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Voluntary Auditory imagery and Music pedagogy.

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Voluntary Auditory Imagery and Music Pedagogy

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Abstract and Keywords

Andrea Halpern and Katie Overy review research on auditory imagery from a psychology perspective. They then argue that auditory imagery can be used actively as a tool in various music education and rehearsal contexts. As exemplified by aspects of the pedagogical approaches of Zoltán Kodály and Edward Gordon, as well as Nelly Ben-Or's techniques of mental representation for concert pianists, Halpern and Overy suggest that the conscious and deliberate use of auditory imagery could be exploited more in music education, as it has profound benefits for musicians as a rehearsal strategy. The authors call for further empirical investigations of how voluntary auditory imagery might be used most effectively as a training technique for both professional musicians and in classroom settings.

Keywords: voluntary auditory imagery, music pedagogy, neuroscience, imagined music, memory, learning

(p. 391) Introduction

AUDITORY imagery is a common everyday experience. People are able to imagine the sound of waves crashing on a beach, the voice of a famous movie actor, or the melody of a familiar song or TV theme tune. Although people vary in the extent to which they report these as vivid experiences, on average they rate vividness of imagined sounds at the upper end of rating scales such as the Bucknell Auditory Imagery Scale (Halpern 2015), averaging about 5 on a 7-point scale, where 7 means "as vivid as actually hearing the sound." Imagined music can also be involuntary (Beaman and Williams 2010; Hyman et al. 2013), or even hallucinatory (Griffiths 2000; Weinel, this volume, chapter 15) but the focus of our discussion is on the willful calling to mind of music. Our argument here is that, in general, auditory imagery is not just something people do when mind-wandering or passing the time; it can have definite positive consequences in mood regulation, self-entertainment, and mental rehearsal. More particularly, musicians, composers, and music educators understand that auditory imagery is a tool, and they regularly employ auditory imagery in both pedagogical and professional capacities. We suggest that this important skill could be used more widely than it is already; for example, to enable musicians to employ more efficient memorization skills and to rehearse both physical and expressive aspects of performance without risking excessive motor practice.

Using imagined music to accomplish something beneficial is reported among non-musicians as well as musicians, of course. People report voluntarily bringing music to mind to regulate their emotional state, and they judge the emotionality of familiar imagined music similarly to judging the emotionality of heard music (Lucas et al. 2010). Recorded music has been shown to assist athletic performance in a variety of situations, (p. 392) including keeping a steady pace during swimming (Karageorghis et al. 2013), and imagined music can have similar benefits. One compelling example was reported by the marathon swimmer Diana Nyad during her record-setting swim of the Straits of Cuba, covering 110 miles in 53 hours:

> Diana Nyad uses singing to help pass the time and the monotony and sensory deprivation inevitable in marathon swimming. To help, she sings silently from a mental playlist of about 65 songs [including] Janis Joplin’s chart-topping version of Me and Bobby McGee. “If I sing that 2,000 times in a row, the whole song, I will get through five hours and 15 minutes,” Nyad said. … “It’s kind of stupid,” she added, “but it gets me through.”[1]

For musicians, imagining a musical performance can be a useful rehearsal tool and even a powerful experience, as expressed by violinist Romel Joseph, who was trapped under the rubble of his music conservatory for eighteen hours after the Haiti earthquake of 2010. This quote captures both the emotional and performance aspects of imagining music in a most deliberate way:

> He didn’t panic—instead, he kept himself to a strict schedule. He spent part of each hour in prayer. The rest of the time he filled by rehearsing his favorite classical music performances in his head, note by note. “For example, if I perform the Franck sonata, which is [sic] 35 minutes long in my honors recital at Juilliard, then I would bring myself to that time. That allows me … to mentally take myself out of the space where I was.”[2]

Psychology Research on Auditory Imagery

If auditory imagery had an arbitrary, or even illusory link to perceiving and performing real music, then advocating for the increased use of imagery in musical rehearsal and pedagogy might not make a compelling argument. However, research over the years has suggested that both musicians and nonmusicians (i.e., those who haven’t studied musical performance to a high level) can mentally represent a surprisingly wide range of auditory characteristics of actual musical sound (see Hubbard 2010 for a comprehensive review), in many cases using imagery very consciously and deliberately. For instance, most individuals, including nonmusicians, can call to mind the melody of a familiar song without any difficulty. For songs with no canonical recorded versions, people are remarkably consistent in reproducing or choosing a similar pitch to the one they produced or chose on a prior occasion for the same song (Halpern 1989). In addition, they are also fairly accurate in reproducing the opening pitches of well-known recordings of (p. 393) music from their mental playlist (Levitin and Cooke 1996; Frieler et al. 2013) and can usually recognize the correct pitch within two semitones (Schellenberg and Trehub 2003).

