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The Involuntary Musical Imagery Scale (IMIS)

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This report comprises 3 studies that delineate the development and validation of the Involuntary Musical Imagery Scale (IMIS) based on data from 2,646 individuals. This new self-report inventory measures individual differences in involuntary musical imagery ("INMI," commonly referred to as "earworms"). The first study involved exploratory factor analysis, leading to the identification of a 4-factor scale structure. The 4 factors are conceived as "Negative Valence," "Movement," "Personal Reflections," and "Help." The second study confirmed this factor structure on an independent sample and derived indices of internal validity and test–retest reliability. The third study reports on IMIS correlates with existing measures of thinking style, imagery abilities, and music-related behaviors. Results showed that the IMIS measures a unique construct compared with existing self-report inventories. Furthermore, significant correlations were found with a combination of self-reported musical behaviors on the one hand and tendencies to engage in task-unrelated thoughts on the other. Overall, these findings provide evidence that IMIS constitutes a reliable scale that captures individual differences in INMI and that its first application reveals previously uncaptured associations between INMI and certain cognitive and behavioral traits.

Keywords: involuntary musical imagery, individual differences, scale development, task-unrelated thoughts

Spontaneous cognitions, in the form of memories, concurrent processing and future planning, comprise a large part of everyday mental activity (Killingsworth & Gilbert, 2010; Kvavilashvili & Mandler, 2004). One prolific type of spontaneous, involuntary cognition is "involuntary musical imagery" (INMI, or "earworms"). The term INMI describes the experience whereby a short section of music comes into the mind, spontaneously, without effort, and then repeats without conscious control (Liikkanen, 2012; Müllensiefen, Fry, et al., 2014; Williamson et al., 2012).

Estimates suggest that >90% of people experience INMI at least once per week (Liikkanen, 2012). The majority of such experiences is evaluated as pleasant (Beaman & Williams, 2010; Halpern & Bartlett, 2011) although around a third of episodes are classified as annoying or disturbing (Hemming, 2009; Williamson, Liikkanen, Jakubowski, & Stewart, 2014). Many individuals develop active strategies to ameliorate unwanted INMI experiences (Williamson et al., 2014).

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Studies exploring INMI have noted a number of triggers for the experience, including situational context and psychological states (moods/emotions) (Liikkanen, 2012; Williamson et al., 2012) and features of the music (Williamson & Müllensiefen, 2012). In addition, demographic studies related to INMI experiences have isolated predispositional traits, including gender (Liikkanen, 2012, though see Beaman & Williams, 2010; Hyman et al., 2013), age (Liikkanen, 2012), and levels of musicality (Beaman & Williams, 2010; Floridou, Williamson et al., 2012; Liikkanen, 2012; Müllensiefen, Fry, et al., 2014).

Despite the growth of INMI research in recent years, few studies have focused on individual differences beyond demographic and lifestyle factors. The small number of studies that have been conducted outside these basic areas focus primarily on personality factors, including the Big Five (Floridou et al., 2012), schizotypy, openness to experience and thought suppression (Beaman & Williams, 2013), transliminality (Wammes & Barušs, 2009), and nonclinical obsessive–compulsive trait (Müllensiefen, Fry, et al., 2014).

One of the abovementioned studies, in particular, is notable, as it involved the development of a Musical Imagery Questionnaire (MIQ; Wammes & Barušs, 2009). This scale, based on the assessment of 67 individuals, was used to measure INMI presence and its relationship to transliminality, susceptibility to and awareness of self-generated thoughts (Thalbourne & Delin, 1994). The authors identified six dimensions in the MIQ, namely, Unconscious, Persistent, Entertainment, Completeness, Musicianship, and Distraction, and reported an association between transliminality and three of these factors (Unconscious, Persistent, and Distraction). This questionnaire was valuable in aiding the identification of relationships between aspects of INMI experiences and individual differences; however, the inclusion of items pertaining to nonspontaneous musical imagery and other musical behaviors in the scale means that it cannot be considered as a pure measure of the INMI experience.

