# 13 Musical Imagery

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Humans have a seemingly innate and universal capacity to engage with music (Fitch, 2015; McDermott and Hauser, 2005), which is underpinned by the emotional rewards (Blood and Zatorre, 2001; Koelsch, 2014), social benefits (Dunbar, 2012; Hallam, 2010), and cognitive stimulation (Chamorro-Premuzic and Furnham, 2007; Hyde et al., 2009) afforded by music. In addition to the vast quantities of time we often spend listening to music (North, Hargreaves, and Hargreaves, 2004; Sloboda, O'Neill, and Ivaldi, 2001), music is also a regular feature of our inner mental worlds. Having a tune "stuck" in one's head is a common everyday phenomenon, while it is also quite easy for most people to intentionally bring a piece of music to mind (e.g. "think of the first phrase of the song 'Happy Birthday'"). In addition, musicians regularly rely on more specialist usages of musical imagery, from mentally running through a piece during a practice session to anticipating the upcoming notes during the course of a performance. This chapter begins with an overview of the general features of musical imagery, before describing research on musical imagery in everyday life and outlining the ways in which imagery is used to facilitate aspects of musical performance. The concluding section offers some suggestions for bringing together several disparate aspects of previous research on this topic. Although the range of human experiences of musical imagery is quite diverse – from the simple replaying of a tune in a listener's head after hearing it on the radio to a composer conjuring up the next notes of a new symphony – it appears such experiences rely on similar underlying mechanisms that can be refined for expert purposes through practice.

## Features of Musical Imagery

Musical imagery comprises the mental experience of music, which can be instigated even in the absence of a direct sensory experience (Intons-Peterson, 1992). Musical imagery has sometimes been classified as a type of auditory imagery; however, it is now clear that musical imagery also often comprises components of motor and visual imagery (Keller, 2012; Reybrouck, 2001). Many early studies on musical imagery focused on testing the extent to which particular perceptual properties of music (e.g. pitch, tempo, timbre, loudness) could be mentally represented, while some work has also investigated higher-level features (e.g. perceived emotions). One main challenge across this literature has been in creating behavioral



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paradigms that ensure the generation of a musical image (i.e. that the task at hand cannot be achieved using another, non-imagery-based strategy). This is an obstacle that will be familiar to researchers of any aspect of imagery or imagination, due to the fact that it can be difficult to confirm the intangible and ephemeral contents of the imagination, which may not be accompanied by overt behaviors. This issue has been dealt with in various ways; for instance, many studies have focused on investigating similarities between music perception and musical imagery, with the underlying assumption that similar behavioral responses across perception and imagery tasks indicate that the imagery task is evoking the generation of a mental image that is similar to a perceptual experience. In addition, the use of cognitive neuroscience methods has allowed for the confirmation that similar neural resources are being recruited during both music perception and imagery tasks.

## Pitch

Early psychophysical research focused on imagery for single pitches, and demonstrated that imagining a pitch could either facilitate or interfere with subsequent detection of the same pitch played aloud, depending on the exact parameters of the task (Farah and Smith, 1983; Okada and Matsuoka, 1992). Janata and Paroo (2006) examined the acuity of pitch imagery in a more musical context, in which participants judged the intonation of the final note of an ascending major scale. Comparisons between a perceived (in which all pitches of the scale were heard) and imagined pitch task (in which three to five pitches of the scale were imagined) indicated equivalent performance on these tasks. Interestingly, performance on an analogous timing task (where the timing of the final note of the scale was judged) revealed that participants performed better on the perception than the imagery task, suggesting that temporal aspects of musical imagery may be more susceptible to distortion than the pitch content. Similar results, in which performance on pitch-related musical imagery tasks was superior to timing-related tasks, have been reported by Bailes (2002) and Weir, Williamson, and Müllensiefen (2015). In addition, participants with more musical training performed more accurately in several of the imagery tasks (pitch and timing tasks of Janata and Paroo, 2006; pitch task of Weir, Williamson, and Müllensiefen, 2015), suggesting these abilities can be refined with practice.

Halpern (1989) investigated the consistency of pitch imagery by asking participants to imagine and then produce (via singing, or a piano keyboard with the keys obstructed from view) the starting pitch to traditional songs such as "Twinkle, Twinkle Little Star" and found that the absolute pitch level of an individual's musical imagery for a specific song was quite stable over time. Pitch productions were also quite stable across sessions separated by forty-eight hours, although more so for musicians than nonmusicians. Finally, Gelding, Thompson, and Johnson (2015) have investigated the manipulation of pitch imagery using a novel paradigm called the Pitch Imagery Arrow Task (PIAT). This task requires participants to imagine a sequences of tones (following an initial presentation of the tonal context and pitch sequence played aloud) in correspondence with a series of upward and downward arrows presented on a screen. It was found that performance on this task substantially improved when participants employed an imagery-based strategy (confirming the task's validity), and was also positively related to musical training and self-reported auditory imagery vividness and control (measured using the Bucknell Auditory Imagery Scale; Halpern, 2015).

## Tempo

Several studies have investigated the similarity between perceived and imagined musical tempo. Weber and Brown (1986) asked participants to track the contour of melodies as quickly as possible by tracing the ups and downs of each melody with a pencil; this was done both while singing each melody out loud (perception task) and while imagining each melody (imagery task). No significant difference was found in the amount of time taken to complete these two tasks, suggesting that participants were utilizing a common mental representation. Halpern (1988) compared perceived and imagined[1] tempo judgments for familiar songs, such as "Happy Birthday," and found a high correlation ($r = .63$) across all trials between perceived and imagined tempi for the same song.

Research on accuracy of tempo recall has revealed that the tempi of familiar pop songs (e.g. "Hotel California") were recalled more accurately in a perceived music condition than in two musical imagery tasks involving (1) tapping to the imagined beat and (2) adjusting a metronome to the imagined beat (Jakubowski, Farrugia, and Stewart, 2016). Tempo recall was also more accurate in the imagery task involving tapping to the beat than the imagery task involving adjusting a metronome, suggesting that motor engagement with imagery may increase the temporal fidelity of the mental image. This work extends the findings of Janata and Paroo (2006), Bailes (2002), and Weir, Williamson, and Müllensiefen (2015) noted in the previous section by revealing a disparity between perception and imagery in terms of *accuracy* of tempo recall, which is also partially influenced by the task via which imagined tempo is measured.

Finally, consistency of imagined tempo has been investigated by Clynes and Walker (1982), who asked musicians to imagine and tap along to a Mozart piano concerto on two consecutive days. Tapping speed when imagining this music was significantly more consistent than tapping to a verbally imagined phrase or tapping without any mental image. In a similar study, participants tapped to imagined versions of the same song across multiple trials within the same session and different sessions separated by two to five days (Halpern, 1992). Both musician and nonmusician participants were highly consistent in their tapped tempo for the same song within the same session, whereas musicians showed greater consistency across sessions on different days than nonmusicians.