Auditory imagery also represents some of the temporal characteristics of sounded music remarkably accurately. If asked to carry out memory tasks comparing pitches at two non-adjacent places in a familiar melody, reaction times increase proportionally to the distance between the notes in beats of the actual tune (Halpern 1988a) and if asked to mentally complete a phrase of a familiar tune after a sounded cue of the opening notes, reaction times similarly increase proportionally for longer phrases (Halpern and Zatorre 1999). A recent study of involuntary musical imagery asked people to tap the tempo of involuntary auditory images that occurred over a five-day period; tempos were recorded via an accelerometer. Results showed that 77 percent of 115 reports of episodes involving recorded music were within 15 percent of the original recorded tempo (Jakubowski et al. 2015).

Even a multidimensional construct such as timbre is processed similarly in hearing and imagery. Halpern and Zatorre (2004) asked people to make similarity judgments between pairs of sounded and imagined musical instruments while undergoing fMRI scanning. Similarity ratings in both conditions were highly correlated. Additionally, both types of judgments involved activation of the secondary auditory cortex (judgments on sounded but not imagined music additionally activated the primary auditory cortex). Thus, we have some basis to conclude that mentally simulating or rehearsing music might involve similar neural processing and thus confer some of the same benefits as actual hearing or even production—given that production includes not only motor but also auditory skills.

On the other hand, apart from the case of auditory hallucinations (Griffiths 2000; Weinel, this volume, chapter 15) most people do not actually confuse imagining with hearing, and thus we should not be surprised if there were behavioral and neural substrate differences between the two. One obvious difference between the two types of auditory experience is that auditory imagery tasks are on average more difficult than matched perceptual tasks. For example, Zatorre and Halpern (1993) presented patients who had undergone surgery removing part of their temporal lobes (mean age about thirty years old) and matched controls with the text of the first line of a familiar tune, such as *Jingle Bells*. Two lyrics were highlighted, as in “Dashing through the SNOW, in a one-horse open SLEIGH.” The task was to judge whether the pitch of the second highlighted lyric was higher or lower in pitch than the first such lyric (the reader is invited to try that now). In one condition, participants heard a recording of someone singing the tune; in the other condition, they had to use mental imagery only. The right-temporal lobectomy patients had lower performance in both conditions compared to the other two groups, implicating the role of the right temporal lobe in pitch perception and imagery, whereas accuracy rates for all participants were about 12–15 percent lower in the imagined than heard condition. In a subsequent study with healthy young adults in which only the two to-be-compared lyrics were presented, similar performance drops from heard to imagined conditions were found (Zatorre and Halpern 1996).

(p. 394) Imagery tasks are likely to be more difficult because they involve considerable working memory resources; indeed, Baddeley and Andrade (2000) found that working memory (WM) performance scores correlated with self-reported vividness of both auditory and visual imagery. WM span is also positively correlated with measures of pitch and temporal imagery ability (Colley et al. 2017). Brain imaging studies also point to the involvement of executive function in auditory imagery. Herholz and colleagues (2012) asked people with a range of musical experience to listen to or imagine familiar songs, while simultaneously viewing the lyrics in a karaoke-type video presentation. Compared to a baseline, cerebral blood flow (measured via fMRI) in imagined and heard conditions activated perceptual areas such as the superior temporal gyrus (STG, the locus of the secondary auditory cortex), but imagining tunes also uniquely activated several areas associated with higher-order planning and other executive functions, such as the supplementary motor area (SMA), intraparietal cortex (IPS), inferior frontal cortex (IFC), and right dorsolateral prefrontal cortex (DLPFC) (see Figure 19.1). This additional neural activity is interpreted as reflecting extra cognitive effort and suggests that imagery tasks are more difficult. However, such tasks may also benefit music learning in both the short and long term precisely *because* of this increased level of cognitive engagement (known as a "desirable difficulty" in the cognitive literature), potentially leading to better encoding and later retention (Bjork et al. 2014).

