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A Review of Literature in Critical Listening Education

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This paper reviews the literature on critical listening education. Broadly speaking, academic research in this field is often limited to qualitative descriptions of curriculum and studies on the effectiveness of technical ear training. Furthermore audio engineering textbooks often view critical listening as secondary to technical concepts. To provide a basis for the development of curriculum and training, this paper investigates both academic and non-academic work in the field. Consequently a range of common curriculum topics is advanced as the focus areas in current practice. Moreover this paper uncovers pedagogical best practice for training sequence and the use of sounds/sight within instruction. A range of specific instructional activities, such as technical ear training, is also explored, thus providing insights into training in this field. Beyond a direct benefit to pedagogues, it is hoped that this review of the literature can provide a starting point for research in critical listening education.

0 INTRODUCTION

As the most important audio-related skill for sound engineers [1], critical listening relates to numerous aspects of their practice [2, 3]. Given the diverse range of possible curriculum inclusions for this topic [4], course design and delivery can be challenging. This paper reviews critical listening literature to uncover the focus areas in current practice and to explore training design.

Since the 1970s, scholars have written about the type of training provided at tonmeister courses (e.g., [5, 6]). However in-depth insights into such training are more recent. Educational research in critical listening often takes the form of technical ear training studies and qualitative descriptions of curriculum. This paper explores both of these, alongside non-academic training resources that provide a complementary view of current practices.

It begins with a short review of the skills necessary for critical listening. Thereafter the literature is presented according to three broad categories: curriculum topics, generic pedagogical best practice, and specific instructional activities. Finally, a summary of findings is offered to provide an easy reference.

1 NECESSARY SKILLS FOR CRITICAL LISTENING

Before delving into the pedagogy of critical listening, it may be helpful to review the processes and skills necessary in this context. This section presents two broad elements: perceptual skills (related to the sensory input of audition) and communication skills (the output that confirms perception).

1.1 Perception

Critical listening requires directed attention [2, 7, 8], developed to enable switching between levels of detail [8, 9]. Further to this intentionality of aural attention, critical listening draws on various perceptual processes [8, 10]. The first is the discrimination among simultaneous sounds. Using a process of parsing in auditory scene analysis [11], it is the figure-ground organization of perceptual objects. The second process in critical listening is the identification of the technical/physical aspects of sound. Beyond these two elements, quality appraisal and the imagination of sonic improvements can further refine the sound object for the perceiver within an audio engineering context [10]. Although discussions regarding perceptual processes may naturally include discussions of listening modes (e.g., [12]), a thorough review of this topic is beyond the scope of this paper. In an educational context, perceptual input requires a confirmatory output to judge whether the learning experience is adequate. As such, communication methods for sound in critical listening education are explored in the next section.

1.2 Communication

Through a series of papers published since the 1980s, Letowski and Miśkiewicz have provided insights into the development of the timbre solfege course at the Chopin Academy of Music [7, 13, 14] and the adaptation of this course to sensory evaluation training in the workplace [15]. In all accounts of their course, objective and subjective language development for sound is put forward. Beyond the objective technical identification of sound causality, they use words such as “dark” and “sharp” to illustrate the subjective language necessary to describe sound. In a quote resembling Corey’s concept of isomorphic mapping [16], Letowski and Miśkiewicz offer a poignant example of this emphasis on communication as they describe the main objective of their course as intending to “develop students’ ability to identify and express verbally various perceptual characteristics of the auditory image in reproduced sound and relate them to the physical characteristics of signal processing in sound recording technology” [7, p. 83]. This emphasis on communication manifests through two principal avenues within their course.

First they provide an example of matching objective characteristics of sound, such as center frequency, with subjective language, such as “nasal” or “hollow” [17, p. 919]. This practice is similar to Corey’s suggestion that students should develop a memory of aural impressions for each specific frequency band using personalized linguistic attributes that unambiguously differ from adjacent frequencies [18]. Second they suggest a greater focus on skills development through group discussions compared with the previous course iterations that were more focused on individual growth. Corey similarly proposes that “inviting students to describe what they hear not only helps solidify their memory for a particular parameter setting, but it also helps other students identify characteristics that may not have been as salient prior to discussion” [18, p. 3]. This idea bears resemblances to Lefford’s social listening activities, which can be beneficial for critical listening development [19]. Similarly Elmosnino uncovered questioning techniques to foster attention regulation through the verbalization of perception [10]. Interestingly Letowski and Miśkiewicz mention psychophysical scaling methods as learning checks for the common understanding of verbal descriptors within the course [7, p. 91], a process usually undertaken within sensory evaluation tasks (e.g., [20]).

This emphasis on communication is also suggested elsewhere throughout the literature. For example, through the analysis of a conversation between stakeholders during a recording session at an audio school, Porcello concluded that developing a language of sound is critical to skills development [21], a view echoed by Moylan [2]. Interestingly Moylan then proposes visual graphing as a more direct and accurate way of representing and communicating about perception. Others also suggest this idea of using visual graphing within critical listening development (e.g., [10, 22]).

Guzman et al. offer an illustration of this duality between perceptual sound and the language used to describe it when they posit that an audio expert is “able to translate aesthetic intentions, usually expressed in the form of descriptive language/adjectives, into a specific type of sound signals: signals that, when presented to listeners/viewers, elicit responses describable by language/adjectives that largely overlap with those accompanying the aesthetic intention(s)” [23, p. 1].

Finally, within the context of musical/aural education, Andrianopoulou views this descriptive language for sound as a way to harness implicit knowledge through embodied experience and therefore promotes its use [24, pp. 175–176]. For example, using metaphors to describe sounds can strengthen learning by relating implicit embodied perceptual experience with technical knowledge. Overall the development of both objective and subjective language of sound is necessary for critical listening and should form part of the curriculum [25].

2 CURRICULUM TOPICS

2.1 Academic Literature

The academic literature that offers insights into the necessary topics for critical listening generally consists of qualitative accounts of training programs (sometimes complemented with empirical data to confirm their validity) and broader suggestions from educators in the field. For example, at the Chopin Academy of Music, Letowski and Miśkiewicz provide several curriculum topics from their timbre solfege course [7]. Directly aimed at training sound engineers, the course developed from a one-semester offering to a four-semester undergraduate program. The initial account of this course offers exercises in relative timbre perception training, focusing on the spectral content of sounds [13]. In a subsequent paper, Miśkiewicz provides a further developed account of the course that includes psychoacoustics and musical, speech, and recorded sound perception as topics [14]. Therefore these topics extend critical listening beyond simple frequency recognition and delve into other sonic elements, such as loudness, masking effects, distortion, spatial hearing, and absolute timbre perception through sound quality evaluation of stand-alone recordings.

