Understanding inner music: A dimensional approach to musical imagery

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Abstract:

Musical imagery—hearing music inside your head that isn't playing in the environment—is a common yet complex experience. To capture the diversity of musical imagery, the present research develops a new conceptual framework consisting of five dimensions, including a distinction between *initiation* and *management* as different ways in which musical imagery can be voluntary. A dimensional approach can represent both common and unusual forms of musical imagery, and it can highlight conceptual similarities between seemingly different experiences. In an experience-sampling study, musicians and people from the university community (n = 132) were contacted throughout the day via a smartphone app and asked about their in vivo experiences with musical imagery, with an emphasis on five dimensions: *valence, repetitiveness, vividness, length*, and *mental control*. The results indicated substantial variability at both the within-person and between-person levels on each dimension—people have a wide variety of musical imagery experiences, not a few types. A within-person network model illustrated that the dimensions were internally coherent and distinct from each other. Taken together, the findings reveal rich heterogeneity in musical imagery and indicate that mental control over musical imagery is both common and multifaceted.

Keywords: musical imagery | experience sampling methods | mental control | network science

Article:

Musical imagery—hearing music in your head that isn't playing in the environment—is a fascinating example of people's engagement with music, and recent years have seen a growing literature devoted to understanding it. Musical imagery is clearly diverse—from hearing involuntary "earworms" (e.g., Floridou, Williamson, Stewart, & Müllensiefen, 2015; Liikkanen, 2008) to mentally rehearsing for a recital (e.g., Bowes, 2009; Holmes, 2005) to deliberately composing music in one's mind (e.g., Agnew, 1922; Cowell, 1926), among many other instances—and it has been studied in several different scholarly fields. As it has grown, however, the literature has become somewhat fragmented, thus obscuring many intriguing parallels between apparently different musical imagery experiences.

The present research proposes a new structural model to capture the rich variety of everyday musical imagery experiences. In this model, we identify five dimensions of musical imagery: *valence, repetitiveness, vividness, length,* and *mental control*. Taking a dimensional approach highlights the variability of musical imagery and allows for studying this variability across a range of music-related contexts and goals. Using both experience-sampling and network-science methods, we examine the dimensional structure of in vivo musical imagery and illustrate the value of using a dimensional approach to represent the breadth and richness of everyday musical imagery.

Approaches in Musical Imagery Research

Hearing musical imagery is largely an example of auditory imagery. Within the broader auditory imagery literature, researchers have long used musical and tonal stimuli to assess people's auditory imagery capabilities. This work has shown that people can use musical imagery to discriminate between the pitches of single tones (Hubbard & Stoeckig, 1988; Janata & Paroo, 2006), to recall the loudness of short musical passages (Bailes, Bishop, Stevens, & Dean, 2012), or to perceive auditory stimuli (Farah & Smith, 1983) when instructed to do so. Other work has examined how well people can manipulate their auditory images (e.g., changing pitches of notes, transforming a melody into a new key; Foster, Halpern, & Zatorre, 2013; Gelding, Thompson, & Johnson, 2015). But in everyday life, musical imagery rarely resembles the single tones, chords, musical scales, or unfamiliar musical passages commonly used as stimuli in these lab-based auditory imagery experiments. People report everyday musical imagery that contains familiar, recently heard songs (Liikkanen, 2008, 2011; Williamson & Jilka, 2014) with vivid representations of the song's melody, lyrics, and timbre (Bailes, 2007). Musicians report using musical imagery in the service of complex creative goals, such as mentally rehearsing their repertoire (Bailes, 2007; Holmes, 2005), anticipating upcoming segments during performance (Keller, 2012; Saintilan, 2014), and developing original compositions (Agnew, 1922; Bailes & Bishop, 2012; Cowell, 1926; Mountain, 2001). Lab-based auditory imagery work has emphasized basic acoustic dimensions, such as pitch, tempo, and dynamics (see Hubbard, 2010, 2013 for review), but the differing environments, contents, and functions of these real-world, everyday musical imagery experiences warrant the development of a dimensional approach to people's musical imagery experiences in daily life.

Past work examining everyday musical imagery has generally emphasized particular types of experiences for study. Without a doubt, the type of experience that has garnered the most attention in recent years has been *involuntary musical imagery* (INMI), often referred to as *earworms.* As its name suggests, this type of musical imagery is primarily marked by being spontaneous and uncontrollable, but it is also typically repetitive (Floridou et al., 2015). A large body of work has developed around INMI. Researchers commonly ask participants to report on their earworms (Floridou & Müllensiefen, 2015; Halpern & Bartlett, 2011) or songs that are stuck in their head, with descriptions limiting respondents to this very specific experience (Beaman & Williams, 2010, 2013; Hyman et al., 2015). In addition, the only everyday musical imagery scale developed to date is entitled "The Involuntary Musical Imagery Scale" (IMIS; Floridou et al., 2015). Collectively, this research program has examined both people's typical earworm experiences (e.g., Floridou & Müllensiefen, 2015; Floridou et al., 2015) and earworm experiences in daily life (e.g., Beaman & Williams, 2010; Hyman et al., 2015). INMI has largely been the focus of psychological investigations of everyday musical imagery, with some exceptions (e.g., Bailes, 2006, 2007, 2015; Beaty et al., 2013).

Another central focus of everyday musical imagery research has been musical imagery as a performance and composition tool. This body of work includes investigations of "hearing" musical notation in the inner ear (Brodsky, Henik, Rubinstein, & Zorman, 2003), mentally performing music (Holmes, 2005; Kleber, Birbaumer, Veit, Trevorrow, & Lotze, 2007; Wöllner & Williamon, 2007), and using musical imagery when composing (Bailes & Bishop, 2012; Mountain, 2001). Unlike the kinds of experiences studied in INMI research, mental rehearsal and composition are tacitly viewed as deliberate, controlled, and rooted in a musician's active musical goals.

Surprisingly, these two literatures have little contact with one another. Some work has considered the musical imagery of musicians (e.g., Bailes, 2007; Bailes & Bishop, 2012) and discussed how spontaneous musical imagery is part of the musical process (e.g., Agnew, 1922; Bailes & Bishop, 2012; Mountain, 2001). Overall, however, the literatures on people's spontaneous musical imagery and musicians' deliberate use of musical imagery have surprisingly few connections. This may be attributable, at least in part, to focusing on distinct types of experiences as well as populations: spontaneous imagery in people in general versus intentional imagery in musical experts. To bridge these seemingly different types of experiences, researchers can step back and abstract the underlying conceptual dimensions of everyday musical imagery that appear in both.

A Dimensional Model of Everyday Musical Imagery

Research on everyday musical imagery, by focusing on a few salient types of experiences, is inadvertently narrowing its scope. If we contrast the field of musical imagery with a more widely studied type of mental imagery—visual imagery—we can see the appeal of considering abstract dimensions that cut across seemingly different experiences. Visual imagery has identified a number of broad dimensions that describe inner visual experiences, such as vividness, control, and preference (see McAvinue & Robertson, 2006–2007 for review). Vividness, the most studied dimension of visual imagery, has a host of measures dedicated to it (e.g., Marks, 1973; Sheehan, 1967). Control, which has been recognized in the large literature on visuospatial abilities (see Carroll, 1993 for review), also has many measures evaluating this aspect of visual imagery (e.g., Gordon, 1949). More recent work has investigated visual imagery preferences, such as the tendency to use object imagery (the ability to generate images of people or objects) or spatial imagery (the ability to generate mental images of spatial relationships or movements; Blazhenkova, 2016). Although there are calls for increased study of the processes involved in visual imagery (Lacey & Lawson, 2013), these examples demonstrate that researchers have fruitfully unpacked some of the complexities of visual imagery by isolating its underlying dimensions.