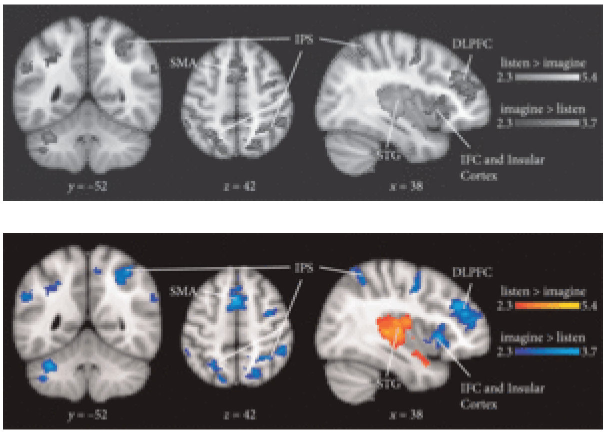

Figure 19.1 Brain areas more active in listening than imagining a familiar tune (the major activity is labeled "STG"—orange on the companion website) and those more active in imagining than listening to a familiar tune (the major activity is labeled "IPS," "SMA," "DLPFC," and "IFC"—blue on the companion website). (Reprinted with permission from Herholz et al. 2012).

As alluded to in our opening remarks, auditory imagery is not always intentional—it can come unbidden in the form of so-called earworms, or what is sometimes called involuntary musical imagery (INMI). Numerous researchers have now studied this phenomenon, documenting the incidence and phenomenology of the experience, the relationship to personality variables, and the characteristics of the triggers and the tunes themselves that come to mind (for example, Bailes 2006; Halpern and Bartlett 2011; Hyman et al. 2013; Müllensiefen et al. 2014; Williamson and Jilka 2013). However, in this chapter we focus on voluntary auditory imagery precisely because it is under the control of the individual and thus can be harnessed and modified as needed to accomplish musical goals.

(p. 395) Individual Differences in Auditory Imagery Abilities

Auditory imagery is sometimes separated into two distinct types of processing—generation and transformation. *Generation* refers to calling a perceptual experience to mind, that is, initiating the auditory (or visual) image. Most individuals are able to generate musical auditory images, such as the initial note of a familiar tune (Halpern 1989), the sounds of two different instruments (Halpern and Zatorre 2004), a phrase of a melody (Herholz et al. 2012), or even an entire minute of a fully realized classical symphony (Lucas et al. 2010). Once an auditory image has been generated, or even during the process, *transformations* can be applied to the internal representations. For instance, if asked to imagine the familiar melody of "Happy Birthday" in a version where the third note moves down instead of up in pitch, most people report they can do so. Other transformations can be more difficult, such as mentally reversing a just-presented tune and answering a question about the reversal accurately (Zatorre et al. 2010).

Both of these processes can be useful in professional musical life, for example a performer engaging in mental rehearsal of a familiar or notated passage of music might rely primarily on generation of the auditory image, but might also use transformation to try out different expressive interpretations prior to executing them. Similarly, composers and arrangers who are working with and developing musical themes can use both types of process. There are considerable variations in both self-reported and objectively measured abilities in these areas of auditory imagery ability, and researchers have become quite interested of late in creating scales and measures that index these differences.

One example of a self-report measure is the Bucknell Auditory Imagery Scale (BAIS), mentioned earlier, which has two subscales that capture self-report of generation (Vividness) and transformation or the ability to control characteristics of the image (Control) (Halpern 2015). An example of an item on the Vividness subscale (BAIS-V) is: "Consider attending a choir rehearsal. [Imagine] the sound of an all-children's choir singing the first verse of a song." An example of an item on the Control subscale (BAIS-C) is: "Consider being present at a jazz club. [First imagine] the sound of a saxophone solo. [Imagine that] the saxophone is now accompanied by a piano." Both subscales typically elicit a wide range of responses on a scale of 1 ("no image present") to 7 ("as vivid as the actual sound") scale. For instance, in the original development sample of seventy-six undergraduates with a variety of musical training backgrounds, seventy-four of them used at least four scale points on at least one of the scales. On average, respondents showed a standard deviation of 1.5 in their ratings over the fourteen items on both the BAIS-V and BAIS-C. Correlations between scores and years of musical training was typically modest on both scales, about .3. Objectively measured auditory imagery performance also varies considerably among people, as shown in tasks as diverse as mentally imagining a pitch contour (Gelding et al. 2015) and recognizing or producing a mentally reversed or transposed phrase (Greenspon et al. 2017).

