Journal of Music Theory Pedagogy

Volume 24 Article 3

1-1-2010

# Error Detection in the Aural Skills Class - Research and Pedagogy

Stacey Davis

# Error Detection in the Aural Skills Class: Research and Pedagogy

By Stacey Davis

The past thirty years have seen a rapid increase in research on music perception and cognition, including the establishment of academic societies, research conferences, and scholarly journals. In general, this research focuses on exploring the mental processes involved in listening to, remembering, understanding, performing, and responding to music. These topics are inherently interdisciplinary, with scholars emerging and collaborating from a variety of research fields, including cognitive psychology, neuroscience, psychoacoustics, music theory, and music education.

In the field of music theory, aural skills pedagogy is a natural place to apply the findings of this perceptual research. The typical ear training activities of identification, sight-singing, dictation, and error detection are clearly dependent upon hearing, perception, and memory. But perceptual research has yet to significantly affect our pedagogical approaches, teaching materials, and classroom activities. Butler and Lochstampfor commented on these "bridges unbuilt" in a 1993 article.

> A cursory examination of references cited in the literature of aural training pedagogy suggests that there is very little correspondence between research activities in music cognition and pedagogical activities in aural training: although there are important individual exceptions, there does not seem to have been a widespread effort to identify, gather, evaluate, and synthesize experimental results from the research area of music cognition so that they may be applied directly to aural training in our college music programs.[1]

The following seven years brought little change, with Karpinski stating that "very little aural skills training has been informed by the explosion of research in music perception and cognition during the past quarter century. Important findings about perception and

[1] David Butler and Mark Lochstampfor, "Bridges Unbuilt: Comparing the Literatures of Music Cognition and Aural Training," *Indiana Theory Review* 4 (1993): 6.

cognition . . . seem to have been unexamined or ignored by the authors of nearly every aural skills text in current use."[2]

Another ten years have passed since Karpinski's comment, but a review of current aural skills research and pedagogical resources yields similar results. Although there are a number of important contributions, many aural skills instructors are not familiar with the findings of music perception research.[3] This results in the creation of pedagogical materials that lack a perceptual foundation. Likewise, some music perception researchers are not aware of the issues of teaching aural skills, thus making it difficult to generate research questions that are most pertinent to pedagogy. As a starting point for linking these two fields, this paper focuses on the important skill of error detection. After a brief review of the components of this skill and its status in the aural skills class, focus is placed on surveying a selection of perceptual studies that reveal information about factors that affect error detection ability. Applying these research findings to pedagogical issues illuminates avenues for future research and generates ideas for improving teaching methods and materials.

## Defining Error Detection

The ability to evaluate music performance and make comparisons between sound and notation is applicable to almost every musical

[2] Gary S. Karpinski, "Lessons From the Past: Music Theory Pedagogy and the Future," *Music Theory Online* 6.3 (2000): 5.3.

[3] For a survey of perception research as it applies to some aspects of music theory pedagogy, see Elizabeth West Marvin, "Research on Tonal Perception and Memory: What Implications for Music Theory Pedagogy?" *Journal of Music Theory Pedagogy* 9 (1995): 31-70. Perceptual research is also mentioned in David Butler, "Why the Gulf Between Music Perception Research and Aural Training?" *Bulletin of the Council of Research in Music Education* 132 (1997): 38-48; Gary Karpinski, "A Model for Music Perception and its Implications in Melodic Dictation," *Journal of Music Theory Pedagogy* 4 (1990): 191-229; Karpinski, *Aural Skills Acquisition: The Development of Listening, Reading, and Performing Skills in College-Level Musicians* (New York: Oxford University Press, 2000); Edward Klonoski, "A Perceptual Learning Hierarchy: An Imperative for Aural Skills Pedagogy," *College Music Symposium* 40 (2000): 168-169; William E. Lake, "Interval and Scale-Degree Strategies in Melodic Perception," *Journal of Music Theory Pedagogy* 7 (1993): 55-67; and Steve Larson, "Scale-Degree Function: A Theory of Expressive Meaning and its Application to Aural Skills Pedagogy," *Journal of Music Theory Pedagogy* 7 (1993): 69-84.

situation, including listening, performing, studio teaching, conducting, and adjudication. As Karpinski described,

> Error detection and correction are indeed indispensable skills that all musicians should possess to a useful degree. Ideally, every time musicians sing or play from notation a constant process of self-correction takes place between their eyes and ears. The more adept musicians are at detecting and correcting discrepancies between sound and notation, the more often such errors can be corrected and even avoided in their own performances.[4]

In all of these situations, error detection requires multi-sensory perception and multi-tasking ability. Listening activities can involve both sound and notation, while performance situations add the variable of concurrently playing an instrument or conducting. In order to notice mistakes in performance, one must have correctly internalized how that music should have sounded, either from hearing it before or from interpreting music notation. Making these comparisons requires the simultaneous use of different perceptual mechanisms and skills.

Comparing different sounds (or performances) involves musical memory and expectation. One must remember what was heard first in order to recognize any changes or errors in a subsequent performance. This ability is required when comparing two consecutive performances of an unfamiliar piece or evaluating a new performance of a well-known piece. Because memory and expectation are influenced by a variety of factors, instructors cannot assume that all students have the ability to listen attentively, compare multiple sounds, and identify similarities and differences. Sound comparison tasks should therefore be an important part of the error detection component of an aural skills curriculum.

Other error detection tasks require comparisons between aural and visual information, thereby relying on the ability to associate what is heard with what is notated in the score. Examples of this task include comparing a performance to a prepared score or matching the sound of a well-known piece (either heard or imagined) to its notation (without hearing what was written). An alternate task requires the comparison of score and sound for an unfamiliar or unprepared piece. Without actually hearing the

[4] Karpinski, *Aural Skills Acquisition*, 130.

piece, listeners imagine the notated sounds in order to evaluate the performance. Gordon coined the term "audiation" to describe this ability to "assimilate and comprehend in our minds music we may or may not have heard, but are reading in notation or composing or improvising."[5] Audiation could be considered a form of "sight-hearing," which is a natural counterpart to the other typical aural skills activity of sight-singing.[6]

Almost all of the error detection examples in ear training textbooks involve this skill of aural imagery or audiation. Students are presented with an unfamiliar score and asked to identify pitch or rhythm errors in its performance. Although this is a vitally important skill, many musical experiences do not involve sight-hearing. For instance, a performer, conductor, or teacher often knows a piece or has prepared a score before needing to evaluate its performance. Likewise, an adjudicator is sometimes required to compare different performances of the same piece. Focusing solely on audiation tasks will not necessarily develop all of these important evaluative skills. Error detection activities therefore need to incorporate a variety of different comparisons, including single sensory comparisons (sound to sound), multi-sensory comparisons (sound to notation), and various combinations of familiar (or prepared) and unfamiliar examples.

A broader definition of error detection would also incorporate the evaluation of a wider variety of musical characteristics. Rather than only listening for differences in pitch and rhythm, students need to be aware of tonality, contour, interval size, meter, harmony, articulation, dynamics, tempo, tone quality, intonation, technical precision, balance, and expression. Being able to detect differences or errors in each of these features requires an assortment of valuable perceptual and evaluative skills.

---

[5] Edwin E. Gordon, *Learning Sequences in Music: A Contemporary Music Learning Theory* (Chicago: GIA Publications, 2007), 4. Daniel Martin used the term "auralization" to refer to the ability to "form a mental impression of sound not yet heard." See Daniel W. Martin, "Do You Auralize?" *Journal of the Acoustical Society of America* 24 (1952): 416.

[6] James L. Byo and Deborah A. Sheldon, "The Effect of Singing While Listening on Undergraduate Music Majors' Ability to Detect Pitch and Rhythm Errors," *Journal of Band Research* 36 (2000): 27.