Everyday musical imagery research can similarly benefit from exploring dimensional aspects of these experiences. Some research has sought to identify themes associated with everyday musical imagery (Williamson & Jilka, 2014; Williamson et al., 2012). For instance, Williamson et al. (2012) asked people why they believed their earworms began. Four groups of themes were identified: *Music Exposure* (previously heard music that reoccurs as INMI), *Memory Triggers* (when INMI is triggered from environmental stimuli, memories, or anticipation of future events), *Affective States* (when INMI is triggered by specific affective states), and *Low Attention States* (the occurrence of INMI when there was low attentional demand). Other work has focused on the valence and form of INMI experiences (Williamson & Jilka, 2014)—people reported positive, negative, and ambivalent experiences and often said that the fidelity of the music in their INMI varied. These qualitative, thematic approaches show the utility of emphasizing qualities, such as triggers, form, or valence, for they provide interesting insights into an experience. These approaches, however, have focused on INMI rather than everyday musical imagery more generally, and how these themes relate to other musical imagery experiences is unknown.

A more general dimensional approach can highlight conceptual similarities between diverse and disparate musical imagery experiences. We propose a five-dimension model to represent musical imagery: *valence, repetitiveness, vividness, length,* and *mental control.* In determining these dimensions, we first consulted the everyday musical imagery literature to see which aspects of musical imagery experiences had been emphasized in past research (e.g., which types of experiences are studied and their associated dimensions, the content of individual items or subscales). We also considered dimensions that are prominent in the study of mental imagery more generally. Below, we describe each of the five dimensions and provide summaries of how these dimensions featured in past research.

Valence

The *valence* dimension reflects how people feel about the music playing in their mind. Specifically, it involves whether having music in one's mind is pleasant or wanted versus irritating, distressing, or unwanted. This dimension is thus metacognitive because people are evaluating their mental states. Valence has been measured in many everyday musical imagery studies and has been phrased as how pleasant (Beaman & Williams, 2010; Floridou & Müllensiefen, 2015; Halpern & Bartlett, 2011), positive (Williamson & Jilka, 2014), liked (Beaty et al., 2013; Hyman et al., 2015), irritating (Bailes, 2007), pesky (Liikkanen, 2011), and negative (Floridou et al., 2015) musical imagery is. Collectively, these studies have found large variability in valence. Most musical imagery experiences are viewed positively (e.g., Beaman & Williams, 2010; Beaty et al., 2013), but neutral and negative experiences are common (e.g., Liikkanen, 2011; Williamson & Jilka, 2014).

Repetitiveness

Repetitiveness addresses whether the music plays as a recurring loop or as an extended auditory image (Margulis, 2014). Liikkanen (2011) found notable variety in repetitiveness: half of respondents reported their INMI to be repetitive, but over a third reported experiencing nonrepetitive INMI. As an alternative, repeating a section of music can be done purposefully, such as musicians mentally repeating problematic sections of music they must learn (e.g., Holmes, 2005). Other research also supports the prevalence of both repetitive and nonrepetitive musical imagery (Bailes, 2007, 2015; Halpern & Bartlett, 2011)—nonrepetitive experiences are sometimes termed *musical mind-pops* (Elua, Laws, & Kvavilashvili, 2012; Kvavilashvili & Anthony, 2012; Kvavilashvili & Mandler, 2004). Repetitiveness is usually identified as a core component of involuntary musical imagery (Floridou & Müllensiefen, 2015; Floridou et al., 2015; Jakubowski, Finkel, Stewart, & Müllensiefen, 2017; Liikkanen, 2008, 2011; Williamson & Jilka, 2014; Williamson et al., 2012).

Vividness

Vividness is a widely studied component of mental imagery. For musical imagery, vividness has several facets. *Realism*—how lifelike mental imagery is—is vividness in its traditional sense. People report their typical musical imagery experiences as being similar to actually listening to the song (Hyman et al., 2015), but there's great variation in the lifelikeness of mental imagery. Vividness has been widely investigated in the visual imagery literature, with a host of measures dedicated to this dimension of imagery (e.g., Betts' Questionnaire Upon Mental Imagery, Sheehan, 1967; Vividness of Visual Imagery Questionnaires, Marks, 1973), and has received some attention in the more closely related auditory imagery literature (see Hubbard, 2013). A recently developed measure—the Bucknell Auditory Imagery Scale (BAIS; Halpern, 2015)—assesses the vividness of auditory imagery using prompts focusing on musical, vocal, and environmental auditory situations. Although not solely a measure of musical imagery, the BAIS does demonstrate that people vary in the vividness of their auditory images.

In addition to realism, musical imagery also varies in *complexity*. Is only the melody heard or are harmonies present? For lyrical music, is it only a voice, or is there backing music? Some research has found that the melody, tempo (Bailes, 2015), and lyrics (Bailes, 2007) were the most vivid aspects of musical imagery, and the lyrics, melody, and singer's voice were the most common components of music present (Hyman et al., 2015). As part of vividness, musical imagery can be *multimodal*. When people are listening to music, there are often physical movements that accompany the experience (e.g., tapping your foot; see Levitin, Grahn, & London, 2018 for review). Similarly, these overt movements can occur when hearing musical imagery (e.g., Campbell & Margulis, 2015; Floridou et al., 2015).

Length

Musical imagery varies in its *length* in two ways: the duration of the whole musical imagery experience, and the length of the section of music playing in the mind (see Floridou et al., 2015). Most research has focused on the length of the entire episode. People report their musical imagery lasting only seconds (Halpern & Bartlett, 2011), for hours (Beaman & Williams, 2010; Halpern & Bartlett, 2011), for several days (Halpern & Bartlett, 2011), or always present, something that has been termed a *perpetual music track* (Brown, 2006). Clearly, there is considerable variability in episode length.

In addition, length can refer to how long a *section* of repeating music is. For example, sometimes someone might hear a catchy two-bar guitar riff repeating mentally, but other times have long passages—such as a full refrain or movement—repeating mentally. People report hearing portions of songs or songs in their entirety (Liikkanen, 2011), indicating some variability, but often only a snippet or segment of imagery is experienced. Not much is known about how long sections of songs tend to be when they repeat. The recently developed IMIS (Floridou et al., 2015) does include an item about the length of musical sections, and recent work shows variation in section length (Cotter, Christensen, & Silvia, 2016). Given past musical imagery research in this dimension and the demonstrated variability in both episode and section length, it is important to examine variation in both length components.

Mental Control

One focus of this project is to explore the role *mental control* plays in musical imagery. Mental control is a fundamental concept in the growing involuntary musical imagery literature, but we would point out that there are distinct senses of "involuntary" with important implications for understanding musical imagery. Drawing on the broader literatures on executive control and visual imagery, we propose two aspects of control over musical imagery: *initiation* and *management*.[1]

Musical imagery can vary in whether people deliberately initiated it or not. Initiation is the sense of "involuntary" that is meant by most INMI research, in that it emphasizes musical imagery that comes to mind spontaneously and unintentionally (Williams, 2015).[2] On the other end, the broader psychology of music offers many examples of voluntarily initiated musical imagery. Typically, these studies focused on musicians—musicians deliberately use musical imagery in preparation for upcoming performances (Bailes, 2006; Gregg, Clark, & Hall, 2008), as well as during their performances through anticipating upcoming musical lines (Keller, 2012; Saintilan, 2014). Initiation in everyday musical imagery experiences, however, has not been examined in nonmusician samples. It is likely that nonmusicians do initiate musical imagery, although the motives for initiation might vary. Some laboratory and neuroimaging work has asked people to deliberately imagine a tone or musical phrase, but many of these studies focused primarily on using auditory imagery to aid in auditory perception (Farah & Smith, 1983; Hubbard & Stoeckig, 1988; Janata & Paroo, 2006) or otherwise told participants to complete a specific task using musical imagery, necessitating voluntary initiation of the experimental stimuli (Brodsky et al., 2003; Kleber et al., 2007; Weir, Williamson, & Müllensiefen, 2015). But given the laboratory setting and nature of the stimuli (e.g., single tones, chords, or musical scales), initiation processes in everyday life may look different.