## Timbre

Timbre, sometimes described as "sound quality," is a multidimensional, perceptual parameter of sound that is affected by acoustic features such as attack rate, spectral

1 Imagined tempo was measured by asking participants to set a metronome to match the beat of the imagined music.

centroid, and spectral variation (McAdams et al., 1995). Crowder (1989) highlighted the similarity between perceived and imagined musical timbre by showing that imagining a tone in a particular instrumental timbre (e.g. trumpet) can facilitate a pitch judgment of a subsequent perceived tone if the imagined and perceived tones are matching in timbre.[2] Pitt and Crowder (1992) built on this work using a more controlled stimulus set that varied timbre in either spectral (i.e. harmonic content) or dynamic (i.e. attack rate) properties only. Results suggested that spectral features were represented within imagery, but no evidence was found that participants were able to mentally represent the different attack rates used in this study. Halpern et al. (2004) found that participants performed similarly in a task in which they were asked to rate the similarity between pairs of perceived timbres and an analogous task of rating pairs of imagined timbres, while also displaying some commonalities in brain activation patterns between the perceived and imagined timbre tasks. Finally, Bailes (2007a) provided further evidence that timbre can be represented within musical imagery, but also revealed that participants did not always report timbre to be a conscious dimension of their imagery, suggesting that timbre is "optionally present in imagery for music" (Bailes, 2007a: 21).

### Loudness

Evidence for the similarity between perceived and imagined loudness was revealed by Intons-Peterson (1980), who asked participants to imagine environmental sounds and found that as the difference between loudness ratings of the two imagined sounds increased, the time taken to identify the louder (or softer) of the two sounds decreased. Similar to results on timbre, however, Intons-Peterson also concluded that loudness is optionally represented within auditory imagery. The investigation of imagined loudness in a more musical context has been pursued by Bishop, Bailes, and Dean (2013a). In this study, participants listened to familiar classical music while continuously adjusting a slider to indicate perceived loudness; all participants also completed an analogous task of imagining and indicating the imagined loudness for the same music. Similarities between rating profiles in the perceived and imagined tasks suggest that the ability to represent loudness within musical imagery is widespread, although musical expertise did increase the fidelity with which loudness was represented in imagery. Bailes et al. (2012) have also provided evidence that imagined loudness within musical sequences relies on a motor representation, as imagined changes in loudness were significantly disrupted when participants were asked to concurrently remember movement sequences, but not when they were asked to remember tone or letter sequences.

### Expressive Features

In addition to the lower-level perceptual features outlined above, some work has also investigated the similarity of emotion perception between perceived and imagined

2 Such a facilitation effect was also shown in a purely perceptual task in a separate experiment.

music (Lucas, Schubert, and Halpern, 2010). In this study, musician participants continuously rated the emotions expressed by familiar classical music (in terms of valence and arousal, and general "emotionality" in a second experiment) in both perceived and imagined conditions. Similar response profiles were found across the perception and imagery tasks. This ability to detect emotional expression in imagined music is likely underpinned by the mental representation of lower-level features such as tempo and loudness as outlined above, as a variety of previous research on perceived music has shown that such features play a key role in influencing judgments of emotional expression (e.g, Eerola, Friberg, and Bresin, 2013; Gabrielsson and Lindström, 2010).

## The Neuroscience of Musical Imagery

Neuroscientific research using functional Magnetic Resonance Imaging (fMRI) has revealed several parallels, as well as some inherent differences, between the brain regions recruited in perceiving and imagining music (see Zatorre and Halpern, 2005, for an overview). Similar activation patterns of the secondary auditory cortex have been found in both music perception and imagery (Kleber et al., 2007; Kraemer et al., 2005; Zatorre and Halpern, 2005). Primary auditory cortex activation has been found during musical imagery only under certain conditions, such as when participants imagined familiar songs with no lyrics (Kraemer et al., 2005), despite the key role this area plays in music perception. Bilateral frontal cortical activations found during musical imagery tasks may relate to the memory retrieval component inherent in imagery (Herholz, Halpern, and Zatorre, 2012; Zatorre, Halpern, and Bouffard, 2010; Zatorre et al., 1996), while activation of the supplementary motor area (SMA) (Halpern et al., 2004; Herholz, Halpern, and Zatorre, 2012; Zatorre et al., 1996) indicates the potential involvement of a motor or sequencing component, which may be related to the rehearsal or maintenance of the image within working memory. Electroencephalography (EEG) studies have also confirmed the presence of similar activation patterns in musical imagery and perception, even across musical stimuli of varying complexity (Schaefer, Desain, and Farquhar, 2013), which may also be modulated by expertise (Herholz et al., 2008).

## Summary

A variety of perceptual properties of music (e.g. pitch, tempo, timbre, loudness) can be represented within imagery, although not all features are necessarily present in all musical imagery experiences. It appears the representation of musical features within imagery can be refined with practice, as musicians' imagery experiences more closely replicated the perceptual experience of music than less musically trained participants in several studies. It is also clear that musical imagery is a multifaceted experience that not only involves auditory imagery but can also invoke aspects of motor representation; this point will be discussed further in section 3: Imagery Uses in Musicians in relation to how musicians use imagery to facilitate action planning in performance.

## Everyday Experiences of Musical Imagery

Beyond the laboratory-based studies described in the previous section, a complementary body of literature has examined the experience of musical imagery in natural, everyday settings (e.g. Bailes, 2006, 2007b, 2015; Beaman and Williams, 2010; Beaty et al., 2013; Floridou and Müllensiefen, 2015; Halpern and Bartlett, 2011; Jakubowski et al., 2018; Jakubowski et al., 2015). This research has highlighted that imagining music is a common everyday occurrence for many people. For instance, Bailes (2015) contacted forty-seven participants (from a range of musical backgrounds) six times per day for one week and found that participants were hearing music 35 percent of the time and imagining music 17 percent of the time.[3] Perhaps the most widely recognized everyday manifestation of musical imagery is the *earworm* – the spontaneous mental recall and repetition of a tune on a loop. This phenomenon has been referred to by various terms in the literature – most commonly as *involuntary musical imagery (INMI)* – although there is some debate over whether this term is too broad (Williams, 2015), as *involuntary musical imagery* could also plausibly be used to describe other experiences such as musical obsessions (Taylor et al., 2014) and musical hallucinations (Stewart et al., 2006). Thus, the term *earworm* will be used here to describe the everyday (nonclinical) experience of having a tune come to mind and "play" on repeat, in which both the initial recall and the replay of the tune are involuntary processes. In one survey of more than 12,000 participants, around 90 percent reported experiencing earworms at least once per week, with around 33 percent reporting earworms at least once per day (Liikkanen, 2012a). Reports of earworms have also been collected from many countries through the world (Liikkanen, Jakubowski, and Toivanen, 2015).

