

Psychometric evaluation of the Involuntary Musical Imagery Scale (IMIS) in a South African sample

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Abstract

Involuntary musical imagery (INMI) is a common variety of musical imagery (MI) that has been a key research interest in the psychology of music over the last ten years. The Involuntary Musical Imagery Scale (IMIS), a closed-ended self-report instrument that offers a standardized means of assessing different aspects of earworm experience, has previously been evaluated psychometrically in at least two predominantly Euro-American samples. This report extends the study of INMI, and of the IMIS in particular, into a multicultural and multilingual African context. Responses to the IMIS from a South African student sample were subjected to factor analysis, reliability analysis, and a series of correlational analyses in order to assess its robustness and suitability for cross-cultural research. Results suggest the IMIS has a robust factor structure, reliability characteristics, and internal intercorrelation patterns when compared to previous findings, even outside a Global North setting. Item and subscale scores generally converged with other indicators of MI and INMI frequency, as well as INMI pleasantness and levels of disturbance. In contrast to the findings of much previous research, IMIS Negative Valence correlated negatively with earworm frequency, section length, and episode length, providing support for the claim that earworms are generally a positive rather than aversive experience. Although IMIS earworm frequency was strongly and positively correlated with INMI frequency, they shared only 36.8% variance – a result consistent with concerns that MI/INMI definitions have considerable impact on self-reports of these phenomena, and specifically that the earworm experience should not be equated with or considered prototypical of INMI experience.

Keywords

Involuntary musical imagery, earworms, IMIS, psychometric, South Africa, cross-cultural

Musical imagery (MI) is a form of auditory imagery commonly experienced by many people. Up to 90% of people report having experiences of MI at least once a week (Liikkanen, 2008). They range from voluntary, controlled imagining of music (e.g., Zatorre et al., 2010; Zatorre, 2012) to persistent, repetitive, and mostly involuntary experiences of music or music fragments that

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have been variously characterized as *earworms*, *sticky tunes*, or (more generally) *involuntary musical imagery* (INMI) (see, for example, Beaman & Williams, 2010; Liikkanen, 2008, 2012a, 2012b; Sacks, 2007; Williamson et al., 2014). Individuals have even reported experiencing MI during most of their waking lives – a kind of “perpetual music track” (Brown, 2006, p. 44) playing inside their head.

As an instance of auditory imagery (see Hubbard, 2010, 2018), INMI can also be assigned, or at least closely related, to broader categories of cognitive phenomena such as involuntary semantic memories (Kvavilashvilia & Mandler, 2004), intrusive thoughts (Beaman & Williams, 2010; Hyman et al., 2015), and mind wandering (Hyman et al., 2013). Beaman and Williams (2010; see also Beaman, 2018) date much of the contemporary scientific interest in INMI and earworms to unpublished empirical work by Kellaris in the early 2000s (e.g., Kellaris, 2001), popular science discussions of earworms by Levitin (2006) and Sacks (2007), and two empirical studies in the field of consciousness studies (Brown, 2006; Wammes & Barušs, 2009). INMI has been investigated both inside and outside the laboratory, with the range of studies including large-scale retrospective surveys (e.g., Liikkanen, 2008, 2012b), experience-sampling studies of everyday INMI experience (e.g., Cotter & Silvia, 2017), qualitative studies (e.g., Williamson et al., 2012; Williamson & Jilka, 2014), and MI induction procedures (e.g., Floridou et al., 2018; Liikkanen, 2012a).

Definitions of INMI vary in the literature (Cotter, 2019; Williams, 2015). While all agree that the phenomenon of INMI is a type of musical imagery, there is much less consensus about the sense in which it is involuntary. Most researchers have considered INMI to be involuntary due to its repetitive looping nature (e.g., Byron & Fowles, 2013; McCullough, 2014; Williamson & Jilka, 2014) and/or its stickiness (e.g., Beaman & Williams, 2010; Beaman et al., 2015). Other definitions have proposed that the onset of INMI is involuntary (e.g., Hemming & Altenmüller, 2012), but agreement on this is not unanimous; it may therefore be more appropriate to refer to its onset as spontaneous (Williamson et al., 2014) or unintentional (Liikkanen, 2012a). It is also a feature of the musical imagery literature that the terms INMI and earworms are frequently used interchangeably (Williams, 2015), even while it has been claimed that earworms are at best only one form or variety of INMI experience, and that use of the common-language term “earworm” may unduly shape and constrain the types of experiences that research participants report on in INMI research (Cotter et al., 2019).

