Journal of Music Theory Pedagogy

Volume 21 Article 2

1-1-2007

Absolute Pitch Perception and the Pedagogy of Relative Pitch

Elizabeth West Marvin

Absolute Pitch Perception and the Pedagogy of Relative Pitch

Elizabeth West Marvin

While intuition suggests that aural skills pedagogy should be closely linked to findings in music-cognitive research, music theorists have only infrequently written about this relationship (Butler 1997, Butler and Lochstampfor 1993). Gary Karpinski's research is a notable exception (Karpinski 2007, 2000, 1990), as are occasional articles appearing in the *Journal of Music Theory Pedagogy* and elsewhere (Lake 1993, Larson 1993, Marvin 1995, Potter 1990). More recently, two experimental studies have empirically tested the effectiveness of various dictation and sight-singing strategies (Killam, Baczewski, and Hayslip 2003, Lorek and Pembrook 2002). Even so, researchers from other fields as disparate as developmental psychology, neurology, genetics, and cognitive science continue to investigate one aspect of musical cognition that both intrigues and inspires them to further research: the phenomenon of absolute pitch (AP). This essay draws upon that research to illuminate the abilities and challenges of AP musicians and to inform an effective aural skills pedagogy appropriate for both AP and non-AP listeners.

Absolute pitch is generally defined as "the ability to identify the frequency or musical name of a specific tone, or, conversely the ability to produce some designated frequency… or musical pitch without comparing the note with any objective reference tone." (Ward 1999, 265). Relative pitch, on the other hand, is characterized by the ability to identify relationships between musical tones (such as intervals or scale degrees), or to identify the name of a musical tone by its relation to a reference tone. One challenge in developing an effective aural skills pedagogy is the mixed population of AP and non-AP students in many music schools. AP students are usually too few in number to create a special course tailored to their needs, and too often the decision is simply to exempt these students from aural skills training based on a placement test. This solution may be ill-advised, however, because fluency in understanding musical structure requires the perception of *relationships* among pitches—in short, relative-pitch abilities. This relational understanding of pitches within the context of a key is arguably more important than knowledge of which particular pitches or keys a musical passage expresses.

Those who have taught AP students in aural skills classes will recognize the student whose strategy for the relatively straightforward task of identifying intervals is to write down every pair of letter names, only to return later to analyze them for their intervallic size and quality. While this strategy is ultimately successful, as shown by typically high scores on standard dictation tests by AP students, it demonstrates a "work-around" strategy for these students rather than true interval perception. The challenge with AP listeners is to teach them how to focus on the relationships between pitches, rather than upon the pitches themselves. In his provocatively titled 1993 article, "Absolute Pitch as an Inability: Identification of Musical Intervals in a Tonal Context," researcher Ken'ichi Miyazaki speaks directly to the issue of pedagogy:

> Considering that pitch relationships in a tonal context are essential in music, the difficulty in recognizing pitch relations is indicative of a sort of musical handicap AP possessors may have. . . . They acquired AP through early musical training, but did not seem to develop relative pitch in its fullness. . . . Their AP has resulted in suppressing the development of relative pitch. This speculation provides an important suggestion for early musical instruction, that is, children who have begun musical lessons from an early age should be given training in relative pitch that is systematically and carefully designed. (Miyazaki 1993, p. 70)

While Miyazaki's words may seem strong, he raises important issues regarding AP acquisition and music teaching. In response, this paper suggests specific strategies for aural skills instruction for

AP students at the collegiate level.[1] Because the impetus for these strategies comes from research in music cognition, we begin with a broad overview experimental research on absolute pitch before turning to the pedagogy of relative pitch.[2]

Music-Cognitive Research Testing Absolute-Pitch Abilities

Melody recognition and dictation:

We begin with experiments that document AP possessors' performance on tasks designed to engage relative-pitch skills: melody recognition under transposition and interval identification. Baczewski and Killam (1992) asked five professional musicians (music performance faculty) with AP to notate a sixteen-measure Mozart duet for viola and violin in G Major, rather than in the B-flat major in which it was heard. Three participants flatly refused to do so and transcribed the tune in B-flat, with high rates of accuracy. The two participants who attempted to notate the tune as instructed, in G Major, had numerous errors—in fact, their performance was less accurate than the fifteen non-AP participants in a control group (20% correct for AP notating in G Major, 45% correct for non-AP). Because this experiment had too few participants for significance testing, the

[1] Of course there is no denying that AP can be helpful to musicians. To name just a few examples, AP assists musicians in hearing long-range tonal relationships over time, tuning and performing atonal music, providing pitches for *a cappella* choral music, hearing unfamiliar music inwardly (from score reading), and transcribing music from sound to paper. Nevertheless, the AP musician who never develops relative-pitch skills may miss an entire dimension of music listening and performance: the aural understanding of dynamic hierarchical relationships within a key. This musician may encounter problems as well, especially in learning to tune to other musicians when a conductor chooses to perform a work in a key other than that notated, when playing on Baroque organs or in early music ensembles, when singing with a choir that creeps flat or sharp, or when doing ethnomusicological research in other tuning systems.

[2] For all experimental studies cited from scientific journals, tests of statistical significance have been performed by the authors, using an alpha level of at least .05. In other words, results are shown to be attributable with 95% probability to the effect of the independent variable, and only 5% to the effect of chance. Participant groups in all experiments cited here are all sufficiently large to achieve this level of statistical significance (unless otherwise specified).

results cannot be generalized to the full population of AP listeners. Marvin (1997) tested a larger sample of AP participants in a melody discrimination experiment using transposed melodies. She found significantly lower accuracy rates for AP than non-AP musicians in one condition. Participants (49 freshmen and sophomore music majors, 10 AP music majors of comparable age, and 34 nonmusician undergraduate psychology students) were to listen to short tonal or atonal melodies, and then to respond "same" or "different" to a comparison tune that was either an exact transposition or a same-contour inexact transposition (one pitch changed). In the tonal melodies, the AP participants distinguished between exact and inexact transpositions better than non-AP listeners (mean "hit" rate of .88 for AP, .80 for non-AP), but this advantage virtually disappeared in the atonal melodies. In the atonal condition, the AP group's performance was not significantly better than the non-AP group, nor better than nonmusicians. (Hit rates were .58 AP, .56 non-AP, and .53 nonmusicians.) The study concluded that given an atonal melody, non-AP listeners may encode a succession of interval names, which remains invariant in the correctly transposed condition and changed only in the inexact transposition. In contrast, AP listeners may remember the sequence of pitch letter names, all of which change in both transposed conditions.[3] To discriminate between exact and inexact transpositions using this strategy, AP listeners would have to perform rapid mental transposition of the entire tune. Without the aid of a key context, this strategy would result in more errors than an intervallic strategy.

In a similar experiment, Miyazaki and Rakowski (2002) presented 26 solfège students (nine of whom had AP) with a seven-note tonal or atonal melody in music notation. Each melody began on C. While viewing the music notation, listeners heard an exact or inexact (one changed note) performance of the melody beginning on C

[3] Miyazaki (2004) suggests, "Listeners with AP can't suppress pitch labeling even when it brings disadvantages." In an experiment with 44 undergraduates enrolled in an introductory psychology course, participants were asked to remember a visually presented sequence of nine random pitch syllables or digits (1-7) while ignoring irrelevant sounds (piano tones, spoken pitch syllables, spoken digits, or no sound). His 22 AP listeners showed greater interference for the piano tones than non-AP, suggesting that AP listeners named these tones even when told to ignore them, and that the naming function interfered with memory for the visually presented sequence.

or transposed to begin on F♯ or G♯. Participants were to determine whether the notation and sounding melody were the same or different (according to principles of relative pitch—that is, allowing for the transposition). In both the tonal and atonal conditions, AP listeners were significantly more accurate than non-AP if the sounding melody began on C and thus matched the notation. However, if the sounding melody was transposed, the non-AP musicians were more accurate than AP in both the tonal and atonal conditions, suggesting that the two groups used different cognitive strategies to complete the task. All three experiments suggest that some AP musicians, when confronted with a task that requires relative-pitch skills, may persist in trying to use AP to complete the task and are unable to switch to a relative-pitch strategy.

