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Musical Activities Predispose to Involuntary Musical Imagery

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ABSTRACT

Involuntary semantic memories are a new topic in psychology. Initial research has suggested that musical memories are a dominant type of involuntary memories. Interestingly, no comprehensive information exists on the commonality of "earworms", or repeated involuntary imagery of music (INMI), and its relationship to the engagement with musical activities. Present study investigated these using cross-sectional, retrospective reports from a questionnaire study that was conducted among Finnish Internet users (N=12,519). The analyses of the data revealed that 89.2 % of participants reported experiencing this phenomenon at least once a week. The amount of music practice and listening was positively related to the frequency of involuntary music. Women reported elevated levels of involuntary imagery episodes in contrast to men who reacted differently to it. In older age groups the frequency of the incidents decreased among both sexes. People with extensive musical practice history seemed to experience longer musical segments and more often instrumental ones. They were less agitated by involuntary music and reported it less often. The results are discussed in a relation to a memory-based hypothesis of involuntary musical imagery. In conclusion, INMI is viewed as an integral part of our musical mind.

INTRODUCTION

Research investigating human musical abilities often focuses on the production and perception of sound. But beyond the basilar membrane, there exists a mental soundscape audible for our "inner ear" that is accessible using musical imagery. Recent studies show that auditory perception and imagery share many neural resources and have great resemblance in terms of structural and temporal features (Hubbard, 2010). This highlights the role of imagery as a central feature of music cognition and calls for deepening the understanding of the function and characteristics of musical imagery.

In music psychology, three forms of musical imagery prevalent in daytime consciousness have been studied: voluntary, anticipatory and involuntary imagery. Voluntary imagery (Halpern & Zatorre, 1999; Zatorre & Halpern, 2005) is a universial ability to recall a musical memory. Voluntary imagery can be honed into a skill, called audiation, which is commonly utilized by professional musicians for training purposes (Brodsky, Kessler, Rubinstein, Ginsborg, & Henik, 2008; Lotze, Scheler, Tan, Braun, & Birbaumer, 2003).

The second type is anticipatory imagery. It occurs in parallel to perception when the features of an ephemeral incoming sound stream are predicted based on prior experience.

This ability can be revealed when expectations for a sound are violated; this effect has been reliably demonstrated in recent studies in cognitive neuroscience (Leaver, Van Lare, Zielinski, Halpern, & Rauschecker, 2009; Rauschecker, 2001).

The third type is involuntary musical imagery. It is commonly known as "earworms" or the "tune in the brain" phenomenon and refers to a non-clinical condition of unintentionally reviving the auditory image of a tune (Bailes, 2007; Brown, 2006; L. A. Liikkanen, forthcoming; Sacks, 2007). Involuntary musical imagery intrudes consciousness without deliberate effort and often in repetition. It is neither an automatic response because can occur without an immediately preceding musical stimulus, but nor is it spontaneous because it can also be triggered by external events. This involuntary musical imagery, or INMI as it abbreviated here, is the subject of this paper.

I claim that INMI is an under-investigated topic. This far there have been no extensive studies probing the nature of unintentional musical imagery. The preliminary results suggest that INMI is real and widespread phenomenon, however, the influence of music listening or practice to the characteristics of INMI experiences are not understood. This lack of scientific knowledge shows off in popular literature. Beaman and Williams (2010) point out the wealth of popular discussion on the topic is full of unwarranted anecdotes and non-referenced facts. The goal of this paper is to clarify this situation. As a starting point, the widely used label "earworm" is discarded in this paper in favour of a more explicit term. For a scientific discussion, a specific term is desired. Explanations in cognitive musicology refer to the mind and the brain, and the terminology should as well. Earworm hardly meets this requirement and could be even considered misleading.