For example, it is noteworthy that despite its name, items in the Involuntary Musical Imagery Scale (Floridou et al., 2015 – the focus of the current study) are all phrased with reference to earworms (e.g., “I find my earworms irritating”), and that the definition of INMI offered to respondents explicitly equates INMI with earworms:¹ “Do you have a tune stuck in your head? This experience is also known as involuntary musical imagery (INMI) or ‘having an earworm.’” This definition also explicitly connects the involuntariness of earworms to the manner in which the music comes to mind (“without effort”) rather than to their repetitive and persistent character. In contrast, the definition of INMI in the survey component of the current study (based on a broad survey of the INMI literature; see 1.3 in the Supplementary Materials) is silent about the onset of INMI, makes no mention of earworms, and explicitly connects the involuntariness of the phenomenon to its repetitive nature and the difficulties people have in trying to terminate episodes. The significance and impact of these nuanced differences in emphasis are perhaps likely to be subtle, but nevertheless worthy of investigation if the issues raised by Williams (2015) and Cotter et al. (2019) are to be taken seriously.

The publication of the Involuntary Musical Imagery Scale (IMIS; Floridou et al., 2015) was an important development in INMI-related research. It is a candidate standardized self-report measure of INMI-related experience that might replace the varied and often limited survey

items and questionnaires (Cotter et al., 2016) used in earlier INMI studies. Floridou et al. (2015) report on the development and psychometric analysis of the IMIS, including its factor structure, reliability estimates, and convergent correlations with potentially related thinking styles, music-related behaviors, and voluntary auditory imagery abilities. The scale consists of 15 items tapping four dimensions of earworm experience: Negative Valence (seven items, e.g., “I find my earworms irritating”), Movement (three items, e.g., “When I get an earworm I move to the beat of the imagined music”), Personal Reflections (three items, e.g., “My earworms result from unresolved matters”), and Help (two items, e.g., “Earworms help me when I’m trying to get things done”), as well as three items dealing with average earworm frequency, section length (i.e., the length of the repetitive section of music), and episode length (i.e., the duration of the entire imagery experience).

Cotter et al. (2016) further assessed this instrument in a study relating IMIS subscale scores to personality factors and facets, as well as schizotypy. Using a sample of undergraduate students ($N=182$), the IMIS subscales were shown to have moderate to good reliability. Observed correlations between INMI frequency and three of the four IMIS subscales (Movement, Personal Reflections and Help) and Openness to experience, Neuroticism, and positive schizotypy traits were, in the authors’ view, theoretically consistent with the construct of INMI (Cotter et al., 2016). For example, the strongest correlations reported in the study included those between the Fantasy facet of Openness to Experience and INMI frequency ($r=.30$), between the Magical Ideation facet of positive schizotypy and Movement ($r=.32$), and between Magical Ideation and Personal Reflections ($r=.30$). This is consistent with the positive associations between these personality characteristics, imagination, and the intensity of inner experience more generally. The authors concluded that the IMIS shows potential as a useful instrument in research on individual differences in INMI.

The scale has subsequently been used in a variety of MI studies, including examinations of INMI accompanied by voluntary and involuntary mental imagery (Floridou et al., 2019b), retrospective versus experience-sampling methods for assessing MI (Cotter & Silvia, 2017), associations between aspects of INMI experience and brain structure (Farrugia et al., 2015), comparisons between INMI as a form of involuntary memory and voluntary MI in terms of tempo recall and emotional response (Jakubowski et al., 2018), and aging and involuntary/voluntary cognitions (Floridou et al., 2019a).

What appears to be generally absent from the INMI literature, including work that utilizes the IMIS, is research in contexts and using samples other than those that are European or American. There are currently three exceptions that we are aware of: a Twitter-based study of earworm-related tweets by Liikkanen et al. (2015) that sampled tweets from 173 countries, an experimental study of earworm induction and working memory in a South African student sample (Geffen & Pitman, 2019), and a recent study on the adaptation and validation of the IMIS in mainland China (Jue et al., 2020).