At Leeds Metropolitan University, Thompson et al. describe their “acoustics and critical listening” module as grouping topics typically delivered separately through practical or theoretical classes into a coherent whole viewed through the lens of critical listening [3]. The rationale provided for such a perspective is that “the development of critical listening abilities is often secondary to the content within the study of these [technical] topics; with little or no emphasis on the role that critical listening can play in the practical exploration of these subject areas" [3, p. 3]. A survey of 45 students in this course concluded that it was well designed to develop critical listening skills. They offer four sample topics and associated tasks viewed through the lens of critical listening: monitoring systems, reverberation, headphones, high-resolution audio, and data compression.

Steering away from specific descriptions of critical listening curricula and toward more generalized suggestions, Walzer proposes several ideas for standardizing critical listening training through a literature review on the subject [26]. The topics suggested include frequency bands memorization, microphone polar patterns and placement, instrument and amplification types/problems (distortion, phasing, clipping, jitter buzzing, and noise), acoustics theory, and listening environments. He also emphasizes the influence of equipment, workflow, historical/cultural contexts, and personal taste on creative decisions. Reba reinforces such emphasis on perspective differences, as he mentions that "students should understand that sound quality is related to the entire process, from performance to consumer playback, and that perspectives and perceptions vary greatly" [27, p. 1], and offers fundamental differences in the definition of sound quality between musician, engineer, average consumer, and audiophile. Finally Moylan posits that a curriculum in acoustics, psychoacoustics, and the dimensions of sound in audio recordings can serve students well in developing listening skills [2, p. 3].

2.2 Textbooks

As an extension to the academic literature, textbooks that relate to sound analysis offer various elements as focus points for listening practice. DeSantis provides a brief chapter on active listening as a means to extract information from music listening [28, pp. 22–25]. Principally interested in the practical implementation of such information within electronic music composition, he proposes deconstructing songs by focusing on instrumentation, timbre/texture, production techniques, and spatialization [28, p. 23]. Similarly Elmosnino suggests focusing on spectral content, dynamic envelope, and spatial attributes when analyzing sounds [29, p. 3]. Gottlieb offers five elements related to sound perception that he uses in listening exercises: loudness, pitch, timbre, location, and duration [30, pp. 24–38]. All three authors suggest both using focused listening exercises and undertaking more "open" listening to everyday sounds. Various other authors also suggest this concept of environmental listening [16, pp. 11–12; 31, pp. 7–8; 32, p. 15].

Adapting elements from the European Broadcasting Union parameters for sound quality evaluation in music, Corey suggests bandwidth, spectral balance, auditory image, spatial impression, dynamics, noise/distortion, and balance as topics for sound analysis [16, pp. 121–122]. He then proposes a range of exercises to undertake in order to develop critical listening in these areas [16, pp. 128–149].

Moylan provides two books dedicated to musical/song analysis and provide similar elements for listening practice: pitch, loudness, duration, timbre, and space [9, p. 16; 33, p. 39]. Although they are aimed toward slightly different outcomes, both books provide very similar exercises to develop critical listening skills. The exercises, often relying on the use of visual graphing, aim to train detection/identification of pitch area and density [9, pp. 115–117, 124–125, 162–164, 294–295; 33, pp. 494–495, 501–513], dynamic levels [9, pp. 122–123, 181–185; 33, pp. 529–534], soundstage localization [9, pp. 123, 235–237, 264–266; 33, pp. 514–521], soundstage quality (reverberation) [9, pp. 238–243, 267; 33, pp. 522–527], and overall assessment of sound quality [9, p. 204; 33, pp. 496–498, 527–528]. Further to these specific elements for sound analysis, Moylan provides a series of practical exercises with prompting questions related to signal processing [9, pp. 439–443], attention regulation and vigilance [9, pp. 121–122, 295–296; 33, pp. 491–493, 535–538], auditory memory [9, pp. 120–121; 33, pp. 490–491], and a language of sound [9, p. 203; 33, pp. 513–514, 534–535]. The subject of developing auditory memory and a language of sound is also discussed extensively by Harley [34, pp. 27–56]. Finally, since Moylan's books revolve around music analysis, he provides an exercise to develop discrimination skills for different instruments [9, pp. 142–143].

This type of discrimination exercise is also found in Oliveros' *Deep Listening* [35] and books/lecture notes from Schafer [31, 32]. Principally aimed at schoolteachers looking for ways to develop their students' critical listening skills, Schafer offers exercises in sound recognition for environmental sounds [31, pp. 7–8; 32, p. 15]. Beyond simple recognition, he provides many other activities related to dynamic levels [32, pp. 17–19, 31–32], spatial position [32, pp. 17–23, 31–32, 40], spatial quality [32, pp. 41, 99], and sound quality [32, pp. 16–19, 26–27, 31–32, 37, 57–59, 127].

3 PEDAGOGICAL BEST PRACTICE

3.1 Training Sequence

Scholars generally agree on sequencing critical listening training in a way that begins with simpler perceptual tasks that gradually become more cognitively complex. For example, Letowski and Miśkiewicz suggest developing relative to absolute timbre perception skills throughout their timbre solfege course. In the beginning, the focus is on "detection, discrimination, recognition, identification, and verbal description" [7, p. 88]. Later in the course, the focus shifts to more integrated processes involving problem-solving and evaluation (e.g., real-world sound processing tasks and recording analysis).

At Kyushu University, Kawahara describes the syllabus in technical listening training as following a similar sequence [36]. First it focuses on developing skills related to the detection of differences in audio signals. From there the course focuses on the identification of differences in sound pressure levels and frequency recognition. Within the context of technical ear training, Martin and Massenburg suggest increasing complexity rather than subtlety for advanced listeners [37].

