

Contracting Earworms: The Roles of Personality and Musicality

Georgia A. Floridou^{*1}, Victoria J. Williamson^{*2}, Daniel Müllensiefen^{*3}

^{*}*Department of Psychology, Goldsmiths College, London, UK*

¹g.floridou@gold.ac.uk, ²v.williamson@gold.ac.uk, ³d.muellensiefen@gold.ac.uk

ABSTRACT

The term ‘earworm’ (also known as ‘Involuntary Musical Imagery’ or INMI) describes the experience of a short melody getting stuck in the mind and being heard repeatedly outside of conscious control. Previous studies have examined the relationship between the occurrence of INMI and individual differences, however important questions still remain; the role of personality in particular remains largely unexplored. The studies presented here explored a) the impact of individual characteristics, related to personality and musicality, on INMI experiences (Study 1) and b) different methods of triggering INMI in the lab (Study 2). In study 1, 332 participants completed the BFI (Big Five Inventory) and Gold-MSI (Musical Sophistication Index) questionnaires online and provided information about their INMI experiences (pleasantness, controllability, length, interference, worrying and expunging strategies). Evaluation of the responses indicated that only Neuroticism correlated with earworm characteristics. Earworm frequency correlated with all Gold-MSI subscales (Importance of Music, Perception and Production, Emotions, Body and Creativity) except Musical Training. Two earworm induction procedures tested in Study 2, based on a musical stimulus and on recall of lyrics, were equally successful, regardless of personality traits. The findings of these studies indicate that a) the characteristics of spontaneously earworms (INMI) show a dependence on certain individual personality traits (neuroticism), whereas the deliberate induction of earworms under laboratory conditions does not, and b) the mental process of recalling song lyrics can be as efficient in triggering earworms as listening to music, suggesting that earworm induction may be linked with basic memory mechanisms.

I. INTRODUCTION

The term «earworm» describes the experience of a short melody getting stuck in the mind and being heard repeatedly without the individuals’s will or conscious control. The term derives from the German term ‘Ohrwurm’ and the phenomenon first entered the public domain through the studies of Kellaris (2001) and writings of Levitin (2006).

Earworms constitute a very common phenomenon, which appears to have been around for a long time. Reik (1953), a well-known psychoanalyst, first described the phenomenon of earworms in his book “The Haunting Melody” from a psychological (more specifically, psychoanalytic) point of view. However, earworms as a psychological phenomenon started to be studied systematically only recently.

Various people have used different terminology for earworms. Levitin (2006) refers to the phenomenon as «stuck song syndrome», Sacks (2007) as “brainworms” or “sticky music”, Wammes & Baruss (2009) as «Spontaneous Musical Imagery», while Liikkanen (2012) established the term

«Involuntary Musical Imagery» (INMI). INMI refers to the process of accessing perceptual information from memory, which then gives rise to the involuntary experience of hearing with the “mind’s ear” and which can be subdivided into activation (without attention) and upkeep (consciously).

The reasons why earworms occur are not yet firmly understood, but the features and patterns of their appearances appear to be related to at least three factors: a) the music, b) the situation, and c) the person.

A. Earworms and musical structure

The first factor, which plays an important role in the final “product” of earworms, relates to the music itself. Kellaris (2001) describes the INMI phenomenon as a “cognitive itch” induced by certain musical properties:

1. Repetition within the musical stimulus, which might be a phrase, a motif or a sequence
2. Musical simplicity, such as that found in children’s songs.
3. Incongruity (an unexpected rhythmic variation)

Beaman and Williams (2010) conducted an earworm diary study and concluded that, although simplicity is likely to be an important factor, recent musical exposure to the tune is more important than its musical characteristics.

In a recent study Finkel et al. (2010) established a computational method for examining the common melodic features of earworm tunes as compared to matched control tunes (controlled for artist and popularity). A paper within these conference proceedings (Williamson & Müllensiefen, 2012) details the new method and the future potential to develop an ‘earworm formula’ based on melodic structure.

B. Situation antecedents to INMI

In addition to properties of music itself, the context or the situation in which a subject finds himself/herself can contribute to the formation of an earworm. Situation-related factors include a piece being the first music to be heard in the morning («primacy effect», Kellaris 2003) or the most recently heard (Liikkanen, 2009). Other such factors include an individual liking a tune and the anticipation of a pleasant event like upcoming holidays (Halpern & Barlett, 2011), exercising, traveling and working alone (Liikkanen, 2012), and interacting with people (Bailes, 2007). Finally, Bennett (2002) found that the appearance of earworms was associated with lack of focus and relaxed states.