Most studies of everyday musical imagery have focused specifically on the earworm phenomenon, although a few diary studies have explored musical imagery more broadly, including instances of both spontaneous and deliberate imagery (e.g. Bailes, 2006, 2007b, 2015; Beaty et al., 2013; Cotter, Christensen, and Silvia, 2018), while only a handful of studies have made more explicit comparisons between voluntary and involuntary musical imagery processes (Jakubowski et al., 2018; Weir et al., 2015). Thus, the majority of the following section will focus on the earworm experience, concluding with some discussion of the relationship between involuntary and voluntary musical imagery.

### Methods for Investigating Everyday Musical Imagery

Several studies have examined musical imagery experiences using participant-led diary methods, in which participants are responsible for recording all musical imagery experiences over a certain time period in a paper or electronic diary, or the Experience Sampling Method (ESM), in which participants record information

3 Interestingly, an earlier study (Bailes, 2006) of 11 musicians using the same methodology revealed that participants were hearing music 44 percent of the time and imagining music 32 percent of the time, suggesting that musicians not only listen more but also imagine more music than participants with less musical experience.

about their musical imagery experiences when prompted by an experimenter (e.g. via experimenter prompts sent to their mobile phones throughout the day). These *in situ* methods are beneficial for capturing the transient experience of musical imagery as it is actually occurring, which can minimize memory biases and forgetting that might otherwise occur in retrospective reporting. However, retrospective methods have also proved useful in various contexts. For instance, the Involuntary Musical Imagery Scale (IMIS; Floridou et al., 2015) is a questionnaire developed for measuring multiple facets of earworms (e.g. frequency, length, appraisal, embodied responses), which has been used to reveal differences in brain structure related to the earworm experience (Farrugia et al., 2015) and has also been shown to correlate with some responses collected via ESM, at least in terms of estimations of earworm frequency, duration and appraisal (Cotter and Silvia, 2017). Efforts to investigate causal predictors of earworms under controlled conditions have also led to the development of experimental paradigms for inducing earworms (Floridou, Williamson, and Stewart, 2017; Hyman et al., 2013; Liikkanen, 2012b). The triangulation of results across these diverse methodologies has allowed researchers to begin to develop a comprehensive picture of the features and phenomenology, situational predictors, individual differences, and affective responses to earworms.

## Features and Phenomenology of Earworms

Earworms most commonly comprise the repetition of a fragment/phrase of music, rather than an entire piece (Brown, 2006; Hyman et al., 2013; Liikkanen, 2012a). In two diary studies, the average reported durations of earworm episodes were 27.25 minutes (Beaman and Williams, 2010) and 36 minutes (Halpern and Bartlett, 2011), although the range of durations can vary widely (e.g. 2 minutes to an entire day, Halpern and Bartlett, 2011).[4] The music that appears as an earworm is typically familiar and liked by the experiencer (Byron and Fowles, 2015; Halpern and Bartlett, 2011; Hyman et al., 2013), which relates to the fact that most earworms are triggered by recent music listening (Williamson et al., 2012). Reports of earworms for entirely novel music are rare, and more typically reported by musicians (Floridou, 2016; Liikkanen, 2012a). It appears music from virtually any genre can become an earworm (Beaman and Williams, 2010; Halpern and Bartlett, 2011; see in particular Lancashire, 2017, in which earworms were experienced for atonal twentieth-century classical music). In many cases earworm experiences are quite idiosyncratic, as the vast majority of songs reported as earworms in previous studies were named by only one participant (e.g. Beaman and Williams, 2010; Jakubowski et al., 2017). However, despite this diversity, some common melodic features of tunes that are likely to be named as earworms have been revealed, including faster tempi, more generic melodic contours and small pitch intervals (Jakubowski et al., 2017; Williamson and Müllensiefen, 2012). It has been suggested that such features facilitate the ability

4 One challenge of attempting to measure earworm duration lies in defining an objective start and end point, as earworms often tend to fade in and out of consciousness.

to sing along to the music (Williamson and Müllensiefen, 2012), which might also facilitate "mental singing" of a tune as an earworm.

In a similar vein to previous laboratory studies on voluntarily generated musical imagery, several studies have offered evidence that *involuntary* musical imagery preserves many features of perceived music. Brown (2006) reported a detailed case study of his own near-constant musical imagery and highlighted that the pitch, loudness, rhythm, tempo and timbre of his imagery often closely replicated the original, perceptual version of the music. Similar qualitative evidence on this topic was provided in an interview study by Williamson and Jilka (2013). In a first attempt to provide objective evidence of the fidelity of earworms, Jakubowski et al. (2015) asked participants to tap to the beat of their earworms during their daily lives using a wrist-worn accelerometer. Most earworms were remembered within 10 percent of the tempo of the original recording of the musical piece, suggesting involuntary recall of musical tempo is typically quite accurate. Further evidence for the fidelity of both the pitch and tempo of earworms was provided by McNally-Gagnon (2016), who asked participants to sing their earworms into a recording device.

Various studies have focused on individual differences and revealed that several demographic and personality variables are positively related to the propensity to experience earworms, including musicianship/musical engagement,[5] openness to experience, neuroticism, transliminality and subclinical obsessive-compulsive traits (Baruss and Wammes, 2009; Beaman and Williams, 2013; Floridou, Williamson, and Müllensiefen, 2012; Liikkanen, 2012a; Müllensiefen et al., 2014). In addition, several such factors (neuroticism, obsessive-compulsive traits, thought suppression, schizotypy) can also explain individual differences in the appraisal of the earworm experience, in particular finding it bothersome or disruptive (Beaman and Williams, 2013; Floridou, Williamson, and Müllensiefen, 2012; Müllensiefen et al., 2014).

## Situational Predictors of Earworms

The most commonly reported trigger of earworms in a large survey was recent and/or repeated exposure to music, although earworms can also be cued by other means, such as memory associations (e.g. seeing a word that reminds one of a piece of music) or affective states (e.g. association between one's current mood and the earworm music) (Williamson et al., 2012). In terms of the situations in which earworms are most likely to occur, Hyman et al. (2013) used multiple methods (survey, diary, experiment) to conclude that earworms occur more often during periods of low cognitive load (e.g. daily chores, walking) and high cognitive load (more earworms were experienced during challenging Sudoku puzzles and anagrams than easier puzzles). However, Floridou, Williamson, and Stewart (2017) examined the occurrence of earworms under conditions of varying cognitive load and found that earworm frequency and duration decreased as cognitive load increased; they

5 In some studies, active engagement with music (e.g. listening behavior and singing) has been shown to be a more significant predictor of earworm experiences than formal training/practice on an instrument (Müllensiefen et al., 2014; Williamson and Müllensiefen, 2012).

suggest that Hyman et al. (2013)'s findings may have been due to participants losing focus while attempting to solve the difficult puzzles, thereby inadvertently causing such tasks to also become low cognitive load tasks. This result shows parallels to other types of spontaneous cognition and task-unrelated thoughts, which also occur more frequently during conditions of low cognitive load, when there is greater cognitive capacity to spare (e.g. Forster and Lavie, 2009; Teasdale et al., 1995). There also appears to be a link between the earworm experience and physical movement: Participants often report that the beat/rhythm of earworms matches their movements (Floridou et al., 2015), 25 percent of earworms reported in a diary study occurred during repetitive movements (Jakubowski et al., 2015), and participants in one experiment were more likely to experience earworms for a song that they had moved or sung along to (McCullough Campbell and Margulis, 2015). Thus, the initiation and/or maintenance of involuntary instances of musical imagery may also draw on the close coupling between the auditory and motor systems.