More importantly for our current purpose, individual differences in self-report can predict objectively measured task-based imagery performance, and this predictive validity appears to vary according to whether the auditory imagery task is more loaded (p. 396) on generation or transformation. So, for instance, performance on the pitch contour task of Gelding and colleagues (2015), which requires the mental continuation of a pitch pattern, was predicted by scores on the BAIS-V. Greenspon and colleagues (2017), on the other hand, gave good and poor vocal pitch-matchers a suite of auditory imagery tasks that required mental transformations of melodies. For instance, given a short target melody (three or four notes), participants had to produce the notes in reverse order or to transpose the segment to a new key. BAIS-C scores (but not BAIS-V scores) predicted the extent to which performance was worse in the transformed versus exact reproduction condition.

These differences in auditory imagery self-report also predict behaviors that are more indirectly linked with auditory imagery skill. For example, self-report of auditory vividness correlates with the extent to which undergraduate students pitch-match accurately (Pfordresher and Halpern 2013). This points to the importance of the sensorimotor relationship of imagining an auditory target to successful execution of the very fine vocal movements involved in accurate singing. In the temporal domain, Colley and colleagues (2017) asked nonmusicians to tap along to expressive piano music (Chopin, Etude op 10, no. 3). The challenge in this task was that, being expressive, the tempo of the music (i.e., the speed of the underlying pulse) changed frequently as the pianist accelerated and decelerated, using rubato in the phrases. The authors measured the overall asynchrony of the taps to the onsets of the beat (i.e., combining anticipating or lagging with respect to the beat), as well as the extent to which the participant learned to anticipate (or predict) the beat, over multiple trials. They also tested performance with a more temporally regular piano piece by Mozart. BAIS-V predicted good synchronization in the Mozart piece. On the more difficult task of tapping with the Chopin, synchronization performance was predicted by BAIS-C, as well as by objective pitch and temporal imagery tasks. BAIS-C and temporal imagery ability correlated with learning to anticipate the beat, which is considered to be a measure of temporal sensitivity.

We can also see individual differences in auditory imagery self-report reflected in functional and structural brain differences. In the study by Herholz and colleagues (2012), where participants were imagining or hearing familiar songs, a functional connectivity analysis showed that the right superior temporal gyrus and the right dorsolateral prefontal cortex (which mediates working memory) were functionally connected when participants were imagining familiar songs. This correlation was stronger in individuals with higher scores on the BAIS-V. Even brain volume in some areas is larger in individuals with more vivid imagery: Lima and colleagues (2015) measured gray matter volume as a function of BAIS-V score and found more gray matter volume in more vivid imagers in the supplementary motor cortex, as well as areas previously associated with auditory imagery in the parietal and frontal lobes. This relationship held independent of age (the age range was from 20 to 81), musical background, or short-term memory span. Indeed, auditory imagery has been shown to vary even among trained musicians. As noted previously, in most studies using the BAIS, the correlation is only about .3 with years of musical training (Halpern 2015), and the differences in brain connectivity shown by Herholz and coauthors (2012) emerged even among the trained musicians in that study.

(p. 397) Given this range of individual differences, the potential complexity of auditory imagery and the links with perception abilities, it seems possible that the deliberate practice of auditory imagery might be of benefit to practicing musicians. As reviewed by Keller (2012), auditory imagery allows for the prediction of upcoming movements by imagining upcoming sounds, which can benefit speed and accuracy of motor sequences such as striking piano keys. This prediction also benefits ensemble coordination, as players must anticipate what other members of the ensemble are about to play. Highben and Palmer (2004) found that pianists with the highest scores on aural skills tests coped the best when auditory feedback was absent during playing from memory, presumably because they could internally generate that feedback. Imagery is even more important for players of non-fixed-pitch instruments where there is no direct, unequivocal mapping between the note to be played and the finger positions on the instrument. An in-depth interview study with elite brass players by Trusheim (1991) revealed that many players reported reliance on auditory imagery to anticipate the movements needed to play the next note in tune and with the desired tone. The human singing voice may benefit most from auditory imagery, which allows planning and error correction, and indeed good pitch-matching singing skills have been linked with both self-reported and objectively measured auditory imagery skills (Pfordresher and Halpern 2013; Greenspon et al. 2017).