Williamson et al. (2011) summarized and classified the everyday circumstances of INMI through an inductive, generative, grounded theory-based analysis. These authors uncovered four major abstract categories that describe the situations associated with the onset of an earworm. The first category is *Music Exposure*, which relates to whether the subject was recently and/or repeatedly exposed to music. The second category was termed *Memory Triggers*. Non musical memory triggers include a) Association, where stimuli from

the environment triggered INMI, which could include a person, a situation, a word or a sound b) Recollection, where the experience of the INMI involved retrieval from autobiographical memory, and c) Anticipation of an upcoming event. The third major category was termed the *Affective State* and includes the influence of a) Mood, b) Stress, c) Emotion and d) Surprise. The final category was termed *Low attention states* and includes earworms that were associated with a) Dreams, and b) Mind wandering, where the subject was involved in a monotonous task.

C. Individual Differences and INMI

Other factors that have been evaluated in connection with earworms include gender and age. With regards to gender, studies have suggested that being female increases the probability of getting earworms (Kellaris, 2001; Bennett, 2002; Sacks, 2007; Liikkanen, 2012), however other studies dispute this claim (Beaman & Williams, 2010; Hemming, 2009). Finally, concerning age, correlations have been reported between youth and the frequency of INMI experiences (Bennett, 2002; Liikkanen, 2012).

Turning to the relationship between earworms and musical training and musicality, Levitin (2006) suggests that musicians experience earworms more often than non-musicians, and a study of Liikkanen (2012) revealed an association between INMI and musicality. Beaman and William (2010) found a relationship between the frequency of earworms and the subjective importance attached to music, but not with musical training.

Personality also plays an important role in the appearance of INMI. A number of studies have looked at the relationship of Obsessive Compulsive Disorder with earworms (Kellaris, 2003; Williamson & Müllensiefen, 2012). Neuroticism has been found to increase the frequency of earworms (Kellaris, 2003) as has 'transliminality', the largely involuntary susceptibility to, and awareness of, large volumes of inwardly generated psychological phenomena of an ideational and affective kind (Wammes & Baruss, 2009).

Based on the above, it was concluded that individual differences in everyday behaviour and personality was an area of study where there was potential to uncover further relationships with INMI that may then shed light on the aetiology of the phenomenon. Therefore, a project consisting of two studies was conducted, to a) investigate the relationship between individual personality or musicality characteristics and spontaneously occurring earworms and b) compare different ways of inducing earworms in a lab setting.

II. STUDY I: Individual Differences and INMI

Study 1 aimed to examine relationships between individual differences and INMI for which previous investigations were either limited or presented problems in relation to the definition of some of the parameters evaluated, namely a) personality and b) musicality.

Regarding the role of personality traits, the relevant research is still at a preliminary level. One of the best-known sets of personality constructs is the "Big Five" (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism), which is evaluated with the Big Five Inventory (John, Donahue & Kentle, 1991). Kellaris (2003) was the first researcher who found a correlation between one of the

BFI factors (Neuroticism) and the frequency (but not the duration) of earworms. Besides this, no known studies have attempted to explore the relationship between INMI and BFI factors. The first objective of the present study therefore was to examine the relationships between the INMI experience as measured by a number of parameters [frequency, strategy (employed to control INMI), pleasantness (pleasure felt while having INMI), controllability (how easy one thinks is to control his/her earworms), length, interference (degree to which INMI interferes with other activities) and worrying (degree of concern caused by INMI)] and personality traits as indicated by the complete set of the BFI factors.

Turning to the relationship between INMI and musicality, existing studies have used a limited number of measures of musicality such as a) musical training and practice, and b) importance (of music). Bennett (2002) found that listening to music was associated with a greater frequency of INMI. Kellaris (2003) noted a relationship between earworms and musical interest, listening behavior, musical training and current musicianship. Liikkanen (2012) reported an association between earworms and 'musicality' as measured by engagement in musical practice and usage of a portable music player. Beaman and Williams (2010) reported an association between the importance attached to music (as a measure of musicality; yes or no response) and INMI. On the other hand, Wammes and Baruss (2009) failed to find such a correlation.