## Incidence of Error Detection in Aural Skills Classes

In 1990, Pembrook and Riggins sent a survey about aural skills teaching to 908 schools in the College Music Society Directory.[7] Responses came from instructors at 336 schools from 45 different states. Survey questions focused on organizational approaches, teaching materials, sight-singing methods, use of computers, and division of class time. The question about materials revealed that 47% of instructors used Benward's *Sight-singing Complete* as an error detection textbook, followed by 30% designing their own materials, 17% using no text, and 5% using CAI software.[8] Interestingly, Benward's text is intended for singing practice and does not contain any specific error detection activities.

Answers to the question about the division of class time revealed additional information about error detection. According to the results of this survey, a majority of time in the freshman aural skills class was spent on sight-singing, followed by identification tasks (i.e., labeling intervals or chord qualities) and dictation. Although error detection was considered important, 84% admitted that it was given the least amount of time in the freshman aural skills class. For sophomores, an equal amount of time was spent on sight-singing and dictation, followed by identification tasks and then error detection.[9] Pembrook and Riggins summarized that "considering the frequency that students will use this skill (e.g., as conductors, classroom and studio instructors, adjudicators, etc.), it is reasonable to suggest that more time should be devoted to developing this vital skill."[10]

Although this survey was completed twenty years ago, the contents of current ear training textbooks suggest that similar results might be gathered today. Only three of the most recently published textbooks contain specific error detection activities. Not only is this number small, but the included error detection tasks are fairly limited in both quantity and scope. In *A New Approach to Ear Training*,

---

[7] Randall G. Pembrook and H. Lee Riggins, "Send Help!: Aural Skills Instruction in U.S. Colleges and Universities," *Journal of Music Theory Pedagogy* 4 (1990): 231-242.

[8] Ibid., 237.

[9] Ibid.

[10] Ibid., 239-240.

Kraft includes three "Hearing Differences" sections.[11] Each of these sections contains four, four-measure melodies whose performances contain mistakes in pitch and/or rhythm. Error detection is included in almost every chapter of Benward and Kolosick's *Ear Training: A Technique for Listening*, with various chapters focusing on finding errors in rhythmic patterns, short pitch patterns, short melodies, excerpts from the literature, two-voice examples, and harmonic progressions.[12] Finally, Marcozzi includes a "Fusion and Transfer" section in each chapter of *Strategies and Patterns for Ear Training*.[13] These activities require students to identify errors in four-note pitch patterns, short melodies, two-voice examples, single chords, and harmonic progressions.[14]

All three of these textbooks have an accompanying CD, with examples played as MIDI files using the piano timbre. Instructors might also choose to perform examples using the classroom piano. In most cases, the notated score is correct and the students are asked to identify errors in the performance. However, the Benward and Kolosick textbook occasionally provides examples with a correct performance and errors in the notated score. In all exercises, students are instructed to identify errors in pitch and/or rhythm. For pitch errors, melodic contour is typically maintained and certain pitches are changed by a whole or half step. Students are usually told how many errors to find, with some examples varying the number of errors (up to 4). Marcozzi includes some "placebo" examples that do not contain any errors at all.

Based on these surveys of class time and textbooks, the attention given to error detection does not match its supposed importance. This small number of pedagogical resources could certainly be affecting class time, with limited materials making it more difficult

---

[11] Leo Kraft, *A New Approach to Ear Training*, 2nd Ed. (New York: W.W. Norton & Company, 1999).

[12] Bruce Benward and J. Timothy Kolosick, *Ear Training: A Technique for Listening*, 7th edition revised (New York: McGraw-Hill, 2010).

[13] Rudy Marcozzi, *Strategies and Patterns for Ear Training* (Upper Saddle River, NJ: Prentice-Hall, 2009).

[14] The following two textbooks contain comments about error detection, but no specific activities: Thomas Durham, *Beginning Tonal Dictation* (Prospect Heights, IL: Waveland Press, 2004) and Gary S. Karpinski, *Manual for Ear Training and Sight Singing* (New York: W.W. Norton & Company, 2007).

and time consuming to include error detection as a classroom activity or assigned practice task. If a wide variety of scores and recordings with errors is not readily accessible, instructors might opt to focus on other activities. Other explanations for this shortage of attention could be teacher experience, student preparation and ability, time constraints, emphasis on other ear training activities, and assumptions about the acquisition of error detection ability. Although additional resources might lessen the effect of many such issues, these resources must incorporate a broader definition of error detection and an awareness of perceptual principles in order to best facilitate the acquisition of this important skill.

## Applying Research to Pedagogy

Error detection has received very little attention from the music theory research community. Although some publications discuss its importance and suggest general teaching strategies, there is very little research on the topic by those that are most likely teaching these classes.[15] The field of music perception, on the other hand, has generated a significant amount of research on error detection. Most of these perceptual studies involve listening tasks that require participants to compare two versions of a short rhythmic, melodic, or harmonic pattern. The second version is either an exact repetition of the first or an altered rendition that contains changes in key, contour, interval size, rhythm, meter, and/or tempo. Although these listening tasks do not typically involve a notated score, they provide information about the perception of a variety of musical characteristics. There are also many studies that investigate the perception of notation and the process of sight-reading in general.

Scholars in the music education community have also produced a substantial amount of perceptual research on error detection. This research focuses on the role of error detection in the training of beginning musicians, conductors, and public school teachers. Participants in these studies are typically children in the early

[15] A description of issues related to error detection is included in Karpinski, *Aural Skills Acquisition*, 130-132. Error detection is not mentioned in Michael R. Rogers, *Teaching Approaches in Music Theory: An Overview of Pedagogical Approaches* (Carbondale, IL: Southern Illinois University Press, 2004) and receives only a brief mention as the "wrong note technique" in John D. White, *College Teaching of Music Theory*, 2nd ed. (Lanham, MD: Scarecrow Press, 2002), 46.

stages of learning to play an instrument or music education majors (student conductors) learning to prepare scores and manage rehearsals. Although there are some natural differences in perceptual skills between children and college students, the findings of these studies are still relevant to the aural skills instructor. Music educators typically ask perceptual questions that are applicable to specific musical skills or stages of development, which allows for connections to be made between cognitive psychology and musical practice. It is therefore important that aural skills instructors are aware of both music perception and music education research, particularly when it addresses concepts that align with the skills we are teaching.

The remainder of this paper contains a survey of selected research from these two disciplines. After a brief summary of research on student-related factors, focus is placed on summarizing studies that investigate how various characteristics of musical structure and performance affect error detection ability. These research findings will be applied to examples from the three ear training textbooks that contain specific error detection activities. The intent is not to criticize these examples, but rather to use them as a starting point for discussing the variables that could be considered when designing effective error detection resources.

### *Student-related factors*

A musician's background and prior experience can significantly affect the ability to make comparisons and identify differences. Some of the factors that might influence error detection accuracy are music reading ability, music memory ability, years of private lessons, number of instruments played, ensemble experience, sight-reading ability (on own instrument and sight-singing), and music theory knowledge. Research on these student-related factors has produced mixed results. Some studies show no relationship between error detection ability and years of private lessons, ensemble experience, number of different instruments played, music theory ability, sight-singing ability, dictation ability, memory skills, and score reading ability.[16] Other studies suggest that theory

[16] Manny Brand and Vernon Burnsed, "Music Abilities and Experiences as Predictors of Error-Detection Skill," *Journal of Research in Music Education* 29 (1981): 91-96; James L. Byo, "The Influence of Textural and Timbral Factors on the Ability of Music Majors to Detect

skills, performance experience, choral arranging experience, and sight-singing ability improve error detection accuracy.[17] Although these results appear inconclusive, they still suggest that error detection is a distinct skill that requires separate practice. It will not necessarily emerge as a byproduct of practicing seemingly related skills. For instance, a student who can successfully perform melodic dictation or sight-sing a melody may not automatically have strong error detection skills. Likewise, a student's performance ability and prior experience may not correlate with their level of error detection ability.