Music Pedagogy and Voluntary Auditory Imagery

It is perhaps unsurprising then, that several approaches to musical training involve the explicit training of auditory imagery skills. In fact, the skill of reading music notation and “hearing” the appropriate auditory image “in one’s head” is so commonly used in musical performance and training that it often is not even given a particular name; its centrality is simply assumed (much like the skill of reading a book “in one’s head” is commonly assumed). The use of auditory imagery in expert musical performance preparation is sometimes called “mental rehearsal” and often combined with motor and visual imagery. Some of the first music psychologists also noted the importance of auditory imagery, starting with the earliest published measures of musical ability (Seashore 1919). Indeed, Carl Seashore regarded auditory imagery as the highest form of musicianship: “[T]he most outstanding mark of the musical mind is a high capacity for auditory imagery” (Seashore 1938, 161). It is thus useful at this point to consider the ways in which voluntary auditory imagery has been employed in particular approaches to music pedagogy. Although not all such approaches have either been documented or investigated empirically, there is nevertheless a long tradition of such training, going back decades and perhaps even centuries.

(p. 398) Two major classroom music education figures of the twentieth century, Zoltán Kodály and Edward Gordon, made auditory imagery an explicit feature of their pedagogical approaches, referring to it as “inner hearing” or “audiation,” respectively. Perhaps the most methodical, worked-out teaching method arose from the work of Kodály, a Hungarian composer and professor at the Liszt Academy in the first half of the twentieth century (Ittzés 2002). Observing that Austrian and Viennese music were held in higher regard than Hungarian folk music during the period of the Austro-Hungarian Empire and apparently unimpressed by both the general quality and the repertoire of urban children’s singing in Hungary, Kodály developed an entirely new approach to classroom music education. This new approach was based on what he considered to be the children’s musical “mother-tongue,” that is, their musical vernacular, Hungarian folk songs, which he collected and preserved in collaboration with Béla Bartók (Kodály 1960, 1974). Essentially the idea, which was developed and put into practice by Kodály’s students (Ádám 1944; Szőnyi 1974), is to begin classroom music lessons with songs already somewhat familiar to children, and through regular repetition and analysis of this familiar repertoire, learn the fundamentals of musical knowledge such as scales, rhythm, musical notation, and sight-singing. The skills acquired can then give children direct access to participating in and understanding the entire world of Western art music (and indeed other music from around the globe). Integral to this process is the use of “inner hearing” as a device to develop children’s musicianship and literacy skills. For example, a primary school music activity might involve learning to miss out a few notes or words during a song and to imagine them instead of singing them. To take *Jingle Bells* as an example again, children might be asked to sing the whole song together, while leaving out the words “bells” and “all the way” throughout the whole song (try it!). Not only does this rehearse the skill of “inner hearing,” it can also be made into an enjoyable game, and additionally, the musical structure appearing from the three repetitions of “Jingle” (mi-mi, mi-mi, mi-so; see Figure 19.2) becomes prominent and can be “discovered” by the children with the guidance of the teacher, leading to an understanding of musical form.

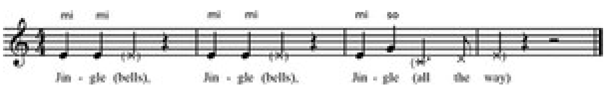

Figure 19.2 First line of the song *Jingle Bells*, where the word “Jingle” is sung aloud each time and the rest of the line is imagined.

Developing such skills to a more advanced level eventually allows older children to be able to sight-sing one melody while imagining a countermelody (i.e., a simultaneous melody), or imagine a familiar chord sequence (e.g., I–VI–IV–V–I) in various major and minor keys, for example (see Figure 19.3).

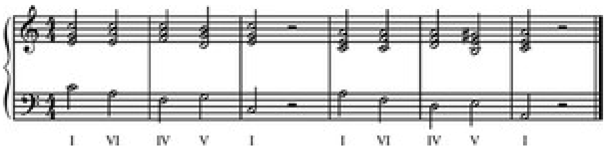

Figure 19.3 Harmonic chord sequence of I, VI, IV, V, I, first shown in the key of C major and then in A minor, where I is the tonic chord and V is the dominant chord.