At Concordia University, Tsabary proposes the concepts of aural atoms and synergetic structures as the basis of his electroacoustics analysis course [38]. Rooted in Bregman's auditory scene analysis [11], the course trains students to break sounds down into the smallest possible parts (aural atoms) before reassembling those into higher-level units (synergetic structures). Following this linear progression during their study, students initially develop their perceptual thresholds by decreasing the just-noticeable difference of certain features or parameters of aural stimuli such as amplitude, frequency, spectral profile, microtime, and space. Following this atomistic approach to critical listening, his students then undertake a synergistic analytical process to integrate aural atoms into larger structures. The exercises then focus on process, gesture, motion, relationships, texture, and form. In order to illustrate how the concepts integrate into a coherent educational whole, Tsabary posits that "once training allows us to perceive minute microtonal variations (say, 3 cents), we may be able to identify a subtle vibrato in what we previously heard as a stable tone" [38, pp. 5–6]. He also suggests that such a type of training is beneficial in strengthening students' ability to focus their attention on specific perceptual objects. Although the overall goal of the course is one of sound analysis, Tsabary posits that sonic analysis and aural training are interdependent, since both rely on information extraction [38, p. 3].

3.2 Illustrating Sound Examples

In order to foster critical listening, technical subjects should include illustrating sound examples [10, 26]. Within audio engineering textbooks, the inclusion of audio samples illustrating technical content can be viewed as an effective means of critical listening development. Through the extensive implementation of such features, two textbooks [29, 39] seem largely interested in critical listening development. Similarly, specifically within a mastering context, Katz offers a chapter dedicated to developing listening skills, including a series of exercises designed to help the reader generate their illustrating sound samples [40, pp. 25–36]. The topics covered relate to the recognition of comb filtering, band-limited signals, the "see-saw" effect of equalization, clipping, data compression, and dynamic range compression. Moylan offers similar exercises that require the reader to generate their own illustrating sound examples for various audio engineering processes such as equalization, noise gates, compression, delays, and reverberation [9, pp. 125, 399–403]. Specifically related to microphones, he also offers exercises to compare microphones, their placement, and techniques [9, pp. 374–376].

The vast amount of online video tutorials, both from providers specializing in audio engineering and audio-centric tutorials from user-uploaded content, generally also work on the principle of providing illustrating sound examples for the topics being studied. Going a step further in this direction, Fabrice Dupont at *PureMix* offers a series of tutorials specifically aimed at developing critical listening skills by comparing various equipment and settings [41]. A similarly critical listening-focused video series is offered by Jonathan Wyner at *iZotope*, covering a range of topics specifically related to mastering [42]. Overall these resources tend to rely on auditory memory to develop critical listening by identifying differences between sounds and linking cause and effect for sound quality.

When critical listening exercises require the user to select their own source material, Harley suggests using sources that are familiar, appropriate to reveal specific sonic characteristics, and only focusing on one sonic variable at a time [34, p. 55]. Swanson echoes this view as he posits that meaningful comparisons can be achieved through reducing variables (e.g., matching signal paths), reducing bias (e.g., using double-blind testing), and generally ensuring that the differences under investigation are significant enough to create a meaningful educational experience [25, p. 6]. Harley [34, p. 55] and Dupont [41] also recommend matching loudness levels to ensure accurate comparisons. Since auditory comparisons invariably rely on auditory memory, Moulton recommends developing this skill by introducing pauses and distractions between comparisons [43, p. 44]. Dupont offers an opposing view by suggesting a lower reliance on memory through switching from one sound to the other in as short a time as possible during comparisons [41].

As a necessary issue related to the inclusion of illustrating sound examples for technical concepts, monitoring must be considered within critical listening. Moulton mentions the importance of working in a calibrated environment at the start of his manual [43, pp. 6–7] and refers back to this point numerous times. This idea of training within a consistent environment is echoed by Elmosnino [10]. When this may not be possible, Swanson suggests considering the impact of the listening environment on the perceived sound [25].

3.3 Visual Distractions

In order to foster attention during critical listening, many authors recommend reducing visual cues when undertaking critical listening assessment (e.g., [10; 28, p. 23; 37; 40, p. 34; 41]). The basis for this suggestion is generally that the eye can fool the ear into imagining auditory events that may not exist, which is an idea somewhat akin to the concept of confirmation bias.

4 INSTRUCTIONAL ACTIVITIES

4.1 Technical Ear Training

Technical ear training is interested in developing perceptual ability alongside the technical parameters of signal processing used to influence audio [16, p. x]. This practice is generally implemented by asking listeners to recognize specific signal processing applied to a sound. Corey suggests that this sort of training can improve the links between objective sonic attributes and subjective perception (isomorphic mapping) and increase the speed and accuracy of making such judgements [16, pp. 5–6]. This section reviews the literature on technical ear training for critical listening education.

4.1.1 Academic Literature

The most common type of technical ear training focuses on relative timbre perception, such as detecting differences in audio signals (perceptual thresholds) and identifying what such differences are (technical knowledge). This training for timbre sensitivity and memory is expected to eventually provide listeners with better absolute timbre perception for the independent technical deconstruction of sound [13].

Related to perceptual thresholds and sensitivity, many education facilities use listening tests to develop critical listening [e.g., 13]. However few studies focus solely on this aspect of perception (e.g., [44, 45]). In effect, the literature generally views the development of perceptual thresholds as an added layer of refinement within timbre memory exercises rather than an area of study of its own. Entry into early tonmeister programs sometimes also made use of such testing regime. For example, Rakowski and Trybula describe the entry test to their faculty at the Academy of Music in Poland as using tests of just-noticeable differences in sound recordings [6]. These tests were implemented to check for hearing thresholds, ensuring a certain level of perceptual ability for the training of audio engineers. As a more recent example, Tsabary uses similar perceptual threshold training at Concordia University in Canada [38, 46].

Remaining within the area of relative timbre perception but focusing on identifying technical parameters, several studies have been conducted over the years that advocate for this sort of training to improve perceptual ability. For example, Quesnel and Woszczyk used a pre and post-test procedure to conclude that students perform better in identifying spectral changes after undertaking consistent relative perception tasks [47]. This type of procedure and conclusion is found in affluence for spectral recognition training (e.g., [48–51]). Scholars have also undertaken comparable studies related to other aspects of sound, such as compression [52] and auditory source width [53]. Using more qualitative methodologies, Tsabary et al. have undertaken a study in frequency identification, loudness discrimination, timbral discrimination, spectral shape identification, and microtemporal hearing with students at Concordia University, also advocating for the use of technical ear training [46].

In related papers, scholars have provided information regarding how technical ear training is delivered at their institutions. This information can prove invaluable to assess the viability of technical ear training implementation. For example, Brixen offers insights into identifying spectral changes exercises at the Danish Acoustical Institute [54]. A similar training related to frequency recognition is presented by Iwamiya et al. at the Kyushu Institute of Design [45] and Quesnel at McGill University [55]. Similarly training related to dynamic range compression is presented by Martin et al. at McGill University [56].