There is also substantial research on the perception of music notation and on sight-reading as it applies to performance. Studies have shown that music reading ability is a separate perceptual skill, with different processes occurring for superior and inferior readers.[18] Skilled readers have better visual memory for notation, stronger grouping (or chunking) ability, and more sensitivity to the structural configurations of notation. These skills also relate to sight-reading while performing. Good sight-readers have better chunking ability, which reflects their understanding of musical structure, expectation, and grouping. For instance, it is advantageous to recognize a triad or seventh chord as a single

Performance Errors," *Journal of Research in Music Education* 41 (1993): 156-167; Harold E. Fiske, "Relationships of Selected Factors in Trumpet Performance Adjudication Reliability," *Journal of Research in Music Education* 25 (1977): 256-263; Robert G. Sidnell, "Self-Instructional Drill Materials for Student Conductors," *Journal of Research in Music Education* 19 (1971): 85-91.

[17] Carroll Lee Gonzo, "An Analysis of Factors Related to Choral Teachers' Ability to Detect Pitch Errors While Reading the Score," *Journal of Research in Music Education* 19 (1971): 259-271; Janice N. Killian, "The Relationship Between Sightsinging Accuracy and Error Detection in Junior High Singers," *Journal of Research in Music Education* 39 (1991): 216-224; Richard C. Larson, "Relationships Between Melodic Error Detection, Melodic Dictation, and Melodic Sightsinging," *Journal of Research in Music Education* 25 (1977): 264-271; Deborah A. Sheldon, "Effects of Contextual Sight-Singing and Aural Skills Training on Error-Detection Abilities," *Journal of Research in Music Education* 46 (1998): 384-395.

[18] Andrea R. Halpern and Gordon H. Bower, "Musical Expertise and Melodic Structure in Memory for Musical Notation," *The American Journal of Psychology* 95 (1982): 31-50; John A. Sloboda, "The Psychology of Music Reading," *Psychology of Music* 6 (1978): 3-20; John A. Sloboda, "Experimental Studies of Music Reading," *Music Perception* 2 (1984): 222-236.

entity rather than as multiple, individual pitches. Noticing such patterns reduces the amount to be remembered and facilitates the performance of unfamiliar music.[19] Studies of eye movements during performance have also shown that good sight-readers consistently look beyond the music they are currently playing.[20] Although many error detection tasks do not require simultaneous performance, there are similarities between sight-reading and sight-hearing. Listeners must understand notation, recognize musical patterns or groups, and look ahead in the score in order to notice errors in the performance of an unfamiliar or unprepared piece.

### *Music-related factors*

Many structural features affect the complexity and perception of music, thereby also affecting error detection accuracy. Some important features to consider are tonal context, contour, interval size, consonance and dissonance, harmonic progression, phrase structure, pattern repetition, rhythm, meter, accents, texture, timbre, and tempo. The location of the error relative to other structural features, along with a person's familiarity with the music, also affects responses to an error detection task. All of these features must be taken into consideration when choosing music for an error detection task, planting errors in a performance, and understanding student strengths and weaknesses.

Memory is a particularly important factor when examining the relationship between musical structure and error detection ability. In tasks that require participants to sing back a short melody from memory, global characteristics like meter, key, overall shape, and

---

[19] For a survey of research on sight-reading, see Andreas C. Lehmann and Victoria McArthur, "Sight-Reading" in *The Science and Psychology of Music Performance*, ed. Richard Parncutt and Gary E. McPherson (New York: Oxford University Press, 2002), 135-150; Andreas C. Lehmann and Reinhard Kopiez, "Sight-reading" in *The Oxford Handbook of Music Psychology*, ed. Susan Hallam, Ian Cross, and Michael Thaut (Oxford: Oxford University Press, 2009), 344-351.

[20] Thomas W. Goolsby, "Profiles of Processing: Eye Movements During Sightreading," *Music Perception* 12 (1994): 97-123; Jaime Madell and Sylvie Hébert, "Eye Movements and Music Reading: Where Do We Look Next?" *Music Perception* 26 (2008): 157-170; Andrew J. Waters and Geoffrey Underwood, "Eye Movements in a Simple Music Reading Task: A Study of Expert and Novice Musicians," *Psychology of Music* 26 (1998): 46-60.

phrase structure are best remembered.[21] Melodies that follow tonal patterns and expectations are also better remembered than those that do not, particularly when those melodic patterns coincide with metric and rhythmic accents.[22] Exact pitches, intervals, implied harmonies, and rhythms are more difficult to remember, with metric context, rhythmic complexity, number of contour changes, and metric placement of contour changes affecting error detection accuracy.

Sheldon studied the role of memory by investigating how the number of repetitions affects error detection accuracy.[23] In this study, participants were given notated scores of twelve examples from the band literature. A correct performance of each piece was followed by an error-filled performance that was repeated three times. The task was to identify mistakes in articulation, intonation, pitch, rhythm, tempo, dynamics, and balance. Results indicated that error detection was most accurate following the first hearing, with accuracy decreasing after the second hearing and then again for the third. During the last two repetitions, participants also identified errors that did not actually occur. Sheldon suggested that the results after the first performance were better because it immediately followed hearing the correct rendition and was less dependent on the listener's memory. Later hearings, on the other hand, required participants to rely on audiation to compare the performance and the score. This suggests that increasing the number of hearings does not necessarily facilitate error detection accuracy. Perhaps it instead causes listeners to mistakenly identify correct notes as errors as they "learn" the error-filled performance and lose either the memory of the correct version or the ability to audiate the notated version. A single listening also more accurately reflects every-day musical experiences. We hear a performance and must immediately respond to adjust our own performance,

[21] John A. Sloboda and David H.H. Parker, "Immediate Recall of Melodies" in *Musical Structure and Cognition*, ed. Peter Howell, Ian Cross, and Robert West (London: Academic Press, 1985); Jack A. Taylor and Randall G. Pembrook, "Strategies in Memory for Short Melodies: An Extension of Otto Ortmann's 1933 Study," *Psychomusicology* 3 (1983): 16-35;

[22] Marilyn Boltz, "Some Structural Determinants of Melody Recall," *Memory and Cognition* 19 (1991): 239-251.

[23] Deborah A. Sheldon, "Effects of Multiple Listenings on Error-Detection Acuity in Multivoice, Multitimbral Musical Examples," *Journal of Research in Music Education* 52 (2004): 102-115.

give corrective feedback to individual students or ensembles, or generate an evaluative opinion.

Dowling has conducted many experiments that investigate how listeners remember the pitch-related elements in a melody, with possible conceptualizations being a set of absolute pitches, a contour, a set of consecutive intervals, or a series of relative pitches in a tonal context.[24] Participants in these listening experiments were asked to compare two different performances of various short melodies. The second performance was an exact transposition of the first to a different key, a transposition that started on a different pitch but maintained the original key (a "tonal answer"), an atonal version that retained the same contour, or a randomly generated melody that had a different contour and different intervals. The task was to indicate whether the second melody was the same as the first. Playing the melodies at different pitch levels allowed Dowling to study the perception of contour, interval size, and scale degree (rather than just exact pitch repetition).

Results of one study showed that listeners were very accurate when distinguishing the original melody from the atonal and random versions. But participants performed at chance when attempting to differentiate between the exact transposition and the tonal answer.[25] A tonal answer has the same contour as an exact intervallic transposition, but some intervals are changed by a semitone in order to stay in the same key as the original melody. Having difficulty telling these two versions apart suggests that listeners remember contour and tonal strength rather than exact intervals when comparing performances of unfamiliar melodies. This is consistent with other studies whose results suggest that listeners identify contour differences better than pitch differences in error detection tasks involving short-term memory.[26] However,

---

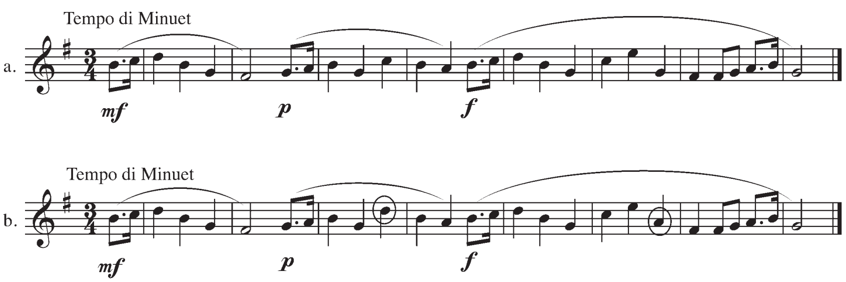
[24] W. Jay Dowling, "Context Effects on Melody Recognition," *Music Perception* 3 (1986): 282-283.