The present study employed the Goldsmiths Musical Sophistication Index (Gold-MSI, Müllensiefen et al., 2011), which allows for a thorough evaluation of multiple aspects of musicality, in an attempt to replicate and extend previous studies on the relationship between musicality and INMI. Importantly, the present study went beyond previous studies by exploring the role of musicality using a total of seven different measures, including:

1. Importance (attached to music)
2. Perception and Production
3. Musical Training
4. Emotions (caused by music)
5. Body (responses to music)
6. Creativity
7. Openness and Events (openness to diverse musical styles and events)

In summary, the goals of the presently reported study were:

- To examine correlations between certain basic characteristics of INMI (frequency, strategy, pleasantness, controllability, length, interference and worrying) and the Big Five personality traits.
- To investigate the links between the above characteristics of INMI and musicality using a wide range of measures.

Method

Design

For this study, recruitment of the participants was done via the Internet and questionnaire forms were completed online. The questionnaire was administered only to participants who have previously taken the online survey instrument hosted at <http://earwormery.com>.

The study used a within-subjects, correlational design. The dependent variables related to INMI were: Frequency of the INMI, strategy, pleasantness, controllability, length, interference and worrying. The independent variables were the BFI and Gold-MSI factors.

Participants

A sample of 332 participants (114 male, 218 female), aged 12-76 (M = 38.46, SD = 13.74), took part in the study. The highest educational qualification attained by participants fell into the following categories: 0.6% none, 4.8% secondary school, 22.9% post-secondary school, 38% undergraduate degree and 33.7% postgraduate degree.

Materials

A section from the earwormery questionnaire (<http://earwormery.com>) relating to INMI factors was used (see independent variables above). A second online questionnaire (Unipark survey tool) was also created, consisting of the questions from the BFI (Big Five inventory; John, Donahue & Kentle, 1991) followed by those of the Gold-MSI (Musical Sophistication Index, Müllensiefen et al., 2011). People were invited to respond to statements about themselves by indicating the degree of agreement/disagreement.

Procedure

One thousand and twenty seven e-mails were sent to people who had completed the Goldsmiths Earworm questionnaire (<http://earwormery.com>) during the previous year and who had indicated their willingness to be contacted again in the future. Invited participants completed the new online questionnaire either via a direct link or via the university's dedicated webpage. Participants were assured that all information would be kept confidential and that they were free to withdraw from participation at any point and for any reason. Their original responses to the Earwormery questionnaire were retrieved and paired with their answers to the current questionnaires. The survey took place over a period of two months, starting on 19 April 2011 and ending on 17 June 2011.

Results

The distributions of the scores for the INMI characteristics frequency, strategy, pleasantness, controllability, length, interference and worrying about earworms, as well as age, and the factors of BFI and Gold-MSI, were checked for normality. With the exception of Neuroticism, none was found to be normally distributed, and consequently statistical evaluations of the relationships between INMI and personality/musicality characteristics were based on Spearman rank correlation.

The significant correlations observed are summarized in Table 1. Neuroticism was found to have the largest number of correlations with INMI characteristics (6 out of 7 examined). Furthermore, amongst all INMI factors, frequency showed the largest number of correlations with Gold-MSI factors (i.e. musicality-related) but none of the BFI factors.

Apart from these correlations, among the BFI factors, Openness to Experience showed positive correlations with INMI Length and Interference while Extraversion showed a negative correlation with INMI Controllability.

Among the Gold-MSI factors, Body correlated with 3 INMI parameters (positively with Frequency and Pleasantness and

negatively with Worrying), Emotions and Importance correlated (positively) with two (Frequency and Length, and Frequency and Worrying, respectively), while Perception and Production correlated (positively) only with Frequency. Interestingly, Musical Training did not correlate significantly with any INMI -related parameters.