Interval and pitch naming:

Miyazaki (1992, 1993) and Benguerel and Westdal (1991) tested AP possessors' ability to identify intervals—a "classic" relative-pitch task—in out-of-tune contexts. In Miyazaki's 1993 experiment, 55 participants (40 AP or "partial AP" and 15 non-AP) were asked to identify various intervals in one of three possible tonal contexts established by a cadential pattern in C Major, F♯ Major, or a quarter-step-flat E Major. After hearing the chordal context, participants were asked to imagine the first note of the following interval as *do* in the key just presented, and to identify the interval by the solfège syllable of the second pitch.[4] Miyazaki then presented his stimuli in "in-tune" and "out-of-tune" conditions, with intervals slightly wide or narrow. When scoring, he used a plus-or-minus 40 cents range for

[4] This response mode is a possible confounding element in Miyazaki's experimental design: participants were asked to name intervals using moveable-do solfège syllables. (For example, for a major third, participants were asked to respond *mi*; for a perfect fourth, they were to respond *fa*, and so on.) This is an unusual method for identifying intervals, not commonly used in music training. Further, if these students were previously trained using a fixed-do pedagogy—or indeed, simply named pitches using fixed-do solfège syllables—then the experimenter's request to respond with moveable-do syllables may have been confusing. Their significantly higher accuracy in the C Major context (over the F-sharp major and flattened E-major) could be attributed to the equivalence of fixed- and moveable-do syllables in the key of C. The author acknowledges this possible confound in his discussion of the experiment in Miyazaki and Rakowski (2002).

each interval: in other words, he scored the response "mi" (a major third, or 400 cents) as correct if the interval presented to the listener spanned anywhere from 360 to 440 cents. Miyazaki's AP possessors showed considerable variability in their performance, and scored significantly lower in the F♯ major and out-of-tune E Major contexts than in the C Major context. The non-AP group maintained a consistent level of performance across all key contexts.

AP possessors' decreased accuracy in the F♯ major and flattened E major conditions may have been affected by two factors: first, the mistunings may have interfered with participants' labeling abilities; and second, these two keys feature predominantly black-key pitches. The black-key hypothesis is based on a finding that has been replicated by a number of researchers (Miyazaki 1989, 1990, Takeuchi and Hulse 1991, Marvin and Brinkman 2000): that AP listeners identify white-key pitches more quickly and more accurately than black-key pitches. Miyazaki (1989) presented seven AP music majors and 18 non-AP psychology students (with varying degrees of music training) with pitches to identify in three timbres: piano tones, complex tones, and pure tones. Participants responded by touching a piano key to identify its pitch name. He reported a significant white-key/black-key difference among AP participants for response time (1.575 secs for white and 1.662 secs for black notes). Accuracy rates were also higher for white-key notes than black-key across all three timbres. Miyazaki reported a timbre effect across white- and black-key responses: 91.6% correct for piano tones, 80.4% correct for complex tones, and 74.4% correct for pure tones.

Takeuchi and Hulse (1991) questioned Miyazaki's experimental design, reasoning that the keyboard interface had caused longer response times for black-key pitches. Their replication asked 19 AP and 6 non-AP participants to respond "same" or "different" to a pitch name flashed on a computer screen each time participants heard a pitch played (non-AP participants were given a reference tone). Even after changing the experiment's design, these researchers found similar effects. Both AP and non-AP participants were more accurate for white-key pitches: AP, 75% black and 90% white; non-AP, 79% black and 88% white. AP participants responded significantly slower for black-key pitches (1310 msec for white and 1650 msec for black), but no response-time difference was found for non-AP listeners.

Timbre effect:

Another aspect of AP perception that has received attention by experimenters is the effect of timbre on pitch identification. Several researchers have found that AP listeners more easily identify tones with rich harmonic spectra than pure tones. As mentioned previously, Miyazaki (1989) found that AP participants' accuracy identifying complex tones fell between the extremes for piano and pure tones; thus it may not be solely a richer harmonic spectrum that assists AP listeners, but also familiarity with the timbre. Indeed, his subjects were all pianists who had begun their piano study as young as three to five years of age.

Marvin and Brinkman (2000) tested for both a timbre effect and familiarity effect by soliciting roughly half of their 20 AP participants from undergraduate keyboard majors and the other half from string majors. Their stimuli were half keyboard and half string timbre: isolated tones in their first experiment, and musical excerpts from piano or string quartet pieces in two additional experiments. Their response-time data for isolated-tone recognition showed a significant effect of timbre, with piano tones identified more quickly (1.99 secs) than string tones (2.3 secs) by both the string and keyboard performers. (This result may be an artifact of collegiate ear training, which typically takes place using the piano timbre.) Where listeners were asked to identify the key of musical excerpts, no significant timbre effect was found. There was an effect of participants' instrument, however: piano performers identified the key significantly faster than other participants, whether the stimulus was in keyboard or string timbre. The authors hypothesize that pianists' experience performing homophonic textures, rather than solo lines, assisted them in determining a tonal center more quickly.

Music-Cognitive Research Informing Theories of AP Acquisition

Early-learning hypothesis:

Experimental findings have led some authors to speculate upon theories of AP acquisition. Most prominent among these theories is the early-learning theory of AP acquisition: that absolute pitch may be acquired only during a "critical period" in childhood, much like the critical period that has been demonstrated for language acquisition.[5] During the critical period—perhaps between the ages of four and six—researchers hypothesize that children have the potential to acquire AP if note names and pitch sounds are explicitly associated, for example in the context of early-childhood instrumental music lessons. This hypothesis has the potential to account for the white-key/black-key effect discussed above.[6] According to this theory, since children in the early stages of piano study typically play pieces using simple five-finger patterns on the white keys, they acquire AP for white keys only. These students move on to repertoire with more black notes only after the critical period has ended; thus their black-key identifications are unconsciously made by half-step displacement from the more familiar white notes, a process that takes slightly longer. A similar case might be made for the open strings of the violin—all "white-key" pitches, as it were.[7] Numerous researchers have demonstrated a relation between AP possession and early musical training by asking participants to report the year in which they began music

[5] See Trainor (2005) for an overview of critical-period research pertaining to absolute pitch acquisition and more generally to the development of the auditory cortex of the brain.

[6] Another hypothesis to explain the key-color effect, posited by Takeuchi and Hulse (1991), is that AP listeners' differences in speed and accuracy may be associated with the frequencies with which black- and white-key pitches occur generally in music literature. Simpson and Huron (1994) support this hypothesis by appealing to the Hick-Hyman law, which relates the reaction time for a given stimulus to its expected frequency of occurrence. Simpson and Huron analyzed a computer-based sample of Western music for frequencies of pitch occurrence and found the results to be consistent with the faster reaction times for white-key pitches. Under this hypothesis, reaction times for all subjects—AP and non-AP—ought to be quicker for white-note identification. This is, in fact, the finding of Marvin and Brinkman (2000), who report key color differences in both speed and accuracy for non-AP musicians, as well as AP.

[7] It should be noted that experimental work on AP is clearly biased toward Western musicians, instruments, tunings, and musical systems. (The white-key/black-key distinction is but one example.) Generalizations to be drawn from this work are therefore only valid for populations familiar with Western tonal music; little is currently known about AP in non-Western musical cultures. Even though a substantial number of experimental studies draw their participants from Asian populations, these participants are without exception Asians trained in Western tonal music (often music conservatory students).

lessons (Deutsch *et al.* 2005, Gregersen *et al.* 2000, 1999, Marvin and Brinkman 2000, Miyazaki 1988). Takeuchi and Hulse (1993) point out that the critical period hypothesis is consistent with a general developmental shift in children from perceiving individual features in early childhood to perceiving relationships among features at an older age.