[25] W. Jay Dowling, "Scale and Contour: Two Components of a Theory of Memory for Melodies," *Psychological Review* 85 (1978): 341-354.

[26] W.L.M. Croonen, "Effects of Length, Tonal Structure, and Contour in the Recognition of Tone Series, *Perception and Psychophysics* 55 (1994): 623-632; Lola L. Cuddy, "On Hearing Patterns in Melody, *Psychology of Music* 10 (1982): 3-10; Lola L. Cuddy, Annabel J. Cohen, and D.J.K. Mewhort, "Perception of Structure in Short Melodic Sequences, *Journal of Experimental Psychology: Human Perception and Performance* 7 (1981): 869-883; Lucinda A. Dewitt and Robert G. Crowder, "Recognition of

the opposite is true for the perception of performances of well-known melodies that are stored in long-term memory. People have extremely accurate memories for the exact intervals of familiar tunes, which aids in the identification of songs transposed to different keys.[27]

This research on the perception of contour, pitch, and tonal context is directly applicable to error detection tasks in the aural skills class. In most ear training textbooks, error detection examples retain contour and change certain pitches by a whole or half step. For instance, both of the errors in the performance of the melody in Example 1 are a whole step higher than the correct note. Although this performance has not been transposed to a new key, these errors create a tonal lure similar to the ones used in the perception studies. Without a fully developed sense of scale degree function and strong audiation skills, students might fail to notice these pitch errors in an unfamiliar melody that exists only in short-term memory. The wrongly played pitches retain overall contour, maintain




Example 1. Adapted from Exercise 3F-1, #3 in Marcozzi, *Strategies and Patterns of Ear Training*, 82 (a. student notated version; b. instructor performed version). Notation is correct, performance errors are circled.

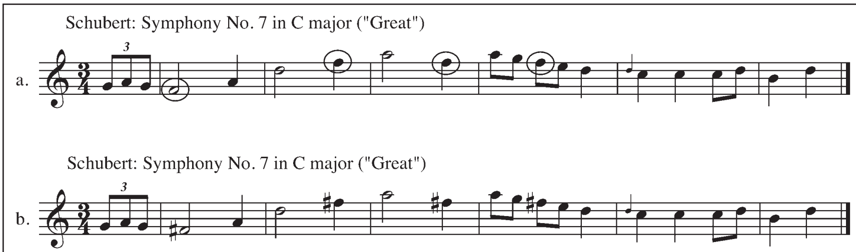
---

Novel Melodies after Brief Delays," *Music Perception* 3 (1986): 259-274; W. Jay Dowling, "Tonal Strength and Melody Recognition After Long and Short Delays," *Perception and Psychophysics* 50 (1991): 305-313; W. Jay Dowling, "Melodic Contour in Hearing and Remembering Melodies," in *Musical Perceptions*, ed. Rita Aiello and John A. Sloboda (Oxford: Oxford University Press, 1994): 173-190; W. Jay Dowling and Diane S. Fujitani, "Contour, Interval, and Pitch Recognition in Memory for Melodies," *Journal of the Acoustical Society of America* 49 (1971): 524-531.

[27] W. Jay Dowling and James C. Bartlett, "The Importance of Interval Information in Long-Term Memory for Melodies," *Psychomusicology* 1 (1981): 30-49.

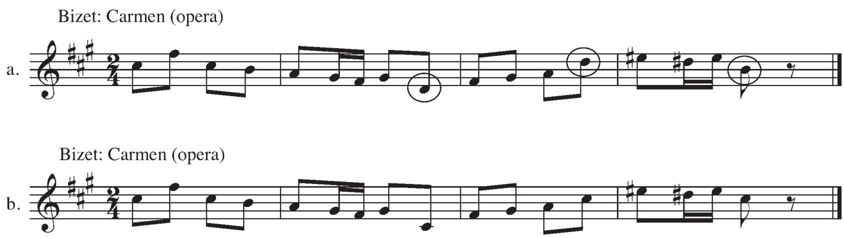
tonal context, avoid disrupting cadences, and create a reasonable alternate melody. Since this type of pitch error can be difficult to hear when comparing the sound of two melodies, it might also be difficult to imagine in an aural-visual comparison task.

The melody in Example 2 also contains errors in exact interval size. This melody is taken from the middle of a piece, where the composer has modulated and the key signature no longer matches the key of the melody. Although the performance correctly reflects this change of key, the accidentals have been omitted from the score. If the instructor establishes this new tonal context, students might correctly perceive that the notated score lacks leading tones. But error detection is more difficult without this tonal context, particularly when the contour is maintained and the incorrectly notated melody looks acceptable in some other key. The ability to notice missing accidentals in the notated C major melody is dependent on the ability to hear the performed melody in the key of G major. It might therefore be more effective to use this example as a key perception task, rather than an error detection task. After hearing a performance of each version of the melody, students could be asked to sing back the tonic pitch. If students correctly perceive the way the F-sharps affect the relationship between whole and half steps and define tonal context, they would sing C for one version and G for the other.




Example 2. Adapted from Melody 10B, #10 in Benward & Kolosick's *Ear Training: A Technique for Listening*, 203 (a. student notated version; b. instructor performed version). Performance is correct, notated errors are circled.

The relationship between pitch and contour is different when listening to a familiar melody, where people have long-term memory for precise interval sizes. Example 3 contains an excerpt of a well-known melody from Bizet's opera *Carmen*. Similar to the melodies in Examples 1 and 2, correct contour is retained and certain pitches are altered by step. But in this case, the performance is correct and the errors are in the notation. The listener therefore does not have the jarring perceptual experience of hearing a familiar tune played incorrectly. Although the error at the end would be easiest to perceive since it occurs at a cadence and does not match tonal context, students who cannot correctly audiate the notated score might find it difficult to identify the two pitch errors in the middle of the melody. Error detection accuracy would be much higher if the task was reversed and the errors instead occurred in the performance. The sound of this familiar melody would not match long-term memory and listeners would be better able to identify misplayed notes and determine corrections.




Example 3. Adapted from Melody 5B, #1 in Benward & Kolosick's *Ear Training: A Technique for Listening*, 95 (a. student notated version; b. instructor performed version). Performance is correct, notated errors are circled.

If error detection is only defined as the ability to match score and sound, location of the error could be deemed irrelevant. But visual perception of music notation is different than aural perception of music performance. Although all errors might create unexpected dissonance, violate tonal context and expectation, or contradict long-term memory, seeing that error and hearing that error are two different perceptual experiences. It is also rare that notated scores have errors. In typical performance and conducting situations, the score is notated correctly and the errors occur in performance. It is important that our pedagogical resources mimic musical practice as much as possible.

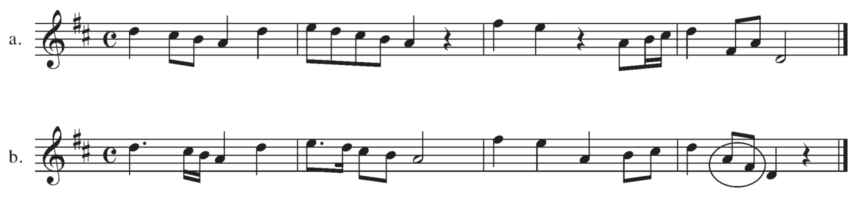
The difference between visually perceived and aurally perceived errors also relates to the role of tonal context in the task of error detection. As Sheldon described,

> An interesting hypothesis concerning the abilities of listeners to detect errors centers on musical context or

> reasonableness of the transgression. Some errors may seem more incorrect than others due to musical context. Errors that are less egregious than others may be more readily 'forgiven' and therefore not detected as errors at all, whereas errors that violate context to a greater degree are more likely to be identified by listeners.[28]

Incorrectly played pitches that violate tonal context are perceptually different than those that remain suitable in the prevailing key. A similar case could be made for rhythmic errors that violate metric context. This could be compared to research on proofreaders' error when reading text, where familiarity, expectation, and context can cause readers to overlook certain typographical or spelling errors. Sloboda tested proofreaders' error in music performance by asking pianists to sight-read simple pieces from scores with planted pitch errors.[29] Rather than playing them as written, the pianists instinctively corrected the pitches to match tonal context and expectation.

