How the mind is easily hooked on musical imagery

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ABSTRACT

Recent studies show that nearly all people living in western societies are affected by involuntary musical imagery, or "earworms". It has been suggested that prior exposure to music is an important predictor of this phenomenon. In comparison, cognitive psychologists use the concepts of recency (serial position) and the priming effect (brief exposure) to describe similar memory features. The aim of this study was to explore the dynamics of involuntary musical imagery in relation to these memory concepts. Two experiments and a novel experimental manipulation to induce the experience were designed to investigate the topic. The experiments utilized a modified musical image scanning task to cue long-term memory and an experience sampling tool to collect data. The first experiment piloted the induction method and screened the stimuli. The second experiment tested a set of hypotheses using five between-subjects experimental groups. The first experiment demonstrated that among 1111 participants familiar with the songs, the induction procedure evoked involuntary musical imagery in 67.1 % of the cases. The second experiment included older songs and was less effective (49.6 %) in evoking the phenomenon (N=6653). There were considerable differences between the songs, but these were very song-context dependent. A recency effect was also discovered.

I. INTRODUCTION

It is a mystery for music psychologists why people get tunes, or so called earworms, caught in their head. Recently this phenomenon has been discussed in relation to musical imagery (Sacks, 2007), which has been extensively studied using behavioral and brain-imaging methods (Godøy & Jørgensen, 2001; Halpern, 1988, 2001; Kraemer, Macrae, Green, & Kelley, 2005; Zatorre & Halpern, 2005). These studies have shown that perceiving acoustic stimulus as music and imagining an auditory event with musical properties both evoke similar brain activation patterns and have similar characteristics, for instance, duration and temporal structure.

Despite advances in understanding voluntary imagery, the nature of involuntary musical imagery (INMI) has received very little attention. Only recently some investigations have shed light on the experiential aspects of INMI, such as the quality, frequency, and pervasiveness of the phenomenon (Bailes, 2007; Baruss & Wammes, 2009; Kellaris, 2001; Liikkanen, 2008). However, there are still many interesting and difficult questions about INMI For example, what causes INMI, why does it exist, is it culture dependent, and how does it exactly emerge as a part of our daily life. Even though many of them will likely remain mysteries for many years to come, I believe the time has come to try to unravel some of them right now.

Related studies of involuntary semantic memories (Kvavilashvili & Mandler, 2004) propose that exposure to stimuli over a long-term plays an important role for these kinds of memory-features and consciousness phenomena. On the other hand, anecdotal reports and some preliminary research (Bailes, 2007) suggests that our brain tends to loop the latest tune processed. This implies the existence of a strong recency effect for INMI. However, hypotheses concerning musical involuntary memories have not been proposed or any scientifically tests reported. Thus all talk around the topic is more or less speculation. In this paper, my attempt is to push the state of the art on the matter. I will present an exploration of how arising INMI experiences are related to preceding activation of musical memory. I further attempt to demonstrate the viability of a quasi-experimental method in dealing with INMI, since some sort of experimental approach is definitely needed to probe the relation of musical activity and INMI.

The primary reason for why INMI studies have taken such a long time to emerge is probably due to the nature of the phenomenon. Being a potentially unstable mental state, it does not pose an easy subject for modern psychology which seeks to reliably quantify mental function. If the data of interest is accessible only by verbal report this renders the topic very challenging by the standards of many experimental psychologists. However, I believe that we can study the topic if we apply adequate care to the experimental design and can produce an adequate amount of independent measurements. Ultimately, the tools of modern biological psychology might be able to overcome the present deficiencies if we could establish some indices of brain activity, for instance, that provide high correlation with an ongoing INMI experience. But in the mean while, other methods need to be explored.

This paper documents one idea that might be used to investigate INMI experimentally. With the intention of examining the relationship of music processing and later experiences of INMI, two experiments involving almost 10 000 Internet users are reported. They both test the experimental method and explore how recent activation of musical material may show up in later INMI experiences.. The intention is to gain new information about the dynamics of INMI experiences.