Likewise, musical imagery can vary in whether people deliberately manage their imagery once it has started. Imagery initiated involuntarily may nevertheless be maintained deliberately, such as when people want to keep listening to a familiar song or to purposefully alter the experience. Research has found that people often want their musical imagery to continue playing (Bailes, 2007) or will employ different tactics to stop their INMI (Beaman & Williams, 2010; Williamson et al., 2014), but few studies have asked questions that would assess management of everyday musical imagery experiences directly. In the auditory imagery literature, there has been more examination of management, such as the ability to change the pitch of an imagined tone as instructed (Gelding et al., 2015) or performing complex transformations of melodies (Foster et al., 2013). Other laboratory work has examined the fidelity of the loudness profiles (Bishop, Bailes, & Dean, 2013) or emotionality profiles of imagined music and found that people can generate and maintain musical images that resemble the profiles when actually listening to the music. In addition, the BAIS includes a control subscale that assesses people's ability to alter constructed images (e.g., initially hearing a trumpet playing "Happy Birthday" and then a violin finishing the song; Halpern, 2015). These

[1] Liikkanen (2008, p. 408) proposed a seemingly similar distinction: *activation* and *upkeep.* These initially seem like they correspond to *initiation* and *management*, but Liikkanen suggests that activation is the involuntary component ("occurs without attention," p. 408) and that upkeep is the controlled component ("allows some conscious control over the imagery," p. 408). Activation and upkeep thus primarily map on to involuntary and voluntary. We are suggesting a broader approach to mental control: initiation and management are two distinct senses in which musical imagery can be involuntary or controlled.

[2] The INMI research has examined what circumstances trigger these experiences (Williamson et al., 2012), but triggers are not the same as initiation. Initiation concerns whether the experience began involuntarily or voluntarily, not the reason why an episode started—these are two interesting but separable issues.

studies demonstrate that people can manage imagery, but like initiation, management may look very different in everyday life contexts than it does in the lab.

A similar initiation–management distinction has recently been made in the related field of mind wandering (see Seli, Risko, Smilek, & Schacter, 2016; Smallwood, 2013, for review). Similar to INMI research, the mind-wandering literature emphasizes involuntary, unintentional forms of mind wandering, but intentional, controlled forms are common (Seli et al., 2016). Furthering this distinction, Seli et al. (2016) state that intentional mind wandering can occur in two ways—through the willful initiation of mind wandering or by choosing to continue the mind-wandering episode (i.e., management; Smallwood, 2013). Although not much is known about the mental control of everyday musical imagery, mental control is clearly an important and multifaceted dimension.

The Advantages of a Dimensional Approach

A dimensional approach has several advantages over one that focuses on types of experiences. First, particular types of experiences can be easily represented within a dimensional framework. For example, INMI can be viewed as imagery that is involuntarily initiated and repetitive but can vary on the other dimensions. If we think about INMI in this way, it becomes apparent that it is only one of many experiences contained within the conceptual space of a five-dimensional model. Second, a dimensional approach provides the ability to more easily compare different musical imagery experiences. For example, on which dimensions do INMI and deliberate mental rehearsal differ? On which are they similar? By providing a common set of qualities, a dimensional approach affords the opportunity to answer these questions. Using a dimensional framework supports the broadening of musical imagery research and allows researchers to address research questions that are not readily evident when emphasizing a handful of types of experiences.

The Present Research

To examine this model of musical imagery, we used experience sampling methods (ESM). Most research on everyday musical imagery has used cross-sectional designs that ask people to retrospectively reflect on and describe their typical musical imagery experiences (Beaman & Williams, 2013; Halpern & Bartlett, 2011; Hyman et al., 2015; Liikkanen, 2011). But it is unclear how well people encode and recall transient imagery experiences, and some work suggests that the qualities of everyday musical imagery are poorly recalled in retrospective reports (Cotter & Silvia, 2017). ESM is unique because it allows participants to report their inner experiences as they happen.

ESM is a valuable tool for catching fleeting and variable states. Asking people to pool diverse experiences to report "typical" or "average" experiences is problematic (Schwarz, 2012; Silvia, Cotter, & Christensen, 2017). Retrospective reports may reflect the most salient, recent, or intense experiences that aren't representative of someone's typical experiences (Reis, 2012). A small literature has applied ESM to musical imagery and shown that it is feasible (e.g., Beaty et al., 2013; Cotter & Silvia, 2017), but most ESM studies to date have either defined musical imagery to participants as involuntary (Byron & Fowles, 2015; Floridou & Müllensiefen, 2015) or have used small, focused samples (e.g., 11 music students; Bailes, 2006, 2007). Thus, our use of ESM should reduce recall errors and sample the diversity of musical imagery experiences (Cotter & Silvia, 2017; Schwarz, 2012; Silvia et al., 2017).

We are interested in everyday musical imagery at the within-person, episode level—that is, we are interested in variation in everyday musical imagery states rather than in the averaged qualities of people's typical everyday musical imagery experience. There are certainly between-person individual differences in everyday musical imagery experiences, such as how often people experience everyday musical imagery and the typical valence of their experiences (e.g., Cotter & Silvia, 2017; Floridou et al., 2015). Between-person individual differences—such as music training, personality traits, and cognitive abilities—can act as confounding "third variables" for between-person models of the structure of musical imagery. By evaluating within-person covariation, within-person models avoid problems caused by potentially confounding individual differences (Nezlek, 2001).

The present research had a sample with a range of musical expertise. We recruited music majors with different concentrations (e.g., performance, education) because they are more likely to use musical imagery for specialized musical goals. Although most people report experiencing everyday musical imagery frequently (Liikkanen, 2011), it is likely that musicians' salient musical goals influence the frequency and content of their musical imagery (Klinger, 1971).

Our project had a few aims. First, we sought to evaluate whether the five dimensions are distinct—especially initiation and management, the two proposed facets of mental control. By assessing musical imagery dozens of times per person in a large sample, we can comprehensively characterize musical imagery states. Because past work has largely asked people to report on everyday musical imagery that is involuntary, actually assessing control over imagery experiences will illuminate how often such experiences are controlled and what kind of control is involved. Second, we can examine the dimensions of musical imagery in more detail by exploring how they relate to each other. Collectively, this project expands our knowledge of musical imagery and provides evidence for the utility of a dimensional approach.

Method

Participants

The data are from a broader project on music expertise and musical experiences in everyday life. Some descriptive findings from this dataset have appeared in a related article (Cotter & Silvia, 2017). Participants were 150 students who volunteered as part of a class research participation option (n = 128) or responded to a flyer asking for music majors interested in participating in psychology research (n = 22). Eighteen participants were excluded from analyses because of elevated scores on items capturing inattention (see Maniaci & Rogge, 2014; McKibben & Silvia, 2016, 2017) or for completing fewer than five ESM surveys, a recommended minimum for daily life research (Bolger & Laurenceau, 2013). This resulted in a final sample of 132 (110 research volunteers; 22 music majors). Overall, the sample was young (M age = 19.90, SD = 4.60, range = 18–53), predominantly female (n = 102, 68%), and racially diverse (49% European American and 42% African American). Participants were compensated with research credits or $20 in cash for participation. People who completed at least 45 ESM surveys were also eligible for entry into a raffle for one of three $40 cash prizes (36% of the sample qualified).