## Emotional Responses to Earworms

In one diary study, 67 percent of earworm episodes were rated as pleasant or neutral in valence (Beaman and Williams, 2010), while 89 percent of respondents to a questionnaire rated their earworms as typically pleasant or neutral (Halpern and Bartlett, 2011). These findings are in contrast to the commonly held conception that having an earworm is a negative or bothersome experience, which may be due to a recollection bias to more vividly recall episodes that are particularly troublesome (Beaman and Williams, 2010). Hyman et al. (2015) investigated factors that might contribute to such feelings of intrusiveness and revealed disliking a song and interference with concurrent tasks as two key predictors. Finally, two studies have revealed that earworms (Jakubowski et al., 2015) and everyday musical imagery more broadly (Bailes, 2015) show a similar relationship with the experiencer's current mood to perceived music, suggesting that musical imagery could serve analogous mood regulatory functions to perceived music.

## Voluntary and Involuntary Musical Imagery

The research on earworms outlined above has evolved somewhat independently to that on voluntary musical imagery, which is partially due to the different methodologies employed (i.e. voluntary imagery is more suited to study under laboratory conditions than the ephemeral experience of earworms). However, several parallels have been revealed, including that both voluntary and involuntary occurrences of musical imagery tend to reproduce a perceptual experience with high fidelity, and that both types of imagery show links with sensorimotor processes, musical expertise and emotional responses. One study has compared voluntary and involuntary musical imagery for the same music within the same paradigm, and revealed that involuntary recall of music as an earworm is no less accurate than deliberate recall, at least in terms of musical tempo (Jakubowski et al., 2018). However, earworms had a more systematic effect on the mood of participants than voluntary imagery, suggesting that unplanned retrieval may heighten the emotional impact of imagined music.

## Imagery Uses in Musicians

Beyond the everyday experience of having a tune playing in one's mind, musicians exhibit several specialist usages of musical imagery. Strategies such as mental practice and *audiation* (Gordon, 1999, 2003), or mentally hearing and comprehending a piece of music, have long been taught and employed by expert musicians. Musicians also rely on imagery during the course of live performances and when composing new music. The diversity, functions, and efficacy of such imagery experiences are now beginning to be understood in a psychological context.

### Music Practice

Musicians rely on a variety of imagery-based strategies within their daily practice. *Mental practice* is a broadly defined and common technique used by musicians, which can also encompass non-imagery-based strategies, such as thinking about a piece or analyzing a score; however, the majority of activities typically described as mental practice fall under the category of imagery (Fine et al., 2015). This imagery is often multimodal in nature, as it may include auditory imagery for the notes to be played, as well as imagination of the movements needed to execute the notes, visual imagery of the score, audience, and performance venue, and so on. Such imagery may be used to aid in learning a piece (e.g. memorization of note sequences or motor commands) or preparing for a performance (e.g. visualization of the anticipated performance conditions). The practice of mentally simulating a performance situation has parallels to other domains requiring a high degree of cognitive and motor expertise, such as sports and surgery (Arora et al., 2011; Gould et al., 2014). One potential benefit of mental practice for musicians is being able to concentrate on aspects of the music without becoming physically tired, which is especially relevant for injury prevention (Holmes, 2005). In addition, qualitative reports from musicians indicate that imagery-based strategies can aid in many aspects of practice, from memorization and overcoming technical difficulties to gaining confidence and fluidity of movement, and connecting with an audience (Connolly and Williamon, 2004; Davidson-Kelly et al., 2015; Trusheim, 1991).

In terms of the efficacy of mental practice, there are mixed results in the literature. Most studies suggest that a combination of mental and physical practice can be as effective as physical practice alone, although mental practice alone is not as effective as physical practice (Coffman, 1990; Driskell, Copper, and Moran, 1994; Highben and Palmer, 2004; Ross, 1985). In a meta-analysis, Driskell, Copper, and Moran (1994) also reported that mental practice more substantially improved results on cognitive than physical tasks. One limitation of making generalizations in relation to efficacy is that the diversity of approaches to mental practice and range of previous experience in using mental practice techniques has often not been taken into account. Thus, future research is needed to more systematically probe the efficacy of specific facets of mental practice and how mental practice abilities develop over longer time periods.

## Music Performance

In performance, musicians frequently rely on mental imagery of upcoming notes or actions (often referred to as "anticipatory" or "online" musical imagery), which can be multimodal in nature (e.g. auditory, motor, visual) and can involve both deliberate (e.g. planning the sound of the next note) and involuntary (e.g. expectancies automatically triggered by previous perceptual input) imagery (Keller, 2012). Anticipatory musical imagery may facilitate performance by aiding action planning and enhancing predictions of co-performers' actions (Keller, 2012). For instance, Pecenka and Keller (2009) and Keller and Appel (2010) have reported a correlation between auditory imagery abilities and sensorimotor synchronization in musicians, suggesting a link between anticipation of a sound and being able to synchronize with it. Anticipatory auditory imagery generated during musical performances has also been found to facilitate the accurate timing of movements (Keller and Koch, 2006) and can aid in controlling the speed and force of movements (Keller, Dalla Bella, and Koch, 2010; Keller and Koch, 2008), thus helping to optimize the precision and efficiency of motor aspects of a performance. In addition, auditory imagery can aid the planning of expressive elements of a performance, such as articulation and dynamics (Bishop, Bailes, and Dean, 2013b). These close relationships between auditory imagery and motor planning are likely underpinned by the increased interactions between the auditory and motor systems that are evidenced with greater musical expertise (Bangert et al., 2006; Chen, Penhune, and Zatorre, 2008).

## Music Composition

One relatively under-researched area in relation to musical imagery usage is music composition. There are various historical reports indicating that famous composers have made extensive use of musical imagery when writing music (Agnew, 1922; Mountain, 2001). One commonly cited example is Ludwig van Beethoven, who composed many of what are now regarded as his greatest works (including Symphony No. 9) after having gone deaf,[6] suggesting an unusual ability to compose *entirely* using musical imagery. A mixture of deliberate and involuntary imagery processes appear to be implicated when composing, and such imagery can also be multimodal in nature (Aranosian, 1981; Mountain, 2001). Floridou (2016) interviewed six composers about the experience of "novel earworms" (i.e. earworms for music that has never been heard before, which may provide material for new

6 See also reports of musical hallucinations in cases of acquired deafness (e.g. Griffiths, 2000), which indicate the capacity for spontaneous (and persistent) musical imagery even in the absence of normal music perceptual functions.

compositions) and found these imagery experiences were more likely to occur during low attention states, periods of focus on inner experiences, and repetitive movements, which bears parallels to other research on earworms and the creative process more generally (e.g. Baird et al., 2012; Williamson et al., 2012). Future research could more closely investigate the balance between the use of strategic and involuntary musical imagery in both written composition and online improvisation (see Limb and Braun, 2008, for some neuroscientific evidence on the spontaneous, non-volitional cognitive processes underlying musical improvisation).