A. Possible accounts of INMI

Although the current study is an explorative one, I present some background as to why the experimental material was chosen. In general, one might argue that there are two different accounts of INMI. First, this experience could be mostly due to the musical characteristics of a song, jingle, or rhyme. This would mean that this kind of music somehow scratches our brain and causes it to involuntary reproduce the stimulus (cf. Kellaris, 2001; Kellaris, 2003). Second, INMI might be linked to the qualities of cognition, rather than to those of music. Maybe it does not matter what sort of input our musical processing brain receives, as long as it is able to perceive it, capture, and imagine it. This would lead us further to investigate the nature of musical memories, or representations. We might argue, for instance, that the most recently acquired or activated memories are most likely experienced as INMI (cf. Bailes, 2007; Kvavilashvili & Mandler, 2004). This is here labelled as the recency INMI. These two accounts may not be mutually exclusive but they serve as a two distinct viewpoints for the study and the interpretation of the acquired data.

In order to assess the merit of these two accounts, we need to experimentally manipulate both the relative recency of exposure and musical characteristics. In the following, I will describe how this was done in this study.

B. How to study INMI

To explore the accounts of INMI we need a method to produce empirical data. Here I introduce a method used to induce INMI experiences. The method combines two ideas: cued-recall and anticipation. Cued-recall (e.g. as in Nobel & Shiffrin, 2001) is a psychological paradigm for facilitated recall of memories. For INMI induction, its value is also in facilitating recall. Anticipation is very important for music and refers to predicting, recalling, and experiencing music, even in the absence of stimulus (Levitin, 2006). Anticipation has also been previously successfully applied to demonstrate implicit musical memory access during a perceptual music task (Kraemer et al., 2005). This implies that there are mechanisms that might facilitate the induction of INMI.

These two ideas were combined in the form of a modified musical image scanning task (Halpern, 1988) with the intention to activate the musical memory and evoke an INMI experience. The task itself required the participants to complete lyrics for several catchy, popular songs (try mentally continuing *Obladi oblada…* for instance). This method involves retrieving information about musical memories through imagery. Because this musical activation is based on imagery, it controls for numerous variables, acoustic and musical, that are present in music listening. This procedure also reminded the subjects about the nature of musical imagery and allowed controlling for familiarity with the songs. The catchiness of music is a difficult parameter to define and control. In the present study, I relied on a pool of pilot data to find songs people had recently experienced as INMI. This operationalized the assumption that catchiness might be a musical property that makes music more likely to produce INMI.

An issue for piloting the experimental method was that INMI is still a poorly understood and potentially very unstable research topic. To minimize experimental artifacts we used single-trial design and took care to disguise the experiments' real intent, INMI induction, from the subjects. For these reasons the experiment was implemented in an electronic medium over the Internet to gather a large, cross-sectional sample. Of course, a web-based experiment requires attention to misuse and technical outliers, increasing the drop-out rate. However, it also provides additional control over the instrument and has become generally accepted both among psychologists and musicologists (see Gosling, Vazire, Srivastava, & John, 2004; Honing & Ladinig, 2008; Skitka & Sargis, 2006). This suggests that the potential gains exceed the risks in data acquisition and support the adaptation of the method.

II. METHODS

A. Participants

The recruitment process started among students in several Finnish universities. They were contacted by email and urged to participate in the "Music in Mind 2007" study accessible at university's web server (see Liikkanen, 2008). After the participants had completed the experiment, they were given the opportunity to invite their personal contacts via email. This option was used several thousand times and expanded the sample beyond university boundaries, so that eventually over 11,000 Finnish Internet participated voluntarily. The mean age of subjects was 28.0 years (SD=8.7), ranging from 8 to 75 years. The total sample included pilot users (N=1553) and incomplete responses. Experiments 1 & 2 together involved 9967. The heterogeneous participant pool was divided between experiments (2172 for Exp. 1 and 7795 for Exp. 2) and experimental groups based on the entry date. The respondents were predominantly female (69%), 89% of the participants were right-handed, 29% were university staff or students, and 8% were suffering from hearing loss, neurological disorder or were currently under medication affecting the CNS.