The focus on repeatedly singing and analyzing familiar songs is key to the Kodály approach, and in the context of auditory imagery it is worth noting the strong emphasis placed on regular practice and depth of understanding. Kodály believed that the collecting (p. 399) of musical experiences is more important than studying music theoretically (Kodály 1974) and placed special emphasis on the use of relative sol-fa (i.e., naming notes according to their position in a musical scale, rather than by their absolute pitch) and two-part singing (Kodály 1962). Baddeley and Andrade suggest that the experience of vivid imagery requires abundant sensory information to be available from long-term memory (2000), and Neisser (1976) has noted that imagery arises (at least in part) from schemata, based on prior experience. Since a voluntary auditory image is self-generated, it reflects considerable prior processing and should not be seen as an uninterpreted sensory copy (Hubbard 2010)—mental models play an important part in musical imagery, much as they do in music perception (Schaefer 2014). Imagery and memory are also considered to be closely linked; mental imagery is an important component of working memory rehearsal, for example (Baddeley and Logie 1992). Singing may also be of particular value in the development of “inner hearing” skills because a vast amount of familiar musical material can be brought to mind through songs, without requiring any instrumental expertise. It has even been shown that musicians subvocalize when performing a notation-reading auditory imagery task (Brodsky et al. 2008), suggesting reliance on an imagined sung version of a melody (although it must be noted that neuroimaging studies to date have not revealed activation of the primary motor cortex during auditory imagery) (see Zatorre and Halpern 2005).

Another point of interest regarding the Kodály approach is that it specifically aims to develop the ability to hear, or imagine, more than one melodic line at the same time, an ability that has recently been shown to be particularly developed in musical conductors (Wöllner and Halpern 2016). While the extent to which such a skill involves actual divided attention, versus rapid switching between parts, is still debated (Alzahabi and Becker 2013), it is nevertheless clear that this ability can be trained and developed to a high level of skill. Indeed, at an advanced level, such as an undergraduate “harmony and counterpoint” or “stylistic composition” exam, a music student might be asked to write a fugue in the style of Bach and a song in the style of Schubert while sitting at a desk in an exam hall, thus relying on auditory imagery of several melodic lines and/or harmonic progressions, as well as expert musical knowledge, in order to complete the task.

A final aspect of the Kodály approach that is rarely discussed but important to note, is the fact that it involves group musical learning, almost always taking place in the school or university classroom. The "inner hearing" activities thus involve what we (p. 400) might describe as group auditory imagery, or "shared auditory imagery," which can bring a highly focused sense of shared attention when used effectively, as well as allowing more generally for the potential benefits of group learning and social music-making (Heyes 2013; Kirschner and Tomasello 2010; Overy and Molnar-Szakacs 2009; Overy 2012). The idea of "shared auditory imagery" is not well documented and perhaps warrants future research.

A second major music education figure of the twentieth century, Edward Gordon, based in the United States, focused his own music education approach much more specifically on auditory imagery, or what he calls "audiation." Gordon proposes that only by understanding where a young child's current audiation skills lie, can the child be taught appropriately, and much of Gordon's work focuses on an interest in the variability of this skill in the general population and how to measure it appropriately (1987). Importantly, Gordon extends the meaning of the word "audiation" from auditory imagery alone to include the process of listening to music with some cognition of its structure, rather than just sensory perception, arguing that "audiation" is part of intelligent music listening. The Gordon measures of music audiation (e.g., Gordon 1979, 1982) have become some of the most commonly used measures of musical ability in children and are often also used in psychology and brain imaging research (e.g., Ellis et al. 2012). Examples of the kinds of tasks used are the melody and rhythm discrimination tests, in which two melodies or rhythms are heard and the child or adult's task is to determine whether they are the same or different, a task commonly found in tests of musical ability (e.g., Bentley 1966; Wing 1970; Overy et al. 2003; 2005). Gordon assumes that, in order to perform this comparison task, a child must be able to hold the initial melody in mind for a short period of time, that is, to "audiate" the short extract. This measure thus links directly with the idea that working memory rehearsal requires mental imagery, as outlined earlier (Baddeley and Logie 1992).

Voluntary auditory imagery is central to the Gordon concept of musical ability and is regarded as an important aspect of musicianship and an effective learning tool in the Kodály approach. On further analysis, there are also some interesting key elements in common between the two approaches. For example, both approaches: (1) use physical movement gestures in the teaching of "inner hearing" or "audiation;" (2) place strong emphasis on what Gordon calls "notational audiation" and what Kodály calls "musical literacy," that is, the ability to read a musical score and hear the music in one's head; and (3) place a strong emphasis of the importance of teacher-training programs in these skills. A detailed comparative analysis of the two approaches would no doubt generate some clear focus points for future research in this area, and perhaps lead to a richer understanding of how auditory imagery can be used, adapted, and developed in a range of different musical and pedagogical contexts.