Table 1. Relationships between characteristics of INMI and BFI/Gold-MSI factors

INMI Characteristics	Frequency	Strategy	Pleasantness	Controllability	Length	Interference	Worrying
BFI/Gold-MSI							
Extraversion				$r_s = -0.121$, $p < 0.05$			
Agreeableness							
Conscientiousness							
Neuroticism	$r_s = 0.128$, $p < 0.05$	$r_s = -0.129$, $p = 0.05$	$r_s = 0.121$, $p < 0.05$	$r_s = 0.178$, $p < 0.01$	$r_s = 0.119$, $p < 0.05$	$r_s = 0.161$, $p < 0.01$	
Openness to Experience					$r_s = 0.118$, $p < 0.05$	$r_s = 0.120$, $p < 0.05$	
Importance	$r_s = 0.165$, $p < 0.01$						$r_s = 0.108$, $p < 0.05$
Perception & Production	$r_s = 0.111$, $p < 0.05$						
Musical Training							
Emotions	$r_s = 0.191$, $p < 0.001$				$r_s = 0.105$, $p = 0.055$		
Body	$r_s = 0.209$, $p < 0.001$		$r_s = 0.121$, $p < 0.05$				$r_s = -0.125$, $p < 0.05$
Creativity	$r_s = 0.151$, $p < 0.01$						
Openness & Events							

Discussion

The present study examined the relationships between various characteristics of INMI and a) personality traits based on the Big Five Inventory, and b) musicality as measured by the Gold MSI. Many statistically significant correlations were observed, which are discussed below, however it is notable that the strength of these correlations was mostly small, with the absolute values of r_s being usually in the range 0.1-0.2.

Frequency: The frequency of INMI correlated positively with 5 of the 7 Gold-MSI factors measured (Importance, Production and Perception, Creativity, Emotions and Body). The observed positive correlation with the factor Importance aligns with results reported by Beaman and Williams (2010). The importance of music may be an important factor that underlies self-rated scores on other scales in the present study, including Perception and Production, Creativity, Emotion for Music and Body.

The observed correlation with Body may have another potential mechanistic role in the experience of earworms. It may be that people who hum, sing, tap or clap along with music experience more frequently INMI as a result of an increased activation of areas of the brain related to musical production. This finding is in line with studies that have found a relationship between sing-along tendency and INMI frequency (Williamson and Mullensiefen, 2012). It is known that brain areas triggered by singing overlap in large part with those areas that are associated with musical imagery (Halpern & Zatorre, 1999; Zatorre & Halpern, 2005). Although a neurological signature for earworms has yet to be documented, it is logical to presume that at least some of the areas involved

in voluntary musical imagery will also be triggered during involuntary musical imagery. Therefore, it may be that activity in one domain promotes spontaneous activity in the other.

In the present study musical training did not show a statistically significant correlation with any of the INMI characteristics examined (Table 1). The absence of a statistically significant correlation between the frequency of INMI experiences and musical training contrasts with findings previously reported by Bennett (2002), Levitin (2006), Kellaris (2003) and Liikkanen (2012). The reason for this difference is unknown. It is possible that absence of any correlations relates to the use of a new and different measure for musicality and previous scales may have confounded musical training and other factors within musicality. If the present finding is valid, it would suggest that the mechanism which leads to INMI experiences may be more related to everyday musical activities as opposed to musical ability as measured by self rated scales.

Strategy: The INMI variable Strategy, which relates to the effort made by people to get rid of the INMI experiences, correlated with Neuroticism (Table 1). This correlation may reflect the tendency of people who are anxious, nervous and tense to develop strategies to confront INMI. Another contributing factor may be that their INMI experiences tend to be longer in duration (positive correlation of Length with Neuroticism, Table 1). The combination of these two factors (longer INMI episodes and greater effort to get rid of them) may also account for the observed positive correlation of Neuroticism and Worrying about INMI shown in Table 1.

Pleasantness: A negative correlation was found between Neuroticism and INMI pleasantness. Pleasantness also correlated positively with the Gold-MSI musicality measure Body, indicating that people who sing, hum, tap or clap along with music tend to enjoy INMI experiences more, probably because this increased enjoyment reflects the pleasure that these physical acts generate.

Controllability: The positive association found between Controllability and Extroversion indicates that people who are active and energetic are able to control their INMI more easily. One expected result was that increased INMI control was associated with shorter INMI duration. Control is also related to reduced interference and worrying.

Length: The duration of INMI was positively associated with Neuroticism and Openness to Experience (Table 1). Kellaris (2003) did not find a correlation between Neuroticism and INMI length, although he did observe a correlation with INMI frequency. Previous studies have also documented a relationship between Openness to Experience and increased variety in an individual's music listening behaviours (Hunter and Schellenberg, 2011; Chamorro-Premuzic and Furnham, 2007, Langmeyer, Guglhör-Rudan, & Tarnai, 2012). This behavior may be a confounding variable in the relationship between this aspect of personality and INMI.