B. Materials and Procedure

A pilot study started the investigation. It tested potential items and scales, and urged people to describe their most recent INMI experiences. The pilot involved more 1500 subjects distinct from subjects who participated in the Experiments 1 and 2. The input from pilot was used to prepare the instrument and materials for the two following experiments, which followed immediately after the pilot phase was completed. Both the pilot and the experiments were organized over the Internet.

To induce INMI, a musical image scanning task facilitated with cued-recall was used. In the task the participants were instructed to complete the next three words of lyrics for five Finnish songs (the stimulus sets), presented in a serial order. Each song was initialized using four or five distinctive words either from the beginning of the song or from the chorus. It was emphasized that the lyrics should be filled in as (or if) remembered and verbatim recollection was nonessential.

Testing the two accounts required an application of an experimental manipulation. The recency and musical characteristics assumptions were evaluated by changing the presentation order of musical cues. A recency effect would be revealed by the serial position curve, but if musical characteristics were important, serial position effects would be diminished and the catchiest song should consistently stand up.

The experiments had a six-part sequence illustrated in Figure 1 and proceeded without a time quota. At the start, the participants were briefed regarding the general purpose of the study, the ethics of data usage, and were asked to provide consent for participation. In the second phase the subjects provided information about their past and present musical activities. This was followed by a memory induction task (third part). In the fourth phase of the trial, subjects spent approximately four minutes completing a filler task, which included questions about personality and involuntary semantic memories. This was followed by an experience sampling phase, in which the respondents were asked if they had experienced

INMI during the current or previous phases (see e.g. Baddeley & Andrade, 2000; Teasdale et al., 1995). If this had occurred, they were asked to identify the song. In the final phase, background information was gathered and the subjects were debriefed.

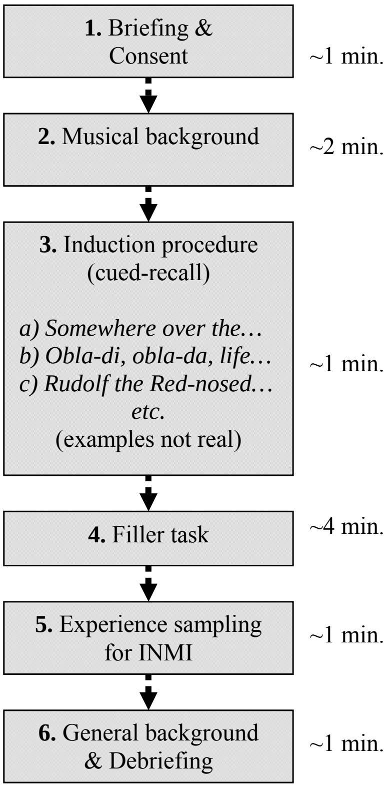

Figure 1. Flowchart of the procedure used in Exp. 1 and 2.

The cued songs for Experiment 1 were selected from the pilot study INMI reports. Repeatedly nominated contemporary songs were chosen in an attempt to control for song catchiness. In addition, a well-known classic tango was selected as a control item. The recency effect was investigated using experimental groups with a variable presentation order. Experiment 1 involved only two groups and the order of the songs was simply reversed between them. For Experiment 2, five experimental groups were created. In the stimulus set, four contemporary songs were replaced by more classic ones, including older pop songs, tangos, and the Finnish national anthem. The stimulus sets were created by a list-wise permutation of these songs, so that every song appeared once in each serial position, relative locations fixed (first set: ABCDE, second: BCDEA, etc.). The subjects were assigned to the groups pseudorandomly and data were collected until at least 1000 (Exp. 1) or 1400 (Exp. 2) responses had been acquired.