Rehearsal Strategies for Instrumental Performance

An entirely different area of musical training in which a highly worked out methodology for voluntary auditory imagery has been explicitly developed is professional (p. 401) instrumental performance, or more specifically, the memorization of musical material for piano performance. The amount of repertoire that a professional pianist needs to be able to play accurately by memory (going back to Franz Liszt, who is reported to have started the showmanship of performing whole piano recitals without the score, see Hamilton 2008) is vast, involving hours of often highly technically demanding music, which must be perfectly executed. Such performances require an extraordinary feat of memory and can sometimes lead to extreme performance anxiety and subsequent medication (e.g., James and Savage 1984). In addition, the motivation to overlearn the material and reduce memory slips in performance can lead to the risk of overpractice, leading to physical strain and personal injury (e.g., Rosety-Rodriguez et al. 2003). The use of voluntary auditory imagery or what is more usually referred to as "mental rehearsal" or "mental practice" to prepare for such concerts is commonly recommended, and has been shown empirically to be effective (e.g., Bernardi et al. 2013) but is rarely specifically trained, even at conservatory level (Clark and Williamon 2011).

One method developed to help prepare expert pianists for performance is that of Nelly Ben-Or, a concert pianist based in London and professor of the Alexander Technique at the Guildhall School of Music. Ben-Or combines concepts from the Alexander Technique, in which body imagery strategies are applied during preparation for action (McEvenue 2002), with auditory, visual, and motor imagery strategies, developing what she calls "techniques of mental representation." Using these multimodal techniques of mental representation, an entire musical piece (or large section, depending on the scale of the piece) is imagined and memorized away from the piano, *prior* to physical rehearsal. Regular piano practice thus becomes a mix of mental imagery rehearsal and physical rehearsal, with the aim that physical rehearsal only takes place once imagined recall is fluent, thus limiting the possibility that any physical or technical performance constraints will impose restraints on what is imagined and ultimately performed and ideally allowing for more musical expression and flexibility.

In an observational, ethnographic study of eleven pianists training in Nelly Ben Or's method, Davidson-Kelly and colleagues (Davidson-Kelly 2014; Davidson-Kelly et al. 2015) described the process as acquiring "total inner memory" prior to performance and noted that the ability to understand a musical score is crucial to the success of the approach, requiring adequate theoretical knowledge as well as aural and technical skills. This relates back to the idea of mental imagery requiring strong schematic and prior knowledge, as mentioned previously (e.g., Neisser 1976; Hubbard 2010). In addition, the method assumes a level of skill in which the performer is not overly hampered by technical difficulties—if a piece requires rapid finger movements or large leaps, these are assumed to be mostly within the technical capabilities of the performer. Interviews with pianists training with Nelly Ben-Or revealed that the method was perceived by most participants to be effortful and challenging, but extremely effective at increasing awareness of the nuances of a piece and consolidating memory: "[I]t is really difficult to change 17 years habit," "It requires enormous … time, effort and concentration," "I am more secure and have less memory mistakes [sic]," "These pieces stay in my head and I can refresh my memory very quickly. They are very reliable" (Davidson-Kelly et al. 2015).

(p. 402) In summary, voluntary auditory imagery is already used regularly and effectively in a variety of music pedagogy, performance, and composition practice contexts. Nevertheless, it has not yet been widely demonstrated or studied empirically in these real-world contexts. Further investigation of the nature, extent, and boundaries of this skill and how to train it most effectively, may prove beneficial to understanding auditory imagery in general and may also elucidate the potential benefits to professional musicians and their rehearsal, memorization, and performance techniques.

Conclusions

Auditory imagery is an ability that most people can access and control, with a fair amount of precision and with fidelity to actual perceived sounds. Such imagery can be used for entertainment and emotional self-regulation (such as imagining calming songs if one is in a stressful situation). But we wish to emphasize another aspect of this experience: what seems at times to be an effortless ability in fact can require a fair amount of cognitive resources, including working and long-term memory. For both musicians and nonmusicians, the successful re-evoking of music often reflects the fact that the material has been encountered multiple times and reflects a detailed knowledge of the piece (particularly in Ben-Or's approach). Thus, we could view voluntary auditory imagery in music learning as a tool that takes some effort to use, but results in superior technical and expressive skills, or a "desirable difficulty." The fact that brain activation during auditory imagery shows areas in common with auditory perception but also unique activation of higher-order areas involved in memory and executive function, supports this idea of imagery being used as a tool to enhance learning.