From a broader perspective, Corey provides more qualitative information regarding his technical ear training class at the University of Michigan [18]. While focusing mainly on frequency recognition with some mention of dynamic range compression and reverberation exercises, he offers insights into the topics explored through perceptual exercises and class discussions. Finally another example of a broader perspective on technical ear training covering various aspects of a sound engineer's skills requirements is provided by Martin and Massenburg at McGill University [37].

4.1.2 Textbooks and Other Training Materials

Steering away from academic literature, some textbooks provide exercises aimed at critical listening development through focused listening drills that are also considered technical ear training. For example, as perhaps one of the most well-known technical ear training textbooks, Moulton's *Golden Ears* provides a range of exercises to develop perceptual skills in critical listening [43]. The CDs and accompanying manual generally present concepts in written and auditory forms, followed by listening drills to practice recognizing each concept. The critical listening elements covered in this resource are frequency band recognition in equalized signals, amplitude differences, total harmonic distortion, compression, stereo field manipulation, time delays, and reverberation. A similarly laid out resource is offered by Everest [57]. In his book and accompanying CD, he offers theoretical content with illustrating sound samples followed by identification exercises covering topics related to frequency band recognition, amplitude, acoustic instruments harmonics recognition, total harmonic distortion, wow and flutter, reverberation, signal-to-noise ratio, comb filters, and some psychoacoustic notions without exercises.

Other resources also provide the reader with specific technical ear training exercises, albeit without the provision of pre-recorded audio materials or training software. For example, Stavrou [58, pp. 252–253] and Katz [40, p. 27] suggest working in pairs with one person equalizing a signal, toggling an effect on and off, and requesting the second person to describe how to equalize the signal to return to the flat sound. Another paired activity also offered by Katz is detecting loudness differences of 0.5 dB [40, pp. 30–31].

Moving toward a more modern way of implementing technical ear training, Serra et al. offer a combination of book and accompanying technical ear training software on CD [59]. Using more recent technological advances in computing, Corey and Benson provide a custom-made, web-based technical ear training software suite to complement Corey's book [16]. The book and software cover various aspects of equalization, reverberation, dynamic range compression/expansion, distortion, and audio edit points. In recent years, this sort of software-based technical ear training has become more common. Some examples of such training available online and as standalone applications include the following:

- *Audio Frequency Trainer* [60],
- *Audio Training* [61],
- *Balancing Channels* [62],
- *Ear Training 1* [63],
- *Ear Training: Frequency Quiz* [64],
- *Golden Ears Challenge* [65],
- *HearEQ* [66],
- *How to Listen* [67],
- *Inner Ear* [68],
- *Match the Mix* [69],
- *Perfect Ear Training* [70],
- *Pro Audio Essentials* [71],
- *Quiztones* [72],
- *SAE Parametric Equaliser Training* [73],
- *SOAR (SOme Assembly Required)* [74],
- *Sonic Learning Applications* [75],
- *SoundGym* [76],
- *SoundWizz Ear Training* [77],
- *StudioEars 2* [78],
- *Technical Ear Trainer* [79],
- *TrainYourEars* [80], and
- *What's the Frequency?* [81].

4.1.3 Best Practice

Beyond research that promotes the use of technical ear training, the literature offers a range of best-practice elements for its implementation. First Moulton suggests keeping training sessions short and only undertaking those for as long as focus is retained or until the listener becomes confused, bored, or impatient [43, pp. 53–54]. Elmosnino also advances a similar notion during interviews with educators in the field [10].

Individualized training that adapts difficulty to the learner can also be beneficial [46, 82–85]. Within the context of traditional musical solfege, a practice often compared to technical ear training [16, p. 3], this idea of individualized training recognizes and fosters individual strengths [24, p. 177].

Feedback systems can provide an avenue for motivation [46]. However scoring in technical ear training may only be helpful as a means to keep track of improvement rather than absolute indicators of skills [10; 43, pp. 45–46].

Technical ear training also benefits from using custom software interfaces [46, 86, 87]. However Elmosnino found that scaffolding user interface complexity can be beneficial to foster motivation [10].

Research generally recommends balancing technical ear training with more authentic audio engineering endeavors. For example, within the context of musical solfege, Andrianopoulou posits that isolated training is necessary but needs to be complemented by integrated training [24, pp. 174–175]. This practice can be done either as gradual movement between isolated to integrated or in parallel (e.g., using a full mix but focusing on specific aspects). Martin and Massenburg mention addressing individual components and their interactions within training to emulate mixing tasks rather than the usual global approach, which resembles mastering tasks only [37]. Additionally they suggest that exercises including non-static parameters such as automation can more accurately reflect industry practice. As examples of the tasks provided to students, they undertake equalization, compression, automation, and full mix matching. Related to this idea of offering more authentic technical ear training activities, Brezina proposes using commercial plugins that students may be familiar with as the basis for exercises in parameter identification [88]. Using a standalone plugin host that randomly alters parameters and requires the user to match sounds, he believes that a more varied learning experience can be achieved.

4.1.4 Discussion

Overall technical ear training should form part of the critical listening curriculum [25]. The literature provides a fairly extensive background into relative timbre perception training. Although it generally focuses on frequency recognition tasks, some research delves into dynamic range compression, auditory source width, and reverberation.

Most studies offer a positivistic view of the usefulness of such training for learners, agreeing on the statistical evidence suggesting that technical ear training improves critical listening skills. However this approach generally leads to a lack of qualitative data and its associated depth of understanding regarding the training experience. Furthermore, although it has sometimes been shown to improve auxiliary skills in audio engineering (e.g., [49]), current research generally fails to prove its usefulness beyond the technical ear training program itself [89].

This type of training is generally not an integrated authentic experience and is often limited to a single aspect of critical listening: the perceptual identification of specific sound processing elements. As such, literature on this topic is of limited use to educators because it misses some crucial aspects of critical listening development. To illustrate this point from a knowledge perspective, the differentiation between technical and practical knowledge as put forward by Cash-Jones can be a helpful analogy. Favoring a more practical approach to curriculum development, she proposes that engineers with technical knowledge may be aware that 440 Hz equals the musical note A, compared with those with practical experience knowing the lowest fundamental frequency of an electric bass guitar [90, p. 2].

