following questions regarding hearing biases covered in this lesson. Write short answers in the space below or on the line provided. Circle the correct answer for multiple choice, yes/no, and true/false questions.

1. What is Weber's Law?

2. How does Weber's Law relate to audio?

3. Just noticeable difference is defined as
    a. the number at which you first notice weight
    b. the ratio at which you notice weight of magnitude
    c. the number at which you first hear a sound
    d. the ratio at which you notice a difference in sensation (sight, smell, hearing, etc)
4. (True or False) Weber's Law is always true.
5. The Equal Loudness curves were developed by _____ and _____.
6. Equal Loudness curves are measured in
    a. dB
    b. phons
    c. Hz
    d. Km
7. (True or False) You cannot hear low sounds as easily at a low volume.
8. Curves represent equal _____ as perceived by the average human ear.
9. Most transducers in the ear are _____.
    a. Mechanical
    b. Electrical
    c. Temperature
    d. Magnetic
10. (True or False) The equalization applied in the ear depends on level.
11. (Yes or No) Does the pitch appear to change when volume is increased?
12. List 3 ways to overcome ear bias when mixing

a. _____

b. _____

c. _____

APPENDIX C

OBSERVATIONS

Observations # 1

Class: Audio Production II section 1
Instructor: Pete Buchwald
Assistant: video camera
Teaching Method: Reading and Discussion
Class makeup- Male: 7 Female: 4

Any noticeable distractions in the room before class?

No major distractions before class. Students came in and talked amongst themselves or used their cell phones. Students from another section sometimes walked in thinking they were in the room, but had missed the announcement of their room change from the professor.

Any distractions 5 minutes in?

A student arrived five minutes late creating a distraction, as I had to stop and assign this student to a group.

How many students are not paying attention? One (arriving)

How many students are restless? none

Any distractions 15 minutes in?

All students are engaged in the article, discussing with their peers. One student is fidgeting a bit but still engaged in the material.

How many students are not paying attention? none

How many students are restless? one

Any distractions 20 minutes in?

One student was texting on her phone, but stopped when the first presentation started. One student demonstrated a nervous or bored tic. Students in this group felt unsure of themselves when presenting the material.

How many students are not paying attention? One (paid attention during presentation)

How many students are restless? one

Any distractions 30 minutes in?

Other than room noise, there was no distraction at this time. Students were engaged, taking notes or listening to their peer speak.

How many students are not paying attention? none

How many students are restless? none

Any distractions 45 minutes in?

Two students had finished up the quiz and were fidgeting a bit before deciding what to do while their peers continued the quiz.

How many students are not paying attention? 2 (completed the task)

How many students are restless? 2 (same ones not paying attention)

Anything to note in this lesson not otherwise expressed?

Students seemed overall engaged with the lesson but were unsure about how to present the material. They defaulted to splitting the article up and giving each group member one section, then having that person discuss the section. In a course setting, a rubric may be useful in guiding students toward the desired goals.

Observations # 2

Class: Audio Production II section 2
Instructor: Pete Buchwald
Teaching Method: Lecture
Assistant: video camera
Class makeup- Male: 9 Female: 3

Any noticeable distractions in the room before class?

No major distractions before class. Students came in and talked amongst themselves or used their cell phones. Students from another section sometimes walked in thinking they were in the room, but had missed the announcement of their room change from the professor. The instructor was discussing microphone techniques for drums with some students, and those not participating in the conversation seemed interested as well.

Any distractions 5 minutes in?

A student arrived a few minutes late creating a slight distraction, but came in quietly and respectfully. All other students were engaged in listening or taking notes on the material being presented.

How many students are not paying attention? One (just arrived)

How many students are restless? none

Any distractions 15 minutes in?

All students are engaged in the material, taking notes or listening. Some were on laptops, so it was difficult to tell if they were engaged in the material or something else on their computers.

How many students are not paying attention? none

How many students are restless? one

Any distractions 20 minutes in?

All students were engaged in the quiz. They just started, so no one had finished it yet.

How many students are not paying attention? none

How many students are restless? none

Any distractions 30 minutes in?

Students had just begun the questionnaire. All students were engaged in accessing or taking the learning survey.

How many students are not paying attention? none

How many students are restless? none

Any distractions 45 minutes in?

Three students had finished up the questionnaire and were quietly discussing amongst themselves while their classmates finished the task.

How many students are not paying attention? 3 (completed the task)

How many students are restless? 3 (same ones not paying attention)

Anything to note in this lesson not otherwise expressed?

Students seemed overall engaged with the lesson but seemed to want something else to do with the material. They were interested in the topic and wanted to engage in more discussion or activity than lecture could provide.

Observations #3

Class: Audio Production II section 3
Instructor: Pete Buchwald
Teaching Method: Activity and Discussion
Assistant: Julian Clifton
Class makeup- Male: 10 Female: 3

Any noticeable distractions in the room before class?

—No notable distractions other than the usual. Before class students were oftentimes on their phones and iPad's, or discussing with each other various topics of interest to them, oftentimes something about spring break.

—One person in the corner started singing "Smooth Criminal" and kept singing it

—Started at 12:35p.m.

—Doors open and people walking through the class

Any distractions 5 minutes in?

— About 5 minutes into the lecture a couple of students walked in, they caused a slight distraction. Each student was still paying a lot of attention, save for one who was playing on his phone.

How many students are not paying attention? One Isn't (playing on phone) He only paid attention when a demonstration was given.

How many students are restless? None.

Any distractions 15 minutes in? Another student walked in about 12 minutes into the lesson.