Musical Imagery Survey

During the data collection period, participants filled out a 29-item survey several times a day. All participants were told the following during the lab portion of the study:

> You will be asked whether you were hearing music in your head. Hearing music in your head is very common and we want to learn more about these experiences. When you receive the notification, you should report on the music you were hearing in your head right before you started the survey. If you weren't hearing music in your head, then you will be asked questions about what you were thinking about before starting the survey. If you weren't hearing music in your head, but there was music playing in your environment—for example, on your computer or phone—you should say that you were not hearing music in your head. Do you understand the difference between music in your head and music in the environment?

A few participants asked about musical imagery that was related to environmental music (e.g., mentally improvising or harmonizing with music on their phone) and were instructed that these experiences did qualify as musical imagery.

Table 1. Musical Imagery Survey Items

Dimension	Item	Response scale
Valence	*Enjoy*: I enjoy hearing the music in my mind. *No Music*: I would rather not have music in my head right now. (*reversed*)	Rated from 1 (*strongly disagree*) to 7 (*strongly agree*)
Repetitiveness	*Repetitive*: Is the music playing over and over in a loop?	*Yes* or *No*
Vividness	*Lifelike*: The music in my mind is lifelike. *Listen*: It feels like I'm actually listening to the song. *Movement*: My body is responding to the music (feet tapping, head and body moving).	Rated from 1 (*strongly disagree*) to 7 (*strongly agree*)
Mental control (*initiation*)	*Purpose*: I made the music in my mind start playing on purpose. *Start*: I intended to start hearing this music in my mind.	Rated from 1 (*strongly disagree*) to 7 (*strongly agree*)
Mental control (*management*)	*Stop*: I could make the music in my head stop if I wanted to. *Keep Playing*: I'm trying to keep the music in my mind playing. *Control*: I feel the music playing in my mind is under my control.	Rated from 1 (*strongly disagree*) to 7 (*strongly agree*)
Length	*Episode length*: How long has the music been playing in your mind? *Section length*: How long is the piece of music in your mind?	Less than 1 min; between 1 to 5 min; between 5 to 30 min; longer than 30 min Less than 5 s; between 5 and 10 s; between 10 and 30 s; between 30 s and 1 min; more than 1 min

All the musical imagery items can be found in Table 1. People were first asked whether they were experiencing musical imagery. Participants who reported hearing musical imagery were directed to questions centered around the five proposed dimensions of musical imagery. If people indicated they were not experiencing musical imagery, they responded to filler items about the quality of their thoughts. After completing the musical imagery or filler items, everyone answered questions about their current feelings, mood, and environment when signaled.[3] We should note that it's possible that repeated exposure to the ESM items could sensitize participants

[3] The full ESM survey can be found in the online supplemental materials along with descriptive statistics and correlations for the mood and environmental ESM items.

to their musical imagery experiences (e.g., Conner & Reid, 2012). Nevertheless, ESM would still be the preferred method because past work has shown that retrospective self-reports correspond weakly with in vivo measures (Cotter & Silvia, 2017).

The ESM items were developed by Katherine N. Cotter and Paul J. Silvia. A pool of items was first generated to assess the core aspects of the five dimensions. When relevant, past work and self-report scales were consulted for potentially useful items. We then reduced these initial items by eliminating wordy and redundant items. For the final pool, we consulted with colleagues experienced with ESM assessment to refine the items to ensure clarity and suitability for repeated assessment during a typical day. We ended up with 13 items assessing the five dimensions. Unlike cross-sectional self-report scales, ESM surveys tend to be short, often with single items, because of the trade-offs inherent in repeated sampling (Silvia, Kwapil, Walsh, & Myin-Germeys, 2014). If the number of items asked per signal is reduced, researchers can increased the number of signals per day, thus sampling the participants' days in finer detail.

Experience-Sampling Procedure

The experience-sampling surveys were programmed into MetricWire—a smartphone application designed for mobile data collection—and participants received a notification when there was a new survey available. After a survey notification appeared, participants had a 5-min window to start the survey before it closed; MetricWire sent a reminder notification after 30 s if the survey had not been opened. Fourteen surveys were sent out each day, and each survey appeared at quasi-random times at least 40 min apart between 8 a.m. and midnight. MetricWire allows researchers to track the completion of surveys in real time, and we selectively contacted participants with poor response rates to address any potential technical malfunctions with the application or their device.

Procedure

Participants came into the lab in small groups. Research assistants then helped participants register their smartphones with MetricWire and complete a practice survey. If participants didn't have a smartphone or didn't want to use their own phone, they were loaned a 7" Android tablet. After completing the practice survey, participants completed a range of cognitive tasks and self-report items.

The ESM data collection occurred over 7 days. People were signaled at quasi-random times to take a survey roughly every 45 min between 8 a.m. and midnight. Participants were instructed to turn off their phone volume when sleeping and to ignore survey notifications if it would be inappropriate or unsafe to complete the survey. Katherine N. Cotter performed a midweek e-mail check-in with each participant to ensure they were not experiencing any technical issues with MetricWire. People with unusually low response rates after 2 days were also contacted by e-mail to make sure there were no technical difficulties. Upon completion of the study, participants who were loaned a tablet returned it and were thanked for their participation. The other participants were told they could remove the MetricWire application from their personal device, thanked for their participation, and notified whether they qualified for raffle entry.

Results

Because survey responses are nested within people, the data were analyzed in a multilevel framework. Our analyses are primarily descriptive. In most cases, the statistics (e.g., within-person correlations, intraclass correlations [ICCs], and other descriptive statistics) were computed with Mplus 8.

Within-Person Musical Imagery Descriptive Statistics

Because our primary aim is to examine the utility of a dimensional model of musical imagery, the descriptive statistics for the five dimensions are theoretically important. To make a case for a credible dimensional model of musical imagery, there must be variation on each of the five dimensions—a lack of variability would suggest that there are a handful of specific types of musical imagery experiences, not underlying dimensions. To support our dimensional approach, we first consider the range and variability of responses in each dimension at the within-person level. We then examine the relationships within and between the dimensions to demonstrate that, while related, the five dimensions are distinct.

All within-person descriptive statistics can be seen in Table 2 (above the diagonal). The distribution of responses for musical imagery items are in Figure 1. ICCs—the proportion of variance at the between-person level—were calculated for the musical imagery items (Figure 2). The size of these statistics (.17–.49) suggests that there tends to be greater variability in musical imagery experiences within people than between people (i.e., 17% to 49% of the variance can be attributed to between-person differences and the remaining variance—51% to 83%—can be attributed to within-person differences).

TABLE 2 AND FIGURE 1 APPEAR AT THE END OF THIS FORMATTED DOCUMENT.