4.2 Miscellaneous

4.2.1 Academic Literature

At Leeds Metropolitan University, Thompson et al. provide an assessment task for their study module that embodies the notion of viewing technical audio engineering concepts through the lens of critical listening [3]. As a tool commonly suggested to standardize monitoring environments (e.g., [10]), they suggest the creation of a research-based personal reference CD that includes test tones, musical materials, and an accompanying report arguing for the validity of the included sounds [3, p. 4]. A similar activity is also suggested by Merchant [91, p. 4].

At Middle Tennessee State University, Merchant proposes a deliberate practice approach to his mixing techniques class to foster motivation [91]. Through a review of instructor comments on the same assessment before and after implementing the deliberate practice model, he posits that such a training regime provides better outcomes for students. The projects that relate to the development of critical listening include performing exercises that focus on foundational mixing competencies and reviewing peers' work to develop critical listening and communication skills.

At Columbia College Chicago, the second course in a series of three on auditory perception and cognition indirectly delves into critical listening through an "auditory world" journaling assessment [23, p. 3]. This assessment asks students to listen and describe environmental sounds through prompting questions related to localization, loudness, and quality.

At Concordia University, Tsabary offers exercises designed to train students in refining their hearing thresholds and discrimination of auditory streams [38, p. 5]. The first requires students to detect and order just-noticeable variations in aural parameters (e.g., click durations, delay times, microtuning, loudness, harmonicity/inharmonicity, spatial features, and others). The second relates to temporal segmentation training, where students hunt for specific items in a sequence of similar items (e.g., hunting for a specific pitch, timbre, vowel, click, or spatial position in a sequence). The third also relates to auditory stream segregation, emphasizing spectral segmentation by isolating parts within a more complex sonic mixture (e.g., identifying frequency boosts and attenuations to force the students to listen intently to parts of the spectrum).

4.2.2 Textbooks

Beyond the activities presented in Secs. 2.2 and 4.1.2, textbooks also offer a range of activities specifically related to critical listening. For example, Gottlieb suggests listening to an instrument in the room to decide where to place microphones, comparing the sound heard in the recording room and through the microphone, and comparing microphones on the same source [30, pp. 158–159]. A similar activity is offered by Elmosnino [10].

Additionally Schafer presents a "sound treasure walk" as a way to practice the many different aspects of critical listening previously offered in the form of an aural orienteering activity [32, pp. 138–141]. He also provides guided imagery exercises requiring students to imagine various sounds and tonalities [32, pp. 44, 46–54, 133], a notion also suggested by Elmosnino to foster critical listening [10]. Finally, from the perspective of fault-finding, Moulton suggests that educated guesses may prove useful for answering questions that perceptual skills alone cannot accurately judge, hinting that critical thinking may play an essential role in critical listening [43, p. 44].

5 SUMMARY

In order to provide an easy reference for the development of courses interested in sound quality evaluation, Tables 1, 2, and 3 summarize the information presented in this paper. Table 1 lists curriculum inclusions for critical listening training. Table 2 presents generic pedagogical best practice for critical listening training. Table 3 offers specific instructional activities for critical listening training.

Table 1. Curriculum inclusions for critical listening training.

Frequency levels and activity	[2, 9, 16, 26, 28–30, 33, 43, 91]
Amplitude and dynamic levels	[2, 9, 16, 29, 30, 32, 33, 43, 91]
Acoustics	[2, 26]
Psychoacoustics	[2]
Soundstage localization and sonic dimensions	[2, 9, 16, 28, 29, 32, 33, 43, 91]
Soundstage quality	[3, 9, 32, 33, 43, 91]
Time judgments and editing	[2, 9, 16, 33, 91]
Noise and distortion	[16, 43]
Technical ear training: non-static parameters	[37]
Monitoring systems	[3, 25, 26]
High resolution audio and data compression	[3]
Microphone polar patterns and placement	[9, 26, 30]
Instrument and amplification	[26, 28]

Table 2. Generic pedagogical best practice for critical listening training.

Communication: develop objective and subjective language	[2, 7, 9, 18, 19, 22–26, 33, 34]
Communication: verbally share auditory perception cues	[7, 10, 18, 19]
Sequencing: adapt difficulty to the listener	[10, 24, 46, 82–85]
Sequencing: increase complexity rather than subtlety for difficulty adjustment	[37]
Sequencing: develop skills from relative to absolute perception	[7]
Sequencing: develop just-noticeable difference and perceptual thresholds early	[36, 38]
Technical ear training: use custom software interface	[46, 86, 87]
Technical ear training: use scoring for gauging improvement rather than assessment	[43]
Technical ear training: limit time spent on technical ear training	[43]
Miscellaneous: develop short and long-term auditory memory	[9, 33, 34, 41, 43]
Miscellaneous: foster motivation	[10, 24]
Miscellaneous: illustrate technical content with sound examples	[10, 26, 29, 39, 40]
Miscellaneous: study technical subjects through the lens of critical listening	[3]
Miscellaneous: avoid visual feedback	[10, 28, 37, 40, 41]
Miscellaneous: reduce bias in listening comparisons	[25]
Miscellaneous: reduce variables in listening comparisons	[25, 34, 41]
Miscellaneous: ensure differences under investigation are significant enough for learning	[25, 34, 43]

Table 3. Specific instructional activities for critical listening training.

Detection thresholds training (identifying and ordering just-noticeable difference variations)	[2, 38]
Auditory stream discrimination training (guided hunting and unguided discovery)	[9, 31, 32, 35, 38]
Undertake authentic tasks (e.g., composition, recording, and mixing)	[10, 26, 37, 43, 91]
Balance isolation (technical ear training) with integration (authentic tasks)	[24]
Undertake learner-designed assessment tasks	[24]
Create a “reference CD” for monitoring evaluation and sound signature memorization	[3, 10, 91]
Discuss the influence of equipment, context, and perspective on creative decisions	[26, 27]
Undertake reflection tasks (e.g., project reflection and journals)	[26, 91]
Undertake sound analysis tasks	[9, 10, 16, 23, 25, 28–30, 32, 33, 38]
Use visual graphing for song analysis	[2, 9, 10, 22, 33]
Encourage non-technical listening	[16, 25, 28–30, 32]
Undertake guided imagery tasks	[9, 10, 32, 33]
Use technical ear training exercises	[10, 16, 25, 40, 43, 47–54, 57–59]

6 CONCLUSION

This paper reviewed the current literature specifically aimed at critical listening training. Beginning with a brief overview of the necessary skills for critical listening, a duality between perception and communication emerges as a crucial element for skills development. Thereafter several topics from qualitative curricula descriptions and textbooks related to sound analysis are advanced. These topics answer the first question posed in this paper regarding the areas of focus in current practice, which in turn may provide guidance to curriculum designers. Three broad best-practice elements are then suggested regarding the training sequence for critical listening (which should gradually increase in cognitive complexity), including illustrating sound examples for teaching technical concepts and reducing visual distractions during critical listening. A range of instructional activities is also offered, including a comprehensive review of technical ear training practices.