There is motivation to study INMI. For one, there exists a spectrum of clinical conditions that show features akin to INMI. They are called musical hallucinations (or hallucinosis; Cope & Baguley, 2009; Evers & Ellger, 2004; Hermesh et al., 2004) and musical obsessions, a subtype of obsessive-compulsive disorder (Dattatreya & Chittaranjan, 2009; Terao & Ikemura, 2000; Zungu-Dirwayi, Hugo, van Heerden, & Stein, 1999). However, there are no published guidelines for clinical psychologists or psychiatrists as to how to discriminate between normal and excessive musical imagery. Second, there has been progress on related topics in the field of general psychology recently. Researchers have successfully studied involuntary semantic memories (Kvavilashvili & Mandler, 2004) and induced autobiographical involuntary memories experimentally (Mace, 2005, 2007). There has been considerable progress in investigating the similarly private phenomenon of synesthesia (Kadosh & Henik, 2007).

Related work

Psychological interest in involuntary music was likely first recorded by Freud (Freud, 1911, p. 140). He had a more musically inclined successor in the psychodynamic tradition: Reik (1953), who discussed the phenomenology and possible functions of INMI. The shared belief between Freud and Reik was that involuntary music carried hidden meaning for one's psychic life. Reik postulated the existence of a "mundane" type of involuntary music, but did not find it worthy of examination. Since then, psychology has embraced behavioural and cognitive paradigms and more oriented toward the study of "mundane" phenomena.

A view of INMI as an everyday phenomenon has emerged since 2001 through a series of independent studies. The first two studies that assessed INMI in retrospect were a survey among 587 college students (Kellaris, 2001) and another involving five hundred young Internet users worldwide (Bennett, 2003). These studies were presented as conference talks and together, along with a longitudinal study (Bailes, 2007), suggest that a person living in a Western country experiences involuntary music almost every day. The surveys (Bennett, 2003; Kellaris,

2001) found that background characteristics such as sex (being female), young age, and active musical hobbies predict more frequent INMI episodes. The Kellaris' study found that students employ three types of coping strategies to stop INMI: distraction, replacement, and miscellaneous tactics. A more recent survey correlated personality traits with the INMI characteristics(Kellaris, 2003; 559 students). It showed that an increased level of neuroticism correlates positively with a high retrospectively reported frequency of INMI. The same relation holds for transliminality, a measure of susceptibility to self-generated mental events (Baruss & Wammes, 2009; N=67), which predicts more distraction by INMI.

The nature of INMI episodes and coping strategies were addressed in a recent study (Beaman & Williams, 2010). Using survey and diary methods, the researchers found that INMI is a recurrent and highly idiosyncratic experience. Among twelve fortnightly diary keepers, the average duration of an episode was just below half an hour. This was shorter than the average time reported by 103 separate survey participants, suggesting a reporting bias. The two methods produced similar findings about the coping strategies. The general displacement strategy (i.e., keeping busy on whatever is at hand), and displacement with music strategy were the most common. The use of coping strategies did not reduce the number of the episodes. The authors interpreted this as compatible with the Wegner's (1994) theory of ironic mental control which predicts that conscious efforts to avoid a mental activity may instead achieve the opposite effect.

There have been recent attempts to induce INMI experimentally. Induction with "catchy" music was tested by presenting five stimulus songs and keeping a diary for the following three days (McNally-Gagnon, Hébert, & Peretz, 2009). With small groups of musicians and non-musicians (18 each), 47% participants experience at least one of the songs and these successfully induced songs were usually familiar. Another study employed a shared CD full of music as priming stimuli. The CD was provided to 59 participants, who described their experiences in an interview after 1-6 weeks of listening to the CD at their convenience (Hemming, 2009). The findings indicated that emotionally distinctive pieces, regardless of the valence, were experienced more often than those without an emotional association. The INMI episodes occurred even after a considerable time had passed. INMI episodes did not differ significantly between the musician and non-musician groups. In another study (Liikkanen, forthcoming), I used five stimulus songs to induce INMI through an imagery-based recall task. I found that the song presented last had an elevated probability of producing an INMI, but only if the music was familiar. The results were interpreted as weak evidence for a recency effect for INMI, but strong evidence for long-term musical memory activation as a mediating mechanism.