Ironically, the results of Liikkanen et al.’s (2015) multinational study tend to confirm the strong Euro-American bias in much INMI research while trying to transcend it. Of the 66,477 tweets sampled in the study that included information about user location, more than 70% came from the US (21,656), UK (17,717), Canada (4,677), and Australia (3,140). This represents a strong geographic and cultural-linguistic (English) bias in the data. In all, the study did achieve a level of diversity in sampling tweets from 173 countries, including contributions from South Africa (639), Kenya (108), Nigeria (98), Egypt (94), and Zimbabwe (34). Yet these contributions were dwarfed by those from sampled from the Global North,² and 93 of the 173 countries contributed only ten or fewer tweets to the dataset. As Jue et al. (2020) note in their

paper, the Liikkanen et al. (2015) study also eliminated all tweets that were not in English, further reducing some of the potential cultural-linguistic diversity in these data.

South Africa presents a context for MI and INMI studies that is more linguistically and culturally diverse than typical samples from the Global North and/or predominantly mono-lingual societies across the globe. The country has 11 official languages, of which nine are indigenous African languages. In the current study, over half of the participants reported a home language other than English, with the vast majority of these being indigenous African languages. South Africa is of further interest because of its mix of multiple musical traditions and genres, including music from various African traditions and local genres such as Kwaito, and strong connections between music, performance, and oral traditions such as praise singing in communal engagements with music (Yang et al., 2019; Erlmann, 2013) and in politics (Wood, 2015). The present study sought to explore and evaluate the psychometric properties of the IMIS in this diverse and multicultural South African context, in order to assess its potential as a tool for MI research on the African continent.

Method

Participants

Participants comprised a sub-sample of 183 first-year undergraduate psychology students at the University of the Witwatersrand, Johannesburg. They had all taken part in a larger survey-based study ($N=270$) on music use and musical imagery, including INMI, and had completed the survey up to and including the IMIS. They were able to earn course credits for participation. Two participants were excluded because they were under 18 years of age, leaving a final sample of 181 (141 females), whose ages ranged between 18 and 52 ($M=20.23$ years; $SD=4.19$; four missing values). Respondents were asked if they played a musical instrument (“Do you play any musical instruments (this includes singing)?”), and further asked to list the relevant instrument/s if they had answered in the affirmative. While the survey included further items on formal training, years of training, and hours of practicing that could have been used to construct a more nuanced operational definition of musicianship (see Zhang et al., 2020), this study identified musicians as those who reported that they did play a musical instrument. This less stringent, more inclusive classification was chosen, in part, because group singing, including communal, political, and religious singing from early childhood, is such a notable feature in most South African communities (Erlmann, 2013; Wood, 2015; Yang et al., 2019). Against this background, differentiating between singing proficiency and performance exhibited within these communal/ cultural practices, and vocal skill acquired through a more individualized, Western-style, formal vocal training, risked re-imposing forms of cultural bias that the diversity of the sample was designed to avoid. Thus, on the basis of self-reported playing of an instrument, the sample was evenly split between musicians ($n=91$) and non-musicians ($n=89$; one missing value). In terms of music listening, the majority ($n=163$) reported listening to music every day (115 reported listening for two or more hours per day). Music preferences were relatively diverse (see Supplementary Materials, Table A1). It is notable that 28.2% indicated a preference (“like” or “love”) for Kwaito, with 24.9% enjoying African traditional music, and that in a sample with a mean age of just over 20 years, many expressed preferences for jazz (54.35%) and for gospel music (47.28%). The most popular genres were R&B (72.82%), pop (66.66%), and hip-hop/rap (60.22%). Participants reported more than 11 different home languages, with 50.82% having one of the indigenous African official languages as their mother tongue, and many students claiming proficiency in three or more of the official languages of the country (see Supplementary Materials, Tables A2 and A3). Since the language of the survey, including

the IMIS, and the medium of instruction in the university were English, participants' home language was classified as English ($n=85$) or other than English ($n=92$; four missing values) for the purpose of analysis.