Levitin and Rogers (2005) believe that acquisition of AP occurs when children are explicitly taught pitch labels as their vocabularies are developing. The process could be viewed as analogous to children learning and practicing the labels for colors: most children are explicitly taught the labels for colors, but most are not taught labels for pitches during this critical period. Russo *et al.* (2003) have provided some experimental evidence for the early-learning hypothesis by explicitly training children and adults to recognize one "special note." Eight children and eight adults were trained over a six-week period to raise a flag when they heard the special note (C5). Although there was no significant difference in pitch-recognition abilities between the children and adults at the beginning of the training period, a clear critical-period effect emerged during training. By the end of the six weeks, children ages three to four years old scored between 30-60% correct, children ages five to six scored 80-100% correct, and adults scored from 10-100% correct (with wide variability in performance). These data suggest that the critical period occurs at around age five to six, but AP is acquired only if children are explicitly taught to associate labels with pitches.[8]

---

[8] While the critical-period theory argues against adult acquisition of AP, some notable attempts have been made to train adult listeners in absolute pitch. Rush and Butler (1995), for example, found significant improvement in pitch recognition for their experimental group as compared with a control group. This improvement was directly related to advancement in the David L. Burge training method. This method associates a particular "affect" with each pitch class: for example, F♯ is perceived as sharp and biting, while E♭ is mellower. Even so, the post-test scores of the experimental group were substantially lower than one would expect for "true" AP possessors, as the authors themselves note. Rush and Butler's best-scoring subgroup scored means of only 50% correct on the post-test. Faivre's (1986) experiment reported much higher scores than Rush and Butler's on her AP post-test; however, she had only three subjects in this high-scoring group—too small a subject group to generalize to a larger population. Because musicians with true AP tend to identify pitches quickly and without much mental effort, a comparison

Unlearning hypothesis:

In contrast to the early-learning hypothesis, Jenny Saffran and collaborators (Saffran and Griepentrog 2001, Saffran 2003, Saffran *et al.* 2005) have explored the question of whether all children are born with AP abilities. They hypothesize a developmental shift from absolute- to relative-pitch processing, which some researchers refer to as the "unlearning" theory of AP acquisition (Levitin and Rogers 2005, Ward 1999) or the "maturational switch" (Trainor 2005). In experiments with eight-month-old infants, Saffran demonstrated that babies use an absolute-pitch strategy to recognize three-note melodies. Saffran's stimuli were constructed according to a statistical-learning model adapted from artificial language-learning experiments. In the language experiments, listeners were exposed to a continuous series of nonsense syllables and learned to segment the incoming stream of syllables into words by tracking the statistical probabilities with which syllables recurred as adjacencies (Saffran *et al.* 1999). At the end of an exposure phase, babies and adults were able to distinguish words from non-words in the artificial language.

In one music adaptation of this design (Saffran and Griepentrog, 2001), a group of 20 eight-month-old babies heard a three-minute continuous recording of 45 randomly ordered instances of four "tone words": for example, G♯ A♯ F, C C♯ D♯, B F♯ G, and A D E. After familiarization with the tone stream, babies heard repetitions either of tone words or part words (that crossed a word boundaries, such as F C C♯). All part words were transpositions of tone words (F C C♯ is a transposition of B F♯ G). Thus if babies responded differently to tone words vs. part words, this difference could be attributed to their recognition of the tone word *at pitch*—in other words, by using AP not non-AP. This was, in fact, the result: infants listened significantly longer to repetitions of part words than words. Saffran has run a series of parallel experiments on adults in tonal (diatonic)

(8 *continued*) of reaction times for the training group vs. a true-AP group would have been a valuable measure of the success of either training program, as would a follow-up test some months later to assess the stability of participants' AP abilities over time.

and atonal (chromatic) conditions as well. She concluded that:

> There is a developmental shift in pitch processing between infancy and adulthood . . . This shift during development — from generally prioritizing absolute pitch patterns to generally prioritizing relative pitch patterns . . . is advantageous to the listener; while absolute pitches are certainly available in the auditory environment, they provide a poor basis for generalization from prior listening experiences for both music and speech. (Saffran 2003, p. 41)

In a later study, and in response to other experimental work (Trehub 2003) showing non-AP abilities in babies, Saffran (2005) found that babies can also use relative pitch, but that the nature of the task itself influences which strategy babies use.[9]

[9] There are parallels here to research on AP perception in animals. Some early research argued that starlings (among several species of birds) recognize songs only at absolute-pitch levels. The argument held that AP is the simpler cognitive strategy, since it does not require higher-level relational processing. However, more recent studies (e.g., MacDougall-Schackleton and Hulse, 1996) have shown that birds are capable of both types of processing, depending upon the nature of the task given. Even so, it appears that birds initially respond to testing using an AP strategy, and only if it fails do they switch to an non-AP strategy.

Wright *et al.* (2000) also found evidence of an AP strategy in rhesus monkeys, who recognized simple tonal melodies (such as "Happy Birthday to You") in transposition by one or two octaves, but not by .5 or 1.5 octaves (that is, transposition by a tritone, an non-AP task). In this case, no non-AP abilities were found, though more research remains to be done that varies the design of the task. Interestingly, the octave generalization found in monkeys for tonal melodies was not replicated in an isolated-tone condition nor in an atonal-melody condition; it appears that a well-formed tonal melody was necessary for the octave generalization to take place.

Genetic and tone-language hypotheses:

The unlearning hypothesis fails to explain why some children retain absolute-pitch abilities into adulthood while others do not. The early-learning hypothesis fails to account for the fact that many children enrolled in early music lessons do not acquire AP (Baharloo *et al.* 1998; Gregersen *et al.* 2000, Saah and Marvin, 2004). Some researchers hypothesize that there must be a genetic marker associated with absolute pitch. Two teams of researchers are actively exploring the genetics of AP (see Baharloo *et al.* 1998, 2000 and Gregersen *et al.* 1999, 2000).[10] Gregersen *et al.* (2000) report on a survey of 1067 music students enrolled in music theory classes at thirteen different colleges and conservatories in North America. Students were asked about musical training and whether they or family members had AP (but no direct AP test was administered). The data suggested a genetic component at work: of the AP music students surveyed, almost 16% had siblings with AP; whereas only 1% of non-AP students had an AP sibling.

Among the findings of these researchers is a higher concentration of AP in Asian musicians than non-Asian.

> The overall rate of AP in this population was 12.2%. . . . There was a markedly increased rate of AP among Asian students (42/80; 47.5%) compared with Caucasian students (75/834; 9.0%). The relatively higher rate in Asians was present among all major ethnic subgroups—Japanese (26%), Korean (37%) and Chinese (65%). (Gregersen 2000, p. 280)

One might hypothesize that the higher instances of AP among Asians is due to a higher proportion giving their children early music instruction, but there was no significant difference in this sample: 80% of Asians and 71% of Caucasians reported early music instruction. What may differ is the type of early music instruction and, perhaps, the cultural value placed upon absolute pitch possession. For example, a much higher proportion of Asian participants reported fixed-do solfège training, which explicitly

[10] Jane Gitschier, one of the co-authors of the Baharloo *et al.* study, maintains a website for recruiting AP participants for genetic testing (http://perfectpitch.ucsf.edu/ppstudy.html). The site summarizes the research of this group, provides article downloads, and includes an online test of AP.

teaches AP through the association of pitches with sung syllables, before the age of seven.[11] Anecdotal stories from students trained in Asia report explicit training of children in pitch recognition and naming, and tests of AP used as one criterion for continuing musical training.

Deutsch *et al.* (2004, 2006) proposed another possible explanation for the higher incidence of AP among Asian music students, hypothesizing that absolute pitch evolved as a feature of speech. Mandarin, Cantonese, and Vietnamese are tone languages; Japanese and Korean are pitch accent languages. In all of these languages, a change in a word's spoken pitch completely transforms its meaning. Because Asian children are exposed, during a critical period in infancy, to a language in which the tones of speech carry lexical meaning, they learn to distinguish between tones. Later they acquire absolute pitch for music in the same way that children learn features of a second tone language.

Deutsch *et al.* (2006) were the first to administer a direct test of AP to comparable populations of musicians in the U.S. and China (all incoming undergraduates at one major music school in each country). All 88 Chinese participants spoke Mandarin; the 115 U.S. participants were non-Asian students who did not speak a tone language. The incidence of absolute pitch in the Chinese group was significantly higher than the U.S. group. Further, the data showed a clear effect of age of onset of music training, in support of the critical-period hypothesis. In both groups, the highest probability of AP was associated with students who began music training at age 4-5, the second highest with those who began at age 6-7, and the lowest probability with those who began at age 8-9.