Present investigation

The current study attempts to shed more light on the characteristics and precursors of INMI. A large-scale, cross-sectional study was designed to overcome several limitations of the previous investigations. The study aims to minimize the sources of retrospective reporting bias and therefore discards a number of questions included in previous studies, such as the duration of INMI experiences. The primary research questions are: how often do people experience INMI? What are the typical characteristics of an INMI experience, what is the subjective experience (i.e. phenomenology) like? The secondary research question is: can background characteristics such as musical activities and training be used to predict these experiences? The pioneering studies (Bennett, 2003; Kellaris, 2001) have indicated several factors that may contribute to the frequency of retrospective INMI. These findings led a set of hypotheses for this study.

The first hypothesis generalizes the previous research and claims that it is "normal" to experience INMI at least sometimes (>50% people report it; H1). The second hypothesis is based on Kellaris (2001) and Bennett (2003)

who claimed that women experience INMI more frequently than men (H2), although Beaman and Williams (2010) did not observe this in their sample. Kellaris (2001) and Bennett (2003) also suggested that both the amount of daily music listening (H3) and the amount of daily music practice (H4) increases the frequency of INMI. Additionally Bennett (2003) had found that left-handed people experience INMI more frequently than the right-handed (H5), and that INMI experiences are more frequent among young people (H6). Finally, both Hemming (2009) and Bennett (2003) claimed that the perceived emotional loading of song makes it more or less likely to produce INMI, and the hypothesis in this research is that people who find INMI irritating report it more often (H7). Bennett (2003) also proposed ethnic background as a predictor but this factor was not explored in the present study due to cultural context.

The present study also asks previously unexplored questions. I wanted to explore the frequency proto-musical behaviours (humming, tapping, and whistling) to INMI, understand the consequences of experiencing INMI, explore the sensitivity to external stimuli to INMI (in contrast to sensitivity to endogenous events, i.e. transliminality), and to learn about subjects' language learning history to examine if INMI serves as a mnemonic

The present investigation was implemented using an online survey. This administration method was considered appropriate because there was little reason to expect that the Internet use, or technology use in general, would be associated with the experiences of INMI. This method was also deemed appropriate because at the time of the study broadband Internet connections were already utilized by 75% of target population (Finnish people) at least weekly (Harala, 2007). Recent publications in psychology and musicology demonstrate the usefulness of Internet-based data acquisition tools (Honing & Ladinig, 2008; Nosek, Banaji, & Greenwald, 2002; Skitka & Sargis, 2006) supported the suitability of the sampling method.

METHODS

An electronic questionnaire called *Music in Mind 2007* was created to gather INMI relevant data from Finnish Internet users. The design was based on the previous studies, but items were focused on topics that were considered meaningful and reliably reportable. The questionnaire was publicly accessible online for three months starting from April. Recruitment occurred by the "snowball" method. Initially respondents were recruited from universities across Finland via email. Each respondent was encouraged to promote the study to their personal contacts. This technique was used to attract participants from other educational and social classes. Subjects could participate anonymously, and were invited to provide contact details if they desired to participate in a raffle of three record store gift certificates (20€ each). The study included a consent document and debriefing information about the intent of the study, emphasizing the confidentiality of the information, and security procedures in research data handling.

The study began by extensive piloting, first on paper (informants N=30) and then online (N=1555). The final survey instrument was clustered into seven sections presented in the following order: (1) musical background, (2) the experimental manipulation and (3) personality survey (both sections serving as filler tasks for the purposes of this study), (4) questions about involuntary memories (including music), (5) question on the characteristics of INMI experiences, (6) experience sampling of potential imagery stimulated by section 2, and (7) personal background. This paper focuses on the experience of INMI, which was elaborated in the fourth section. To demonstrate an INMI, a reference was made to a task utilizing voluntary musical imagery presented in section (2). The details of (2) and (6) are omitted from this report (see L. A. Liikkanen, forthcoming). The questionnaire included over 50 items and was administered in Finnish. The original instrument

is available from the corresponding author by request.