Müllensiefen, Fry, et al. (2014) developed a questionnaire with an exclusive focus on the INMI experience, in order to investigate associations with personality. This questionnaire was completed by 1,787 individuals and factor analysis yielded a single factor, "INMI disturbance." This factor included items relating to the subjective valence of INMI experiences and the degree to which INMI episodes were considered disturbing. This study demonstrated an interesting correlation between scores on "INMI disturbance" and high levels of (subclinical) Obsessive Compulsive Trait, but the presence of only a single factor in the scale suggests that the original questionnaire items were insufficiently broad to capture multiple aspects of the INMI experience. The present study was conducted with the aim of developing and validating an improved questionnaire, which would capture multiple aspects of the INMI experience. The existence of such a scale would allow the study of associations between distinct aspects of the INMI experience and (a) involuntary but nonmusical cognitions such as task-unrelated thoughts, (b) voluntary auditory imagery, and (c) musical background and behaviors.

Overview of the Paper

The present article is divided into three studies. The first study covers the development of the questionnaire items as well as an exploratory factor analysis to identify the scale factor structure. The second study validates the factor structure using confirmatory factor analysis on data from an independent sample. Finally, the third study comprises a series of correlations between the new Involuntary Musical Imagery Scale (IMIS) and a range of existing inventories that assess thinking styles, auditory imagery abilities, musical and nonmusical everyday behaviors.

Study 1: IMIS Development

Method

We first established a working definition of INMI: the experience of a short section of music that comes into the mind without effort (it is involuntary, i.e., it comes without any intention to retrieve or remember the music) and then repeats (immediately repeating at least once, on a loop, i.e., without consciously trying to replay the musical image). This definition is congruent with other working definitions of INMI (Liikkanen, 2012; Müllensiefen, Fry, et al., 2014; Williamson et al., 2012). The content of the short section of music could include lyrics and a full orchestration, or it could just be a single melody or a rhythm. This detailed definition was subsequently used to describe INMI to participants. Questionnaire item writing was informed by an extensive review of the INMI literature and existing scales/questionnaires. In addition, we drew on thousands of reports from individuals contained within our preexisting database of INMI reports (see Müllensiefen, Fry, et al., 2014; Williamson et al., 2012, [2014]).

From the above studies and reports, a list of items was compiled covering reported aspects of the INMI experience. This list of 68 items (see Table A1) formed the basis of the first version of the IMIS. A preliminary thematic analysis grouped these 68 items into 9 dimensions: Intensity, Disturbance, Trigger, Match, Vividness, Valence, Content, Reaction, and Length. For INMI Length a distinction was made between an INMI section (the section of a musical phrase that is experienced) and an INMI episode (the period of time for which a musical phrase is experienced).

A 5-point frequency scale (ranging from Always to Never) was used for all 68 items, with an additional category of Not Applicable (*N*/A) in order to identify and exclude items that were not considered relevant by participants. A screening item was positioned at the beginning of the questionnaire to identify individuals who never experience INMI and therefore would not be able to complete the rest of the questionnaire ("I experience earworms": Always–Never).

Participants. A total of 360 individuals (231 female; 3 people chose not to disclose their gender) ranging in age from 19 to 89 years ($M = 47.61$, $SD = 14.81$) took part in Study 1. These individuals had completed an online survey concerning INMI between 2010 and 2012 (http://www.earwormery.com) and had indicated their willingness to be contacted for future studies.

Material and procedure. Participants were asked to fill out the new 68 item online questionnaire implemented in Qualtrics software (Qualtrics, Provo, UT). The questionnaire took about 10 min to complete.

Results and Discussion

An initial screening of the questionnaire indicated that eight items had more than 5% of responses in the « Not applicable » option; these items were therefore excluded from the analysis. Four additional items were excluded because they were found to

have a strongly skewed distribution. The remaining 56 items were carried forward for further analysis.

The initial exploratory factor analysis (EFA) based on the hypothesized nine dimensions resulted in a shared variance of .32, while the scree plot of the factors' eigenvalues and a parallel analysis (Horn, 1965) suggested the existence of six factors. This result indicated the need for further analyses in order to identify a coherent factor structure.

As a first step we removed 24 items that showed only weak relationships with all other questionnaire items, as indicated by high uniqueness scores (>.50) and/or low communality scores (<.50). We also excluded 13 items with low values on the anti-image matrix (<.70). This resulted in a total of 19 items remaining. A subsequent factor analysis on these 19 items using an oblique factor rotation yielded a four-factor model as suggested by the scree plot, parallel analysis, and the VSS criterion (Very Simple Structure; Revelle & Rocklin, 1979). The VSS criterion compares the fit of a number of factor solutions with the "simplified" loading matrix, that is, a matrix where only the c greatest loadings per item are retained and where c is taken as a measure of factor complexity. Four additional items were excluded from this solution because of their low loadings (<.5) and the model was then refit with the 15 remaining items. This final four-factor model explained .67 of the variance, with all factors having eigenvalues of >1.