Two-component hypothesis:

Daniel Levitin (1994) has hypothesized that long-term pitch memory, one component of AP, is more widespread in the general population than previously thought. According to his

[11] With regard to sibling data and early-music instruction: of AP music students whose siblings had fixed-do training before age 7, almost 23% of those siblings also have AP; whereas only 1% of non-AP students' siblings acquired AP even if trained on fixed-do before age 7. In siblings of AP students who had no music training of any type before age 7, 14% of them nevertheless acquired absolute pitch. Thus it appears that a combination of nature and nurture is at work in shaping AP listeners.

two-component theory of absolute pitch, many listeners (even nonmusicians) possess this first component of AP—pitch memory—but only "true" AP listeners possess the second component: pitch labeling.[12] Levitin tested this hypothesis experimentally by asking 46 undergraduate psychology students, unselected for musical ability, to select two CDs of popular music from shelf of recordings in a sound-proof room. They were to hold each CD, choose a familiar song, try to hear it in their heads, and then sing as much of it as they wished. On the first trial, roughly a quarter of the participants began the song on the correct pitch, and a little over half of them sang within a semitone of the correct pitch. Levitin concludes that "for at least some well-known popular songs, a larger percentage of people than previously recognized possess absolute memory for musical pitch." (p. 421)[13]

[12] The pitch labeling aspect of AP accounts for some findings obtained in brain imaging experiments on AP participants. An extremely simplified explanation of hemispheric specialization in the brain would ascribe language processing to the left hemisphere and musical processing (pitch, melody, contour) to the right hemisphere. Yet in two publications from 2003, Robert Zatorre shows that AP musicians, and not non-AP, activate the left side (the left posterior dorsolateral frontal cortex) when listening to tones. One possible explanation for this left activation is the assignment of labels (a left-hemisphere language function) to pitches as they are heard. Support for this claim comes from the fact that when asked to label pairs of pitches with interval names, both AP and non-AP musicians activate this area. Non-AP musicians also activate the right frontal area of the brain that is responsible for working memory, presumably because they need to keep updating the memory trace of the pitches in order to compare and name the interval. AP musicians, because they can instead use a label to remember the pitches, do not need to use working memory in the same way and do not activate the right side. Schaug (2001), Zatorre, and others also report a brain size asymmetry in AP musicians, with a larger leftward asymmetry in the planum temporale. Such an asymmetry, if present at birth, suggests a genetic factor at work; infants born with this asymmetry may be more likely to acquire AP if given training at the right time.

[13] Related experiments explore pitch memory for melodies, such as folk songs or lullabies that are learned by rote without a canonical "correct" key and pitch level. For example, Andrea Halpern (1989) asked adults to sing folk tunes and holiday songs from Western popular culture (such as "Happy Birthday to You") on two different occasions without giving them a starting pitch. She found very low variability between participants' two starting pitches from the first to second performance, suggesting that they had a stable mental representation that retained the tunes at an absolute pitch level. Bergeson and Trehub (2002) tested mothers' speech and singing to their infants, comparing tempo and pitch measurements taken on two different days a week apart. They found high variability between

In a similar study that tested 48 college students' (unselected for musical training) memory for the pitch of television theme songs such as *Friends, Jeopardy, Law & Order*, Schellenberg and Trehub (2003) found that participants were able to distinguish between the original key and one-semitone shifts 58% of the time, and between the original and two-semitone shifts 70% of the time. Significant to the design of this study was the fact that participants were required neither to provide a pitch letter name nor sing. Rather, participants merely chose between two recordings the one they believed was heard at the "usual" pitch. By removing the requirements of pitch naming and vocal production, and by providing a rich musical context (familiar pieces rather than isolated tones), Schellenberg and Trehub demonstrated high levels of pitch memory in a group of participants unselected for musical ability. The authors conclude that:

> . . . [C]ontrary to scholarly wisdom, adults with little musical background retain fine-grained information about pitch level over extended periods. This finding advances the case that music listeners construct precise memory representations of music that include absolute as well as relational features. . . . It also demystifies aspects of AP such as its rarity, its bimodal distribution, and the reported critical period for AP acquisition. Once pitch-naming or reproduction requirements are eliminated and familiar materials are used, memory for specific pitch levels seems to be widespread and normally distributed. (p. 265)

([13] *continued*) the spoken utterances on the two days, but in contrast, the pitch and tempo of the songs was virtually unchanged from the first to the second day. Halpern's and Bergeson and Trehub's results are consistent with Levitin's in that they show some type of pitch memory to be a widespread phenomenon among adults who are not selected for musical ability.

All three of these experiments share a design based upon production: measurement of pitch by vocal production. Thus it is possible that they are confounded somewhat by the effect of by vocal tessitura—that is, men and women may have a preferred tessitura for singing popular tunes or folk melodies, and they may choose beginning pitches for vocal comfort, rather than from pitch memory. Or they may use "muscle memory" in their larynxes, rather than pitch memory in their minds, to reproduce songs in a consistent key.

Like Levitin, these authors demonstrate that once the labeling function is removed and meaningful musical contexts rather than isolated pitches are tested, then absolute pitch—more broadly defined as pitch memory—maybe be seen as a more widespread attribute than previously thought, one that is acquired by many people in the absence of specific training.

The Pedagogy of Relative-Pitch Perception

What does this research on AP perception tell us that can assist in the development of an effective relative-pitch pedagogy? First and foremost, we know that as AP musicians listen to music, they identify pitch names almost effortlessly and automatically. To AP students this naming strategy comes to them unbidden, just as color names come to us when we survey a landscape. To teach them to hear music in a different, relational way requires powerful tools—tools that will not "fight against" their AP abilities but will complement them. We need to communicate to all students that their primary objective in aural skills training is to learn to perceive musical function, and while class activities may include singing at sight or taking dictation, these skills are not the primary objective. This broader objective will inform many pedagogical decisions: in particular, the question of "fixed" versus "moveable" syllable systems, the development of class activities that reinforce functional understanding, and the role and timing of notation-based activities. Second, research tells us that for AP listeners, not all keys, registers, or timbres are equal when the task is pitch labeling. An effective pedagogy will use transposition strategically—including especially keys with black-note tonics—to teach musical function within a transpositionally equivalent tonal system. Likewise, it will find ways to augment dictation from the piano with other timbres and including many registers. Third, experiments show that musical contexts (as opposed to isolated tones or even isolated intervals) provide powerful cognitive cues, even providing non-AP listeners with strong pitch memories that are associated with particular pieces of music. Musical contexts are important for AP listeners, too, because they provide a wealth of functional relationships to be discerned. Finally, because we are focusing on a pedagogy of relative pitch—our objective for all students—the approaches discussed here are appropriate for both AP and non-AP students who may be taught together in a single classroom with the same materials and method.

Modeling Relative Pitch through Syllable Systems

We turn now from general pedagogical points to more concrete ones, beginning with the perennial fixed- versus moveable-do question.[14] Students with AP, particularly international students with AP, often come to the classroom with strong fixed-do experience. For many international students, the fixed-do syllable *is* the note name. Singing note names reinforces an absolute-pitch strategy for sight singing and dictation. It teaches nothing about relative pitch, our objective. Should we then convert all our fixed-do AP students to moveable-do, in order to model scale-degree functional relationships? While this might seem the easy solution, it simply doesn't work very well in practice. Although it is possible, it is very difficult for AP students with a fixed-do background to associate deeply ingrained solfège syllables with a new relational system—one that changes its pitch associations with each and every new key encountered. Further, AP students may resent being retrained in a syllable system they have already mastered. An effective solution is to sing instead on scale-degree numbers. Scale-degree numbers have most of the relative-pitch benefits of moveable-do solfège without the burden of forcing AP students to readjust to new syllable associations.[15]

[14] It is beyond the scope of this essay to recount the pros and cons of the various solfège systems in use in the United States today. Suffice it to say that fixed-do and moveable-do systems both teach valuable musical concepts—but they teach *different* concepts: the first teaches pitch recognition and the second teaches functional relations within a key. The choice of a solfège system is therefore intimately tied to course objectives. For an overview of the on-going debate about the two systems, see Lorek and Pembrook (2002), Michael Rogers's review-essay in the same publication, and the cited articles in both essays.

[15] There are a few disadvantages to scale-degree singing in relation to moveable-do solfège. First, the English words for scale degrees 1-7 are less musical to sing than the corresponding solfège syllables. Nevertheless, scale-degree numbers accurately model the functional system AP students need to learn, and they are easy to implement since rising numbers model rising pitch, and since scale-degree terminology is usually familiar to students from their theory classes. To avoid the two-syllable problem with "seven," many teachers simply use "sev." A second disadvantage arises over the problem of "inflecting" numbers to model altered scale degrees: for example, raising the fourth scale degree from *fa* to *fi* to tonicize V, or lowering the third scale degree from *mi* to *me* to sing in minor keys. Various solutions are possible, from working

A second relative-pitch technique that will benefit all students is to avoid pitch notation altogether for an extended period of time. Notation may be abandoned in favor of interactive activities such as call-and-response singing or dictation in scale-degrees, without benefit of a staff or announced key. The technique of teaching by interaction with sounding music, without music notation, has a long history. Sometimes dubbed "sound before sight," its advocates include well-known pedagogical writers of the past, like Zoltan Kodaly, and more recent ones like Edwin E. Gordon (2003). How do you structure an aural skills curriculum that avoids music notation? You design interactive musical tasks where students sing, read, and write using solely scale-degree representations. One way to begin this process is by vocalizing the students at the beginning of each class, singing scale segments and arpeggios on numbers while progressively changing key up or down by half step to warm up and extend the singing range of the voice. In practice, as patterns are transposed, the instructor would model the new tonal level by a vocal or keyboard cue (in the manner of a choral warm-up). The acts of associating numbers with these pitch patterns, and of continuously transposing the patterns, help AP students begin to make relative-pitch associations. Because patterns are learned by rote, no notation is involved. Example 1 (see next page) shows some possible patterns for vocalization.