The majority of the items were presented with Likert-scale response options and only six open-ended questions were included. The scales were initially derived from the previous studies, but they were adjusted after the pilots. Adjustments were needed to achieve more normal distributions for the background variables (e.g. the daily amount of music listening category "over 2 hours" was split into two, "2-6" and "over 6").

The section on musical background included questions about passive and active musical hobbies, the length of musical practice, musical behaviour and music technology use. All questions regarding behaviour specified behaviour over the past couple of months. Involuntary memory questions addressed the 'peskiness' and frequency of involuntary semantic memories (Kvavilashvili & Mandler, 2004) in multiple domains. In the section about INMI characteristics, subjects were asked about the valence of INMI experiences, the type of music, the typical situations and consequences of INMI in everyday life. The background section included questions of sex, age, handedness, hearing, answering location, and tinnitus. In this part, participants could optionally include their contact details. Additionally, the IP address, response times, and date and time information were automatically recorded for each subject.

Data analysis

The survey yielded a considerable amount of data some of which are reported here (the rest of the findings can will be available in L. A. Liikkanen, forthcoming). The main dependent variable analyzed here is the retrospectively reported frequency of INMI experiences during the last two months. During the period of the study, a small number of questions were removed or added, producing differences in the sample size, which are denoted in the results. Several statistical tests were conducted to test the hypotheses and explore associations between the variables. Non-parametric tests were preferred because the data were mostly measured on an ordinal or nominal scale. Further, I observed issues with heteroskedasticity . For proportions, binomial tests were complemented with 99% confidence intervals to compensate for the number of explorations and reduce type I error. All statistical analyses were computed using SPSS and Excel for Windows.

RESULTS

Participants

During the three month data collection period, 12,519 complete responses from distinct IP and email addresses were stored at the University of Helsinki web server. Although only complete submissions were accepted, it became evident that some exclusion criteria were needed. These were defined as follows: the total response time is above 3 minutes and below 30 minutes, open questions in the experimental section are answered to indicate task comprehension, and that there is some variation in the Likert-scale responses throughout the questionnaire. Application of these rules reduced the sample by 609 cases. The application of time limits was the most important filter, taking out 61.6% of the disqualified ones. The time thresholds were based on original time statistics (M= 12.3 min, SD = 37.6 min) that were changed after the filtering (M = 9.9 min, SD = 4.4 min).

The background characteristics of the 11,910 included cases are displayed in Table 1. The respondents were primarily female (68.4 %) and on average 27.8 years of age (SD = 8.4 years). The participants were generally right-handed (89.5 %), experienced no tinnitus (58.9%), and 7.6% reported hearing disabilities, neurological dysfunction, or the use of medication affecting the central-nervous system. Subjects were dominantly city dwellers (88.0 %) and less than a third (31.9%) had an identified association with university (staff or students).

TABLE 1 HERE

The subjects were generally musically oriented and active. When asked about the last two months of activity, over 98% of people had been listening to music at least every week and almost half (49.9%) had been practicing music on a weekly or daily basis. 49.4 % of the subjects reported a period of at least one year of music practice during their lives. These figures are somewhat higher than those reported by Finnish National Statistics Centre (91 % for weekly listening and 19 % for current practice; see M. Liikkanen, 2009). This indicates that musically active people were over-represented in the sample. *Musicians* were defined as those who reported over a fifteen year period of continuous musical practice (27.7 % of the sample). Musicians were equally prominent among both sexes (28.5% and 27.3%, men and women respectively; $p > .1$). The majority of the respondents indicated awareness of some "protomusical" spontaneous behaviors, singing or humming to oneself (92.8%), clapping or tapping to the beat (71.6%), or whistling (50.3%).

Involuntary Music Experiences

The prevalence of INMI within the sample was high. The most commonly reported frequency in the retrospective self-assessment was "everyday" (33.2 %). A quarter of all informants (26.2%) had incidents several times a day, and more than 90 % of all indicated that they had INMI experiences at least every week. These results support the hypothesis H1. The distribution of the responses for both sexes is provided separately in Figure 1. It shows that significantly higher proportion of women reported INMI "every day". This trend was confirmed by a Kruskal-Wallis test (χ^2=35.154, df=1, $p < .001$), which supports H2. From now on, the results will highlight the differences between sexes and the musically trained between when they exist. Additionally, it was found 68.9% of all respondents reported that they had an INMI experience while taking the survey.