C. Analysis

Before data analysis, the data were inspected and refined applying several rejection criteria. These terms included unrealistically short or long duration of experiment (less than 2 minutes or more than 30 minutes), repeated entries from the same individual, semantic signs of mischief, unrealistic response styles (the lack of intra-individual variation between items). Finally, the familiarity with the songs was controlled by including only subjects who had correctly completed lyrics for at least four of the five songs presented.

The measured variables included a familiarity index and the "pop-up" probability for each song, both calculated over all subjects. The familiarity index represented the proportion of correctly recognized songs of all responses. Familiarity on an individual level was not considered because subjects were constantly performing at the ceiling level of the scale. The count of reported INMI experiences during the experiment was transformed into a relative pop-up probability describing how often a particular song among all stimuli induced an INMI experience.

III. RESULTS

A. Experiment 1: Contemporary songs

The average familiarity with the contemporary songs of the first experiment was 71.5%. Combined over all songs, the threshold of four correctly recognized songs reduced the number of eligible subjects to 1111 (55.9% of all subjects). Of them, 67.1% reported experiencing one of the cued songs during the experiment (Fig. 2).

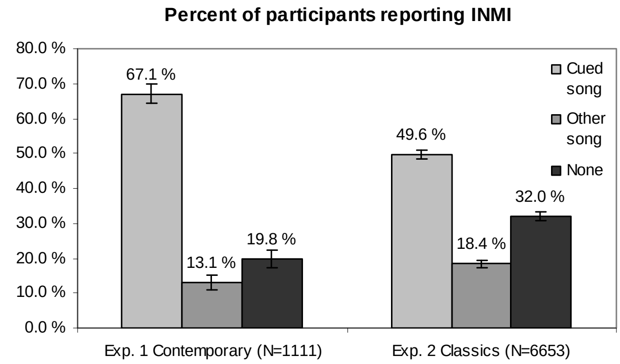

Figure 2. Vertical bars display proportions of people reporting a cued song, or some other song in the experience sampling phase. This indicates the success of induction procedure in the two experiments, involving either contemporary or classic songs. The error bars denote 95% confidence intervals.

Table 1 displays the INMI prevalence of each stimulus song. It reveals considerable differences between the pieces in Exp. 1, without noticeable serial position effect. Thus the imagery task did not evoke a recency effect, but was effective for inducing INMI as the cued songs were more likely to pop up than any other tune. Suspecting that the lack of serial position effects was related to new stimuli (strong prolonged activation effect), the stimulus set was changed for the next experiment.

Table 1. The pop-up probabilities for the different stimuli songs utilized in Experiments 1 and 2. Table indicates average pop-up probabilities for each song across groups and the familiarity index.

	Experiment 1 Contemporary			Experiment 2 Classics	
Song	Familiarity	Average pop-up	Song	Familiarity	Average pop-up
A1	0.617	12.1 %	A2	0.909	3.0 %
B1	0.709	20.0 %	B2	0.926	14.0 %
C1	0.933	21.2 %	C2	0.910	27.6 %
D1	0.715	10.0 %	D1	0.908	49.6 %
E1	0.604	36.8 %	E2	0.908	5.8 %

B. Experiment 2: Classic songs

The second experiment employed an identical procedure, but with five experimental groups. Four songs were replaced with classics to increase familiarity. The old tango from Experiment 1 remained as a reference item. The stimuli songs were better recognized than in the first experiment (average familiarity 91.2%). Among the 6653 qualified participants, an INMI experience was now evoked more seldom than in the first experiment ($p < .001$) and 49.6% of the participants reported experiencing a cued song (see Fig. 2). The difference was not explained by any systematic discrepancy in background variables. There was again a substantial difference between the songs as illustrated in Table 1 shown ($\chi 2 = 93.69$, $df = 16$, $p < .001$; cell-wise data not included in this report), but now also at different serial positions. To visualize this effect, the pop-up probabilities were plotted against their serial positions. This revealed a curve displayed in Figure 3, in which the final song position has non-overlapping 95% confidence intervals with other positions. Hence, this experiment demonstrated a recency effect for INMI.