Instruments

The larger survey consisted of items drawn or adapted from previously published musical imagery studies (e.g., Liikkanen, 2008), and included demographic items such as age, sex, home language, musical instrument(s) played including voice, and years of performance and years of formal training on instrument(s). Further self-report items relevant to the current analysis included frequency of music listening; MI frequency; INMI frequency; pleasantness/unpleasantness of INMI; and extent of disturbance associated with INMI experiences (see 1.1 in the Supplementary Materials, Selected demographic and other survey items).

Over the course of the survey, participants were introduced to three definitions of MI (see Supplementary Materials 1.2 to 1.5). The first was a general definition in relation to frequency: "How often do you experience musical imagery (that is, hearing a song or piece of music 'in your head' without the music coming from any external source)?" The second was a definition of INMI also in relation to frequency: "How often would you say you have the experience of having a piece of music 'stuck in your head'—i.e., an experience of involuntary musical imagery (INMI):?". This INMI frequency question was accompanied by a brief description of INMI, based on various definitions in the literature, in which the involuntariness of the phenomenon is explicitly linked to both its repetitive nature and the difficulty people have when trying to terminate episodes. The third was the definition of an earworm, slightly modified from the one provided in the original Involuntary Musical Imagery Scale (IMIS: Floridou et al., 2015) by removing their statement of equivalence between INMI and earworm phenomena (compare 1.4. and 1.5. in the Supplementary Materials). This small change enabled the study to avoid using "INMI" and "earworms" interchangeably, while also subtly contrasting what respondents were told about the form of involuntariness at issue in each definition. This, in turn, opened up the possibility that participants might respond differently to items anchored to each definition, such as the self-reported frequency of these phenomena.

The IMIS is a 15-item scale intended to measure four different aspects of INMI experience: Negative Valence, Movement, Personal Reflections, and Help, using a five-point scale anchored by 1=*Never* and 5=*Always*. Higher scores indicate higher values for the construct on each subscale. A further three items ask about the frequency of earworm experience on a six-point scale from 1=*Never* to 6=*Almost continuously*, the average length of the section or fragment of music that keeps repeating on a five-point scale from 1=*less than 5 seconds* to 5=*more than 10 minutes* (earworm section length), and the average length of time over which an earworm continues to repeat itself on a five-point scale from 1=*less than 10 minutes* to 5=*more than 3 hours* (earworm episode length). Floridou et al. (2015) reported alphas of .91 (Negative Valence), .88 (Movement), .76 (Personal Reflections), and .84 (Help) for each of the four subscales. Cotter et al. (2016) estimated alphas at .88 (Negative Valence), .85 (Movement), .72 (Personal Reflections), and .79 (Help).

Procedure

Clearance to conduct the study was obtained from the University of the Witwatersrand Human Research Ethics Committee – Non-medical (protocol number: H15/05/34). First-year psychology students received an emailed announcement regarding the study via the university's teaching platform (SAKAI) containing a brief description of the study, an invitation to participate,

and a hyperlink to a custom SurveyMonkey URL. Students who followed the link arrived at a full participant information sheet outlining all aspects of participation in the study, including all salient ethical issues, and this was followed by an explicit question about consent. Only volunteers who gave consent were able to proceed to the full survey. On average, participants took 20 minutes to complete the full online survey.

Results

Descriptive demographic statistics for the sample, including a variety of music-related variables, are presented in Table 1. Respondents generally evinced a high degree of engagement with music, whether via playing and receiving formal training on an instrument, or daily listening to music.

Response frequencies for the IMIS items dealing with earworm frequency, section length, and episode length are presented in Table 2. Earworm experience was common: 71.3% of the sample reported experiencing earworms several times a week or more, with 31.5% experiencing earworms on a daily basis. The modal response (29.3%) reported for earworm section length was 5–10 seconds, with 53.1% of participants reporting average earworm section lengths of 5–30 seconds, and 21.5% claiming average earworm section lengths of more than a minute. The majority of participants (65.8%) reported average earworm episode lengths of less than half an hour, with the most frequent episode length (34.3%) being less than ten minutes. As many as 18.2% of participants reported their average earworm episode length at more than an hour.