Proofreaders' error could explain why some listeners would fail to notice all of the performance mistakes in Example 4. The rhythmic errors that add dotted rhythms or omit rests might be easily identified, but the pitch errors in the last measure could be more challenging. Although these errors occur at a cadence and change contour, they create an alternate arpeggiation of the final tonic chord and provide a reasonable close to this melody. A listener that is focused more on sound than on notation might overlook an acceptable cadential pattern that does not happen to match the one on the score.




Example 4. Adapted from "Hearing Differences 2" in Kraft, *A New Approach to Ear Training*, 137-138 (a. student notated version; b. instructor performed version). Notation is correct, pitch-related performance errors are circled.

---

[28] Sheldon, "Effects of Multiple Listenings," 103.

[29] John A. Sloboda, "The Effect of Item Position on the Likelihood of Identification by Inference in Prose Reading and Music Reading," *Canadian Journal of Psychology* 30 (1976): 228-237.

Repp addressed issues of context and expectation by studying the perception of different types of pitch errors in piano performance.[30] His categories of pitch errors were substitutions (playing a wrong note at the right time), omissions (skipping a note in the score), and intrusions (playing a note that is not in the score). After one hour of rehearsal, ten graduate student pianists were recorded performing four different pieces three times each. Analysis of these performances showed that omission errors were most common, followed by intrusions and substitutions. This suggests that we should include omission errors in our error detection activities. It might be more likely for a performer to omit a correct note than to replace that note with something that violates the tonal context and thereby attracts the listener's attention.

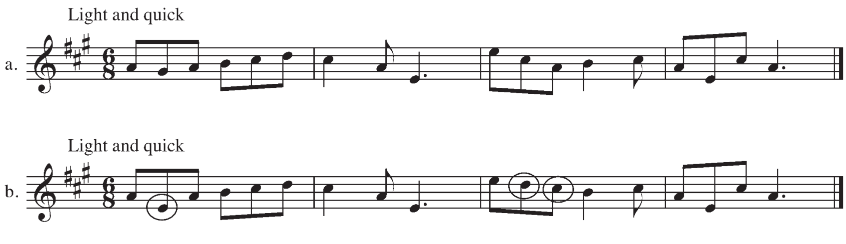
Repp then examined how listeners responded to these analyzed performance errors. A different group of pianists listened to the recorded performances from the first part of the experiment and was instructed to circle all pitch errors on the notated score. Results indicated that listeners only noticed 38% of the performance errors, with only 1.5% of errors being correctly identified by all listeners. As hypothesized, the most commonly perceived errors were those that violated tonal, harmonic, or melodic context in some way. Errors that fit the underlying context were rarely noticed or identified, making them "perceptually inconscipuous." As Repp summarized,

> The present results demonstrate that performance errors vary along a continuum of perceptual salience . . . The listener's musical experience, knowledge of the music, availability of the score, level of attention, and other factors determine a perceptual criterion or threshold that admits only a certain proportion of errors to consciousness. Even errors that have been detected still vary in degree of severity, and a listener probably could rate them accordingly. Errors then are a matter of degree.[31]

[30] Bruno H. Repp, "The Art of Inaccuracy: Why Pianists' Errors are Difficult to Hear," *Music Perception* 14 (1996): 161-184.

[31] Ibid., 179.

One of these "reasonable" errors occurs in the performance of the melody in Example 5. In m. 1, the distance between the correct note and the performed note is a major third. This interval size, along with the familiarity of the expected do-ti-do pattern, might facilitate the identification of this error. However, the error is drawn from the same implied dominant chord and does not disrupt perception of harmony and key. Listeners that are attending to larger-scale aspects of the piece might therefore overlook this error. The errors in the third measure involve pitch and contour, respectively. Although both of these errors fit with tonal context and occur in metrically weak positions, research suggests that the change of contour prior to the second beat of the measure would be more readily perceived than the pitch change on the preceding note.




Example 5. Adapted from Exercise 2F-1, #10 in Marcozzi, *Strategies and Patterns of Ear Training*, 59 (a. student notated version; b. instructor performed version). Notation is correct, performance errors are circled.

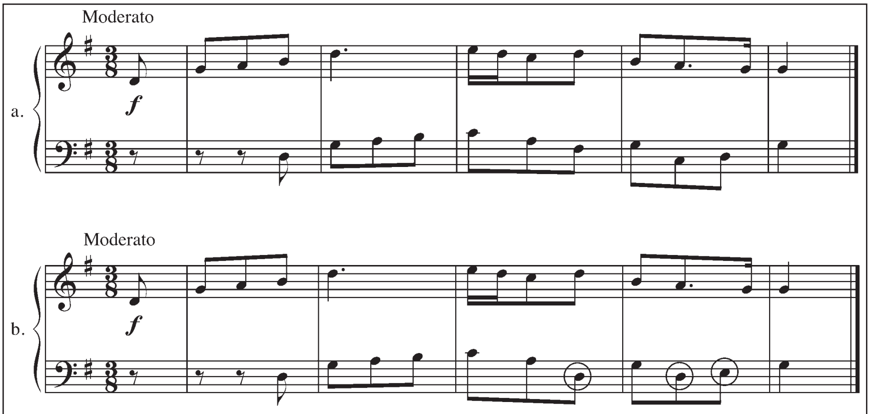
Bigand, McAdams, and Forêt discussed the role of tonal context when investigating the detection of errors in multi-part music.[32] Earlier research suggests that listeners follow either a divided attention model that allows them to simultaneously perceive multiple melodies (as in polyphonic music) or a selective attention model that focuses on an individual melody (or voice) while staying aware of the other background voices.[33] This study proposed a third alternative, which the authors called an integrated perception model. When using this approach, listeners fuse all parts into a single stream that has a certain tonal and harmonic coherence. Error detection ability is therefore dependent on how the mistake

[32] Emmanuel Bigand, Stephen McAdams, and S. Forêt, "Divided Attention in Music," *International Journal of Psychology* 35 (2000): 270-278.

[33] John A. Sloboda and Judy Edworthy, "Attending to Two Melodies at Once: The Effect of Key Relatedness," *Psychology of Music* 9 (1981): 39-43.

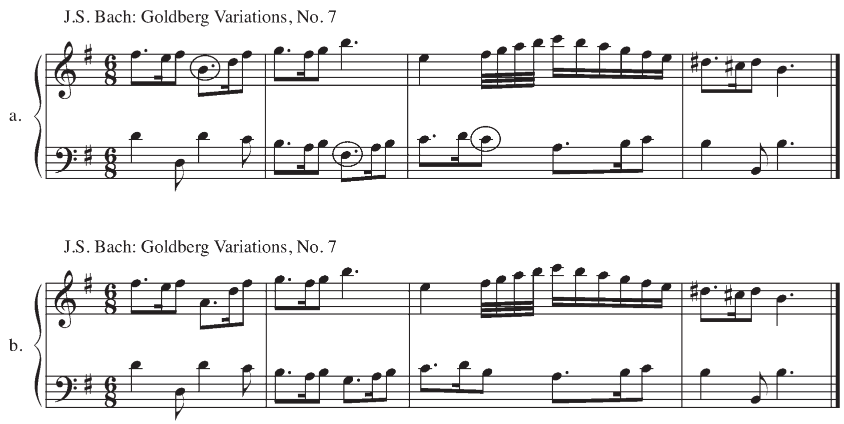
affects this integrated perception, with errors being more noticeable if they create unexpected dissonance and change the perception of the whole. Purposely planted errors that maintain the underlying harmony or do not create dissonance are harder to hear. This helps to explain why it is difficult to perceive errors in polytonal music. The lack of harmonic and tonal coherence prohibits the establishment of an integrated context and thereby challenges the ability to simultaneously process multiple melodies.