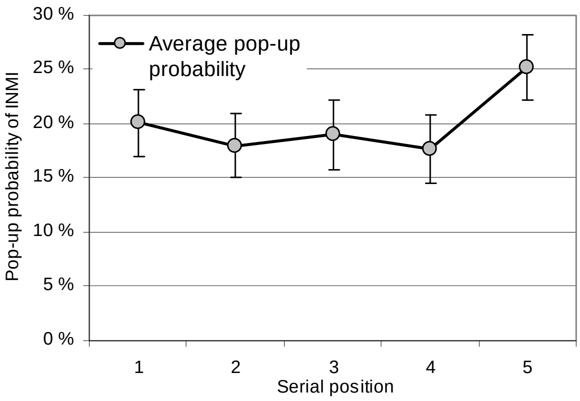

Fig. 3. Results of the second INMI induction experiment. The figure illustrates the average pop-up probabilities across all songs relative to the serial positions. Error bars denote 95% confidence interval for the proportion (N=3290).

IV. DISCUSSION

The results of the two experiments showed that the adopted induction procedure worked quite well, based on the self reports provided by some 9000 participants. In overall, this confirms the generic assumption that processing musical material is an important precursor for INMI.

Several observations regarding the two INMI accounts were made. Across the 9 stimuli songs applied, there were considerable differences in how often they produced INMI. Experiment 2 also provided support for the recent activation hypothesis by revealing the existence of a recency effect for INMI. However, the effect was subtle at only a few percents, in comparison to the 10% differences between the songs. But more interestingly, the newer songs in the first experiment evoked INMI more often than the older ones, even though they were generally less well-known (see Table 1). This suggests that in addition to “short-term recency” we should consider “long-term recency” or some prolonged activation account that might be more powerful predictor of INMI. This would be compatible with the spreading activation account as well (Kvavilashvili & Mandler, 2004).

Do the considerable differences between the songs support the musical characteristics hypothesis? If the musical characteristics were a very strong factor, they would predict that a single song should be completely dominant over the other songs (assuming comparable familiarity). The results of Experiment 1 do not support this prediction, but the second experiment had a dominating song. However, this particular song (D) was included in both experiments with a statistically constant familiarity, but had a high pop-up probability only in the second. Therefore this effect is more likely explained by prolonged activation due to the relative freshness of song (D) rather than by its musical characteristics. Firm conclusion on the matter is difficult, as we could not measure or control the amount of preceding activation or exposure to this music.

V. CONCLUSION

In this study I have documented the first steps towards conducting experimental studies of INMI. One of the most important findings was the demonstration that INMI can be experimentally induced, even though there are so many sources of variance that running the present procedure in a laboratory would hardly be feasible. Here, the large sample size and single trial design made up for the deficiencies of the methodology, but it is obvious that both the induction method, experimental design, and the measurement of dependent variables must be developed much further from the present.

The present study could be criticized for not being very clear about the definition of INMI. Even though the experiment included fairly accurate descriptions and even an example of musical imagery, the reports of conscious states must always be interpreted with caution. Theoretically an important distinction that was neglected here concerns the relation of INMI to other mechanisms of musical mind, particularly anticipation. Future studies should analyse these components and possibly distinguish between different forms of INMI.

On the theory side, the search for testable hypotheses regarding INMI continues. The present empirical data might also be open for new explanations and tests should more predictive theories arise. For instance, the prolonged activation seems to be an important feature that was now neglected. From the tested theories, it now seems justified to conclude that neither the most recent musical activation, nor musical characteristics can solely explain the emergence of an INMI experience. However, studies that can control for musical exposure and combine it to reliable measures of INMI will likely take us far on the topic. Future studies need to consider both measurement and control of exposure, and the quantification of INMI.

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