Interference: The variable Interference, i.e. the degree to which INMI experiences interfere with people's other activities, increased as scores for Neuroticism and Openness to Experience increased (Table 1). This may be explained by the fact that people who are Open to Experience have a higher engagement in trying to learn and experience new things and INMI may interfere with this effort. On the other hand,

individuals who are high on Neuroticism exhibit a need to focus on their activities, which may explain why they feel increasingly distracted by the presence of INMI.

Worrying: As previously noted, Worrying about INMI correlated positively with Neuroticism and Openness to Experience (Table 1). This finding is likely to be connected with the previous finding regarding Interference.

Overall, the present study has identified a number of key relationships between personality and everyday musical behaviours, and earworm experiences. The strongest positive relationships were between INMI frequency and both musical engagement (including creativity and emotional response) and Neuroticism. Neuroticism was also associated with a predicted negative pattern of cognitive response to unpleasant INMI, namely an increase in concern and coping strategies.

III. STUDY II: Triggering earworms

In Study 2, the main objective was to examine various parameters affecting the onset of INMI by attempting to trigger INMI under controlled conditions. This study also evaluated the influence of song 'stickiness' and personality traits.

Until today only three studies have tried to induce INMI. McNally et al. (2009) exposed 36 participants (18 musicians, 18 non-musicians) to five stimulus songs and provided them with a recording machine and questionnaires (one for each day) to use over the next 3.5 days. Participants were asked to record a vocal production for each "obsessive" song they had experienced following a break of two weeks; the procedure was repeated one more time. The result was that 47% of the participants experienced a minimum of one INMI episode related to the songs that were previously presented. Most of the times these INMI-related songs were characterized as familiar and the section that was most frequently reported as INMI was the chorus. Non-musicians had significantly more INMI experiences based on songs with lyrics relative to musicians. Musicians also reported that their "obsessive" song episodes were less pleasant, possibly because of their longer duration. Finally, participants' mood was typically positive before INMI, while after the episodes it was more neutral.

The second study was conducted by Hemming (2008, 2009). He distributed a CD with 20 "catchy" tunes (20 different genres) to 59 participants and asked them to listen to it as often as possible for up to six weeks. The participants also completed a questionnaire, rating their liking for the title and the genre of the songs. Post-hoc interviews were conducted in which the participants were asked to reproduce the tunes, which they had experienced as INMI, and to give their own explanation about the phenomenon. The results showed that frequent INMI pieces tended to have a higher emotional association, either positive or negative, as compared to those that did not induce INMI. Furthermore, INMI-inducing tunes were mostly lyrical. The most common activities in which participants were engaged when the INMI episodes occurred were 'doing nothing special', being engaged in background activities, travelling in the train/car, or waiting. The majority of participants rated their INMI experiences as pleasant. Musicians and non-musicians showed no significant differences concerning INMI episodes. Finally, INMI episodes happened primarily after a significant time had passed from the initial induction procedure.

Finally, a study by Liikkanen (2009) investigated the dynamics of INMI in relation to certain memory concepts (specifically recency and priming effects). The experiment was run on the Internet and 9,967 participants took part. Two experiments were conducted. In the first, the participants had to complete missing words from the lyrics of five contemporary songs. The average familiarity of the songs was 71.5% and the induction procedure was successful for the 67.1% of the participants. The second experiment followed the same procedure, but this time used five classic songs (pop songs, tangos and the Finish national anthem). This time the familiarity was increased to 91.2% and induction was successful in 49.6% of the participants. In addition, a recency effect for the song last heard was noted, something that had not been seen in the previous experiment.

Study 2 of the present project aimed to extend previous findings by using two approaches (one novel and one old) in an attempt to elucidate further the mechanisms of INMI induction. Although diary studies provide a way of investigating INMI mechanisms in relation to their effects in time, this study used a more direct way that does not rely on retrospective reporting. More specifically, the goals of the present study were the following:

A. To investigate and compare two procedures for triggering earworms.

B. To examine individual differences in responses to the two INMI triggering procedures.

C. To test the “stickiness” (i.e. ability to induce earworms) of the songs that were presented

D. To investigate the relationship between memory/familiarity of the tunes and their ability to induce INMI

E. To examine serial position effects to determine whether songs that are presented first or last in a list appear more frequently as INMI

Method

Design

The study used a 2x2 factorial design, both between- and within-participant. The dependent variable was the number of INMI induced and the independent variables were the BFI and Gold-MSI factors (see Study 1). Logistic regression and chi-square tests were chosen as analysis tools. All results were analyzed with SPSS 18.0 for Mac OSX.