Examples 6 and 7 highlight the role of tonal context during two-part melodic error detection tasks. The first error in Example 6 changes the inversion of the implied dominant chord. A listener who has analyzed the specific intervals between voices might notice that the expected minor sixth was instead performed as an octave. But a listener who has integrated the voices and is perceiving overall harmonic function might fail to notice this error. The subsequent two errors affect the closing cadence. Cadences are structurally significant and have stereotypical patterns. An awareness of conventional cadence patterns would therefore make it easier to recognize errors in the two penultimate chords. Errors at cadences also benefit from the recency effect, which is the tendency to better remember items that are presented last in a sequence.




Example 6. Adapted from Exercise 7F-1, #5 in Marcozzi, *Strategies and Patterns of Ear Training*, 193 (a. student notated version; b. instructor performed version). Notation is correct, performance errors are circled.

Similar to previous examples, the errors in Example 7 maintain contour and change exact interval size. Although the error in the first measure alters the implied harmony, it still creates consonance between the two voices. The error would therefore be more difficult to identify if the listener has integrated the two parts and is listening for unexpected dissonance. The second and third errors, on the other hand, create dissonance and would theoretically be more readily perceived. But this example provides a correct performance and an error-filled score, which means that these dissonances will not actually be heard. A listener must therefore analyze the score and audiate all expected interval relationships in order to identify the errors. Error detection accuracy would be significantly higher if the mistakes were instead in the performance, thereby creating aural dissonance rather than visual dissonance. In addition, the third error is in the accompaniment part, underneath the fastest notes in the melody, and on a weak part of the beat. This is always less noticeable than an error in the melody part that occurs on a strong beat.




Example 7. Adapted from Melody 12B, #4 in Benward & Kolosick's, *Ear Training: A Technique for Listening*, 255 (a. student notated version; b. instructor performed version). Performance is correct, notated errors are circled.

Musical context is also created by timbre and texture. Using excerpts from the band literature, Byo found that error detection is affected by the location of the error within the texture and by the number of different timbres in the performance.[34] In his studies, error detection accuracy was higher if the error occurred in a single timbre example or in the melody part of the piece. As he summarized,

[34] James L. Byo, "The Influence of Textural and Timbral Factors on the Ability of Music Majors to Detect Performance Errors," *Journal of Research in Music Education* 41 (1993): 156-167 and James L. Byo, "The Effects of Texture and Number of Parts on the Ability of Music Majors to Detect Performance Errors," *Journal of Research in Music Education* 45 (1997): 51-66.

> Results from the present study indicate that the musical context within which an error exists can have a consequential effect on error detectability. A pitch error in one context (e.g., polyphonic texture, single timbre, alto voice, melodic function) may have a different degree of detectability than the same error inserted within another context (e.g., homophonic texture, multitimbre, soprano voice, harmonic function). . . . This raises the possibility that the error-detection process may be context-specific, that is, idiosyncratic to a particular musical work, piece, section of a piece, or experimental excerpt, thus complicating this already complex phenomenon.[35]

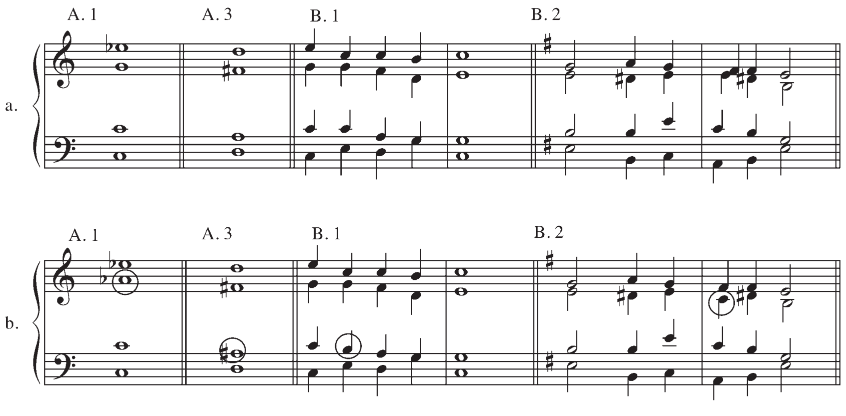
In Example 8, isolated chords and short harmonic progressions are used to demonstrate the role of texture and context in multi-part error detection tasks. Although the errors change the quality of the two chords in A.1 and A.3, the sounding chords are still a recognized type of triad. A student must therefore correctly audiate the notated chord quality without any tonal context in order to notice that the performed chord is different. This is made even more difficult by the placement of the error in an inner voice.

In the performance of exercise B.1, a seventh is added to a notated triad. The opposite occurs in exercise B.2, where a notated seventh chord is played as a triad. Although some students might recognize the addition of the chord seventh and identify the errors, others would struggle to notice errors that occur in the inner voices, do not change the underlying harmonic progression, and fit with tonal context.[36] Error detection accuracy would likely increase if the misplayed note introduced an unexpected dissonance or changed harmonic function. Type and location of error within a musical texture also depends on the instrumentation of the piece. Pianists playing multiple simultaneous parts (or chords) might make different errors than ensembles made up of multiple melody instruments.

---

[35] Byo, "The Influence of Textural and Timbral Factors," 165.

[36] Caroline Palmer and Susan Holleran, "Harmonic, Melodic, and Frequency Height Influences in the Perception of Multivoiced Music," *Perception and Psychophysics* 56 (1994): 301-312.




Example 8. Adapted from Exercise 9F-1 in Marcozzi, *Strategies and Patterns of Ear Training*, 250 (a. student notated version; b. instructor performed version). Notation is correct, performance errors are circled.

Finally, research has shown that stimulus length affects the establishment of context and expectation. Although it is typical for an aural skills instructor to provide tonal and metric context prior to playing an example in class, this information is not provided in a "real" listening situation. Edworthy investigated the response to melodies under these "natural listening conditions."[37] Participants heard two versions of melodies of different lengths, an original and a transposition that contained either a pitch error or a contour error. Results confirmed her hypothesis that tonal context emerges as the notes of the melody are heard, thereby causing listeners to more accurately identify contour errors in the shorter melodies and pitch errors in the longer melodies. In addition, participants more accurately identified pitch errors that occurred later in those longer melodies, rather than at the beginning. This could be compared to the recognition of contour errors in unfamiliar melodies (short-term memory) and pitch errors in learned melodies (long-term memory).

All of these studies suggest that we should carefully consider error type, context, and stimulus length when designing and evaluating error detection tasks. Errors that do not violate context or expectation might simply be more difficult to notice and correct. In addition, the perception of errors depends on the extent to which context has been established, with contour errors being perceived

[37] Judy Edworthy, "Pitch and Contour in Music Processing," *Psychomusicology* 2 (1982): 44-46; Judy Edworthy, "Interval and Contour in Melody Processing," *Music Perception* 2 (1985): 375-388.

differently than pitch errors and short pitch patterns being different than longer melodies. Finally, students might benefit from discussing the relationship between context and perception as it relates to errors in performance. As Sloboda described,

> . . . experienced performers soon come to realize just how much they can "get away with" in live performance. I have often been amazed, when listening to a recording of my own performance, just how unnoticeable were errors which, at the time of performance, struck me as catastrophic. Indeed, part of the art of sight reading is knowing which parts of the music will not be salient for a listener. One learns how to create an impression of accuracy in a performance that is actually far from faithful to the score.[38]

A deeper understanding of musical structure and context could help students acquire this ability to create the "impression of accuracy" during sight-reading and performance while singing or playing their own instruments.

## Improving Error Detection Pedagogy

Pedagogical improvement in any discipline requires the continual assessment of methods, approaches, and materials. In speaking about aural skills pedagogy, Kate Covington admitted being troubled by "the dilemma that good musicians sometimes demonstrate a rather low level of aural ability as taught and tested with traditional materials. That seems to imply that either we are teaching the wrong things or we are not teaching well, certainly not in a way that is compatible with how students already perceive and relate to music."[39] A knowledge of existing perceptual research could help instructors become more aware of the factors that affect error detection ability, thereby allowing for the creation of effective pedagogical resources and teaching techniques that help reduce this gap between performance skills and aural skills.