Both the best-practice elements and instructional activities uncovered present an opportunity to answer the second question posed in this paper regarding how might effective critical listening training be designed. Although the literature does not generally propose how critical listening training affects the completion of authentic tasks, this paper argues that incorporating these best-practice elements complemented by tried and tested activities such as technical ear training can help improve sound analysis skills, which in turn are expected to improve authentic practice. Nevertheless the wide range of views offered in this paper point to a need for a learning experience that integrates multiple elements presented in order to provide real-world results. Overall this paper fulfills its intended purpose to provide a basis for developing and delivering courses interested in critical listening.

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8 REFERENCES

[1] F. Otondo, "Music Technology, Composition Teaching and Employability Skills," *J. Music. Technol. Educ.*, vol. 9, no. 3, pp. 229–240 (2016 Dec.). https://doi.org/10.1386/jmte.9.3.229_1.

[2] W. D. Moylan, "Teaching Listening," in *Proceedings of the AES UK 26th Conference: Audio Education* (2015 Aug.), paper 15.

[3] P. Thompson, B. Mosley, and M. Ward, "Critical Listening and Acoustics as an Essential Part of the Audio Production and Sound Technology Curriculum," in *Proceedings of the AES 50th International Conference: Audio Education* (2013 Jul.), paper 2-2.

[4] S. Elmosnino, "Mental Representations in Critical Listening Education: A Preliminary Study," presented at the *147th Convention of the Audio Engineering Society* (2019 Oct.), paper 10299.

[5] J. Borwick, "The Tonmeister Concept," presented at the *46th Convention of the Audio Engineering Society* (1973 Sep.), paper 938.

[6] A. Rakowski and A. Trybula, "Auditory Tests of Timbre Sensitivity at the Tonmeisters Faculty," presented at the *50th Convention of the Audio Engineering Society* (1975 Mar.), paper L-44.

[7] T. Letowski and A. Miśkiewicz, "Timbre Solfege: A Course in Perceptual Analysis of Sound," in J. A. Adamczyk (Ed.), *Signal Processing in Sound Engineering*, pp. 83–96 (IPPT PAN, Warsaw, Poland, 2013).

[8] E. Tsabary, "Which Aural Skills Are Necessary for Composing, Performing and Understanding Electroacoustic Music, and to What Extent Are They Teachable by Traditional Aural Training?" *Organ. Sound*, vol. 14, no. 3, pp. 299–309 (2009 Dec.). https://doi.org/10.1017/S1355771809990112.

[9] W. Moylan, *Understanding and Crafting the Mix: The Art of Recording* (Focal Press, Burlington, MA, 2015), 3rd ed.

[10] S. Elmosnino, "Educational Strategies in Critical Listening: Interviews With Instructors," in *Proceedings of the AES International Audio Education Conference* (2021 Jul.), paper 6.

[11] A. S. Bregman, *Auditory Scene Analysis: The Perceptual Organization of Sound* (MIT Press, Cambridge, MA, 1990).

[12] P. Schaeffer, *Treatise on Musical Objects: An Essay Across Disciplines*, California Studies in 20th-Century Music, vol. 20 (University of California Press, Oakland, CA, 2017). https://doi.org/10.1525/9780520967465.

[13] T. Letowski, "Development of Technical Listening Skills: Timbre Solfeggio," *J. Audio Eng. Soc.*, vol. 33, no. 4, pp. 240–244 (1985 Apr.).

[14] A. Miśkiewicz, "Timbre Solfege: A Course in Technical Listening for Sound Engineers," *J. Audio Eng. Soc.*, vol. 40, no. 7/8, pp. 621–625 (1992 Jul.).

[15] A. Miśkiewicz and T. Letowski, "Timbre Solfege Training in Automotive Industry," in *Proceedings of the 7th Forum Acusticum* (Krakow, Poland), pp. 83–96 (2014 Sep.).

[16] J. Corey, *Audio Production and Critical Listening: Technical Ear Training* (Routledge, New York, NY, 2017), 2nd ed. https://doi.org/10.4324/9781315727813.

[17] T. Letowski and A. Miśkiewicz, "Development of Technical Listening Skills for Sound Quality Assessment," in *Proceedings of the International Congress and Exposition on Noise Control Engineering (INTER-NOISE)*, pp. 917–920 (Newport Beach, CA) (1995 Jul.).

[18] J. Corey, "Technical Ear Training: Tools and Practical Methods," *Proc. Mtgs. Acoust.*, vol. 19, no. 1, paper 025016 (2013 Jun.). https://doi.org/10.1121/1.4795853.

[19] M. N. Lefford, "Listening Sessions: Critical Listening in a Social Context," in D. Walzer and M. Lopez (Eds.), *Audio Education: Theory, Culture, and Practice*, pp. 115–130 (Routledge, New York, NY, 2021).

[20] S. Bech and N. Zacharov, *Perceptual Audio Evaluation – Theory, Method and Application* (Wiley, Chichester, UK, 2006).

[21] T. Porcello, "Speaking of Sound: Language and the Professionalization of Sound-Recording Engineers," *Soc. Stud. Sci.*, vol. 34, no. 5, pp. 733–758 (2004 Oct.). https://doi.org/10.1177/0306312704047328.

[22] M. Jones, "Practical Production Analysis: Helping Students Produce Competitive Songs," *J. Music Entertain. Ind. Educ. Assoc.*, vol. 17, no. 1, pp. 59–78 (2017). https://doi.org/10.25101/17.3.

[23] S. J. Guzman, S. B. Kanters, and P. N. Vassilakis, "Utilizing Effective Media, Demonstrations, and Exercises on the Perception of Sound," in *Proceedings of the 50th AES International Conference: Audio Education* (2013 Jul.), paper 2-5.