We can extend the "sound before sight" concept beyond the vocal warm-up, by incorporating call-and-response activities into each aural skills class. In these activities, the instructor sings a tonal pattern, then the class or an individual echoes it back. As students' skills increase, new challenges may be added to the patterns. At the earliest stages, the instructor sings simple patterns that arpeggiate tonic and dominant triads on a neutral syllable (see Example 2 from Grunow *et al.* 1998 for sample patterns). Students echo back on the same neutral syllable, until they feel comfortable with the call-and-response format and are singing consistently in tune. In the second stage, instructors sing on scale degree numbers and ask students to

([15] *continued*) out a system of inflected numbers, to using a simple one-syllable word that shows the direction of the inflection (like "raise" and "low," or "sharp" and "flat"), to abandoning inflection altogether and simply making the necessary pitch alteration with the voice. For a class without fixed-do AP students, these two disadvantages may be reason enough to chose moveable-do solfège over numeric singing to teach scale-degree relations.

echo back on numbers. This gives students the immediate verbal association of scale degree numbers with the functional role of pitches within a key.[16] The alternation of one or two patterns based

Example 1: Vocalization on Scale-Degree Numbers

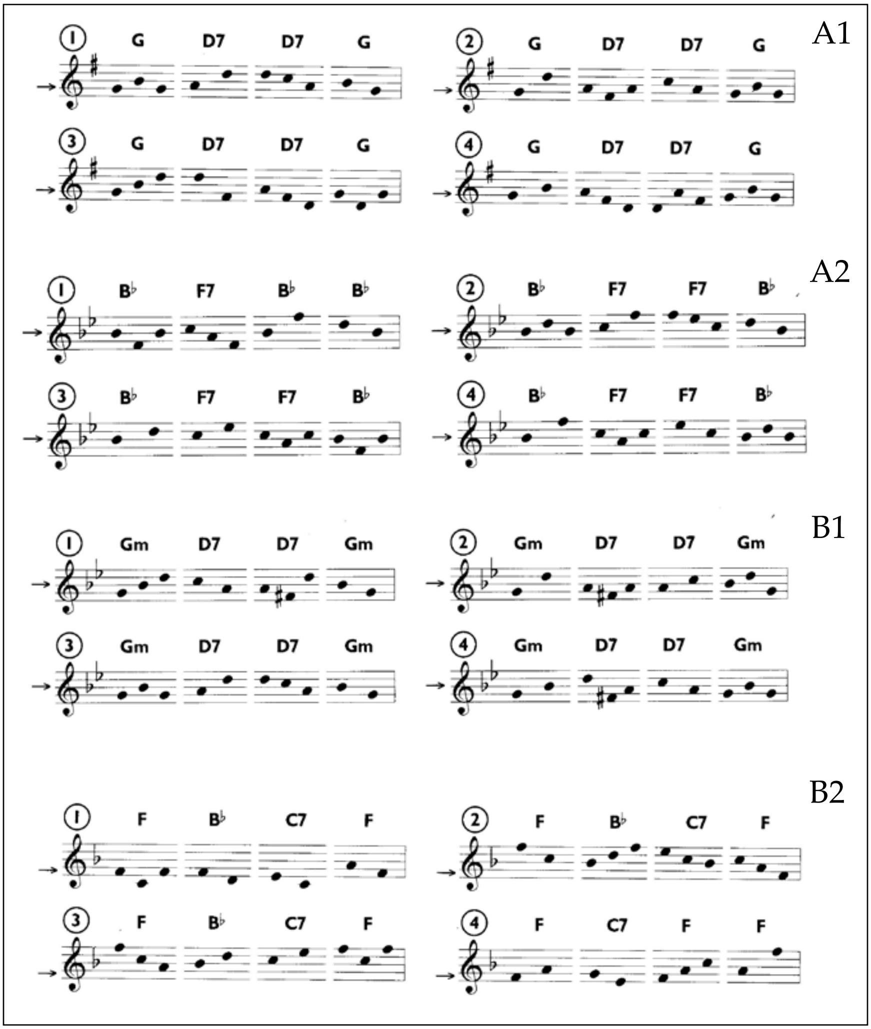
[16] "Verbal Association" is one of the terms associated with Edwin E. Gordon's music learning sequence (Gordon 2003, see Chapter 5 "Skill Learning Sequence"). For a succinct overview of Gordon's music learning theories, see Walters (1989). Gordon's work is sometimes criticized for its use of idiosyncratic terminology; nevertheless, aspects of Gordon's music learning theory may be successfully adapted to the collegiate classroom. In particular, Gordon advocates a call-and-response classroom activity with tonal and rhythm patterns that is carried out in several distinct stages in his skill learning sequence. In the first stage ("aural/oral"), students echo the teacher's sung patterns on a neutral syllable until mastery is achieved. In the second stage ("verbal association"), patterns are linked with meaningful syllables; for tonal patterns, Gordon uses moveable-do solfège with la-based minor. Patterns are also used as the basis for improvisation exercises. Only in the fourth stage ("symbolic association") is any music notation introduced. The pedagogy described here for collegiate students is consonant in many ways with Gordon's method, but it differs with

on tonic arpeggiations with one or two patterns based on the dominant or dominant-seventh harmonies helps instill a sense of harmonic progression in the sung exercises. Students attend better if the patterns are unpredictable in length, varying from two to three pitches in the early stages as Example 2 shows (see next page). Because of the variable rhythm, instructors may wish to guide the timing of responses with hand gestures, which may also be used to single out individuals for singing alone. The objective is that students echo the instructor accurately, and with good intonation, in group and solo singing in each stage before moving to the next one.

In the third stage of the call-and-response activity, the instructor sings the now-familiar tonal patterns on a neutral syllable and the students respond by singing back on scale degree numbers. For AP students, this ensures—in real time—that they are able to interpret a musical stimulus functionally within a key context. The pedagogical progression through a set of increasingly familiar tonal patterns from (1) neutral call and response, to (2) scale-degree call and response, and finally to (3) a neutral call answered by a numeric response, helps most students attain a high degree of fluency. The real-time challenge of answering the instructor immediately with sung patterns converted to scale degree numbers, and the possibility of being randomly chosen at any moment to sing a solo response, keeps the activity engaging even for AP students and those who may find the beginning levels easy. By calling for solo responses, instructors will soon discover which students respond well to more challenging patterns, and which students need to experience success with easier patterns, and so can tailor the activity to individual differences and abilities. As the aural skills curriculum progresses from semester to semester, the call-and-response activities can be increased in difficulty by asking students to improvise their own patterns according to specific guidelines,[17] by singing in minor keys, adding stepwise filling in of triads, adding length to the patterns, and adding new harmonies as they are studied. Of these, improvisation is a particularly powerful activity for AP students, since it requires functional thinking (e.g. "Sing a five-note dominant pattern then resolve it to a three-note tonic pattern").

([16] *continued*) respect to the amount of time students spend at each stage, in the sequence of tonal patterns used, and in its use of do-based rather than Gordon's la-based minor.

[17] For examples of improvisation exercises using tonal patterns, see Azzara *et al.* (2006, 1997).



Example 2: Tonal Patterns for Call-and-Response Singing

How might call-and-response activities be tailored especially to the needs of AP students? First, change keys periodically during the activity, choosing especially keys with black-note tonics (unlike those in Example 2). Establish each new key with a short progression at the piano, then begin tonal echoes again in the new key—never announcing the name of the key, or paying any attention to letter name identification at all. Give AP students (indeed, all students) opportunities to sing in "difficult" keys like C♯ Major. For non-AP students, this won't matter; for AP students, opportunities to work with black-note tonics are important. Second, vary the timbre used for the calls. Instructors who play an instrument other than piano might occasionally play the calls on that instrument. Students who are performing well on the sung responses can be called upon to lead the group by playing the calls on their instrument. Very capable students can be asked to improvise the calls along guidelines given, or the instructor can write out a sequence of patterns for student leaders to use.