FIGURE 1 HERE

Participants reported on different types of involuntary semantic memories. Music was the most commonly occurring form of involuntary memory, as shown in Table 2. The present results resemble those reported earlier (Kvavilashvili & Mandler, 2004), showing the privileged status of music, visual images and words over tactile or olfactory experiences. An exploratory factor analysis (Maximum likelihood estimation, Varimax rotation, eigenvalue threshold 1) did not show a good fit, which suggests that musical memories were not correlated with other types of memories. The best fitting two-factor solution (33% of total variance explained) identified one factor loading smells and odours, and another for images, words, kinetics imagery, and sensations. Musical memories did not load on either factor, implying their independence with regards to other involuntary memory types.

TABLE 2 HERE

Several questions about the phenomenology of an INMI experience were posed, including the kind of music experienced. Familiar lyrical (average 91 %) music dominated over instrumental (26 %; Fig. 2), or new music (16%). Musicians had a higher proportion of instrumental INMI ($p <.001$ for both sexes) and INMI with new music ($p <.001$ for women; $p=.006$ for men; see Figure 2). Men reported experiencing INMI with novel and instrumental music more often than women ($p<.001$ for musicians and non-musicians). The language of the lyrics important, as both foreign and native language song INMIs were experienced frequently (averages foreign 77% and native 75%). Men reported more foreign and less native language song INMIs than women ($p<.001$) regardless of musicianship.

FIGURE 2 HERE

Respondents reported most often experiencing one repeating part of the song (Table 3 top), and musicians tended to hear longer musical segments. Experiencing complete songs was reported by 9.8% of the musicians vs. 7.6% of the non-musicians among both sexes ($p<.001$ for both). Among non-musicians, men reported experiencing whole songs slightly more often when compared to women (8.2% vs. 7.4%; $p<.001$).

As part of the survey, participants described situations in which INMI experiences occurred. The most often nominated conditions were working alone, traveling, and exercising (Table 3 bottom). INMIs did not frequently occur in situations that involved auditory engagement, for example, while conversing.

TABLE 3 HERE

Respondents were generally not annoyed by INMIs. Although the respondents nominated music as the most annoying type of involuntary semantic memory (15.1% of all; Table 2), two thirds of people (63.2%) were not annoyed by any type of involuntary memory. When asked specifically about the nature of musical memories(see Figure 3), only a quarter of the participants choose a negative over a positive term and about half were indifferent to it. Interestingly, the musicians reported little less negative feelings (3.4 percentage point difference; $p=.001$) than the non-musicians.

FIGURE 3 HERE

The impact of INMI on people's daily lives was assessed with eight questions regarding how INMI made them to behave (see Table 4). The participants most often indicated musical activities; such as starting to sing or hum along with the tune. This activity was more common among women than men and among musicians than non-musicians. Other actions taken by the majority of the respondents included listening to or identifying the particular tune, or focusing on something else. For a third of all subjects, INMI seemed to be an incentive for acquiring a recording of the song in question. Interestingly not a single person indicated that they avoided listening to music in response to INMI. Further, men seemed more active in using music technologies in relation to their INMI experience. Men reported acting more often on the experience than women, trying to identify the tune, and acquiring the recording and listening to it.

TABLE 4 HERE

Predicting INMI Reports

Several analysis methods were used to predict individual disposition to INMI. The first analysis utilizes crosstabulation to illustrate how background variables separate the respondents based on the frequency of INMI (Table 5). Each background variable was split into two groups at its median. The resulting high and low groups are significantly different by each background variable; music listening frequency ($\chi^2=669.58$; $df=5$; $p<.001$), current musical activity ($\chi^2=383.29$; $df=5$; $p<.001$), and the length of musical practice ($\chi^2=186.86$; $df=5$; $p<.001$). Dividing the participants by age to four categories (below 25, 25 to 30, 31 to 40, and over 40) revealed different frequencies of INMI reports by category ($\chi^2=240.77$; $df=15$; $p<.001$).