The next step in the analysis was to define appropriate labels for the four factors. Items that loaded on the first factor indicated a negative (vs. positive) evaluation of the INMI experience and for this reason the factor was labeled "Negative Valence." The second factor was related to the movement expressed while experiencing INMI and was labeled "Movement." The third IMIS factor concerned personal responses to INMI and was labeled "Personal Reflections." Finally, the fourth factor concerned the perceived utility of the INMI experience and was labeled "Help." Details of the four factors, their items and loadings, are presented in Table 1.

The factor model represents a compact scale covering four different dimensions related to INMI experiences, which are not covered by any of the existing scales. Three items from the initial questionnaire relating to INMI Frequency and Length (section, episode) did not load on any of the factors. However, because of their individual importance when characterizing the INMI experience they were retained as individual items in the subsequent questionnaire.

Study 2: Confirmatory Factor Analysis and Test–Retest Reliability

The purpose of Study 2 was to confirm the four-factor scale structure suggested by the EFA (Study 1), through a confirmatory factor analysis (CFA) based on a different sample of participants. In addition, we aimed to establish the test–retest reliability of the IMIS scale (version 2) on a subset of participants from the same sample.

Method

Participants. A total of 2,671 individuals took part. Participants were recruited from our online databases derived from studies of INMI (http://www.earwormery.com) or amusia (www.delosis.com/listening/home.html; only individuals who did not score in the amusic range), or were 1st year undergraduate psychology students who took part for credits in a "pen and paper questionnaire" session of a course. We excluded individuals who had never experienced INMI ($n = 29$) or reported severe hearing impairments ($n = 356$). The final total of 2,286 participants (1370 female; 15 did not disclose their gender) ranged in age from 17 to 81 ($M = 42.6$, $SD = 13.5$). Of these participants, 2,141 came from the online survey and 145 from the pen and paper version. A subset of the participants who completed the online survey were invited to take the questionnaire for a second time, following an intervening period of two months. In total, 649 participants (373 female), ranging in age from 19–74 ($M = 45.71$, $SD = 12.22$) took the questionnaire on both occasions.

Procedure. Participants received an e-mail invitation to complete the IMIS (version 2) online or completed a pen and paper version for the CFA purposes. In both cases participants filled in additional questionnaires (reported in Study 3). Completion of all the questionnaires took approximately 10–15 min.

Participants for the test–retest analysis received an e-mail invitation approximately two months after the initial completion of IMIS (version 2). In addition to the IMIS they completed two new questionnaires (reported in Study 3), which took around 10 min.

Table 1
Structure Matrix and Item Loadings for the Involuntary Musical Imagery Scale (IMIS)

IMIS items	Negative valence	Movement	Personal reflections	Help
1. I try hard to get rid of my earworms	.85			
2. It worries me when I have an earworm stuck in my head	.64			
3. I find my earworms irritating	.87			
4. My earworms agitate me	.83			
5. The experience of my earworms is unpleasant	.85			
6. I wish I could stop my earworms	.79			
7. When I get an earworm I try to block it	.86			
8. The rhythms of my earworms match my movements		.78		
9. The way I move is in sync with my earworms		.87		
10. When I get an earworm I move to the beat of the imagined music		.74		
11. My earworms result from unresolved matters			.72	
12. Personal issues trigger my earworms			.78	
13. The content of my earworms mirrors my state of worry or concern			.80	
14. I find my earworms help me focus on the task that I'm doing				.84
15. Earworms help me when I'm trying to get things done				.83

Results and Discussion

Four different factor models were assessed, each using the four factors identified in the EFA (Study 1) but differing in the specification of the interfactor correlations. The first model examined was the one previously identified in the EFA, which allows interfactor correlations between all four factors. The second model did not allow any factor intercorrelations, while the third model included a general factor subsuming the interfactor correlations into one factor. The fourth model contained a general factor with loadings from all items while the items were also loading on one of the four factors. The first model that allowed for interfactor correlations—as originally identified by the EFA—had the best confirmatory fit to the data (χ^2 = 819.99, df = 80) as can be seen from Table 2.