Singing at Sight

Although AP students will become accustomed to rapid-fire translation of pitches into scale degrees from call-and-response activities, they will nevertheless naturally return to pitch-processing rather than relationship-processing if given traditional pitch-reading tasks like singing melodies from music notation. One way to counter this tendency is to ask students to sing from scale degree numbers alone. A textbook that takes this approach—teaching sight singing from scale-degree representations in each chapter before introducing staff notation—is Yasui and Trubitt's, *Basic Sight Singing.*

Example 3 illustrates Yasui and Trubitt's typical unit of study, incorporating steps and skips within scale-degrees $\hat{1}$ through $\hat{5}$. The authors begin with numbers alone (or alternatively movable-do solfège), and then move to pitches written on a staff that has no clef, and finally to traditional staff notation. The use of the clef-less staff allows students to begin making an association with lines and spaces in a relative sense, but not with particular pitches—in a relative notational system, not an absolute one. The instructor may establish various possible tonic keys at the piano, then ask students to sing from this notation. Instructors of AP students may create progressively more difficult melodies, while avoiding traditional staff notation, in several ways. Scale-degree numbers may be written above or below traditional rhythmic notation, replacing the Yasui and Trubitt arhythmic format. Or instructors can use staff notation, but excise the clefs and key signatures from tunes originally notated in various clefs (including C-clefs), asking students to sing on scale degrees in major or natural minor from a variety of possible tonics. Singing on scale-degree numbers from this notation helps AP students get used to reading scalar and triadic patterns in relation to a tonic that may appear in different positions on the staff, but without associating any letter names with these pitches.

Level 6 Exercises: scale degrees 1 2 3 4 5 / d r m f s (steps and skips)

Scale Degree Number

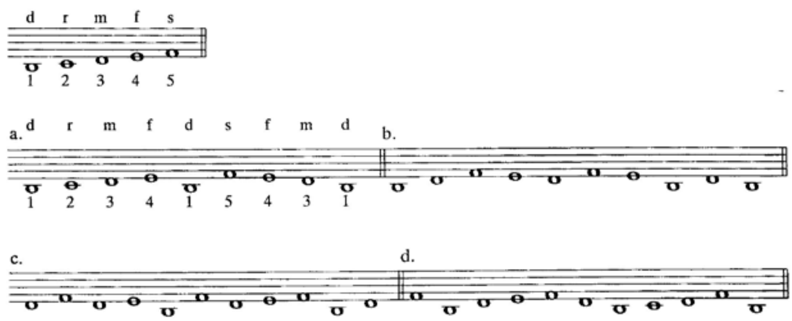
a. 1 2 3 5 4 1 3 2 3 4 1 2 5
b. 3 5 4 1 2 3 1 5 3 1 5 4 3
c. 2 3 2 1 2 5 4 3 4 1 3 2 5
d. 1 5 3 4 1 5 4 1 3 2 5 1 2
e. 5 1 3 2 5 4 1 3 4 1 2 5 3
f. 3 1 5 4 3 1 2 5 3 4 1 3 2
g. 3 2 5 4 3 1 2 5 3 4 1 2 5
h. 3 1 2 5 4 1 3 2 1 3 4 1 5
i. 1 5 3 4 1 3 2 5 4 1 2 5 3
j. 3 1 2 5 3 4 1 5 4 3 1 5 3
k. 1 3 2 5 3 4 5 1 3 2 5 1 2
l. 1 5 4 1 3 2 1 5 1 2 5 3 1

Solfège

a. d r m s f d m r m f d r s
b. m s f d r m d s m d s f m
c. r m r d r s f m f d m r s
d. d s m f d s f d m r s d r
e. s d m r s f d m f d r s m
f. m d s f m d r s m f d m r
g. m r s f m d r s m f d r s
h. m d r s f d m r d m f d s
i. d s m f d m r s f d r s m
j. m d r s m f d s f m d s m
k. d m r s m f s d m r s d r
l. d s f d m r d s d r s m d

Notes on the Staff

Tonic is on the second space below the staff.



Example 3: Relative-Pitch Exercises from Yasui and Trubitt *Basic Sight Singing* (p. 27)

Another fruitful relative-pitch activity is to sing chordal arpeggiations on scale degrees from Roman numerals in various keys. Students arpeggiate harmonies up and down, as Example 4 shows, singing at sight from a succession of Roman numerals with no staff notation or key specified.[18]

Example 4: Singing Chordal Arpeggiations from Roman Numerals

The instructor can set a different key for each progression by playing tonic and dominant at the keyboard before students begin singing. Progressions with stepwise bass lines, which provide practice reading inversion symbols, make better-sung patterns (and help minimize parallel fifths). Sung harmonic progressions can begin quite simply in the early stages of study, and then can continue throughout the curriculum by incorporating more challenging chromatic harmonies as study progresses.[19]

[18] Karpinski (2000) discusses this technique (p. 180) and gives an example using simple diatonic chords, as well as a more advanced example with an augmented-sixth chord. Singing arpeggios from Roman numerals is featured in a number of recent aural skills texts, including Karpinski (2007) and Phillips *et al.* (2005).

[19] This activity can, conversely, serve as a powerful lesson in chord spelling for non-AP students when the key is announced and students are asked to sing the progressions on letter names (or fixed-do syllables) instead of scale-degree numbers. While AP students are much more likely to excel at this (because it is quite natural for them to supply letter names for sung pitches), non-AP students will be challenged to think concretely in each key requested in order to spell the harmonies correctly.

As students advance, they will sing more often from traditional notation, but the instructor can continue to encourage relative-pitch strategies by asking the class to sing in keys other than notated. This strategy can help with melodic tessitura problems as well—if a melody lies too high, simply sing in a lower key. Although AP students who are asked to sing a melody in a key other than notated sometimes look upon transposed sight singing as persecution for having AP, complaints will be fewer if the instructor has prepared the class carefully for this activity with a unified relative-pitch pedagogy throughout the curriculum—by singing from numeric notation, by vocalizing and improvising in various keys using numbers, by singing from the clef-less staff, and so on.

Dictation

Dictation can be an easy matter for AP students, who simply hear the notes and write them. There is little pedagogical value in such an activity for AP students, who are not learning anything new and can easily become bored after one or two hearings. Two teaching strategies—familiar from our discussion of call-and-response activities—will help to ground this activity in the realm of relative-pitch skill development. First, the strategy of avoiding or delaying staff notation should be maintained. Consider the typical harmonic dictation exercise: repeatedly playing a chorale phrase in four-part harmony and asking students to notate on a grand staff. AP students typically write down the pitches of the soprano, alto, tenor, and bass lines as four melodic dictations, then go back to analyze the harmonies from these pitches. While this strategy produces a correct answer, the Roman numerals that result are an analytical rather than a perceived product. We can encourage functional hearing when giving harmonic dictation by eliminating staff paper altogether. Before playing the chorale phrase, the instructor would not announce a key, nor would students write any clefs or key signature on staff paper. Rather, on regular notebook paper, students write the soprano and bass lines as scale-degree numbers and place a Roman numeral beneath each soprano-bass simultaneity, as shown in Example 5.[20] This technique reinforces knowledge of scale-degree membership within each harmony and