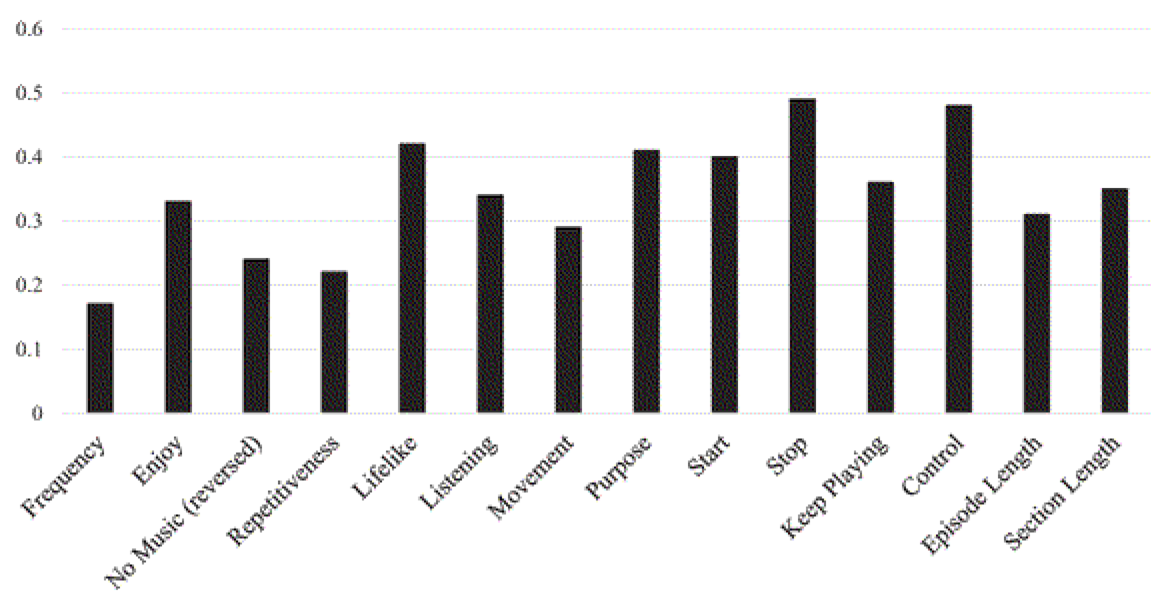

Figure 2. Intraclass correlations for musical imagery items.

Frequency. Although not one of the proposed dimensions, how often people experience musical imagery is interesting in its own right. The sample completed a total of 4,403 ESM surveys—on average, people completed the ESM survey 33.48 times (*SD* = 17.23, range = 5–80). Of these responses, 1,112 (25.26%) surveys captured episodes of musical imagery. This rate is consistent with prior research that suggests musical imagery is a relatively common experience.

Valence. The valence dimension was measured with two ESM items: "I enjoy hearing the music in my mind" and "I would rather not have music in my head right now" (reverse-scored). Both items had high within-person means (*M* = 5.23, *SD* = 1.56 and *M* = 6.00, *SD* = 1.00, respectively), indicating that, on average, people viewed their musical imagery episodes favorably. This becomes more striking when examining the distribution of responses (Figure 1, a and b)—only 138 of the 1,104 (12.50%) responses on the "Enjoy" item fell below the scale's midpoint, and none of the responses for the "No Music" item fell below the scale's midpoint. Thus, it appears that unpleasant musical imagery experiences were a small portion of musical imagery experiences. Although most episodes were positive, our findings do show notable variability across episodes, suggesting that valence is not simply "positive" or "negative" and supporting the inclusion of the valence dimension.

Repetitiveness. Repetitiveness was measured with a single item: "Is the music playing over and over in a loop?" Overall, 805 of the 1,112 episodes (72.39%) were reported to be repetitive. Most episodes thus featured repetitive mental music, but many episodes contained nonrepetitive music.

Vividness. The vividness dimension contained three items: "The music in my mind is lifelike," "It feels like I'm actually listening to the song," and "My body is responding to the music (feet tapping, head and body moving)." The first two items—the lifelikeness and realism of the musical imagery—showed that, on average, people had musical imagery experiences that were moderately vivid (*M* = 4.74, *SD* = 1.69 and *M* = 4.74, *SD* = 1.78, respectively). Even though more episodes were reported to be vivid than not (59.57% of lifelikeness responses and 58.46% of realism responses fell above the scale midpoint), many of the episodes weren't particularly vivid (Figure 1, c and d). The third item captured movement in response to musical imagery. Movement did occur occasionally (*M* = 3.33, *SD* = 2.17), but most musical imagery episodes were not reported to evoke movement (58.46% of responses fell below the scale midpoint; Figure 1e). Although the findings did differ between the two more traditional vividness items and the movement item, all three yielded responses that spanned the whole response scale. Given this variability at the episode level, vividness appears to be a credible dimension of musical imagery.

Length. Both the perceived length of the overall episode and the section of music were measured (Figure 1, k and l). Most episodes (76.31%) were less than 5 min long, but there were a handful (5.41%) that lasted over 30 min. Similarly, most sections of musical imagery were short—80.25% of sections lasted less than 30 s—but there were some music sections that lasted longer—11.72% of sections lasted over 1 min. Although most episodes and sections of music were relatively short, people did experience long episodes and sections of music, demonstrating variability in episode and section length. This variability supports length's inclusion as a dimension of musical imagery.

Mental control. The mental control dimension has two components: initiation and management. The initiation component was measured by two items: "I made the music in my mind start playing on purpose” and “I intended to start hearing this music in my mind.” Both items had low means (*M* = 2.89, *SD* = 2.01 and *M* = 2.94, *SD* = 2.02, respectively), suggesting that, on average, people were not initiating musical imagery episodes. This is further supported by the distribution of responses (Figure 1, f and g)—most responses fall below the scale’s midpoint (66.97% of “Purpose” responses, and 65.70% of “Start” responses), but it is important to note the many instances in which people were willfully initiating musical imagery.

The second component, management, was assessed with three items: “I could make the music in my head stop if I wanted to,” “I’m trying to keep the music in my mind playing,” and “I feel the music playing in my mind is under my control.” Trying to keep musical imagery playing (*M* = 3.07, *SD* = 1.90) mirrored the initiation items—during most episodes (61.59% of responses were below the scale midpoint), people were not intentionally keeping the music going, but there were episodes in which people deliberately maintained their imagery (Figure 1i). The other management items followed a different pattern. Responses on both items indicated that for many episodes, people felt low levels of control over their musical imagery (“Stop”: *M* = 3.58, *SD* = 1.97; “Control”: *M* = 3.77, *SD* = 1.95); however, approximately one third of episodes were controllable (32.94% of “Stop” responses, and 37.58% of “Control” responses fell above the scale midpoint). The distributions for these items were not as imbalanced as those of the other mental control items (Figure 1, h and j). The variability across the three management items supports inclusion of the mental control dimension in the proposed model, as well as management as an aspect of mental control.

Summary. The descriptive statistics from each of the five proposed dimensions show considerable variation between episodes. This variability supports the use of a dimensional approach: Musical imagery appears to be diverse and variable within a person’s week.

The Structure of the Musical Imagery Dimensions

How distinct are the musical imagery dimensions, and how do they relate to each other? We used network models to evaluate and display the within-person relationships between all the musical imagery items. Like traditional methods for evaluating item structures, such as principal components or factor analysis, network models can statistically evaluate the patterns of relationships between items to identify likely groupings. Network approaches, however, have some additional virtues. Unlike traditional methods, a network approach can illustrate the relationships between item clusters. For example, one factor may be relatively central but others could be relatively peripheral. In addition, network methods lend themselves to intuitive visual displays that make it easy to understand the structure of a set of items.

Network models graphically depict the connections between variables (e.g., items), which form emergent constructs (e.g., musical imagery). The theoretical interpretation of a network is that the mutualistic relations between the items are potential causal pathways, which form manifest or latent variables (Kruis & Maris, 2016). Previous work shows that network models can produce dimensional structures that resemble traditional factor analyses while providing a more nuanced interpretation of the relations below higher-order constructs (Christensen, Cotter, & Silvia, in press; Christensen, Kenett, Aste, Silvia, & Kwapil, 2018; Costantini et al., 2015). In our network, for example, an item within the vividness dimension should have many connections with other vividness items (indicating within-dimension structure). The same vividness item should have relatively fewer connections to items in other dimensions (indicating between-dimension structure). Therefore, we created a network of the musical imagery items to inspect the within and between dimension relationships of musical imagery.