Non-parametric Mann–Whitney U tests were used to make groupwise comparisons of these three variables by sex, home language, and musicianship (see Table 3). No significant differences were found between musicians and non-musicians. Women and men experienced significantly different lengths of earworm episode ($p=.015$, Kendall's τ -b = $-.165$, small effect). Women tended to report longer average episode lengths than men. These results should be viewed with caution, given the imbalance between sexes reported in the sample (141 women versus 40 men). English home language speakers differed from those with a home language other than English in terms of average reported section length ($p=.023$, Kendall's τ -b = $.156$, small effect). English home language speakers tended to report shorter average earworm section lengths (median response 10–30 s, modal responses of both 5–10 s and 10–30 s) than participants with other home languages (median and modal response 30 s to 1 min).

In order to assess the factor structure of the IMIS (Floridou et al., 2015), responses to the 15 IMIS items were entered into a Principal Components Analysis (PCA) with Varimax rotation, using IBM SPSS version 25. As in Studies 1 and 2 reported by (Floridou et al., 2015) the three IMIS items relating to earworm frequency, section length, and episode length were not included in the factor analysis. The correlation matrix indicated that all item variables had one or more correlations above .30 with other item variables. The overall Kaiser–Meyer–Olkin (KMO) measure was .823 (good sampling adequacy), and all individual item KMO measures were above .6 (12 KMOs above .7). Bartlett's test of sphericity was also significant ($p<.001$).

Based on component eigenvalues greater than 1, and the inflection point of the scree plot, PCA suggested a clear four-factor solution, cumulatively explaining 78.2% of the variance. The four unrotated factors explained 37.2%, 21.1%, 11.8%, and 8% of the variance respectively. The orthogonal Varimax rotation procedure yielded a clear four-component structure, with no cross-loadings above .3 (Table 4), that conforms exactly to the structure reported by Floridou et al. (2015). The rotated-factor solution reported is based on the responses of 181 participants, with variable mean substitution for nine cases evidencing at most one missing

Table 1. Descriptive demographic statistics.

	<i>n</i>	%
Participant sex		
Female	141	77.9
Male	40	22.1
Home language		
English	85	47.0
Other than English	92	50.8
Missing	4	2.2
Musicianship		
Musician	91	50.3
Non-musician	89	49.2
Missing	1	.6
Years on instrument/s		
<1yr	4	4.5
1–2yrs	10	11.4
3–4yrs	14	15.9
5–6yrs	14	15.9
7–8yrs	10	11.4
9–10yrs	9	10.2
>10yrs	27	30.7
Missing	3	
Formal training		
Yes	50	54.9
No	41	45.1
Years of formal training		
<1yr	2	4
1–2yrs	14	28
3–4yrs	10	20
5–6yrs	14	28
7–8yrs	4	8
9–10yrs	2	4
>10yrs	3	6
Missing	1	2
Music listening		
Daily	163	90.1
Less than daily	16	8.8
Missing	2	1.1
Hours of listening (p/d)		
Less than an hour per day	15	9.2
1–2 hours	35	21.5
2–3 hours	48	29.4
3–4 hours	25	15.3
4–5 hours	19	11.7
more than 5 hours	22	13.5

Note. *N* = 181. Participants were on average 20.2 years old (*SD* = 4.2), with a range of 18 to 52 years.

Table 2. Frequencies for IMIS earworm frequency, section length, and episode length.

	<i>n</i>	%	Cumulative %
On average, I experience earworms _____.			
Once a month	19	10.5	10.5
Once a week	33	18.2	28.7
Several times a week	72	39.8	68.5
Several times a day	41	22.7	91.2
Almost continuously	16	8.8	100.0
Total	181	100.0	
On average, my earworm (the section of music that is stuck) lasts:			
Less than 5 seconds	4	2.2	2.2
Between 5 and 10 seconds	53	29.3	31.5
Between 10 and 30 seconds	43	23.8	55.2
Between 30 seconds and 1 minute	42	23.2	78.5
More than 1 minute	39	21.5	100.0
Total	181	100.0	
On average, one earworm episode (a period of time when one particular tune gets stuck) lasts:			
Less than 10 minutes	62	34.3	34.3
Between 10 minutes and half an hour	57	31.5	65.7
Between half an hour and 1 hour	29	16.0	81.8
Between 1 and 3 hours	23	12.7	94.5
More than 3 hours	10	5.5	100.0
Total	181	100.0	

Table 3. Nonparametric pairwise comparisons – Mann-Whitney U (M-WU).