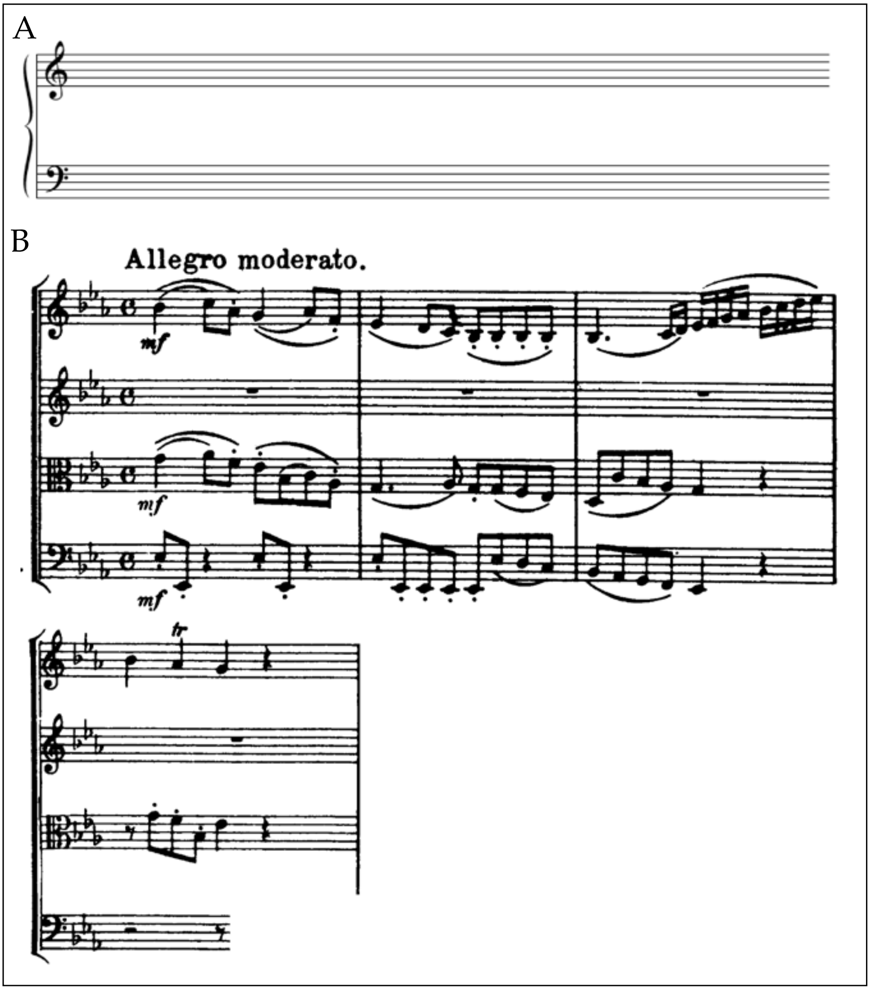
[20] Examples 4 to 6 are adapted from exercises in Phillips *et al.* (2005). See especially pages 266-268 (Ex. 4 and 5), and 137 (Ex. 6).

helps students to learn common harmonizations of soprano-bass patterns. The instructor can categorize common harmonizations—for example, bass moves $\hat{1}$-$\hat{2}$-$\hat{3}$ with the soprano $\hat{3}$-$\hat{4}$-$\hat{5}$, bass moves $\hat{1}$-$\hat{2}$-$\hat{3}$ with the soprano $\hat{3}$-$\hat{2}$-$\hat{1}$, or bass moves $\hat{5}$-$\hat{5}$-$\hat{1}$ with the soprano $\hat{3}$-$\hat{2}$-$\hat{1}$—so that students know which Roman numerals to anticipate given the soprano-bass context. Emphasis upon scale-degree patterns and their possible harmonizations helps dissuade AP students from writing letter names or pitches on a staff, in favor of learning tonal patterning. Once students have completely notated the scale-degree and Roman numeral representations, they may be asked to transcribe the progression onto the staff in the key played or perhaps in some other key.

Example 5: Harmonic Dictation without Staff Notation

Melodic dictation can be taught by a similar method. Students might be asked initially to identify the meter and take rhythmic dictation from a performed melody, and then on subsequent hearings to write scale degree numbers of the melody above or below the notated rhythms. As with harmonic dictation, no key or starting pitch is announced. Karpinksi (2002, pp. 89-91) recommends a similar method for dictation away from the staff, which he calls “protonotation.” This dictation strategy is incorporated systematically in Karpinski (2007), and serves as a reminder that all activities recommended here for teaching AP listeners are equally appropriate as strategies for non-AP students. Once the melody has been completely notated with scale degrees, that information may be used to transcribe the melody on to the staff, either in the key played or in another key. Because some students will be required to transpose at sight in careers as practicing musicians, it can be helpful to demonstrate how scale-degree notation aids in transposing music. Asking students to transcribe their scale-degree notation into more than one key addresses this objective while also reinforcing the relative-pitch aspects of dictation for AP students.

Finally, contextual listening exercises—which require students to take dictation and identify musical structures (intervals, chords, cadence or phase types, and so on) from "real" musical contexts—provide an important opportunity for AP students to practice relative-pitch skills in timbres other than piano.[21] Example 6 is a contextual listening exercise, based on a short excerpt from a Haydn string quartet that is designed



Example 6: Dictation from Music Literature

[21] Contextual listening exercises may be found in Wittlich and Humphries (1974), Advanced Placement Exam preparation materials, and Phillips *et al.* (2005), or may be created by the instructor.

to practice dictation skills in the musical context of a composition for strings. The exercise requires students to take dictation in scale degrees, transcribe in another key, and identify intervals in a musical context.

Conclusion

How has research in music cognition informed a pedagogy of relative pitch? First, work by Miyazaki and others reinforce anecdotal classroom evidence that some AP students would benefit from specific training in relative pitch skills. This has been a guiding factor in pedagogical strategy of avoiding pitch names and staff notation in any form for as long as possible. Instead, we choose activities that reinforce scale degree associations, by singing and improvising on scale degree numbers and by taking dictation in scale degrees rather than in pitches. Second, the white-key/black-key differences found by Miyazaki, Takeuchi and Hulse, and Marvin and Brinkman influenced the decision to make transposition an integral part of the curriculum—from transposing vocal warm-ups to transcribing dictation exercises in several keys. Third, another of Miyazaki's findings—on AP listeners' difficulties with out-of-tune musical contexts and with timbres other than piano—influenced our choice of dictation from real music using contextual listening exercises rather than (or in addition to) the more typical piano transcriptions. Finally, while the validity of the early-learning hypothesis is not universally accepted, converging evidence suggests that early training in music does play a role in AP acquisition (perhaps only in children who are genetically predisposed to acquire AP). For those who teach pre-collegiate music students, this suggests that relative-pitch singing games (on scale degrees or moveable-do solfège) such as the call-and-response activities described above are an important way to exercise non-AP abilities in children who show early evidence of AP.

To close, we return to the quandary discussed at the outset—the mixed population of AP and non-AP students, and the question of whether AP students should be required to enroll in aural skills classes at all. Placement questionnaires for incoming students ought to ask students whether they have AP, along with questions about previous theory study. Individual placement interviews should be scheduled for those who answer in the affirmative. In such an interview, the examiner might have the student identify a set of intervals as rapidly as possible, to assess whether the student is "converting" from pitch names to intervals names. The interviewer should also ask AP students to sing a melody at sight in a key other than notated and to write a simple diatonic dictation in a key other than that played. If a student can perform these tasks relatively effortlessly, then he or she should indeed be exempted from the beginning levels of aural skills instruction. If, on the other hand, it is clear that the AP student struggles with relative-pitch tasks, then enrollment in aural skills is appropriate—as is a pedagogical focus on relative-pitch activities like those discussed here. While absolute pitch can be a valuable asset to musicians, ideally AP musicians should develop relative-pitch skills as well. This dual perspective on musical structure will give these musicians more flexibility in diverse musical situations and will enrich their functional hearing of tonal relations.

Reference List

Azzara, Christopher D. and Richard F. Grunow. 2006. *Developing musicianship through improvisation*. Chicago: GIA Publications, Inc.

Azzara, Christopher D., Richard F. Grunow, and Edwin E. Gordon. 1997. *Creativity in improvisation*, 2 vols. Chicago: GIA Publications, Inc.

Baczewski, P. and R. Killam. 1992. "Perception of a musical construct by musicians with absolute pitch." Paper presented at the International Conference on Music Perception and Cognition, Los Angeles, February 22-26.

Baharloo, S., P. A. Johnston, S. K. Service, J. Gitschier, and N. B. Freimer. 1998. "Absolute pitch: An approach for identification of genetic and nongenetic components." *American Journal of Human Genetics* 62: 244-231.

Baharloo, S., S. K. Service, N. Risch, J. Gitschier, and N. B. Freimer. 2000. "Familial aggregation of absolute pitch." *American Journal of Human Genetics* 67: 755-758.

Benguerel, A. and C. Westdal. 1991. "Absolute pitch and the perception of sequential musical intervals." *Music Perception* 9 (1): 105-119.

Bergeson, T. R., and S. E. Trehub. 2002. "Absolute pitch and tempo in mothers' songs to infants." *Psychological Science* 13, 72-75.

Butler, D. 1997. "Why the gulf between music perception research and aural training?" *Bulletin of the Council for Research in Music Education* 32: 38-48.

Butler, D. and M. Lochstampfor. 1993. "Bridges unbuilt: Aural training and cognitive science." *Indiana Theory Review* 14 (1): 1-17.

Deutsch, D., T. Henthorn, and M. Dolson. 2004. "Absolute pitch, speech, and tone language: Some experiments and a proposed framework." *Music Perception* 21 (3): 339-356.

Deutsch, D., T. Henthorn, E. W. Marvin, and H. Xu. 2006. "Absolute pitch among American and Chinese conservatory students: Prevalence differences and evidence for a speech-related critical period." *Journal of the Acoustical Society of America* 119 (2): 719-722.