The internal reliability of the subscales associated with each factor was assessed using three different measures (Cronbach's alpha, MacDonald's omega total, and Guttman's lambda6). All the subscales showed good or very good estimates of internal reliability, as given in Table 3.

Table 3 also gives the test–retest correlations of the four factors, which were found to be moderate to high (.65 to .79) and significant at the $p < .05$ level or higher.

Overall, the confirmatory factor analysis and the observed reliability coefficients indicated that the 15-item IMIS questionnaire possessed the required level of reliability and internal validity, justifying its use as a measurement instrument to assess individual differences in INMI experiences as part of Study 3.

Study 3: Correlates of the IMIS

In Studies 1 and 2, we developed a scale (IMIS[1]) with four factors related to the INMI experience, and confirmed its structure across samples and over time. Study 3 assessed correlations between the four IMIS factors, as well as items covering INMI Frequency and Length, with already validated instruments that capture potentially related thinking styles (spontaneous, task unrelated, intrusive, and repetitive), music-related behaviors, and voluntary auditory imagery abilities. Thus, the overall aim of this study was to identify how the IMIS may be related to similar constructs.

Method

Participants. The same participants took part in Study 2 and the current study. It is noted that while all participants completed the IMIS, the collection of data was carried out across different samples and at different points in time, meaning not all participants completed all of the other questionnaires. Table 4 summarizes sample sizes for each of the additional questionnaires.

Materials. Questionnaires were selected that measure individual differences in (a) potentially related thinking styles, (b) voluntary auditory imagery abilities, and (c) general musical behaviors.

Table 2
Fit Indices for the Four Models Tested in CFA

CFA models	χ^2	RMSEA	CFI	SRMR	AIC	BIC
1st model	819.99	.06	.96	.05	891.99	1310.40
2nd model	2011.56	.10	.89	.15	2066.28	1310.40
3rd model	1098.5	.07	.94	.10	1166.5	433.55
4th model	851.35	.07	.96	.09	939.36	263.73

Table 3
Indicators of Reliability for the Four Factors of IMIS (n = 2280) and Test–Retest Reliability (n = 649)

Reliability indicators	Negative valence	Movement	Personal reflections	Help
alpha	.91	.88	.76	.84
omega.tot	.91	.88	.77	.84
G6	.9	.83	.69	.73
Test–retest	.79**	.66*	.65*	.65**

* $p < .05$ level. ** $p < .01$ level.

For thinking styles and everyday behaviors we selected: (a) the "Mind Wandering," "Daydreaming Frequency," and "Auditory Images in Daydreams" subscales of the Imaginal Processes Inventory (IPI; Singer & Antrobus, 1970); (b) the "Intensity," "Emotions," and "Effectiveness" subscales of the Cognitive Intrusion Questionnaire (CIQ; Freeston, Ladouceur, Thibodeau, & Gagnonu, 1992); and (c) the Obsessive Compulsive Inventory—Revised questionnaire (OCI-R; Foa et al., 2002).

Two scales were selected in order to measure voluntary auditory imagery: (a) The Bucknell Auditory Imagery Scale (BAIS) and (b) the Clarity of Auditory Imagery Scale (CAIS; Willander & Baraldi, 2010).

Finally, for musical behaviors we selected: (a) The five subscales of the Goldsmiths Musical Sophistication Index (Gold-MSI; Müllensiefen, Gingras, Musil, & Stewart, 2014), measuring "Musical Training," "Active Engagement," "Perceptual Abilities," "Singing Abilities," and "Emotions"; and (b) The "Reactive Musical Behavior" subscale of the Music Experience Questionnaire (MEQ; Werner, Swope & Heide, 2006).

Procedure. All participants followed the same procedure as detailed in Study 2.

Results and Discussion

Given the gender bias of the sample (1,370 female, 901 male), a t test was computed comparing the average INMI frequency ratings for females and males for significance. Although a significant difference was found suggesting INMI is more frequent in females, $t(2285) = -2.23$, $p = .026$, the effect size was very small ($d = 0.04$).

Table 4 summarizes the correlations of the four IMIS factors and INMI characteristics with all the questionnaires used.