The first step is to recognize that error detection is a complex skill that is affected by many factors and unlikely to be developed solely

[38] John A. Sloboda, *The Musical Mind: The Cognitive Psychology of Music* (Oxford University Press, 1985), 85.

[39] Kate Covington, "An Alternate Approach to Aural Training," *Journal of Music Theory Pedagogy* 6 (1992): 6.

by practicing related skills. Karpinski identified four different steps for dictation – hearing, memory, understanding, and notation.[40] Error detection likely has the same components. Students therefore need opportunities to practice tasks that develop each of these skills, both individually and in combination. We must also reconsider the relationship between error detection and dictation. As White described,

> Unlike sight-reading, melodic dictation is not a skill that musicians are frequently called upon to use, per se, in the practice of their art. There may be occasions when musicians hear a melody that they later jot down, but for the most part melodic dictation is practiced for what it contributes to the other skills – the ability to identify incorrectly performed notes in rehearsal, the ability to hear a passage inwardly in order to read it in rehearsal or performance, sensitivity to other parts in ensemble, and so on."[41]

This suggests that error detection is not just a preliminary skill that acts as a means to the end goal of performing dictation. Instead, error detection is an end goal in and of itself. If this is the case, instructors must increase the amount of classroom time spent on error detection and avoid the assumption that students will automatically develop those skills by only practicing dictation.

It is also important to consider a much broader definition of error detection. In addition to working on audiation, students must be given opportunities to develop focused listening skills, good habits of score study, and knowledge of tonal and metric context in order to generate musical expectations. Error detection tasks should include sound to sound comparisons, sound to notation comparisons, and examples with both familiar and unfamiliar pieces. In addition, students should practice listening to a wider variety of musical characteristics. Rather than focusing on only pitch and rhythm, emphasis should be placed on evaluating meter, harmony, articulation, dynamics, tempo, tone quality, intonation, balance, and expressive nuance. This requires an increase in perceptual research on these characteristics and the development of error detection materials that exhibit a greater variety of texture, timbre, and instrumentation.

Research has shown that timbre and texture affect error

[40] Karpinski, *Aural Skills Acquisition*, 64-91.

[41] White, *College Teaching of Music Theory*, 43.

detection difficulty, depending on the number of parts, the number of different timbres, the relationship between the parts, the location of the error within a certain part, and how the error affects the perception of the whole. As Byo summarized,

> In the preparation of prospective instrumental conductors, there is an obvious need for students to transfer knowledge and skills gained through conventional, piano-centered ear-training experiences to the heterogeneous timbres of the band and orchestra. . . . It is evident from these data that instructors of university ear-training courses must take steps to facilitate the transfer of knowledge from a piano focus to issues involving heterogeneous tone qualities."[42]

One method of facilitating this transfer would be to incorporate a greater variety of performances into the classroom. Although it might be simpler to perform on classroom pianos or use MIDI files of monophonic melodies, using recordings of both solo and ensemble music provides students with richer sound sources and better captures future musical experiences. Instructors might also include more live performances in the classroom, with students either singing or playing their own instruments. This can be done with prepared and sight-read music, thereby allowing for the discussion of a variety of natural performance errors and expressive nuances.

Error detection ability is also affected by a complex interaction between an assortment of structural features, including tonality, meter, rhythm, intervals, contour, harmony, phrase structure, timbre, texture, and tempo. The type of error, along with its location relative to other features, significantly affects the likelihood of identification. For instance, research has consistently shown that contour errors are more easily identified than pitch errors for short melodies in short-term memory. In addition, errors that do not disrupt tonal, metric, or harmonic context are considered "reasonable" and are easily overlooked. Knowing that these errors are less noticeable might help to explain many student strengths and weaknesses.

---

[42] Byo, "The Influence of Textural and Timbral Factors," 166.

An awareness of the relationship between musical structure and perception could also affect the creation of error detection examples with planted performance errors. In general, error detection exercises should not always contain the same type of error, such as a pitch change of a whole step in one direction or another. This "same" error can be perceptually different, depending on the surrounding musical context. In addition, this limits the comparisons students are asked to make and does not mimic the variety of errors that might be encountered in typical teaching, performing, and conducting situations. It might also be helpful to occasionally include errors of omissions. When working with notation, we should consistently provide a correct score and a performance with errors. Not only does this reflect actual musical experience, but it accounts for the fact that visual errors are often perceived differently than aural errors.

Methods of presentation and instructions to students could also better mimic typical musical situations. Instructors must consider the number of times that students hear an example during an error detection task. Research has shown that repetition does not necessarily facilitate error detection accuracy. Likewise, we are generally not granted a predetermined number of repetitions in a typical musical situation. In terms of instructions, it might be necessary to focus on certain types of errors in the beginning stages in order to help students concentrate on individual musical parameters. But students must eventually have opportunities to evaluate performances without being told what type or how many errors to listen for. It would also be helpful to include more "placebo" examples, where the performances do not have any errors at all. Knowing that something is performed correctly is just as important as being able to identify errors. Finally, students should be required to both detect and correct the error. Rather than simply circling the error on the score, students must learn to describe what should have been played, correct the error themselves, or instruct others how to make that correction. Karpinski suggested that having students use words to describe errors could also develop important writing skills.[43]

All of these suggestions require the creation of additional pedagogical methods and resources. In order for these resources to reflect music perception and practice, instructors must be familiar

[43] Karpinski, *Aural Skills Acquisition*, 132.

with existing research and willing to create additional research. Perspectives as musicians and pedagogues must be combined with principles of perception, cognition, and skill development. As Karpinski summarized, "all of us who teach and write about aural skills should pay heed and be certain that these advances inform our work."[44] This collaboration could inspire the creation of teaching materials that better capture White's definition of the broad purpose of aural skills.

> To be thoroughly mastered, every musical and theoretical concept must be comprehended from the perspective of sound itself. Ear-training, then, should be more than developing the ability to identify intervals, chords, or rhythmic patterns or learning the skills of melodic and harmonic dictation. It is the development of the ear for the study of music, for the performance of music, for the creation of music, and for enhancing the pleasure of simply listening to music.[45]

[44] Karpinski, "Lessons From the Past," 5.3.

[45] White, *College Teaching of Music Theory*, 27.

## Bibliography

Benward, Bruce and J. Timothy Kolosick. *Ear Training: A Technique for Listening*, 7th ed. Revised. New York: McGraw-Hill, 2010.

Bigand, Emmanuel, Stephen McAdams, and S. Forêt. "Divided Attention in Music." *International Journal of Psychology* 35 (2000): 270-278.

Boltz, Marilyn. "Some Structural Determinants of Melody Recall." *Memory and Cognition* 19 (1991): 239-251.

Brand, Manny and Vernon Burnsed. "Music Abilities and Experiences as Predictors of Error-Detection Skill." *Journal of Research in Music Education* 29 (1981): 91-96.

Butler, David. "Why the Gulf Between Music Perception Research and Aural Training?" *Bulletin of the Council of Research in Music Education* 132 (1997): 38-48.

Butler, David and Mark Lochstampfor. "Bridges Unbuilt: Comparing the Literatures of Music Cognition and Aural Training," *Indiana Theory Review* 4 (1993): 1-17.

Byo, James L. "The Influence of Textural and Timbral Factors on the Ability of Music Majors to Detect Performance Errors." *Journal of Research in Music Education* 41 (1993): 156-167.

_____. "The Effects of Texture and Number of Parts on the Ability of Music Majors to Detect Performance Errors." *Journal of Research in Music Education* 45 (1997): 51-66.

Byo, James L. and Deborah A. Sheldon. (2000). "The Effect of Singing While Listening on Undergraduate Music Majors' Ability to Detect Pitch and Rhythm Errors." *Journal of Band Research* 36 (2000): 26-46.

Covington, Kate. "An Alternate Approach to Aural Training." *Journal of Music Theory Pedagogy* 6 (1992): 5-18.