TABLE 5 HERE

Figure 4 shows the relationships between the background variables relevant for hypothesis testing and mean INMI frequency. The relationships of both listening and practice activity to INMI (Fig.4, panels A and B) show how the average INMI frequency increases as the amount exposure through listening or

practice increases. The third graph (Fig. 4, panel C) describing the length of musical practice reveals a relationship that is linear up to the second most educated segment. However, musicians on the top end of the scale report the lowest INMI incidence rate among participants with some history of music practice.

FIGURE 4 HERE

Correlations were calculated next to identify direction of the relationships. Some correlations matching the hypotheses were found, although the associations were not particularly strong, as reported in Table 6. Both hypotheses 3 and 4 were supported. The bivariate correlations show that frequent music practice was more strongly associated with repeated INMI experiences ($\rho = .241$; $p < .001$) than music listening ($\rho = .190$; $p < .001$). The INMI frequency correlated weakly, but positively with the length of musical practice ($\rho = .122$; $p < .001$), but not with the valence of a typical INMI experience nor handedness made a difference, failing to support hypotheses 5 and 7. The correlation of the length of musical practice to INMI was not linear. If the subsample with the greatest amount of practice, the musicians, did not fit the trend and they were removed, the overall correlation increased slightly to .157 (for both $p < .001$). Age (continuous, not categorized variable) revealed a weak negative correlation to the frequency INMI ($\rho = -.114$; $p < .001$) in accordance with hypothesis 6.

TABLE 6 HERE

Beyond the hypothesis tests, I sought to relate INMI to some additional variables. This examination showed that the self-evaluated musicality was positively related (Table 6) to the INMI frequency. The ease of learning to pronounce foreign languages (self-assessed on a 6-point Likert scale) was related to the INMI frequency, as was the frequent use of a portable music player (Table 6). Finally, a weak positive connection between INMI and tinnitus frequencies was observed ($\rho = .073$; $p < .001$).

It is evident that the background variables are not independent of each other. Table 6 reports this, for instance, length of musical practice and active musical practice were moderately correlated. There was also heteroskedasticity in the distribution for age and the length of musical practice, as the younger respondents reported more practice than the older. For this reason, the bivariate correlation measures were complemented with partial correlations, which control for the effects of the related background variables: age, active practice, length of practice, and listening activity. The partial correlations shown in Table 7 reveal some weaker associations and new ones, mostly the length of musical practice and portable music device use are non-significant while active practice, listening, and self-assessed musicality are the strongest links.

TABLE 7 HERE

The final exploration of the data focused assessing the capacity of these background variables to predict INMI. To this end, a regression analysis using a general linear model (GLM) was conducted. The first analysis explored a selection of independent variables in an extensive, full factorial model. Non-significant terms and terms without explanatory power (due to considerable statistical power of the measurement) were removed from the model, including handedness, irritation by INMI, and self-assessed musicality. The final block of factors entered in the model simultaneously were sex, age, musical practice, music listening, and the length of practice. The model included the main effects for each and the interaction of practice and musicality. The resulting model fit is not very overall, (r^2=.128), but reveals several distinctive predictors reported in Table 8. These results were also

confirmed using a multinomial logistic regression model.

TABLE 8 HERE

The analysis shows that sex sets a baseline level for INMI, which is altered by both listening and practice activity. The standardized beta co-efficient for the former is a bit larger. Age demonstrates a slightly decreasing trend to the frequency of INMI, but the effects of length of practice as well as the interaction effects of practice to INMI were negligible in size. Additionally, a model including the covariate "ease of pronunciation" was computed (r^2=.134). Fewer cases available with data for this variable (N=2974). In this model (Table 8, bottom), the self-assessed proficiency in pronunciation is clearly connected to the self-reported frequency of INMI. The interaction effect is difficult to interpret. Based on the estimated marginal means it appears that people with over one year of musical practice have much higher INMI susceptibility, but only if they do not report even the slightest linguistic difficulties, i.e. if they feel troubled with learning foreign language pronunciation their INMI frequency is lower than expected based on their musical practice history.