Participants

An opportunity sample of 40 participants (16 male, 24 female), aged 19-32 (mean = 24.4, SD = 3.1) was tested at Goldsmiths, University of London. Thirty five percent were British, 82.5% were still at university and 80% declared that they listen to rock/pop. The study had the form of a single-blind experiment, where the participants did not know the real purpose of the research (INMI induction) but, instead, were told that it was about Musical Memory, Personality and Musical Sophistication.

Material

Twelve excerpts of songs were used. Six of them were reported as INMI in the earwormery database (based on data collected at <http://earwormery.com>). In addition, they appeared in the database of GREERDES MIDI MUSIC, a database of successful chart songs. These songs, being good

INMI inducers according to the earwormery database and their long-standing in the charts, were considered a priori as high probability inducers of INMI and were classified as High (H) in the study. The other six songs also appeared in the GREERDES database, however they were not mentioned in the database as INMI. For this reason they were considered as having a low potential (L) for inducing INMI.

One short questionnaire was used in order to check familiarity: a) Have you heard this song before you heard it here? b) Can you indicate the name of the artist who sings the specific song? c) Can you indicate the name of the song?

It was necessary to develop a non-auditory (visual) interpolation task as part of the procedure, which would be presented after the INMI induction and before participants were asked about the occurrence of subsequent INMI. We chose to use the book "Where's Wally?" (Martin Handford, 2010), which contains eight different coloured posters of a crowd scene within which the participant tried to locate an individual. A paper with the lyrics of six songs, with three unique words missing from each, was used in one of the two triggering procedures.

As in Study 1, the Big Five Inventory (BFI) and the Goldsmiths Musical Sophistication Index (Gold-MSI, Müllensiefen et al., 2011) were used as measures of individual differences.

Procedure

The experiment comprised two induction procedures (within subjects, counterbalanced task order), which each followed a similar procedure apart from the initial induction mechanism. There were two lists of six songs, which were counterbalanced and presented equally across each of the conditions.

The first procedure was called *Name That Tune* (NTT). Twenty participants listened to the six INMI excerpts over headphones. The semi-randomized order of the songs was H-L-H-L-L-H (H=High; L=Low). The first and last songs were always H rated, in order to give equal probability of serial position effects. After listening to each excerpt, participants completed the short familiarity questionnaire where they had to identify the song title and the artist. The duration of each excerpt was approximately 30 seconds and each set lasted around four minutes. Next they were asked to complete a visual search task («find Wally») for 5 minutes. Immediately afterwards they were given a questionnaire to ascertain whether they had experienced INMI in the last 5 minutes, and to give information about the particular tune they had in their mind (part/singer/title).

The second procedure was called *Lyrics*. Instead of hearing the songs, participants were given a piece of paper with the excerpts of the lyrics of six songs selected in a same way as in the previous procedure. Some of the words were missing from these lyrics and the participants were asked to fill in the gaps to the best of their knowledge. In addition to completing the missing lyrics, they had the option (indicated with a, b or c) to indicate if they did not know the song, if they knew the song but did not remember the lyrics, or if they knew the song but they did not know the lyrics, in order to check their memory about the songs. Subsequently, the participants completed the visual task (“find Wally”) and the INMI questionnaire.

After completing both procedures (counterbalanced order), the participants completed the BFI and the Gold-MSI questionnaires. The whole procedure lasted around 35 minutes.

Results

In order to compare the ability of the two triggering procedures (NTT and Lyrics) to induce INMI, 20 participants were tested first by the NTT and then by the Lyrics procedure and another 20 in the reverse order. We focused the initial analysis on those who received as their first treatment NTT or Lyrics, since they were blind as to the purpose of the experiment. The two induction procedures did not differ statistically significantly in their ability to induce INMI, with NTT doing so in 13 and Lyrics in 17 out of 20 participants [$\chi^2(1) = 2.13, p = .273$] (Figure 1).