IMIS and INMI characteristics. "Negative Valence" (IMIS) was associated with INMI Length Episode ($r(2139) = .25$, $p < .05$). This relationship confirms previous findings that INMI disturbance is associated with the length of the episode (Müllensiefen, Fry, et al., 2014) and confirms that INMI disturbance is not related to the length of the musical section that is experienced ($r(2139) = .002$, p = ns). The correlation between INMI Frequency and all IMIS factors (except "Negative Valence") indicates that individuals who experience more frequent INMI tend to move more with their INMI, find their INMI experiences to be related to their personal concerns, and

[1] The IMIS materials, including the scale and the scoring sheet, can be found online at: http://www.gold.ac.uk/music-mind-brain/imis/

Table 4
Correlation Coefficients of IMIS and INMI Characteristics With Gold-MSI, MEQ, CAIS, IPI, CIQ, OCI-R, and BAIS

INMI characteristics and other questionnaires	Negative valence	Movement	Personal reflections	Help	INMI frequency	INMI length (Section)	INMI length (Episode)
INMI characteristics							
INMI frequency (n = 2141)	.03	**.25****	**.11****	**.17****			
INMI length (Section) (n = 2141)	.002	.06*	−.003	.06*			
INMI length (Episode) (n = 2141)	**.25****	.04	.06	−.06**			
Gold-MSI							
Musical training (n = 2141)	−.05*	**.18****	.03	.07**	**.13****	−.002	.01
Active engagement (n = 2141)	**−.12****	**.23****	**.13****	**.23****	**.17****	.03	.01
Perceptual abilities (n = 649)	−.10*	**.16****	.01	.11**	**.24****	.11**	.16**
Singing abilities (n = 649)	−.07	**.21****	.05	.15**	**.26****	.09*	.14**
Emotions (n = 649)	**−.15****	**.23****	**.19****	**.34****	**.26****	.06	.12**
MEQ (n = 2141)							
Reactive musical behavior	**−.09****	**.39****	**.12****	**.22****	.20**	.04	.09**
CAIS (n = 2141)	−.05*	.06**	−.01	.07**	.08**	.04	.09**
IPI (n = 2141)							
Daydreaming frequency	.06**	**.22****	**.19****	**.14****	**.21****	.01	**.14****
Mind wandering	**.12****	**.14****	**.12****	.04	**.17****	−.07**	**.13****
Auditory images in daydreams	.05*	**.28****	**.18****	**.22****	**.26****	.10**	**.14****
CIQ (n = 2141)							
Intensity	**.15****	**.10****	**.22****	**.05***	.12**	.01	.11**
Emotions	**.14****	**.10****	**.18****	**.04***	.10**	−.02	.10**
Effectiveness	**.11****	.02	**.07****	−.04	.06**	−.03	.10**
OCI-R (n = 649)							
Washing	**.16****	.11**	**.22****	.08*	.06	.05	.09*
Obsessing	**.20****	.16**	**.28****	.04	.09*	.002	.07
Hoarding	**.14****	.07	**.18****	−.01	.01	.04	.01
Checking	**.13****	.07	**.17****	.01	.05	.04	.02
Neutralising	**.11****	.18**	**.18****	.07	.08*	.02	.16**
Total	**.20****	.16**	**.28****	.05	.08	.04	.09
BAIS (n = 145)							
Vividness	−.12	**.25****	.16	.14	.23**	.06	.08
Control	−.01	.08	.04	.07	.13	.01	.12

Note. Correlation coefficients in bold indicate the highest correlations (and significant) that will be discussed in the "Results and Discussion" section. * $p < .05$ level. ** $p < .01$ level.

find INMI experiences to be useful. The absence of a significant correlation between INMI Frequency and "Negative Valence" (IMIS) fails to bear out the commonly held view that prolific earworms are typically experienced as annoying, confirming the analogous findings of Liikkanen (2012) and Müllensiefen, Fry, et al. (2014).

IMIS, INMI characteristics, thinking styles, and everyday behaviors. All the IMIS factors, as well as INMI Frequency and INMI Length Episode, were significantly correlated with almost all the IPI subscales. In general, IMIS factors correlated with CIQ subscales except for "Effectiveness" (in strategies to expunge the thought) and "Movement" and "Help" of the IMIS. OCI-R scores revealed significant relationships between two IMIS factors, "Negative Valence" and "Personal Reflections" and all OCI-R subscales, as well as total OCI-R score. This finding is in line with the relationship between high OC trait individuals and INMI disturbance as reported in Müllensiefen, Fry, et al. (2014).