[24] M. Andrianopoulou, *Aural Education: Reconceptualising Ear Training in Higher Music Learning* (Routledge, London, UK, 2020).

[25] B. Swanson, "Encouraging Students Towards Meaningful Subjective Comparisons," in *Proceedings of the 50th AES International Conference: Audio Education* (2013 Jul.), paper 2-3.

[26] D. A. Walzer, "Critical Listening Assessment in Undergraduate Music Technology Programmes," *J. Music. Technol. Educ.*, vol. 8, no. 1, pp. 41–53 (2015 May). https://doi.org/10.1386/jmte.8.1.41_1.

[27] C. H. Reba, "Sound Quality Education: Pedagogical Issues, Concepts and Practices," in *Proceedings of the 38th AES International Conference: Sound Quality Evaluation* (2010 Jun.), paper 6-1.

[28] D. DeSantis, *Making Music - 74 Creative Strategies for Electronic Music Producers* (Ableton AG, Berlin, Germany, 2015).

[29] S. Elmosnino, *Audio Production Principles: Practical Studio Applications* (Oxford University Press, New York, NY, 2018).

[30] G. Gottlieb, *Shaping Sound in the Studio and Beyond: Audio Aesthetics and Technology* (Thomson Course Technology, Boston, MA, 2007).

[31] R. M. Schafer, *Ear Cleaning: Notes for an Experimental Music Course* (Clark & Cruikshank, Toronto, Canada, 1967).

[32] R. M. Schafer, *A Sound Education: 100 Exercises in Listening and Sound-Making* (Arcana Editions, Indian River, Canada, 1992).

[33] W. Moylan, *Recording Analysis: How the Record Shapes the Song* (Routledge, New York, NY, 2020).

[34] R. Harley, *The Complete Guide to High-End Audio* (Acapella Publishing, Carlsbad, CA, 2010), 4th ed.

[35] P. Oliveros, *Deep Listening: A Composers' Sound Practice* (iUniverse, Lincoln, NE, 2005).

[36] K. Kawahara, "Syllabus of Technical Listening Training in Kyushu University," in *Proceedings of the AES International Audio Education Conference* (2021 Jul.), paper 5.

[37] D. Martin and G. Massenburg, "Advanced Technical Ear Training: Development of an Innovative Set of Exercises for Audio Engineers," presented at the *139th Convention of the Audio Engineering Society* (2015 Oct.), e-Brief 217.

[38] E. Tsabary, "Aural Atoms and Structures: From Electroacoustic Ear Training to Analysis and Back Again," in *Proceedings of the Electroacoustic Music Studies Network Conference: The Art of Electroacoustic Music* (Sheffield, UK), pp. 1–12 (2015 Jun.).

[39] R. Izhaki, *Mixing Audio: Concepts, Practices, and Tools* (Routledge, New York, NY, 2018), 3rd ed.

[40] R. A. Katz, *Mastering Audio: The Art and the Science* (Focal Press, Burlington, MA, 2015), 3rd ed.

[41] F. Dupont, "How to Listen," https://www.puremix.net/how-to-listen-series.html (accessed Aug. 18, 2020).

[42] J. Wyner, "Are You Listening?" https://www.izotope.com/en/lp/are-you-listening.html (accessed Feb. 3, 2022).

[43] D. Moulton, *Golden Ears* (KIQ Productions Inc, Sherman Oaks, CA, 1995).

[44] S. Bech, "Selection and Training of Subjects for Listening Tests on Sound-Reproducing Equipment," *J. Audio Eng. Soc.*, vol. 40, no. 7/8, pp. 590–610 (1992 Jul.).

[45] S. Iwamiya, Y. Nakajima, K. Ueda, K. Kawahara, and M. Takada, "Technical Listening Training: Improvement of Sound Sensitivity for Acoustic Engineers and Sound Designers," *Acoust. Sci. Technol.*, vol. 24, no. 1, pp. 27–31 (2003 Jan.). https://doi.org/10.1250/ast.24.27.

[46] E. Tsabary, D. Savage, D. Ogborn, et al., "Inner Ear: A Tool for Individualizing Sound-Focused Aural Skill Acquisition," *J. Music. Technol. Educ.*, vol. 12, no. 3, pp. 261–278 (2019 Dec.). https://doi.org/10.1386/jmte_00010_1.

[47] R. Quesnel and W. R. Woszczyk, "A Computer-Aided System for Timbral Ear Training," presented at the *96th Convention of the Audio Engineering Society* (1994 Feb.), paper 3856.

[48] M. A. Bassett, *The Influence of Training Method on Tone Colour Discrimination*, Ph.D. thesis, The University of Sydney, Sydney, Australia (2018 Mar.).

[49] M. J. Indelicato, C. Hochgraf, and S. Kim, "How Critical Listening Exercises Complement Technical Courses to Effectively Provide Audio Education for Engineering Technology Students," presented at the *137th Convention of the Audio Engineering Society* (2014 Oct.), paper 9189.

[50] Z. Liu, F. Wu, and Q. Yang, "The Practice and Study of Ear Training on Discrimination of Sound Attributes," presented at the *122nd Convention of the Audio Engineering Society* (2007 May), paper 7114.

[51] M. McKinnon-Bassett and W. L. Martens, "Experimental Comparison of Two Versions of a Technical Ear Training Program: Transfer of Training on Tone Colour Identification to a Dissimilarity-Rating Task," in *Proceedings of the 50th AES International Conference: Audio Education* (2013 Jul.), paper 2-4.

[52] D. Martin, G. Massenburg, and R. King, "Dynamic Range Controller Ear Training: Analysis of Audio Engineering Student Training Data," presented at the *144th*

Convention of the Audio Engineering Society (2018 May), paper 9994.

[53] S. Kim and H. Imamura, "An Assessment of a Spatial Ear Training Program for Perceived Auditory Source Width," *J. Acoust. Soc. Am.*, vol. 142, no. 2, pp. EL201–EL204 (2017 Aug.). https://doi.org/10.1121/1.4998185.

[54] E. B. Brixen, "Spectral Ear Training," presented at the *94th Convention of the Audio Engineering Society* (1993 Mar.), paper 3474.

[55] R. Quesnel, "Timbral Ear Trainer: Adaptive, Interactive Training of Listening Skills for Evaluation of Timbre Differences," presented at the *100th Convention of the Audio Engineering Society* (1996 May), paper 4241.