In summary, these results indicate that there is a lot individual variation and that much of INMI frequencies cannot be explained by the given background characteristics. On the other hand, several statistical tests indicate that listening to music directly increases INMI, while the connection between musical practice and INMI is less straightforward. The study found support for all initial hypotheses, with the exception of handedness (#5) and valence (#7).

DISCUSSION

This paper has presented survey data supporting the contention that involuntary musical imagery is a widespread experience. Using multiple statistical analyses, it was shown how different background characteristics and musical activities predispose people to INMI. Involuntary music imagery is a prevalent not only among college students (Kellaris, 2001) and music graduates (Bailes, 2007), but in a large sample of young Finnish Internet users. The reported frequencies of INMI were correlated with musical activities and modulated by the length of musical practice. These findings are of direct interest for musicologists and cognitive scientists, but also to remote topics such as musical hallucinations and obsessions (Cope & Baguley, 2009; Praharaj et al., 2009) in biological psychiatry.

Music was found to be the dominant type of semantic involuntary memory. The majority of survey respondents experienced involuntary music every week. In addition to considerable individual variation, several factors associated with increased frequencies of INMI were discovered. These findings confirm some, but not all, of the connections from the previous studies (5 out of 7 hypotheses). The partial correlations and regression analysis showed that retrospective INMI frequency was most significantly and positively affected by the amount of active music practice, followed by listening activity, although neither of these connections were very strong. Both these factors involve active processing of music. This evidence is most compatible with a theory of INMI as a memory-based phenomenon. In this account, involuntary semantic memories emerge through activation in cross-domain semantic networks (Kvavilashvili & Mandler, 2004; see, Mandler, 1994; Liikkanen, forthcoming). That is, the repeated processing of musical memories leads to prolonged high activation levels within a music-relevant memory network. This increases the likelihood that these memories might pop into mind unintentionally later on. Considering the negative results, handedness and attitude towards INMI were unrelated to the INMI frequency. This seems natural as particularly handedness is not strongly associated with the function of musical memory. Despite some beliefs expressed in popular discussion, our respondents did not generally describe INMI in negative terms. The language

of lyrical music did not affect the capacity of music to evoke INMI, songs in native and non-native languages were mentioned equally often.

The history of musical practice and current practice activity were found to affect on the phenomenology of INMI. People who had been practicing music for over 15 years (musicians) reported fewer INMI experiences than people with less practice. Musicians were also less irritated by the phenomenon and tended to experience longer segments and more often instrumental pieces of music than non-musicians. This suggests that extensive musical practice may promote cognitive skills and strategies, possibly related to intentional imagery, that provide control over the imagery, making INMI less irritating and less frequent.

Alternatively, if INMI were related to human learning processes, such as the consolidation and maintenance of memories, then musicians with superior memory skills of might be expected to experience INMI differently. If music memorization and assimilation occur effortlessly, involuntary memory experiences, or any underlying functional mechanism producing them, might become less necessary if not redundant and the frequency and phenomenology of the experiences altered. It is unlikely that musical training alone constitutes a complete explanation. People with long-term musical involvement may differ from non-musicians in many other aspects, musical and non-musical alike, so the differences in INMI may be collateral rather than consequential. The present study was correlational rather than causal so it is impossible to tell how current or past practice influence INMI experiences without an experimental or longitudinal study. An alternative explanation might be that the sheer volume of voluntary imagery exercises and music practice constraints opportunities for involuntary experiences to occur.