## Key Themes and Future Directions

The literature reviewed above highlights the diversity of experiences that fall under the categorization of "musical imagery." Although having a tune stuck in one's head and anticipating the next notes to be played in a piano recital may seem at first distantly related concepts, these processes rely on similar underlying mechanisms that can be refined for specialist purposes. There are several key themes that emerge across these different streams of research on musical imagery that contribute to our wider understanding of the imagination.

The first theme is **expertise**. It is clear that the capacity to experience vivid and veridical musical imagery is widespread, as even non-experts can mentally replicate the pitch, tempo, timbre, and loudness of familiar music and spend a surprisingly large proportion of their everyday lives engaged in musical imagery. However, many studies have revealed expertise effects, demonstrating that musicians exhibit a more diverse range of imagery experiences and are often able to produce mental images that more closely replicate a perceptual experience. This suggests that imaginative processes related to music can be developed and diversified through experience. Although imagery-related processes such as audiation have been stressed for many years as a fundamental skill by music educators (e.g. Gordon, 1999, 2003), there is still much more interdisciplinary cross-talk needed to understand the psychological processes underlying imagery use in expert musicians, in particular in terms of how such abilities can be most efficaciously developed through long-term training.

A second theme is the **fidelity** of musical imagery. A large amount of research has investigated the degree to which imagery experiences replicate aspects of the perceptual experience and has revealed that both voluntary and involuntary experiences of musical imagery often exhibit a high degree of fidelity. This precise mental replication ability can serve important functions, for instance, in facilitating performance by enabling musicians to form vivid and accurate predictions via anticipatory images before producing a sound (Keller, 2012). The fidelity of musical imagery may also play a role in creative processes, such as composition, by allowing a composer to mentally simulate and vividly imagine new combinations of sounds before committing them to paper. Being able to mentally recreate a wide variety of sounds and features of music (e.g. timbre, dynamics) may thereby enhance the creative process, providing a more diverse "palette" of sounds for the musical artist to work with.

A third key theme is **intentionality**. Most previous research has focused specifically on either voluntary *or* involuntary musical imagery, although it is clear that both everyday and expert usages of musical imagery typically comprise a mixture of both types of imagery. Although there are parallels between findings on voluntary and involuntary imagery, some differences have been highlighted as well (Jakubowski et al., 2018), suggesting that the two types of imagery could play somewhat different roles in our everyday lives. In addition, there is a dearth of research examining the different functions that voluntary vs. involuntary imagery might play in musical practice and performance. Other possible directions for future research include the examination of fluctuations between spontaneous and deliberate imagery, as well as how intentionality of imagery might relate to other concepts such as creativity. One difficulty here is that the boundary between deliberate and spontaneous recall is often blurry, and may require methodological advances beyond self-report measures to fully capture the range of experiences in terms of intentionality.

A final theme is the **multimodality** of musical imagery. Musical imagery presents an ideal case for studying the intersection of auditory, motor, and visual imagery. Of particular note are the close links that have been highlighted throughout this chapter between the auditory and motor systems. For instance, it is clear that aspects of auditory imagery are affected by, or can affect,[7] motor processes both in everyday instances of imagery (e.g. earworms) and in expert usages (e.g. music performances). Thus, musical imagery research provides a diverse range of contexts in which to explore questions of how imagery in one modality can affect overt behaviors in another modality.

To conclude, there are many questions yet to be investigated in terms of how musical imagery research can inform our understanding of the imagination. A few of these are highlighted below.

1. What is the function of musical imagery in everyday life?
   Although the purposes for which musicians use imagery in practice and performance are fairly well defined, a less well understood question is why many people, regardless of expertise, spend a large proportion of their daily lives imagining music. The cognitive and emotional role these mental soundtracks may play in our lives is only beginning to be understood.
2. What is the relationship between musical imagery and creativity?
   Potential sub-questions here include whether and how the development of musical imagery abilities can facilitate creativity, and what reconstructive and recombinant imagery processes are at play when creating new music (e.g. via composition or improvisation).
3. How can we best integrate psychological research on musical imagery and creative musical practice?

   As in any interdisciplinary undertaking, the definitions and goals outlined by researchers and practitioners of music may not always align. In particular, the typically slow and offline nature of psychological research and the instantaneous

7 In some cases a direction of causality has not yet been ascertained.

nature of music-making may be at odds in some cases. However, the questions of interest to musicians may facilitate the development of new methodological approaches and a more practical understanding of the nature of musical imagery in real-world performance contexts.

## References

Agnew, M. (1922). The Auditory Imagery of Great Composers. *Psychological Monographs*, *31*(1), 279.

Aranosian, C. M. (1981). Musical Creativity: The Stream of Consciousness in Composition, Improvisation, and Education. *Imagination, Cognition and Personality*, *1*(1), 67–88.

Arora, S., Aggarwal, R., Sirimanna, P., et al. (2011). Mental Practice Enhances Surgical Technical Skills: A Randomized Controlled Study. *Annals of Surgery*, *253*(2), 265–270.

Bailes, F. A. (2002). *Musical Imagery: Hearing and Imagining Music*. Sheffield, UK: University of Sheffield, PhD thesis.

(2006). The Use of Experience-Sampling Methods to Monitor Musical Imagery in everyday life. *Musicae Scientiae*, *10*, 173–190.

(2007a). Timbre as an Elusive Component of Imagery for Music. *Empirical Musicology Review*, *2*, 21–34.

(2007b). The Prevalence and Nature of Imagined Music in the Everyday Lives of Music Students. *Psychology of Music*, *35*, 555–570.

(2015). Music in Mind? An Experience Sampling Study of What and When, Towards an Understanding of Why. *Psychomusicology: Music, Mind and Brain*, *25*(1), 58–68.

Bailes, F., Bishop, L., Stevens, C. J., and Dean, R. T. (2012). Mental Imagery for Musical Changes in Loudness. *Frontiers in Psychology*, *3* (Dec).

Baird, B., Smallwood, J., Mrazek, M. D., et al. (2012). Inspired by Distraction: Mind-Wandering Facilitates Creative Incubation. *Psychological Science*, *23*, 1117–1122.

Bangert, M., Peschel, T., Schlaug, G., et al. (2006). Shared Networks for Auditory and Motor Processing in Professional Pianists: Evidence from fMRI Conjunction. *NeuroImage*, *30*(3), 917–926.