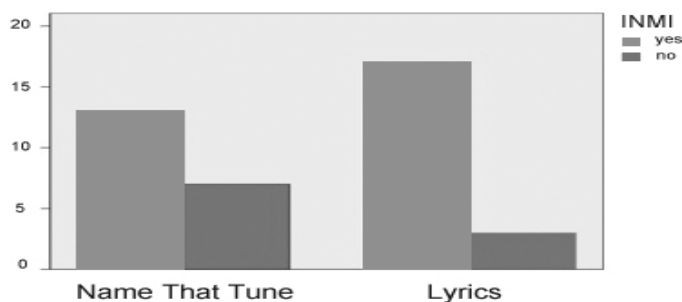


Figure 1. Triggering procedures and resulting experiences of INMI (first procedure only)

In order to evaluate the relationship of susceptibility to earworms induction with individual personality traits and musicality, a «total» susceptibility score was created for each participant, with the value of 1 being given if an INMI was induced by either procedure and 0 if no INMI was induced. Logistic regression analysis did not reveal any significant association of this score with the BFI and Gold-MSI factors apart from a significant relationship between those subjects whose earworms were induced during the second procedure used in each stage and the Gold-MSI's factor Body ($p < 0.05$).

The songs that were a priori considered as more likely to end up as earworms (H) and those not (L) were compared for their success in inducing INMI (chi-square test). The results showed no significant difference between the two types of the songs [$\chi^2(1) = 0.03, p = 0.87$].

A logistic regression analysis was conducted to ascertain whether people with better memory for the tunes (as evaluated from their responses to the familiarity questionnaire) experienced more INMI. No significant association was found between INMI induction and the memory scores ($p = 0.348$).

The songs most commonly leading to the induction of INMI can be seen in Figure 2.

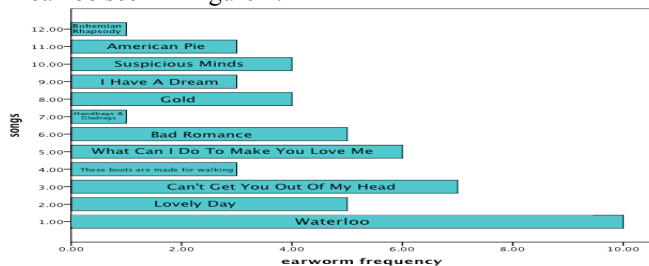


Figure 2. List of songs and frequency of earworm induction.

A chi-square test between the serial position of the various songs in the triggering procedures and the frequency of INMI induction showed the operation of a recency effect [$\chi^2(5) = 14, p < .05$] for the first set of songs but not the second (Figure 3).

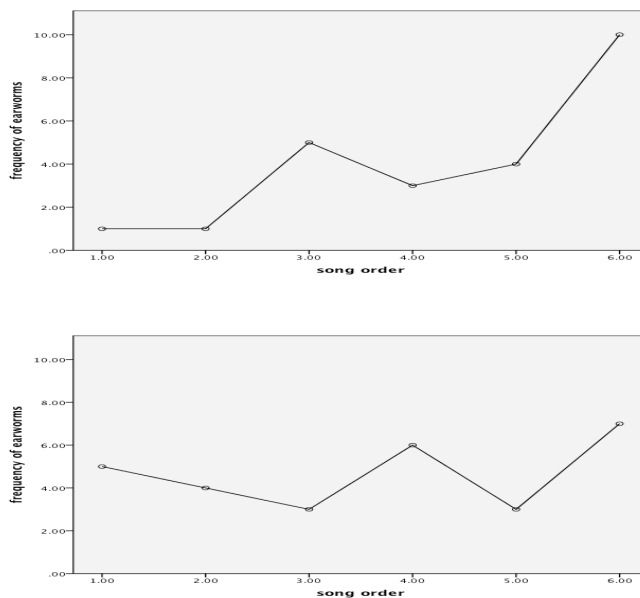


Figure 3. Serial Position Curve for the first set of songs (up) and the second set of songs (down).