The construction of our networks follows previous research using mixed graphical models (MGM; Haslbeck & Waldorp, 2016), which allows Gaussian (continuous), categorical, and Poisson data to be graphed together. Using the open-source *R* software (R Core Team, 2017), the *mgm* package (Haslbeck & Waldorp, 2016) was used to construct our network models. One specific parameter—the hyperparameter (γ)—was taken into consideration when generating our models. The hyperparameter, a parameter in the extended Bayesian Information Criterion (EBIC) formula, determines the sparseness of the network (the number of connections). The EBIC formula is used to determine the $\ell 1$-regularization penalty, which eliminates spurious connections in the network. Previous research suggests that the hyperparameter is typically optimal when equal to .25 (Barber & Drton, 2015). Epskamp and Fried (in press), however, suggest that the researcher must make an informed decision about the *true* network structure—the real-world structure of the network—when setting this parameter. Therefore, when constructing our networks, we believed the *true* network to be less sparse because of the structure of relationships between the survey items. This knowledge led us to set the hyperparameter equal to 0.

In our network model (Figure 3), nodes represent items and their connections (edges) represent partial correlations given all other items in the network. In this depiction, the thickness of an edge indicates an increasingly strong correlation between two items. Green edges signify a positive relationship, and red edges signify a negative one. Moreover, nodes are color coded to aid dimensional identification. To examine if our theoretical dimensional definitions were supported by the network model, we applied the walktrap algorithm—a community detection measure, which quantifies how many parts the networks can be broken into (i.e., dimensions; Christensen, Cotter, & Silvia, in press). This algorithm was applied via the *igraph* package (Csardi & Nepusz, 2006) in *R*. From this analysis, five clusters emerged.

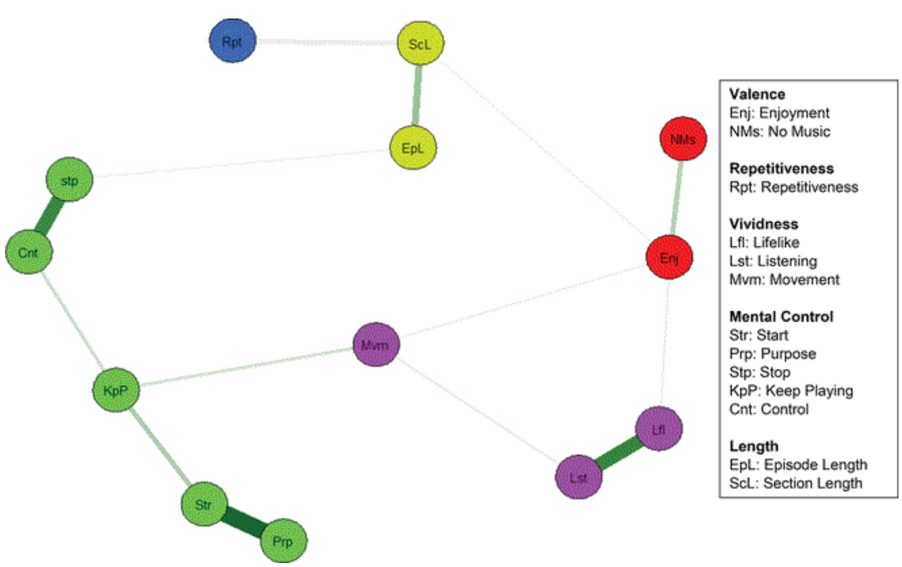

Figure 3. Network structure of musical imagery.

Cluster 1. The first cluster contained the two valence items: “Enjoy” and “No Music” (*reversed*). These items were positively related ($r = .22$; see Table 2 for all correlations). The network suggests this cluster has few connections to the other clusters, and the items had modest correlations with the other items (*r*s = .16 to .29).

Cluster 2. The second cluster contained two of the three vividness items: “Lifelike” and “Listening.” These items were strongly, positively related ($r = .60$) but had notably smaller correlations with the third vividness item, “Movement” (*r*s = .25 and .30, respectively), which was not placed into this network-identified cluster. In our theoretical framework, this may suggest that movement should be considered its own independent dimension. Outside of “Movement,” the network suggests that this cluster was connected only to the valence cluster (*r*s = .28 and .29).

Cluster 3. The next cluster contained three items: both “Episode Length” and “Section Length” items and “Repetitiveness.” This network-identified cluster diverges from our theoretical dimensional structure, which would place repetitiveness as its own dimension. Repetitiveness is connected only through its relationship with section length ($r = -.26$)—repetitive musical imagery episodes tended to contain shorter sections of music. Although repetitiveness and length are theoretically and qualitatively distinct dimensions of musical imagery, the measurement of section length depends on whether the music is repetitive. Therefore, repetitiveness being grouped with the two length items likely reflects the dependency in how repetitiveness and section length are measured.[4]

Cluster 4. The fourth cluster contained three mental control items—“Start,” “Purpose,” and “Keep Playing”—along with “Movement.” The first three describe actively exerting control over an episode as opposed to the other control items (“Control” and “Stop”) that assess perceived ability to control the imagery. The final item assesses physical engagement with musical imagery. Movement’s inclusion here further suggests that it is not a component of vividness and likely represents an additional dimension. It is interesting that “Keep Playing” was grouped with the initiation items rather than the management items despite being moderately correlated with the other two management items ($r = .24$ and .40). This grouping may also be the result of the two initiation items and “Keep Playing” assessing active instances of mental control rather than perceived control abilities. Visually, the “Keep Playing” item bridges the initiation and management dimensions.

Cluster 5. The final cluster contained two of the three management items: “Control” and “Stop.” These items were positively related ($r = .49$), and both assessed perceived mental control abilities.

Node impact*.* To investigate how orthogonal the dimensions of the network were, we measured each variable’s *impact* (Kenett, Kenett, Ben-Jacob, & Faust, 2011). Node impact measures how the removal of an individual variable influences the integrity (or structure) of the network. This measure was computed using the *NetworkToolbox* package (Christensen, 2018) in *R* and is quantified by the difference between the average distance—the mean number of edges from one node to another—when the variable is *not* included in the network and the average distance when the variable *is* included in the network (the original network). Positive values suggest that the

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[4] Consistent with our interpretation, a follow-up dependency analysis suggested that section length responses are dependent on repetitiveness ($z = 2.22$, $p = .026$).

network becomes more disconnected (i.e., more orthogonal) when removing the variable; negative values suggest that the network becomes more connected (i.e., less orthogonal) when removing the variable. This analysis revealed that "Movement" had the highest, positive impact, suggesting when this variable is removed, the network's clusters become more distinct and orthogonal. In contrast, "Keep Playing" had the lowest, negative impact, suggesting when this variable is removed, the network's clusters become less distinct and more interconnected.

We examined the network structure when either the "Movement" or "Keep Playing" variables were removed to see if this affected the network's structure. When "Movement" was removed, the structure stayed the same. When "Keep Playing" was removed, the structure stayed the same but with one exception: "Movement" was now classified as a part of the vividness cluster with the "Lifelikeness" and "Listening" variables. This shows that "Movement" is connected to the mental control cluster specifically through "Keep Playing," perhaps suggesting that both represent continuous active processes that can occur during musical imagery episodes. In addition, this supports our contention that initiation and management are separate components of mental control because they are not grouped in either the original model or models with impactful nodes removed. Finally, this suggests that the network structure is robust to the removal of "Movement".