Baruss, I., and Wammes, M. (2009). Characteristics of Spontaneous Musical Imagery. *Journal Of Consciousness Studies*, *16*(1), 37–61.

Beaman, C. P., and Williams, T. I. (2010). Earworms (Stuck Song Syndrome): Towards a Natural History of Intrusive Thoughts. *British Journal of Psychology*, *101*, 637–653.

(2013). Individual Differences in Mental Control Predict Involuntary Musical Imagery. *Musicae Scientiae*, *17*, 398–409.

Beaty, R. E., Burgin, C. J., Nusbaum, E. C., et al. (2013). Music to the Inner Ears: Exploring Individual Differences in Musical Imagery. *Consciousness and Cognition*, *22*(4), 1163–1173.

Bishop, L., Bailes, F., and Dean, R. T. (2013a). Musical Expertise and the Ability to Imagine Loudness. *PLoS ONE*, *8*(2).

(2013b). Musical Imagery and the Planning of Dynamics and Articulation During Performance. *Music Perception: An Interdisciplinary Journal*, *31*(2), 97–117.

Blood, A. J., and Zatorre, R. J. (2001). Intensely Pleasurable Responses to Music Correlate with Activity in Brain Regions Implicated in Reward and Emotion. *Proceedings of the National Academy of Sciences*, *98*(20), 11818–11823.

Brown, S. (2006). The Perpetual Music Track: The Phenomenon of Constant Musical Imagery. *Journal of Consciousness Studies*, *13*(6), 43–62.

Byron, T. P., and Fowles, L. C. (2015). Repetition and Recency Increases Involuntary Musical Imagery of Previously Unfamiliar Songs. *Psychology of Music*, *43*(3), 375–389.

Chamorro-Premuzic, T., and Furnham, A. (2007). Personality and Music: Can Traits Explain How People Use Music in Everyday Life? *British Journal of Psychology*, *98*(2), 175–185.

Chen, J. L., Penhune, V. B., and Zatorre, R. J. (2008). Moving on Time: Brain Network for Auditory-Motor Synchronization Is Modulated by Rhythm Complexity and Musical Training. *Journal of Cognitive Neuroscience*, *20*(2), 226–239.

Clynes, M., and Walker, J. (1982). Neurobiologic Functions of Rhythm, Time, and Pulse in Music. In M. Clynes (ed.), *Music, Mind, and Brain: The Neuropsychology of Music*. New York: Plenum, 171–216.

Coffman, D. D. (1990). Effects of Mental Practice, Physical Practice, and Knowledge of Results on Piano Performance. *Journal of Research in Music Education*, *38*(3), 187.

Connolly, C., and Williamon, A. (2004). Mental Skills Training. In A. Williamon (ed.), *Music Excellence: Strategies and Techniques to Enhance Performance*. Oxford, UK: Oxford University Press, 221–242.

Cotter, K. N., Christensen, A. P., and Silvia, P. J. (2018). Understanding Inner Music: A Dimensional Approach to Musical Imagery. *Psychology of Aesthetics, Creativity, and the Arts*. dx.doi.org/10.1037/aca0000195.

Cotter, K. N., and Silvia, P. J. (2017). Measuring Mental Music: Comparing Retrospective and Experience Sampling Methods for Assessing Musical Imagery. *Psychology of Aesthetics, Creativity, and the Arts*, *11*(3), 335–343.

Crowder, R. G. (1989). Imagery for Musical Timbre. *Journal of Experimental Psychology: Human Perception and Performance*, *15*(3), 472.

Davidson-Kelly, K., Schaefer, R. S., Moran, N., and Overy, K. (2015). "Total Inner Memory": Deliberate Uses of Multimodal Musical Imagery During Performance Preparation. *Psychomusicology: Music, Mind, and Brain*, *25*(1), 83.

Driskell, J. E., Copper, C., and Moran, A. (1994). Does Mental Practice Enhance Performance? *Journal of Applied Psychology*, *79*(4), 481–492.

Dunbar, R. (2012). On the Evolutionary Function of Song and Dance. In N. Bannan (ed.), *Music, Language and Human Evolution*. Oxford, UK: Oxford University Press, 201–214.

Eerola, T., Friberg, A., and Bresin, R. (2013). Emotional Expression in Music: Contribution, Linearity, and Additivity of Primary Musical Cues. *Frontiers in Psychology*, *4*, 487.

Farah, M. J., and Smith, A. F. (1983). Perceptual Interference and Facilitation with Auditory Imagery. *Perception & Psychophysics*, *33*(5), 475–478.

Farrugia, N., Jakubowski, K., Cusack, R., and Stewart, L. (2015). Tunes Stuck in Your Brain: The Frequency and Affective Evaluation of Involuntary Musical Imagery Correlate with Cortical Structure. *Consciousness and Cognition*, *35*, 66–77.

Fine, P. A., Wise, K. J., Goldemberg, R., and Bravo, A. (2015). Performing Musicians' Understanding of the Terms "Mental Practice" and "Score Analysis". *Psychomusicology: Music, Mind, and Brain*, *25*(1), 69–82.

Fitch, W. T. (2015). Four Principles of Bio-Musicology. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *370*(1664), 20140091.

Floridou, G. A. (2016). *Investigating the Relationship between Involuntary Musical Imagery and Other Forms of Spontaneous Cognition*. London, UK: Goldsmiths, University of London, PhD thesis.

Floridou, G. A., and Müllensiefen, D. (2015). Environmental and Mental Conditions Predicting the Experience of Involuntary Musical Imagery: An Experience Sampling Method Study. *Consciousness and Cognition*, *33*, 472–486.

Floridou, G., Williamson, V. J., and Müllensiefen, D. (2012). Contracting Earworms: The Roles of Personality and Musicality. In E. Cambouropoulos, C. Tsougras, K. Mavromatis, and K. Pastiadis, (eds.), *Proceedings of ICMPC-ESCOM 12, Thessaloniki, Greece,* 302–310.

Floridou, G. A., Williamson, V. J., and Stewart, L. (2017). A Novel Indirect Method for Capturing Involuntary Musical Imagery under Varying Cognitive Load. *Quarterly Journal of Experimental Psychology*, *70*(11), 2189–2199.

Floridou, G. A., Williamson, V. J., Stewart, L., and Müllensiefen, D. (2015). The Involuntary Musical Imagery Scale (IMIS). *Psychomusicology: Music, Mind and Brain*, *25*(1), 28–36.

Forster, S., and Lavie, N. (2009). Harnessing the Wandering Mind: The Role of Perceptual Load. *Cognition*, *111*(3), 345–355.

Gabrielsson, A., and Lindström, E. (2010). The Role of Structure in the Musical Expression of Emotions. In P. N. Juslin and J. A. Sloboda (eds.), *Handbook of Music and Emotion: Theory, Research, and Applications*. Oxford, UK: Oxford University Press, 367–400.