IMIS, INMI characteristics, and auditory imagery abilities. No significant relationships were found between IMIS and the BAIS except for "Movement" (IMIS) and "Vividness" (BAIS: $r(143) = .25$, $p = <.01$). CAIS showed significant but very low correlations (from $r(2139) = -.05$, $p < .05$ to $r(2139) = .07$, $p < .01$) with all the IMIS factors. These findings imply that there may be fundamental differences between voluntary and involuntary auditory imagery qualities.

IMIS, INMI Characteristics, and Musical Behaviors

"Active Engagement" (Gold-MSI) correlated with all IMIS factors; however, "Musical Training" (Gold-MSI) showed only low correlations with a subset of IMIS factors. This finding concurs with a similar finding reported in Müllensiefen, Fry, et al. (2014) and further contradicts anecdotal evidence that musicians experience more INMI compared with nonmusicians. The only significant correlation ($r(2139) = .18$, $p < .01$) between the IMIS and "Musical Training" (Gold-MSI) concerns "Movement," which could be related to the fact that musicians have learned to respond through movement to music and, by extension, to INMI. In contrast, "Musical Training" is not strongly associated with the other IMIS factors, which are more personal and subjective.

It is also important to note that although INMI Frequency is associated with all Gold-MSI subscales, it shows the lowest correlation ($r(2139) = .13$, $p < .01$) with "Musical Training" and the highest ($r(647) = .26$, $p < .01$) with "Singing Abilities" and "Emotions." This is in agreement with the report of Müllensiefen, Fry, et al. (2014) who found that "Singing" is the only musical

behavior to be related positively to the frequency of INMI experiences.

The factor "Emotions" (Gold-MSI) is related positively to all IMIS factors and in particular to "Help" ($r(647) = .34$, $p < .01$). This suggests a possible overlap in the roles of both real and spontaneously imagined music in regulating mood and emotions. Congruence between mood/emotion states and INMI was reported by Williamson et al. (2012) in their study of INMI situational antecedents, but this is the first finding to suggest that INMI may regulate these states as well as trigger them. The possible role of INMI as a form of regulation may extend to physical movement as well as psychological states. In the present study there were significant correlations between "Reactive Musical Behavior" (MEQ) and all the IMIS factors, with the highest coming from "Movement" ($r(2139) = .39$, $p < .01$). This relationship indicates similarities between physical responses to hearing real music and the experience of INMI.

IMIS concurrent validity. Findings that contribute to the concurrent validity of the IMIS come from the association of: (a) the "Reactive Musical Behavior" subscale (MEQ) with the factor "Movement" (IMIS: $r(2139) = .39$, $p < .01$); (b) all the IMIS factors (except "Negative Valence") with the IPI subscales "Daydreaming Frequency" and "Auditory Images in Daydreams"; and (c) CIQ subscales "Intensity" and "Emotion" with "Personal Reflections" (IMIS).

General Discussion

We report on the development of IMIS, a new self-report scale, which measures individual differences within the INMI experience. The four IMIS factors represent a range of behaviors, emotions, reactions, and evaluations related to INMI. The factors cover, confirm, and quantify aspects of INMI that have been explored before in isolation, bringing them together in a single measurement instrument for the first time. The development of the IMIS factors has also permitted new insights into INMI, which are highlighted below.

"Negative Valence" (IMIS) measures the subjective evaluation of the INMI experience. The reported evaluation of INMI has proven diverse in the literature, ranging from pleasant and neutral (Beaman & Williams, 2010; Halpern & Bartlett, 2011) to annoying and disturbing (Hemming, 2009; Williamson et al., 2014). This situation is likely to be a consequence of the different ways in which people have been asked about their subjective responses to INMI in the various studies. Therefore, this IMIS factor provides the potential for a more consistent picture regarding subjective responses to INMI in the future.