Discussion

The first finding of the present study indicates that listening to a tune and recalling lyrics seem to induce similar levels of INMI. The importance of this finding lies in the fact that *Name that Tune* was an auditory/musical procedure, which might be expected to trigger INMI more easily than a verbal procedure like *Lyrics*, which is entirely mental and dependent on memory. This finding affirms the idea that the presentation of written lyrics can trigger INMI, in support of the procedure used by Liikkanen (2009). It also demonstrates that such a procedure can be even more successful in a controlled lab situation.

The fact that no significant associations were found between individual personality and musicality traits and susceptibility to INMI induction was somewhat unexpected, given the relationships between personality traits and INMI frequency, found in Study 1. One factor that may have influenced this result, however, is the high rate of INMI induction by both procedures, which likely reduced the statistical power to detect differences in the susceptibility of different groups.

The significant correlation between the factor Body and the appearance of INMI after the second procedure supports the theory that people who sing, hum, tap or clap along with music get earworms more easily, as indicated in the findings and Discussion of Study 1.

The absence of a significant difference in the ability to induce INMI between songs considered a priori as High and Low probability for INMI induction may be due to the fact that all the songs had been in the charts list for a long time, meaning that participants had been subjected to high exposure

to them which neutralised other differences related to their presence of absence from the earworm database. Future research should address this issue by selecting songs at lower levels of popularity, while also addressing issues like the importance of the artist's identity (i.e. comparing high- and low-probability songs of the same artist).

A result of the present study which agrees with findings of previous research (Kellaris, 2003; Bailes 2007; Liikkanen, 2009) is the presence of a significant recency effect. This finding supports the theory that recent activation (short-term recency) of music in memory can enable the appearance of INMI (Liikkanen, 2009).

IV. GENERAL DISCUSSION AND CONCLUSIONS

The research presented here contributes towards increased understanding of the INMI phenomenon, especially in relation to the role of personality traits and musicality as well as susceptibility to both everyday spontaneous and lab-based induction of INMI.

As regards the relationship between personality traits and the frequency of INMI, the main finding is that Neuroticism influences most reported INMI characteristics, namely expunging strategy, pleasantness experienced, controllability, length, degree of interference, and degree of concern. One important limitation to this conclusion is that Study 1 was based on self-report so it is not clear whether the neurotic trait influenced the actual experience of INMI or tendencies when reporting these experiences retroactively. This question could be investigated by future studies that apply behavioural experimental settings rather than retrospective questionnaires. It is hoped that there will now be an increase in the number of the former studies, given the success seen in this and previous studies of INMI induction.

Among the various characteristics of INMI, frequency shows the largest number of correlations with musicality as measured by the Gold-MSI method (importance attached to music, perception and production of music, emotions associated with music, body responses to music and musical creativity), however, as in previous studies, the associations are small. This finding suggests that, although musicality may have an influence on INMI experiences, it is likely that this effect is minimal and only observable in large population sizes.

By comparison, in Study 2 INMI experiences were not found to be influenced by personality traits or musicality. If this difference were to be replicated in additional studies of increased statistical power, it would imply that the personality traits and musicality characteristics of individuals are more important in the spontaneous establishment of INMI. This possibility underlines, in turn, the need to develop tools that would facilitate the study in real time of spontaneously arising INMI, thus allowing the identification of emotions as well as on-going events, which may be causally linked, with the appearance of INMI.

Turning to the efficiency of different stimuli in triggering INMI, Study 2 revealed a potentially important finding, i.e. that the mental process of recalling song lyrics from memory can be as efficient as musical exposure in triggering INMI. This finding implies that INMI induction is linked with general memory mechanisms and not just those associated

with recent memories of musical sounds, a finding which supports the evidence from Williamson et al. (2011).

The currently reported studies employed the Gold-MSI questionnaire for the first time in INMI research. This questionnaire characterises diverse parameters related to musicality and while of its related findings replicate previously reported findings, others go counter to previous studies. For example, the finding of absence of a significant relationship of INMI frequency with Musical Training is in agreement with the finding of Beaman and Williams (2010) although it contradicts other reports (Bennet, 2002; Liikkanen, 2012). The contradictory nature of these results may be related to the absence of standard measure of musical training, and, from this point of view, the use in the present study of the diverse Gold-MSI measure may help to resolve these contradictions.

In summary, the present paper contributes to the literature on INMI by reporting on the successful testing of the first lab-based induction of INMI and the confirmation of the low but significant associations between certain stable individual differences (personality) and everyday musical behaviours, and spontaneous INMI experiences.

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