Gelding, R. W., Thompson, W. F., and Johnson, B. W. (2015). The Pitch Imagery Arrow Task: Effects of Musical Training, Vividness, and Mental Control. *PLoS ONE*, *10*(3), e0121809.

Gordon, E. E. (1999). All About Audiation and Music Aptitudes. *Music Educators Journal*, *86*(2), 41–44.

(2003). *Learning Sequences in Music: Skill, Content, and Patterns*. Chicago, IL: GIA Publications.

Gould, D., Voelker, D. F., Damarjian, N., and Greenleaf, C. (2014). Imagery Training for Peak Performance. In J. L. van Raalte and B. W. Brewer (eds.), *Exploring Sport and Exercise Psychology*. 3rd edition. Washington, DC: American Psychological Association, 55–82.

Griffiths, T. D. (2000). Musical Hallucinosis in Acquired Deafness: Phenomenology and Brain Substrate. *Brain*, *123*(10), 2065–2076.

Hallam, S. (2010). The Power of Music: Its Impact on the Intellectual, Social and Personal Development of Children and Young People. *International Journal of Music Education*, *28*(3), 269–289.

Halpern, A. R. (1988). Perceived and Imagined Tempos of Familiar Songs. *Music Perception*, *6*(2), 193–202.

(1989). Memory for the Absolute Pitch of Familiar Songs. *Memory & Cognition*, *17*(5), 572–581.

(1992). Musical Aspects of Auditory Imagery. In D. Reisberg (ed.), *Auditory Imagery.* Hillsdale, NJ: Erlbaum, 1–27.

(2015). Differences in Auditory Imagery Self-Report Predict Neural and Behavioral Outcomes. *Psychomusicology: Music, Mind, and Brain*, *25*(1), 37–47.

Halpern, A. R., and Bartlett, J. C. (2011). The Persistence of Musical Memories: A Descriptive Study of Earworms. *Music Perception*, *28*(4), 425–432.

Halpern, A. R., Zatorre, R. J., Bouffard, M., and Johnson, J. A. (2004). Behavioral and Neural Correlates of Perceived and Imagined Musical Timbre. *Neuropsychologia*, *42*(9), 1281–1292.

Herholz, S. C., Halpern, A. R., and Zatorre, R. J. (2012). Neuronal Correlates of Perception, Imagery, and Memory for Familiar Tunes. *Journal of Cognitive Neuroscience*, *24* (6), 1382–1397.

Herholz, S. C., Lappe, C., Knief, A., and Pantev, C. (2008). Neural Basis of Music Imagery and the Effect of Musical Expertise. *The European Journal of Neuroscience*, *28*(11), 2352–2360.

Highben, Z., and Palmer, C. (2004). Effects of Auditory and Motor Mental Practice in Memorized Piano Performance. *Bulletin of the Council for Research in Music Education*, *159*, 58–65.

Holmes, P. (2005). Imagination in Practice: A Study of the Integrated Roles of Interpretation, Imagery and Technique in the Learning and Memorisation Processes of Two Experienced Solo Performers. *British Journal of Music Education*, *22*(3), 217–235.

Hyde, K. L., Lerch, J., Norton, A., et al. (2009). The Effects of Musical Training on Structural Brain Development: A Longitudinal Study. *Annals of the New York Academy of Sciences*, *1169*(1), 182–186.

Hyman, I. E., Burland, N. K., Duskin, H. M., et al. (2013). Going Gaga: Investigating, Creating, and Manipulating the Song Stuck in My Head. *Applied Cognitive Psychology*, *27*, 204–215.

Hyman, I. E., Cutshaw, K. I., Hall, C. M., et al. (2015). Involuntary to Intrusive : Using Involuntary Musical Imagery to Explore Individual Differences and the Nature of Intrusive Thoughts. *Psychomusicology: Music, Mind and Brain*, *25*(1), 14–27.

Intons-Peterson, M. J. (1980). The Role of Loudness in Auditory Imagery. *Memory & Cognition*, *8*(5), 385–393. dx.doi.org/10.3758/BF03211134.

(1992). Components of Auditory Imagery. In D. Reisberg (ed.), *Auditory Imagery*. Hillsdale, NJ: Lawrence Erlbaum Associates, 45–72.

Jakubowski, K., Bashir, Z., Farrugia, N., and Stewart, L. (2018). Involuntary and Voluntary Recall of Musical Memories: A Comparison of Temporal Accuracy and Emotional Responses. *Memory and Cognition*, *46*(5), 741–756.

Jakubowski, K., Farrugia, N., Halpern, A. R., Sankarpandi, S. K., and Stewart, L. (2015). The Speed of Our Mental Soundtracks: Tracking the Tempo of Involuntary Musical Imagery in Everyday Life. *Memory and Cognition*, *43*(8), 1229–1242.

Jakubowski, K., Farrugia, N., and Stewart, L. (2016). Probing Imagined Tempo for Music: Effects of Motor Engagement and Musical Experience. *Psychology of Music*, *44*(6), 1274–1288.

Jakubowski, K., Finkel, S., Stewart, L., and Müllensiefen, D. (2017). Dissecting an Earworm: Melodic Features and Song Popularity Predict Involuntary Musical Imagery. *Psychology of Aesthetics, Creativity, and the Arts*, *11*(2), 122–135.

Janata, P., and Paroo, K. (2006). Acuity of Auditory Images in Pitch and Time. *Perception & Psychophysics*, *68*(5), 829–844.

Keller, P. E. (2012). Mental Imagery in Music Performance: Underlying Mechanisms and Potential Benefits. *Annals of the New York Academy of Sciences*, *1252*, 206–213.

Keller, P. E., and Appel, M. (2010). Individual Differences, Auditory Imagery, and the Coordination of Body Movements and Sounds in Musical Ensembles. *Music Perception*, *28*(1), 27–46.

Keller, P. E., Dalla Bella, S., and Koch, I. (2010). Auditory Imagery Shapes Movement Timing and Kinematics: Evidence from a Musical Task. *Journal of Experimental Psychology: Human Perception and Performance*, *36*(2), 508–513.

Keller, P. E., and Koch, I. (2006). The Planning and Execution of Short Auditory Sequences. *Psychonomic Bulletin & Review*, *13*(4), 711–716.

(2008). Action Planning in Sequential Skills: Relations to Music Performance. *Quarterly Journal of Experimental Psychology*, *61*(2), 275–291.

Kleber, B., Birbaumer, N., Veit, R., Trevorrow, T., and Lotze, M. (2007). Overt and Imagined Singing of an Italian Aria. *NeuroImage*, *36*(3), 889–900.

Koelsch, S. (2014). Brain Correlates of Music-Evoked Emotions. *Nature Reviews Neuroscience*, *15*, 170–180.

Kraemer, D. J. M., Macrae, C. N., Green, A. E., and Kelley, W. M. (2005). Musical Imagery: Sound of Silence Activates Auditory Cortex. *Nature*, *434*(7030), 158.