Auditory imagery does not occur in a vacuum of course. Musicians can also use motor and kinesthetic imagery (Meister et al. 2004), as they imagine their hand and body movements during playing, and visual imagery when imagining a score, a piano keyboard, or a conductor's gestures from a prior rehearsal. Much research has pointed to the multimodality of imagery, both behaviorally and in terms of neural function (McNorgan 2012). The translation of a visual score into an auditory experience requires coordination across the two modalities, often via some representation of the motor system. Some of the pedagogy techniques described here exploit this interaction and could perhaps still be extended. For example, in the Kodály approach, preschool children are often asked to keep a sequence of learned motor actions going throughout an "action song" while imagining some melodic lines and singing the others. Similarly, Curwen hand-signs (Curwen 1854) are used in the Kodály approach with young children to represent pitch for both imagined and sung musical activities, before moving on to written notation and more advanced musical materials. This use of the motor system to represent sound while it is being imagined might be further exploited in more advanced ways, yet to be conceived and developed.

(p. 403) In this chapter, we have discussed the role of auditory imagery in primary music education as well as in professional musical situations. These methods explicitly recognize that individuals with different levels of ability and training might use imagery in different ways. For example, Ben-Or proposes using multimodal imagery or "total inner memory" (Davidson-Kelly et al. 2015) to memorize and mentally rehearse a piece, assuming that the piece is largely within the performer's current technical expertise. The Kodály approach extends from preschool to undergraduate levels of musicianship, entailing the wide range of beginner to expert levels of repertoire and musical skill therein. We assume that other approaches to music learning, such as imitative, oral transmission styles found in non-Western cultures and nonnotated musical genres such as pop and folk, may also use features of voluntary auditory imagery in a variety of different ways.

We would also like to recognize here that adults older (even!) than undergraduates often have an interest in beginning or furthering their musical experiences or training. Some of the training methods referred to in this chapter could easily be adapted so that the training was appropriate for middle-aged or senior adults, for example by using generation-appropriate songs and physical activities. For adults with more seriously limited mobility, such adapted techniques might even be helpful for motor rehabilitation, for example in cases of stroke survival or Parkinson's disease, where musical imagery of a steady beat, for example, has been proposed as potentially helpful in the rehabilitation of motor skills (Schaefer 2014).

Of course, we should also emphasize that auditory imagery in music pedagogy is not always focused on (eventual) proficiency in singing, playing a musical instrument or reading music notation. We mentioned the value of social music-making earlier on, and fully recognize that many adults who are not necessarily formally trained in music nevertheless enjoy singing together in a group. However, many of these individuals are not satisfied with their vocal abilities and wish they could improve. Some adults do not sing at all, but wish they could improve their skills in order to enjoy both the artistic and social benefits of music-making such as choral singing (Clift and Hancox 2010). Research in progress with colleagues at a UK music conservatory is currently investigating a new way to teach adults who do not sing much, or well, to sing more confidently and more accurately. Given the strong relationship between auditory imagery vividness and pitch matching ability, and the importance of musical imagery skills in many pedagogical approaches, one aspect of the research will be to create an intervention to train and improve auditory imagery skills. The study will include a version of the mental pitch comparison task mentioned earlier (Zatorre and Halpern 1993), where difficulty is gradually increased by probing pitches that are increasingly distant from each other within the song. Developed as an enjoyable app that can be accessed at home, the study will track whether (1) it is possible to measure the improvement of auditory imagery skills and (2) whether that improvement correlates with improved pitch matching and vocal quality. Such improved skills may also lead to new possibilities in the areas of improvising and composing for these adult learners.

(p. 404) We close with the thought that auditory imagery tasks are both inexpensive (one only has to imagine sounds!) and can be fun, such as asking people to imagine and play with famous tunes in their heads (we will leave you with an auditory image of the beautiful song “Danny Boy” and ask you to enjoy and spend too long on the highest note). Auditory imagery tasks can be developed for individuals with a wide range of musical backgrounds and performance goals and can thus serve to enhance the traditional tools of music educators.

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