[56] D. Martin, G. Massenburg, and R. King, "Dynamic Range Controller Ear Training: Description of a Methodology, Software Application, and Required Stimuli," presented at the *143rd Convention of the Audio Engineering Society* (2017 Oct.), paper 9888.

[57] F. A. Everest, *Critical Listening Skills for Audio Professionals* (Thomson Course Technology, Boston, MA, 2007).

[58] M. P. Stavrou, *Mixing With Your Mind* (Flux Research, Mosman, Australia, 2003).

[59] M.-H. Serra, J. Baboni-Schilingi, J.-F. Rey, and J. Lochard, *10 Jeux d'écoute: Ateliers Ircam* (Hyptique, Paris, France, 2000).

[60] D. Owen, "Audio Frequency Trainer," https://www.mediacollege.com/media-guru/audio/frequency-trainer.html (accessed Jan. 1, 2021).

[61] S. Salas Díaz, "Audio Training (Ear Training for EQ and Feedback)," https://play.google.com/store/apps/details?id=com.saninnsalas.audiotraining (accessed Jan. 1, 2021).

[62] T. Frampton, "Balancing Channels," https://ultimateproducer.co.uk/challenges/balancing-channels (accessed Jan. 1, 2021).

[63] Pro Audio Master Classes, "Ear Training 1," https://proaudiomasterclasses.com/classes/ear-training-1 (accessed Jan. 1, 2021).

[64] PureMix, "Ear Training: Frequency Quiz," https://www.puremix.net/ear-training.html (accessed Jan. 1, 2021).

[65] Røde Microphones, "Golden Ears Challenge," https://videomicrange.com/goldenearsquiz (accessed Jan. 1, 2021).

[66] A. Andrews, "hearEQ," https://www.tenkettles.com/heareq/ (accessed Jan. 1, 2021).

[67] S. Olive, "How to Listen," http://harmanhowtolisten.blogspot.com/ (accessed Jan. 1, 2021).

[68] E. Tsabary, "Inner Ear," http://intramuros.mcmaster.ca:8000/ (accessed Jan. 1, 2021).

[69] Sonarworks, "Match the Mix," https://matchthemix.sonarworks.com/ (accessed Jan. 1, 2021).

[70] S. Salas Díaz, "Perfect Ear Training," https://www.saninnsalas.com/coding/audio-training/ (accessed Jan. 1, 2021).

[71] J. Wyner, "Pro Audio Essentials," https://pae.izotope.com/ (accessed Jan. 1, 2021).

[72] D. Comerchero and E. Olcott, "Quiztones," https://theproaudiofiles.com/quiztones/ (accessed Jan. 1, 2021).

[73] M. Bassett, "SAE Parametric Equaliser Training," https://sae.edu.au/insights/software/ (accessed Jan. 1, 2021).

[74] Auricula, "SOAR Suite," https://www.auriculaonline.com/soap/ (accessed Jan. 1, 2021).

[75] A. Szigetvári and B. Horváth, "Sonic Learning Applications," https://www.interkonyv.hu/konyvek?book_id=2158 (accessed Jan. 1, 2021).

[76] SoundGym, "SoundGym," https://www.soundgym.co/ (accessed Jan. 1, 2021).

[77] S. Keith, "SoundWizz Ear Training - Audio Engineering, EQ, FX," https://play.google.com/store/apps/details?id=com.soundwizz (accessed Jan. 1, 2021).

[78] S. Keith, "StudioEars 2.0," http://www.studio-ears.com/ (accessed Jan. 1, 2021).

[79] J. Corey and D. H. Benson, "Technical Ear Trainer," https://webtet.net/apcl/#/ (accessed Jan. 1, 2021).

[80] L. Herranz Sanz, "TrainYourEars," https://www.trainyourears.com/ (accessed Jan. 1, 2021).

[81] H. Bourne, "What's the Frequency?," https://www.henrybourne.uk/whats-the-frequency/ (accessed Jan. 1, 2021).

[82] T. Kaniwa, S. Kim, H. Terasawa, et al., "Towards a Personalized Technical Ear Training Program: An Investigation of the Effect of Adaptive Feedback," in *Proceedings of the 8th Sound and Music Computing Conference* (Padova, Italy) (2011 Jul.).

[83] S. Kim, "An Assessment of Individualized Technical Ear Training for Audio Production," *J. Acoust. Soc. Am.*, vol. 138, no. 1, pp. EL110–EL113 (2015 Jul.). https://doi.org/10.1121/1.4922622.

[84] S. Kim, T. Kaniwa, H. Terasawa, T. Yamada, and S. Makino, "Inter-Subject Differences in Personalized Technical Ear Training and the Influence of an Individually Optimized Training Sequence," *Acoust. Sci. Technol.*, vol. 34, no. 6, pp. 424–431 (2013 Jun.). https://doi.org/10.1250/ast.34.424.

[85] A. Marui and T. Kamekawa, "Towards the Development of Objective Difficulty Measure in Technical Ear Training Tasks," *Proc. Mtgs. Acoust.*, vol. 19, no. 1, paper 025020 (2013 Jun.). https://doi.org/10.1121/1.4800094.

[86] M. Bassett, "Max as an Interactive, Multi-Modal Learning and Teaching Tool for Audio Engineering," presented at the *141st Convention of the Audio Engineering Society* (2016 Sep.), e-Brief 304.

[87] M. Bassett and W. L. Martens, "SAE Parametric Equalizer Training: Development of a Technical Ear Training Program Using Max," presented at the *141st Convention of the Audio Engineering Society* (2016 Sep.), e-Brief 298.

[88] P. Brezina, "Perspectives of Advanced Ear Training Using Audio Plug-Ins," *J. Audio Eng. Soc.*, vol. 69, no. 5, pp. 351–358 (2021 May). https://doi.org/10.17743/jaes.2020.0029.

[89] M. Bassett, "Precursor Criteria for Assessing the Effectiveness of Technical Ear Training Programs," in *Proceedings of the AES International Audio Education Conference* (2021 Jul.), paper 13.

[90] L. Cash-Jones, "Finding a Recording Audio Education Program That Suits Your Career Choice," presented at the *113th Convention of the Audio Engineering Society* (2002 Oct.), paper 5697.

[91] III J. H. Merchant, "A Revised Approach to Teaching Audio Mixing Techniques: Applying the Deliberate Practice Model," presented at the *131st Convention of the Audio Engineering Society* (2011 Oct.), paper 8543.

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