Lancashire, R. (2017). An Experience-Sampling Study to Investigate the Role of Familiarity in Involuntary Musical Imagery Induction. In P. M. C. Harrison (ed.), *Proceedings of the 10th International Conference of Students of Systematic Musicology (SysMus17), London, UK*.

Liikkanen, L. A. (2012a). Musical Activities Predispose to Involuntary Musical Imagery. *Psychology of Music*, *40*, 236–256.

(2012b). Inducing Involuntary Musical Imagery: An Experimental Study. *Musicae Scientiae*, *16*(2), 217–234.

Liikkanen, L. A., Jakubowski, K., and Toivanen, J. M. (2015). Catching Earworms on Twitter: Using Big Data to Study Involuntary Musical Imagery. *Music Perception*, *33*(2), 199–216.

Limb, C. J., and Braun, A. R. (2008). Neural Substrates of Spontaneous Musical Performance: An fMRI Study of Jazz Improvisation. *PLoS one*, *3*(2), e1679.

Lucas, B. J., Schubert, E., and Halpern, A. R. (2010). Perception of Emotion in Sounded and Imagined Music. *Music Perception*, *27*(5), 399–412.

McAdams, S., Winsberg, S., Donnadieu, S., de Soete, G., and Krimphoff, J. (1995). Perceptual Scaling of Synthesized Musical Timbres: Common Dimensions, Specificities, and Latent Subject Classes. *Psychological Research*, *58*(3), 177–192.

McCullough Campbell, S., and Margulis, E. H. (2015). Catching an Earworm Through Movement. *Journal of New Music Research*, *44*(4), 347–358.

McDermott, J., and Hauser, M. (2005). The Origins of Music: Innateness, Uniqueness, and Evolution. *Music Perception*, *23*(1), 29–59.

McNally-Gagnon, A. (2016). *Imagerie musicale involontaire: caractéristiques phénoménologiques et mnésiques*. Montreal, Canada: University of Montreal, PhD thesis.

Mountain, R. (2001). Composers and Imagery: Myths and Realities. In R. I. Godøy and H. Jörgensen (eds.), *Musical Imagery*. New York, NY: Taylor & Francis, 271–288.

Müllensiefen, D., Jones, R., Jilka, S., Stewart, L., and Williamson, V. J. (2014). Individual Differences Predict Patterns in Spontaneous Involuntary Musical Imagery. *Music Perception*, *31*(4), 323–338.

North, A. C., Hargreaves, D. J., and Hargreaves, J. J. (2004). Uses of Music in Everyday Life. *Music Perception: An Interdisciplinary Journal*, *22*(1), 41–77.

Okada, H., and Matsuoka, K. (1992). Effects of Auditory Imagery on the Detection of a Pure Tone in White Noise: Experimental Evidence of the Auditory Perky Effect. *Perceptual and Motor Skills*, *74*(2), 443–448.

Pecenka, N., and Keller, P. E. (2009). Auditory Pitch Imagery and Its Relationship to Musical Synchronization. *Annals of the New York Academy of Sciences*, *1169*, 282–286.

Pitt, M. A., and Crowder, R. G. (1992). The Role of Spectral and Dynamic Cues in Imagery for Musical Timbre. *Journal of Experimental Psychology. Human Perception and Performance*, *18*(3), 728–738.

Reybrouck, M. (2001). Musical Imagery between Sensory Processing and Ideomotor Simulation. In R. I. Godøy and H. Jörgensen (eds.), *Musical imagery.* New York: Taylor & Francis, 117–136.

Ross, S. L. (1985). The Effectiveness of Mental Practice in Improving the Performance of College Trombonists. *Journal of Research in Music Education*, *33*(4), 221.

Schaefer, R. S., Desain, P., and Farquhar, J. (2013). Shared Processing of Perception and Imagery of Music in Decomposed EEG. *NeuroImage*, *70*, 317–326. dx.doi.org/10.1016/j.neuroimage.2012.12.064.

Sloboda, J. A., O'Neill, S. A., and Ivaldi, A. (2001). Functions of Music in Everyday Life: An Exploratory Study Using the Experience Sampling Method. *Musicae Scientiae*, *5* (1), 9–32.

Stewart, L., von Kriegstein, K., Warren, J. D., and Griffiths, T. D. (2006). Music and the Brain: Disorders of Musical Listening. *Brain*, *129*(10), 2533–2553.

Taylor, S., McKay, D., Miguel, E. C., et al. (2014). Musical Obsessions: A Comprehensive Review of Neglected Clinical Phenomena. *Journal of Anxiety Disorders*, *28*(6), 580–589.

Teasdale, J. D., Dritschel, B. H., Taylor, M. J., et al. (1995). Stimulus-Independent Thought Depends on Central Executive Resources. *Memory & Cognition*, *23* (5), 551–559.

Trusheim, W. H. (1991). Audiation and Mental Imagery: Implications for Artistic Performance. *Quarterly Journal of Music Teaching and Learning*, *2*, 138–147.

Weber, R. J., and Brown, S. (1986). Musical Imagery. *Music Perception*, *3*(4), 411–426.

Weir, G., Williamson, V. J., and Müllensiefen, D. (2015). Increased Involuntary Musical Mental Activity Is Not Associated with More Accurate Voluntary Musical Imagery. *Psychomusicology: Music, Mind, and Brain*, *25*(1), 48–57.

Williams, T. I. (2015). The Classification of Involuntary Musical Imagery: The Case for Earworms. *Psychomusicology: Music, Mind and Brain*, *25*(1), 5–13.

Williamson, V. J., and Jilka, S. R. (2013). Experiencing Earworms: An Interview Study of Involuntary Musical Imagery. *Psychology of Music*, *42* (5), 653–670.

Williamson, V. J., Jilka, S. R., Fry, J., et al. (2012). How Do Earworms Start? Classifying the Everyday Circumstances of Involuntary Musical Imagery. *Psychology of Music*, *40* (3), 259–284.

Williamson, V. J., and Müllensiefen, D. (2012). Earworms from Three Angles. In E. Cambouropoulos, C. Tsougras, K. Mavromatis, and K. Pastiadis, (eds.), *Proceedings of ICMPC-ESCOM 12, Thessaloniki, Greece,* 1124–1133.

Zatorre, R. J., and Halpern, A. R. (2005). Mental Concerts: Musical Imagery and Auditory Cortex. *Neuron 47*(1), 9–12.

Zatorre, R. J., Halpern, A. R., and Bouffard, M. (2010). Mental Reversal of Imagined Melodies: A Role for the Posterior Parietal Cortex. *Journal of Cognitive Neuroscience*, *22*(4), 775–789.

Zatorre, R. J., Halpern, A. R., Perry, D. W., Meyer, E., and Evans, A. C. (1996). Hearing in the Mind's Ear: A PET Investigation of Musical Imagery and Perception. *Journal of Cognitive Neuroscience*, *8*(1), 29–46.