Age and sex played an interesting role in INMI. Older people reported fewer INMI experiences even if music listening and musical activities were controlled for. This was expected based on previous research (Bennett, 2003; Schlagman, Kliegel, Schulz, & Kvavilashvili, 2009). Gender differences were prominent in the frequency of INMI but also with regards to phenomenology of and the responses to INMI. For men, the experiences seemed to include more instrumental, new, and foreign music, and less vocal music in native language in comparison to women. To my knowledge, to present study is the first attempt to explore INMI in relation to the acquisition and using music technology to try to manage INMI. This is an interesting corollary to the present Walkman and iPod society (Bull, 2008). The higher mean frequency of INMI experiences among women begs the question that if this difference is real, what is behind it; emergence, perception, or reporting difference? Does female brain generate more of these experiences, do women report them more often, or are females more sensitive to this phenomenon, i.e. are high on transliminality (Baruss & Wammes, 2009), but report experiences accurately? The possible sex difference in transliminality should be investigated in future studies, as the Baruss and Wammes (2009) study mentioned sex as a factor "close to being significant" in a MANOVA test.

One can pose several questions about the validity of the findings. First, the data have a known sampling bias in that an unusually high proportion of musically inclined young individuals were included. However, based on lowest quartile splits (unreported) and the median split shown in Table 5, the differences between musically active and passive people are subtle changes in the mean responses. It is possible that the people who actively rehearse music report more INMI experiences in retrospect because they are more interested in music generally and thus pay more attention to it. There is a general caution towards retrospective self-reports because they tend to biased (Wells & Olson, 2003). This applies to INMI too (Beaman & Williams, 2010). In this study, the details about the phenomenology of "typical INMI experiences" are most vulnerable to this kind of bias (e.g. Tables 2, 3, and 4). It is uncertain whether everyone can recall features

of these experiences accurately later on as they have not had any particular reason to pay attention to them at the time of occurrence. The countermeasure here was to ask people to respond based on their most immediate experiences.

There is a multitude of open questions for future INMI research. This study documented the INMI experiences among Internet users in one country with a rather ethnically homogeneous population. If INMI is driven by an integral psychological mechanism, then the experience should be shared universally. It would be desired to extend the cultural boundaries within and outside the Western world for future studies. Possible bias in retrospective recall indicates a need for methods that tap on to the experiences immediately. The present study discovered several background variables that associated with INMI frequency without an evident reason. For instance, self-assessed musicality was not very strongly correlated with the length of musical practice. This poses a question is there an uncharted musical capacity to be found in future, e.g. a "gene for musicality" (see Ukkola-Vuoti et al., 2011)?

In this paper involuntary music imagery has been equaled with involuntary musical memory. The question remains are these two distinct or parallel phenomena, is there a conceptual difference? Factor analysis suggested that involuntary musical memory was not strongly associated with the other types of involuntary semantic memories. This could be a question for new studies to investigate; do different types of involuntary semantic memories hold different characteristics? Is music a special cognitive domain, more capable of capturing our consciousness than the other memory domains? If the dominance of musical memories over other types were indeed demonstrated, what conclusions might we draw from its importance? Does involuntary music serve a significant psychological function or is it mere epiphenomenal byproduct, like Pinker referred to as an auditory cheesecake? (Pinker, 1997) The weak link to linguistic ability could suggest an evolutionary hypothesis on the usefulness of INMI as a mnemonic device, a tool for acquisition and recall of knowledge embedded in music, or just in learning of a prosodic lexicon. Or are these results a consequence of Finnish music consumption habits, where foreign and native tunes are both prominent?

In conclusion, the present study found involuntary music to be a widespread feature of our daytime consciousness. Higher frequencies of INMI experiences were associated with musical activities, practice and listening, but also with being female. Consisten with evidence from previous investigations (Bailes, 2007; Baruss & Wammes, 2009; Beaman & Williams, 2010; Hemming, 2009; Kellaris, 2001), INMI appears to be a highly individual phenomenon. The attempts here to statistically model it left much to be desired. Most of us experience INMI, but the frequency and phenomenology vary. INMI occurrence seems to be dependent on musical activities and personal disposition, but the phenomenology is affected by the musical contents processed in the past – i.e. the future of your involuntary memories lies in your past and present musical activities. For the small proportion of individuals disturbed by the phenomenon reducing musical activities might well alleviate the frequency of involuntary musical episodes.

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