Croonen, W.L.M. "Effects of Length, Tonal Structure, and Contour in the Recognition of Tone Series." *Perception & Psychophysics* 55 (1994): 623-632.

Cuddy, Lola L. "On Hearing Pattern in Melody." *Psychology of Music* 10 (1982): 3-10.

Cuddy, Lola L., Annabel J. Cohen, and D.J.K. Mewhort. "Perception of Structure in Short Melodic Sequences." *Journal of Experimental Psychology: Human Perception and Performance* 7 (1981): 869-883.

Dewitt, Lucinda A. and Robert G. Crowder. "Recognition of Novel Melodies after Brief Delays." *Music Perception* 3 (1986): 259-274.

Dowling, W. Jay. "Scale and Contour: Two Components of a Theory of Memory for Melodies." *Psychological Review* 85 (1978): 341-354.

_____. "Context Effect on Melody Recognition." *Music Perception* 3 (1986): 281-296.

_____. "Tonal Strength and Melody Recognition After Long and Short Delays." *Perception and Psychophysics* 50 (1991): 305-313.

_____. "Melodic Contour in Hearing and Remembering Melodies." In *Musical Perceptions*, ed. Rita Aiello, 173-176. Oxford: Oxford University Press, 1994.

Dowling, W. Jay and James C. Bartlett. "The Importance of Interval Information in Long-Term Memory for Melodies." *Psychomusicology* 1 (1981): 30-49.

Dowling, W. Jay and Diane S. Fujitani. "Contour, Interval, and Pitch Recognition in Memory for Melodies." *Journal of the Acoustical Society of America* 49 (1971): 524-531.

Durham, Thomas. *Beginning Tonal Dictation*. Prospect Heights, IL: Waveland Press, 2004.

Edworthy, Judy. "Pitch and Contour in Music Processing." *Psychomusicology* 2 (1982): 44-46.

_____. "Interval and Contour in Melody Processing." *Music Perception* 2 (1985): 375-388.

Fiske, Harold E. "Relationships of Selected Factors in Trumpet Performance Adjudication Reliability." *Journal of Research in Music Education* 25 (1977): 256-263.

Gordon, Edwin E. *Learning Sequences in Music: A Contemporary Music Learning Theory.* Chicago: GIA Publications, 2007.

Gonzo, Carol Lee. "An Analysis of Factors Related to Choral Teachers' Ability to Detect Pitch Errors While Reading the Score." *Journal of Research in Music Education* 19 (1971): 259-271.

Goolsby, Thomas. "Profiles of Processing: Eye Movements During Sightreading." *Music Perception* 12 (1994): 97-123.

Halpern, Andrea R. and Gordon H. Bower. "Music Expertise and Melodic Structure in Memory for Musical Notation." *American Journal of Psychology* 95 (1982): 31-50.

Karpinski, Gary S. "A Model for Music Perception and its Implications in Melodic Dictation." *Journal of Music Theory Pedagogy* 4 (1990): 191-229.

_____. "Lessons From the Past: Music Theory Pedagogy and the Future." *Music Theory Online*, 6.3 (2000).

_____. *Aural Skills Acquisition: The Development of Listening, Reading, and Performing Skills in College-Level Musicians*. New York: Oxford University Press, 2000.

_____. *Manual for Ear Training and Sight Singing*. New York: W.W. Norton & Company, 2007.

Killian, Janice N. "The Relationship Between Sightsinging Accuracy and Error Detection in Junior High Singers." *Journal of Research in Music Education* 39 (1991): 216-224.

Klonoski, Edward. "A Perceptual Learning Hierarchy: An Imperative for Aural Skills Pedagogy." *College Music Symposium* 40 (2000): 168-169.

Kraft, Leo. *A New Approach to Ear Training*, 2nd ed. New York: W.W. Norton & Company, 1999.

Lake, William E. "Interval and Scale-Degree Strategies in Melodic Perception." *Journal of Music Theory Pedagogy* 7 (1993): 55-67.

Larson, Richard C. "Relationships Between Melodic Error Detection, Melodic Dictation, and Melodic Sightsinging." *Journal of Research in Music Education* 25 (1977): 264-271.

Larson, Steve. "Scale-Degree Function: A Theory of Expressive Meaning and its Application to Aural Skills Pedagogy." *Journal of Music Theory Pedagogy* 7 (1993): 69-84.

Lehmann, Andreas C. and Reinhard Kopiez. "Sight-reading." In *The Oxford Handbook of Music Psychology*, ed. S. Hallam, I. Cross, and M. Thaut, 344-351. Oxford: Oxford University Press, 2009.

Lehmann, Andreas C. and Victoria McArthur. "Sight-Reading." In *The Science and Psychology of Music Performance*, ed. R. Parncutt and G.E. McPherson, 135-150. New York: Oxford University Press, 2002.

Madell, Jaime. & Sylvie Hébert, S. "Eye Movements and Music Reading: What Next?" *Music Perception* 26 (2008): 157-170.

Marcozzi, Rudy. *Strategies and Patterns for Ear Training*. Upper Saddle River, NJ: Prentice-Hall, 2009.

Martin, Daniel E. "Do You Auralize?" *Journal of the Acoustical Society of America* 24 (1952): 416.

Marvin, Elizabeth West. "Research on Tonal Perception and Memory: What Implications for Music Theory Pedagogy?" *Journal of Music Theory Pedagogy* 9 (1995): 31-70.

Palmer, Caroline and Susan Holleran. "Harmonic, Melodic, and Frequency Height Influences in the Perception of Multivoiced Music." *Perception and Psychophysics* 56 (1994): 301-312.

Pembrook, Randall G. and H. Lee Riggins. "Send Help!: Aural Skills Instruction in U.S. Colleges and Universities." *Journal of Music Theory Pedagogy* 3 (1990): 231-242

Repp, Bruno H. "The Art of Inaccuracy: Why Pianists' Errors are Difficult to Hear." *Music Perception* 14 (1996): 161-184.

Rogers, Michael R. *Teaching Approaches in Music Theory: An Overview of Pedagogical Philosophies*, 2nd ed. Carbondale, IL: Southern Illinois University Press, 2004.

Sheldon, Deborah A. "Effects of Contextual Sight-Singing and Aural Skills Training on Error-Detection Abilities." *Journal of Research in Music Education* 4 (1998): 384-395.

_____. "Effects of Multiple Listenings on Error-Detection Acuity in Multivoice, Multitimbral Musical Examples." *Journal of Research in Music Education* 52 (2004): 102-115.

Sidnell, Robert G. "Self-Instructional Drill Materials for Student Conductors." *Journal of Research in Music Education* 19 (1971): 85-91.

Sloboda, John A. "The Effect of Item Position on the Likelihood of Identification by Inference in Prose Reading and Music Reading." *Canadian Journal of Psychology* 30 (1976): 228-237.

_____. "The Psychology of Music Reading." *Psychology of Music* 6 (1978): 3-20.

_____. "Experimental Studies of Music Reading: A Review." *Music Perception* 2 (1984): 222-236.

_____. *The Musical Mind: The Cognitive Psychology of Music*. Oxford: Clarendon Press, 1985.

Sloboda, John A. and Judy Edworthy. "Attending to Two Melodies at Once: The Effect of Key Relatedness." *Psychology of Music* 9 (1981): 39-43.

Sloboda, John A. and David H.H. Parker. "Immediate Recall of Melodies." In *Musical Structure and Cognition*, ed. P. Howell, I. Cross, and R. West, 143-167. London: Academic Press, 1985.

Taylor, Jack A. and Randall G. Pembrook. "Strategies in Memory for Short Melodies: An Extension of Otto Ortmann's 1933 Study." *Psychomusicology* 3 (1983): 16-35.

Waters, Andrew J. and Geoffrey Underwood. "Eye Movements in a Simple Music Reading Task: A Study of Expert and Novice Musicians." *Psychology of Music* 26 (1998): 46-60.

White, John D. Guidelines for College *Teaching of Music Theory*, 2nd ed. Lanham, MD: Scarecrow Press, Inc, 2002.