Summary. Collectively, the network model and correlations among the musical imagery items demonstrate that relationships within the dimensions are stronger than those between dimensions, with a couple exceptions. First, moving along to musical imagery does not appear to be an aspect of vividness as initially thought and may warrant being its own dimension. Second, intentionally keeping the mental music playing—a process related to management—was grouped with the initiation items and appeared to bridge the two facets of mental control. This is likely a product of the particular items representing active engagement with controlling the imagery as opposed to the other management items, which assessed perceived ability to manage the imagery. Overall, this network model suggests that the five proposed dimensions are related but distinct, so each one provides useful information about musical imagery experiences.[5]

Discussion

Musical Imagery Dimensional Structure

Musical imagery is pervasive in everyday life, but what is it like? How can research on musical imagery represent the ways in which people's experiences of musical imagery vary? The present research proposed a dimensional framework to capture the breadth of musical imagery experiences. This project investigated five dimensions of musical imagery—*valence, repetitiveness, vividness, length,* and *mental control*. Each of these dimensions demonstrated considerable within-person variability, suggesting that there are fluctuating aspects of musical imagery and that each warrants inclusion in the model. Furthermore, the network analysis of the items revealed discrete clusters of items that largely corresponded to the dimensions. As

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[5] The *between-person* inner music descriptive statistics and correlations resembled the within-person effects. Just as individual episodes of musical imagery had variable qualities, individual people also varied in their tendencies to have certain experiences. For example, some people tend to move along with their inner music fairly frequently, whereas others very rarely do so. As expected, the correlations for items from the same dimension were stronger than those between different dimensions—this further supports that these dimensions are separate components of the inner music experience. For additional discussion, please refer to the online supplemental materials.

expected, the correlational relationships were stronger for items within the same dimension than relations between dimensions. Taken together, the present findings support these five dimensions as independent qualities of musical imagery.

Prior work has looked at most of these dimensions of musical imagery (e.g., Bailes, 2007, 2015; Beaty et al., 2013; Cotter et al., 2016; Liikkanen, 2011). It hasn't, however, developed a general framework to examine these qualities simultaneously, and has focused largely on a few regions of the dimensional space, such as experiences that start involuntarily (e.g., Beaman & Williams, 2010, 2013; Floridou & Müllensiefen, 2015; Floridou et al., 2015). The present work, however, suggests that there is substantial variability in the typical person's daily experience of musical imagery. A general model of the basic dimensions of musical imagery appears fertile for capturing the diversity of these musical imagery experiences in the real world.

For the dimension of mental control, we investigated the distinction between *initiation* and *management* of musical imagery. To date, research on INMI has generally termed these experiences to be "spontaneous" or "uncontrollable" but has not been consistent in describing in what sense it was involuntary (e.g., Beaman & Williams, 2010; Floridou et al., 2015; Liikkanen, 2011). In our sample, we found that perceiving control over musical imagery was common, that people do occasionally exert control over their imagery, and that initiating imagery and managing imagery sorted into distinct clusters of experiences. Related fields, such as mind wandering (see Seli et al., 2016; Smallwood, 2013), have recognized the distinction between the ways in which mental experiences can be controlled or involuntary and have begun to examine voluntary instances of mind wandering. Likewise, there has been an emphasis in the everyday musical imagery literature on involuntary experiences, and such parallels reinforce the need to consider distinct ways in which people control musical imagery.

Implications for Future Research

The "type" focus. Most everyday musical imagery research has focused on types of experiences—such as earworms or mental rehearsal—and these types are contained within the space formed by a dimensional model. A dimensional approach can thus speak to popular kinds of experiences like earworms and illuminate a much wider range of experiences. For example, rather than asking people to report only on musical imagery experiences that are both involuntary *and* repetitive (e.g., Floridou et al., 2015), people could report on the underlying qualities of their experiences. With this method, INMI can still be identified, but researchers are now provided with additional information, such as the degree to which the imagery was involuntary or if people elected to exert control over the experience after it had spontaneously begun.

Terminology. The terminology in the everyday musical imagery literature reflects the prominence of a few specific types of experiences—in psychology this has been INMI, but this term has been applied somewhat inconsistently. As Williams (2015) notes, researchers have often used the terms INMI and earworms interchangeably (e.g., Floridou et al., 2015; Jakubowski et al., 2017) even though earworms are only one type of INMI—experiences that are involuntary but also repetitive. At other times, qualities such as negative valence have been included in the definitions explicitly (e.g., "This involuntary mental imagery is generally held to be annoying and/or distracting," Halpern & Bartlett, 2011, p. 425) or more subtly (e.g., including a subscale entitled "Negative Valence" as opposed to the neutral "Valence," Floridou et al., 2015). Further still, Williamson et al. (2014) state in their paper focusing on INMI experiences, “the present study has shown that people feel that they can successfully manage their unwanted INMI, if and when they determine that coping is necessary” (p. 8) but earlier in the same paper define INMI to be something that cannot be consciously controlled. Although only one example, the term “involuntary musical imagery,” which may have initially been used to describe spontaneous, uncontrolled episodes of musical imagery, has evolved to encompass a variety of experiences that do not conform to its original intent.

As this literature grows, the field’s terminology should be sharpened. For experiences lacking a common label, a description of its underlying qualities within a dimensional framework provides more clarity. Terms such as *musical imagery* are more appropriate to describe this phenomenon in general. Earworms, INMI, and other descriptors of specific musical imagery experiences should only be used to describe experiences whose qualities match their individual definitions. To make these distinctions clear in future research, the language used to describe musical imagery to participants should be included. This will allow other researchers to better determine if the focus was on a particular kind of musical imagery experience, or if the work encapsulated a variety of experiences.

Likewise, when measuring musical imagery, researchers should consider if their terms carry loaded or unintended meanings for the participants. For example, *earworm* is frequently used in self-report measures (e.g., “When you were experiencing the earworm, did you feel irritated?” Beaman & Williams, 2010; “Earworms help me when I’m trying to get things done,” Floridou et al., 2015). *Earworm* is a popular colloquial term that carries an idea of a specific experience for many people. If we aim to measure musical imagery in general or even INMI specifically, asking participants to answer questions about their “earworms” may not be capturing the types of experiences we hope to assess. Even if participants are provided with a specific definition, it potentially introduces unnecessary noise into the data. Using neutral terms may be more appropriate (e.g., “The music in my head. . .”; Bailes, 2006, 2007, 2015; Beaty et al., 2013).

The inclusion of mental control. The field has not yet examined the many interesting forms that controlled musical imagery can take in daily life, and the components proposed here (initiation and management) provide a starting point. Future work should look at new and different ways control can be used in musical imagery. We studied instances of control during naturally occurring episodes, but there are other ways that we can learn about people’s abilities to exert control over these internal experiences. For example, using ESM, we could ask people who are hearing musical imagery when signaled to perform specific controlled manipulations (e.g., speed up the tempo, change songs completely). For people who are not hearing musical imagery when signaled, they could be asked to initiate an episode of musical imagery and perform similar manipulations to the initiated music.

Additional dimensions. The present work demonstrated that a dimensional approach to musical imagery is fruitful. The dimensions detailed here, however, should not be considered the only dimensions of musical imagery. We believe that the five dimensions examined are likely the most salient and variable aspects of everyday musical imagery in typical populations, but there is room for further development. For example, we initially thought that moving along to musical imagery reflected the overall vividness of musical imagery. Movement was only moderately related to the other vividness items, however, and did not group with those items in our network analysis. Movement likely represents an additional dimension of everyday musical imagery, rather than part of the vividness dimension. Interestingly, the IMIS includes a subscale focusing on movements associated with INMI, and people report occasionally moving along to their INMI (Cotter & Silvia, 2017). The final version of the IMIS does not include any items assessing vividness of the imagery, however, and future research should attempt to replicate the present findings suggesting that movement and vividness are distinct.