Faivre, I. A. 1986. A theory of skill development in the absolute judgment of tones: Training, pitch, memory. PhD diss.: University of Colorado, Boulder.

Gordon, Edwin E. 2003. (First edition, 1980). *Learning sequences in music: Skill, content, and patterns.* Chicago: GIA Publications, Inc.

Gregersen, P., E. Kowalsky, N. Kohn, and E. W. Marvin. 1999. "Absolute pitch: Prevalence, ethnic variation, and the estimation of the genetic component," *American Journal of Human Genetics* 65 (3): 911-3.

____________. 2000. "Early childhood musical education and predisposition to absolute pitch: Teasing apart genes and environment," *American Journal of Medical Genetics* 98: 280-282.

Grunow, Richard F., Edwin E. Gordon, and Christopher D. Azzara. 1998. *Jump right in: The instrumental series (Student book I: Soprano recorder)*. Chicago: GIA Publications, Inc.

Halpern, A. R. 1989. "Memory for the absolute pitch of familiar songs," *Memory & Cognition* 17: 572-81.

Karpinski, G. 1990. "A model for music perception and its implications in melodic dictation." *Journal of Music Theory Pedagogy* 4: 191-229.

____________. 2000. *Aural skills acquisition: The development of listening, reading, and performing skills in college-level musicians.* New York: Oxford University Press.

____________. 2007. *Manual for ear training and sight singing.* New York: W. W. Norton.

Killam, R. N., P. Baczewski, and B. Hayslip Jr. 2003. "A model of performing musicians' melodic perception through transcription of two-voice contrapuntal music." *Musicae Scientiae* 7: 263-291.

Larson, S. 1993. "The value of cognitive models in evaluating solfege systems." *Indiana Theory Review* 14 (2): 115.

Lake, W. E. 1993. "Interval and scale-degree strategies in melodic perception." *Journal of Music Theory Pedagogy* 7: 55-67.

Levitin, D. 1994. "Absolute memory for musical pitch: Evidence from the production of learned melodies. *Perception & Psychophysics* 56: 414-423.

____________. 1999. "Absolute pitch: Self-reference and human memory." *International Journal of Computing and Anticipatory Systems* 4: 255-266.

Levitin, D. J. and S. E. Rogers. 2005. "Absolute pitch: Perception, coding, and controversies." *Trends in Cognitive Sciences* 9 (1): 26-33.

Lorek, M. J. and R. G. Pembrook. 2002. "To *doh* or not to *doh:* The comparative effectiveness of sightsinging syllable systems." *Journal of Music Theory Pedagogy* 14: 1-14.

Marvin, E. W. 1995. "Research on tonal perception and memory: What implications for music theory pedagogy?" *Journal of Music Theory Pedagogy* 9: 31-70.

___________. 1997. "Tonal/Atonal: Cognitive strategies for recognition of transposed melodies," in *Music Theory in Concept and Practice*, ed. James Baker, David Beach, and Jonathan Bernard, 217-236. Rochester, NY: University of Rochester Press.

Marvin, E. W. and A. R. Brinkman. 2000. "The effect of key color and timbre on absolute-pitch recognition in musical contexts," *Music Perception* 18 (2): 111-137.

MacDougall-Shackleton, S. A. and S. H. Hulse. 1996. "Concurrent absolute and relative pitch processing by European starlings *(Sturnus vulgaris)."* *Journal of Comparative Psychology* 110 (2): 139-146.

Miyazaki, K. 1989. "Absolute pitch identification: Effects of timbre and pitch region. *Music Perception* 7 (1): 1-14.

___________. 1990. The speed of musical pitch identification by absolute-pitch possessors. *Music Perception* 8 (2): 177-188.

___________. 1992. "Perception of musical intervals by absolute pitch possessors." *Music Perception* 9: 413-426.

___________. 1993. "Absolute pitch as an inability: Identification of musical intervals in a tonal context." *Music Perception* 11 (1): 55-71.

___________. 2004. "The auditory Stroop interference and the irrelevant speech/pitch effect: Absolute-pitch listeners can't suppress pitch labeling." Paper presented at the International Congress on Acoustics, Kyoto, Japan, April 4-9.

Miyazaki, K. and A. Rakowski. 2002. "Recognition of notated melodies by possessors and non-possessors of absolute-pitch." *Perception & Psychophysics* 64: 1337-1345.

Phillips, Joel, Jane Piper Clendinning, and Elizabeth West Marvin. 2005. *The musician's guide to aural skills*, vol. 1. New York: W. W. Norton and Co.

Potter, G. 1990. "Identifying successful dictation strategies." *Journal of Music Theory Pedagogy* 4 (1): 63-71.

Rogers, M. R. "Review of 'To *doh* or not to *doh*'," *Journal of Music Theory Pedagogy* 14: 15-25.

Rush, M. A. 1989. An experimental investigation of the effectiveness of training on absolute pitch in adult musicians. PhD diss., Ohio State University.

Rush, M. A. and D. Butler. 1995. "The acquisition of absolute pitch by adult musicians." Presented at the 4th Society for Music Perception and Cognition, Berkeley, CA.

Russo, F. A., D. L. Windell, and L. Cuddy. 2003. "Learning the 'special note': Evidence for a critical period for absolute pitch acquisition." *Music Perception* 21 (1): 119-127.

Saah, V. and Marvin, E. W. 2004. "Absolute memory of learned melodies in children trained by the Suzuki violin method." *Proceedings of the 8th International Conference on Music Perception & Cognition*, Northwestern University, Evanston, IL.

Saffran, J. R. 2003. "Absolute pitch in infancy and adulthood: The role of tonal structure. *Developmental Science* 6 (1): 35-42.

___________. 2003. "Birds do It – Why not babies?" (Response to Trehub.) *Developmental Science* 6 (1): 46-47.

Saffran, J. R. and G. J. Griepentrog. 2001. "Absolute pitch in infant auditory learning: Evidence for developmental reorganization." *Developmental Psychology* 37 (1): 74-85.

Saffran, J. R., E. K. Johnson, R. N. Aslin, and E. L. Newport. 1999. "Statistical learning of tone sequences by human infants and adults." *Cognition* 70: 27-52.

Saffran, J. R., K. Reeck, A. Niebuhr, and D. Wilson. 2005. "Changing the tune: The structure of the input affects infants' use of absolute and relative pitch. *Developmental Science* 8 (1): 1-7.

Simpson, J. and D. Huron. 1994. "Absolute pitch as a learned phenomenon: Evidence consistent with the Hick-Hyman law." *Music Perception* 12 (1): 267-270.

Schellenberg, E. G. and S. E. Trehub. 2003. "Good pitch memory is widespread." *Psychological Science* 14 (3): 262-266.

Schlaug, G. 2001. "The brain of musicians: A model for functional and structural adaptation." *Annals of the New York Academy of Sciences* 930: 281-299.

Takeuchi, A. H. and S. H. Hulse. 1991. "Absolute-pitch judgments of black- and white-key pitches." *Music Perception* 9 (1): 27-46.

Trainor, L. J. 2005. "Are there critical periods for musical development?" *Developmental Psychobiology* 46: 262-278.

Trehub, S. 2003. "Absolute and relative pitch processing in tone learning tasks." (Commentary on Saffran.) *Developmental Science* 6 (1): 44-45.

Walters, D. L. 1989. "Skill learning sequence," in *Readings in music learning theory*, ed. Darrel L. Walters and Cynthia Crump Taggert. Chicago: GIA Publications, Inc., 12-25.

Ward, W. D. 1999. "Absolute pitch," in *Psychology of Music*, ed. Diana Deutsch. San Diego: Academic Press, 265-298.

Wittlich, Gary and Lee Humphries. 1974. *Ear training: An approach through music literature*. New York: Harcourt, Brace, Jovanovich.

Wright, A. A., J. J. Rivera, S. H. Hulse, M. Shyan, J. J Neiworth. 2000. "Music perception and octave generalization in Rhesus monkeys." *Journal of Experimental Psychology: General* 129: 291-307.

Yasui, Byron and Allen Trubitt. 1989. *Basic sight singing*. Mountain View, CA: Mayfield Publishing.

Zatorre, R. J. 2003a. "Absolute pitch: A model for understanding the influence of genes and development on neural and cognitive function." *Nature Neuroscience* 6: 692-695.

____________. 2003b. "Music and the brain." *Annals of the New York Academy of Sciences* 999: 4-14.