"Movement" (IMIS) reveals a new aspect of INMI related to embodied responses, one that has not yet been reported in the INMI literature but existed only as an implication in previous studies. Beaman and Williams (2010) found that the chorus is the part of a song most often experienced as INMI, which usually contains a catchy "vocal hook" (Kachulis, 2005). Furthermore, Müllensiefen, Fry, et al. (2014) reported an association between "Singing" and the length of INMI episodes. These findings contribute to the understanding of the embodied responses in the INMI experience. In addition, similar findings relating musical imagery to the sensation or instigation of movement come from research on music listening (Werner et al., 2006) where a factor measuring a similar behavior has been reported ("Reactive Musical Behavior": MEQ). This result suggests potential for overlap in embodied responses to hearing real music and experiencing spontaneous INMI, a link that could be explored with both behavioral and neuroimaging studies.

"Personal Reflections" (IMIS) represents a personal quality associated with INMI. The personal quality can be related to the INMI trigger or its content, but it is important to note that "Personal Reflections" constitutes a separate component of the INMI experience that is not directly related to its subjective evaluation (valence), as indicated by the results of the factor analysis. This finding is in accordance with studies on task-unrelated thought (Andrews-Hanna, 2012; Klinger, 2008; Klinger & Cox, 1987-1988; Smallwood, Fitzgerald, Miles & Phillips, 2009), which found that a large amount of spontaneous thoughts centers on personal concerns and unresolved matters.

The last IMIS factor, "Help," comprises the beneficial and constructive aspects of INMI experiences. Throughout the literature INMI has been described as (un)pleasant, annoying, and disruptive (Beaman & Williams, 2010; Halpern & Bartlett, 2011; Hemming, 2009; Williamson et al., 2014) but never as helpful. The finding that INMI can actually be perceived as a supportive experience on some occasions but disruptive on others concurs with background music studies, which have shown that music listening can have beneficial effects (Cassidy & MacDonald, 2007; Kang & Williamson, 2014; Schellenberg, Nakata, Hunter, & Tamoto, 2007) but also disruptive consequences (Avila, Furnham, & McClelland, 2012; Schellenberg, 2012) on task performance depending on the type of music (Jäncke, Brügger, Brummer, Scherrers, & Alahmadi, 2014; Judde & Rickard, 2010; Rickard, Wong & Velik, 2012), personality (Furnham & Allass, 1999), or the level of neurophysiological arousal related to music (Furnham & Strbac, 2002; Jones, West & Estell, 2006). This result is also in accordance with studies on task-unrelated thought that demonstrated beneficial (Baird, Smallwood, & Schooler, 2010; Franklin et al., 2013) but also disruptive effects of the experience (Cheyne, Solman, Carriere & Smilek, 2009; Mrazek, Smallwood & Schooler, 2012; Smallwood et al., 2004). The factor "Help" (IMIS) could therefore potentially reflect similarities in the attributes of unfocused music listening, INMI and task-unrelated thought.

We observed strong associations between INMI and task-unrelated thought. For example, all the IMIS factors and INMI frequency were associated with measures of mind wandering (IPI), daydreaming (IPI), and musical behaviors (Gold-MSI, MEQ). This result concurs with previous findings that captured analogous relationships with self-report measures of musical and general activities (Hyman et al., 2013; Liikkanen, 2012; Müllensiefen, Fry, et al., 2014; Williamson et al., 2012), thereby linking task-unrelated thought and music behaviors with the INMI experience.

In summary, IMIS is a novel, reliable, and validated instrument that allows for systematic measurement of multiple, distinct aspects of the INMI experience. We envisage that the scale will be of use to researchers who aim to understand the origins of the INMI experience, as well as the commonalities and differences between INMI and other forms of spontaneous cognition, in terms of phenomenology and possible function.

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Appendix

Initial Hypothesized IMIS (Version 1) Items, Dimensions, and Scales

Dimensions, Scales, and Items of the Initial IMIS

Intensity/Frequency (Frequency scale[a])
1. I experience earworms
2. If I have an earworm it appears only once throughout the day
3. I get earworms soon after waking up
4. I get earworms at the end of the day
5. I get the same earworm coming back again and again

Disturbance (Frequency scale)
6. I try hard to get rid of my earworms
7. I find it difficult to get rid of my earworms
8. I find my earworms help me focus on the task that I'm doing
9. Earworms help me when I'm trying to get things done
10. When I have an earworm I find it easy to focus my attention
11. It worries me when I have an earworm stuck in my head
12. I find my earworms irritating
13. My earworms prevent me from sleeping
14. Earworms prevent me from falling asleep
15. My earworms agitate me