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Table 2. Correlations and Descriptive Statistics of Musical Imagery Items

Variable	*M* (range)	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
M (range)			.25 (0, 1)	5.23 (1, 7)	6.00 (4, 7)	.72 (0, 1)	4.74 (1, 7)	4.74 (1, 7)	3.33 (1, 7)	2.89 (1, 7)	2.94 (1, 7)	3.58 (1, 7)	3.07 (1, 7)	3.77 (1, 7)	1.01 (0, 3)	1.59 (0, 4)
SD			.43	1.56	1.00	.45	1.69	1.78	2.17	2.01	2.02	1.97	1.90	1.95	.83	1.19
Skew			—	–.75	–.59	—	–.47	–.47	.44	.78	.72	.28	.58	.11	—	—
Kurtosis			—	.02	–.81	—	–.55	–.77	–1.28	–.73	–.84	–1.12	–.84	–1.18	—	—
1. Frequency	.25 (.02, .86)	.17	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2. Enjoy	5.22 (3.29, 7.01)	.86	–.08	—	.22	–.09	.28	.29	.24	.19	.22	.16	.25	.20	.17	.22
3. No music (reversed)	5.99 (4.99, 6.96)	.42	–.18	.74	—	–.02	.18	.18	.09	.06	.11	.02	.12	.14	.10	.11
4. Repetitive	.72 (.25, 1.01)	.17	.10	.01	.02	—	–.12	–.14	–.12	–.13	–.15	–.15	–.14	–.11	.03	–.26
5. Lifelike	4.64 (1.99, 6.80)	1.08	.03	.52	.33	.19	—	.60	.25	.19	.21	.09	.27	.15	.14	.24
6. Listen	4.67 (2.13, 6.73)	1.02	.01	.44	.21	.17	.90	—	.30	.21	.25	.12	.28	.17	.16	.29
7. Movement	3.50 (1.27, 6.22)	1.10	–.33	.41	.25	.02	.48	.44	—	.24	.27	.06	.31	.17	.13	.21
8. Purpose	3.22 (.92, 6.26)	1.30	–.23	.25	–.04	–.27	.23	.20	.30	—	.79	.28	.48	.37	.13	.28
9. Start	3.29 (1.00, 6.47)	1.34	–.26	.27	–.02	–.30	.24	.20	.35	.98	—	.26	.51	.38	.16	.29
10. Stop	3.96 (1.04, 6.42)	1.27	–.35	.38	.23	–.35	.22	.18	.28	.61	.65	—	.24	.49	–.04	.09
11. Keep playing	3.35 (1.20, 6.52)	1.17	–.26	.47	.14	–.33	.38	.37	.58	.70	.78	.67	—	.40	.17	.26
12. Control	4.17 (1.27, 7.00)	1.30	–.36	.42	.21	–.34	.26	.22	.26	.70	.71	.94	.71	—	.07	.15
13. Episode length	.93 (.13, 2.19)	.39	.20	.16	.06	.09	.34	.31	.35	–.16	–.09	–.17	.10	–.15	—	.35
14. Section length	1.48 (.40, 3.38)	.65	.22	.39	.21	–.23	.43	.37	.43	.14	.20	.25	.45	.26	.58	—

Note. Within-person descriptive statistics (row) and correlations are presented above the diagonal; between-person descriptive statistics (column) and correlations are below the diagonal. These correlations can be interpreted as effect sizes using the following guidelines: small effect: $r > .10$, medium effect: $r > .30$, and large effect: $r > .50$ (Cumming, 2012). The p values for within-person correlations based on multilevel data are more variable than for a cross-sectional, between-person design because the clusters have different variances and numbers of observations. Monte Carlo power simulations, however, indicate that within-person rs > .10 are significant at the $p > .05$ level. Within-person correlations between the frequency and other experience items are undefined due to survey branching. For the between level, the estimated min/max values could slightly exceed the nominal scale values (1 to 7) because of the latent variable method used by Mplus to estimate between-level means (see Lüdtke et al., 2008).

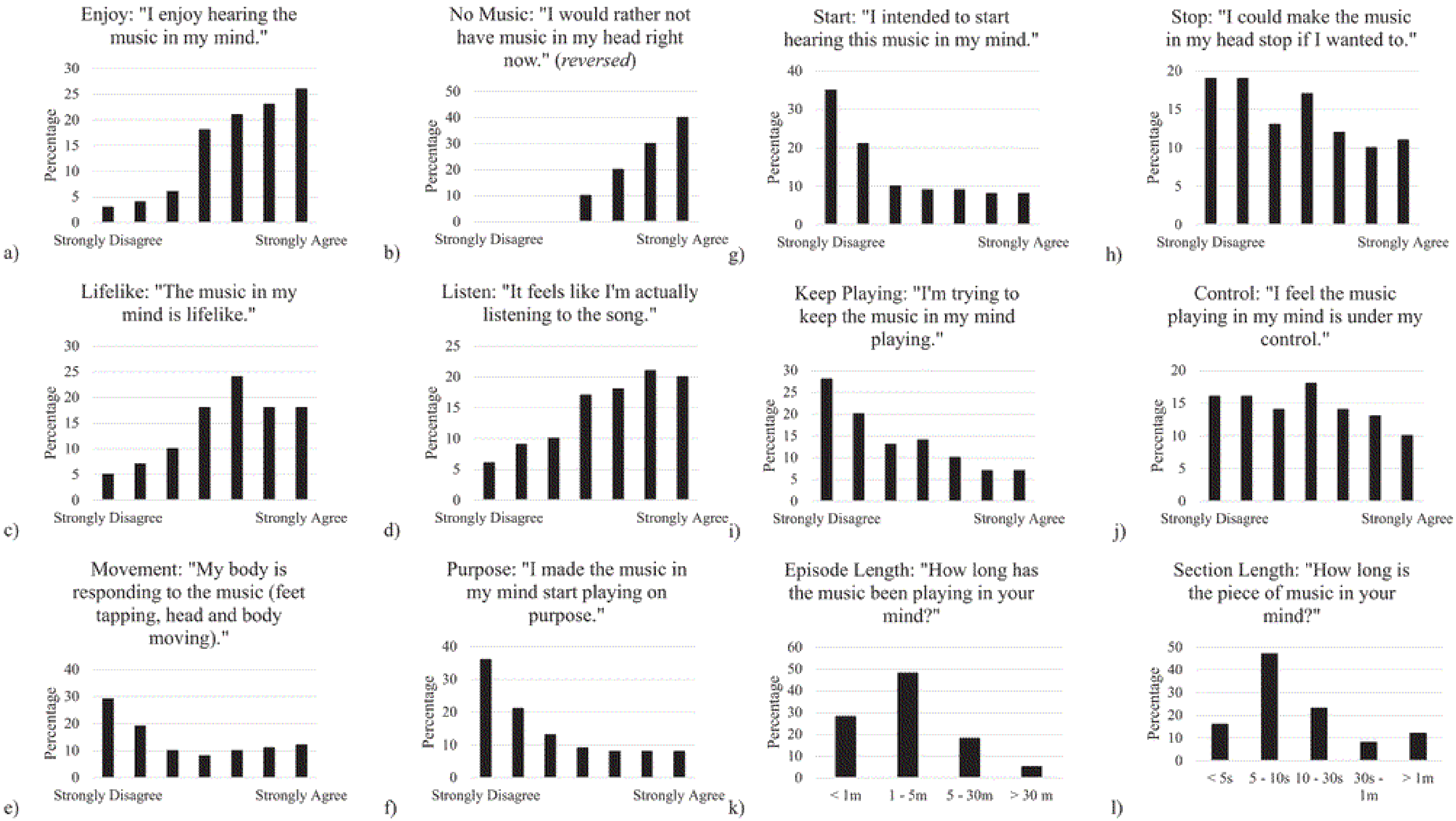

Figure 1. Within-person distributions of musical imagery items.