How many students are not paying attention? Same student as before was playing on his phone 15 minutes in. He had been paying attention for 10 minutes already.

He started paying attention again, briefly, when the song was played. At about 10 minutes in, one of the girls started playing with her nails, and a student who arrived late played on his phone. So, during the 5 to 15 minute mark, two or three people weren't paying attention. At the 15 minute mark, only 1 was not.

How many students are restless? None.

Any distractions 20 minutes in? None.

How many students are not paying attention? Same student continues playing with his phone. He tries to chime in even though he isn't fully paying attention.

How many students are restless? Same student. Just one is restless.

Any distractions 30 minutes in?

No outside distractions. Most of the distractions arose from devices.

How many students are not paying attention? Three people were not actively paying attention at the 30 minute mark. However, for the most part between the 20-30 minute mark, only 1 person was having difficulty paying attention.

How many students are restless? Three.

Paying attention during the Quiz:

One person left just after the quiz was handed out.

Most people paid as much attention as possible during the quiz and tried to write the answers they knew best. I noticed that the one student who was consistently playing on his phone skipped the first two questions, as did the people who weren't here on time. When the quiz was over, most people started texting and playing on their phones.

Some people received texts during the quiz

During the online quiz:

Most people were paying attention to it. Hard to tell when they weren't because of the use of their devices. One person responded to texts, and one or two looked like they were very tired/restless.

Any distractions 45 minutes in?

None, except the class was drawing to a close at the 40-43 minute mark. Students started to finish the online quiz and walk out.

> **How many students are not paying attention?** None, perhaps 1.
>
> **How many students are restless?** Two-Three, most people seemed to stay focused well enough and weren't too restless.

Anything to note in this lesson not otherwise expressed?

Class started with an attendance sheet. Most people started paying attention at that point, but not all of them.

APPENDIX D

LECTURE NOTES

Hearing Biases

Audio Production II

- Weber's Law ("Weber's Law," n.d.)
    - Qualifies the perception of change in a given stimulus
    - Definition: the change in a stimulus that will be just noticeable is a constant ratio of the original stimulus
    - Book example
    - Relation to Audio
- Weber's Law
    - Just Noticeable Difference: The minimum point at which you notice a **change** in sensation (Difference Threshold)
    - Absolute Threshold: The minimum point at which you first notice a stimulus
- Weber's Law Limitations
    - Not always true
        - Environmental factors
        - extremes
    - Used as a reference, not an absolute
- Equal Loudness Curves (Nave, n.d.)
    - Also known as Fletcher-Munson Curves
    - Represents equal loudness as perceived by the average human ear
    - Measured in phons
- Equal Loudness Curves
    - How are low frequencies treated at…
        - High volume
        - Low volume

- The Ear's Bias (Deruty, 2011)
    - Most transducers in the ear are mechanical
        - Eardrum
        - Ossicles
    - Our ears contain 4 EQs and 3 Compressors
- The Ear's Bias
    - EQs in our ears depend on volume
        - How is this different from EQ-7 Band?
        - Pitch appears to change as volume changes
- How to overcome this when mixing (Deruty, 2011)
    - Listen at different volumes
    - Walk around the room
    - Listen on different speakers
    - Use meters
    - Listen on speakers and headphones

APPENDIX E

TABLE OF SCORES

Section	Identifier	Gender	# of questions right	Percentage	reflective/ active	intuitive/ sensing	verbal/ visual	global/ sequential
1	A	F	14	93	reflective	intuitive	Verbal	sequential
1	B	M	14	93	active	sensing	Visual	sequential
1	C	M	12	80	active	sensing	Verbal	global
1	D	F	15	100	active	intuitive	Visual	global
1	E	M	15	100	active	intuitive	Visual	sequential
1	F	F	13	87	reflective	sensing	Verbal	global
1	G	F	15	100	reflective	intuitive	Visual	global
1	H	M	12	80	active	intuitive	Visual	global
1	I	M	14	93	active	intuitive	Visual	global
1	J	M	12	80	active	sensing	Visual	sequential
1	K	M	14	93	active	intuitive	Visual	global
2	L	M	14	93	reflective	intuitive	Visual	sequential
2	M	M	15	100	active	intuitive	Visual	sequential
2	N	F	13	87	reflective	intuitive	Visual	sequential
2	O	F	14	93	active	sensing	Verbal	sequential
2	P	M	15	100	active	intuitive	Verbal	global
2	Q	M	15	100	active	sensing	Visual	sequential
2	R	F	10	67	reflective	sensing	Visual	global
2	S	M	15	100	active	intuitive	Visual	global
2	T	M	14	93	active	intuitive	Visual	global
2	U	M	14	93	reflective	sensing	Visual	global
2	V	M	15	100	active	sensing	Visual	sequential
2	W	M	12	87	reflective	sensing	Visual	global
3	X	M	15	100	active	sensing	Visual	global
3	Y	M	12	87	active	intuitive	Visual	sequential
3	Z	M	12	87	active	intuitive	Visual	sequential
3	AA	M	14	93	active	sensing	Visual	global
3	BB	M	10	67	reflective	intuitive	Visual	global
3	CC	F	10	67	reflective	intuitive	Visual	sequential
3	DD	M	10	67	reflective	intuitive	Visual	sequential

3	EE	M	15	100	reflective	intuitive	Visual	global
3	FF	F	14	93	reflective	intuitive	Visual	sequential
3	GG	M	13	87	reflective	intuitive	Visual	global
3	HH	F	14	93	active	intuitive	Visual	global
3	II	M	14	93	active	intuitive	Visual	global
3	JJ	M	13	87	active	intuitive	Visual	global