Trigger sensitivity (Frequency Scale)
16. I'm unaware of what caused an earworm
17. I try to work out what might have triggered my earworms
18. Hearing music triggers my earworms
19. My earworms result from unresolved matters
20. Personal issues trigger my earworms
21. Earworms happen when I'm absorbed in what I'm doing
22. My earworms are triggered when I think about past events
23. I get earworms when I'm doing physical activities such as exercise, walking, or cycling
24. I get earworms when I'm doing engaging mental activities such as reading or writing
25. I get earworms when I'm doing routine activities such as housework, cleaning, or brushing my teeth
26. Words that I hear or read trigger my earworms
27. Earworms happen when I'm not particularly focused on what I'm doing
28. My earworms are triggered when I think about future events

Psycho-physiological match (Frequency Scale)
29. My earworms don't necessarily match my mood
30. My earworms have a connection to what I'm currently doing
31. The content of my earworms mirrors my state of worry or concern
32. The rhythms of my earworms match my movements
33. The way I move is in sync with my earworms

(*Appendix continues*)

Appendix (*continued*)

Dimensions, Scales, and Items of the Initial IMIS
34. I get fewer earworms when I'm stressed
35. The speed of my earworms doesn't relate to how fast I move
Vividness (Frequency Scale)
36. My earworms are not as vivid as hearing real music
37. The speed of my earworm matches the speed of the original music
38. If my earworm contains lyrics then the singing voice I hear sounds like my own voice (rather than the original singer)
39. If my earworm contains many instruments I'm not able to hear them all at the same time
40. The lyrics in my earworms are not accurate
41. If my earworm contains an instrument (e.g., a trumpet) then it sounds very much like the original
42. If my earworm contains singing then the voice/s sounds very much like the original version
43. If my earworm is a song I experience only the tune without the words
Induced emotions: Valence (Frequency Scale)
44. The experience of earworms is not pleasant
45. I don't like the music I have as earworms
46. I like my earworms
47. I find my earworms boring
48. My earworms get more annoying the longer they stick in my head
49. Earworms are 'welcome guests' in my head
50. I wish I could stop my earworms
51. My earworms energize me
52. My earworms bring back past emotional associations
Approach vs withdraw (Frequency Scale)
53. My typical reaction to an earworm is to do nothing
54. When I get an earworm I try to block it
55. When I get an earworm I try to manipulate it in my head (e.g., make it play to the end, fill in musical details)
56. When I get an earworm I mention it to other people around me
57. My reaction to an earworm is to focus my mind on another task or activity
58. I try to distract myself from an earworm by doing something physical
59. When I get an earworm I move to the beat of the imagined music
60. My reaction to an earworm is to listen to/ sing/ hum/play the imagined music
Familiarity (Frequency Scale)
61. My earworms contain music that I have never heard before
62. The earworms I get are from styles of music to which I would not normally choose to listen
Time, length
63. On average, my earworm (the section of music that is stuck) lasts 1) Less than 5 s 2) Between 5 and 10 s 3) Between 10 and 30 s 4) Between 30 s and 1 min 5) More than 1 min 6) I don't know 7) N/A
64. Compared to the complete original music my earworm (the section of music that is stuck) is 1) Very much shorter 2) Somewhat shorter 3) A little shorter 4) About the same length 5) Longer 6) I don't know 7) N/A
65. On average, one earworm episode (a period of time where one particular tune gets stuck) lasts 1) Less than 10 min 2) Between 10 min and half an hour 3) Between half an hour and 1 hr 4) Between 1 and 3 hr 5) More than 3 hr 6) I don't know 7) N/A
66. On a day when I get a particular earworm I tend to notice it 1) Only once that day 2) Two or three times that day 3) More than five times that day 4) More than ten times that day 5) Almost continuously during the day 6) I don't know 7) N/A
67. My most recurring earworm has visited for 1) Days 2) A week or so 3) Two weeks or more 4) A month or more 5) Over a year 6) I don't know 7) N/A
68. In my life, there have been times when I've had earworms more frequently and times when they were less frequent 1) Strongly Disagree 2) Moderately Disagree 3) Neither Agree nor Disagree 4) Moderately Agree 5) Strongly Agree 6) I don't know 7) N/A

[a] Frequency scale.
1) Always 2) Most of the time 3) Sometimes 4) Not very often 5) Never.

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