	Pairwise comparison				<i>M</i> – <i>WU</i>	<i>p</i>	<i>Effect size</i> (Kendall's <i>tau</i> – <i>b</i>)
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Musicianship	Mus		N–Mus				
Earworm frequency	4.10	0.94	3.93	1.23	3,870.0	.592	–.036
Section length	3.43	1.06	3.31	1.25	3,884.5	.626	–.033
Episode length	2.36	1.20	2.16	1.23	3,593.0	.174	–.093
Sex	Female		Male				
Earworm frequency	4.01	1.08	4.05	1.1	2,887.0	.811	.016
Section length	3.44	1.15	3.11	1.16	2,337.0	.088	–.116
Episode length	2.35	1.19	1.95	1.25	2,137.0	.015*	.165*
Home language	Eng		O–Eng				
Earworm frequency	4.07	1.02	3.97	1.16	3,725.0	.571	–.039
Section length	3.15	1.13	3.57	1.16	4,661.5	.023*	.156*
Episode length	2.33	1.28	2.20	1.28	3,518.0	.231	–.082

value. The same analysis (not reported here) was run excluding all nine cases with a missing value, and the same factor structure was obtained (the factor solution also accounting for 78.2% of the variance). Reliability analysis for each of the subscales yielded alphas of .938

Table 4. Rotated factor solution for the Involuntary Musical Imagery Scale (IMIS).

IMIS Item	Factor loading			
	1	2	3	4
Factor 1: Negative Valence				
1. I try hard to get rid of my earworms	0.803	0.099	0.040	−0.154
2. It worries me when I have an earworm stuck in my head	0.773	0.221	−0.020	0.090
3. I find my earworms irritating	0.893	0.025	0.119	−0.115
4. My earworms agitate me	0.846	0.181	0.150	−0.098
5. The experience of my earworms is unpleasant	0.893	0.088	0.047	−0.036
6. I wish I could stop my earworms	0.843	0.038	−0.044	−0.010
7. When I get an earworm I try to block it	0.852	0.100	−0.002	−0.176
Factor 2: Personal Reflections				
11. My earworms result from unresolved matters	0.251	0.796	0.091	0.134
12. Personal issues trigger my earworms	0.157	0.905	0.095	0.062
13. The content of my earworms mirrors my state of worry or concern	0.050	0.879	0.101	0.053
Factor 3: Movement				
8. The rhythms of my earworms match my movements	0.094	0.127	0.874	0.147
9. The way I move is in sync with my earworms	0.089	0.092	0.913	0.008
10. When I get an earworm I move to the beat of the imagined music	−0.020	0.059	0.790	0.180
Factor 4: Help				
14. I find my earworms help me focus on the task that I'm doing	−0.194	0.071	0.188	0.901
15. Earworms help me when I'm trying to get things done	−0.096	0.160	0.144	0.910

Note. $N = 181$. The extraction method was Principal Component Analysis employing Varimax rotation (with Kaiser Normalization).

(Negative Valence), .847 (Movement), .861 (Personal Reflections), and .877 (Help) respectively.

Intercorrelations between the IMIS subscale scores, and earworm frequency, section length, and episode length, can be found in Table 5. Earworm frequency, section length, and episode length were significantly but weakly intercorrelated (as they are, for example, in Cotter & Silvia, 2017), suggesting that more frequent occurrences of earworms would tend to be associated, on average, with longer fragments of music that were experienced as earworms for longer periods of time. Intercorrelations between the IMIS subscales were also largely consistent with their item content and underlying constructs. In particular, Negative Valence showed close to no association with Movement, a significant but weak positive correlation with IMIS Personal Reflection, whose items all refer to more ruminative or brooding forms of self-reflection, and a significant weak negative correlation with Help, whose two items tap the positive outcomes of earworms. Negative Valence was negatively correlated with earworm frequency, section length, and episode length, suggesting that more negative experiences of earworms (i.e., producing high scores on Negative Valence) were associated with fewer, shorter, and less persistent earworms.

While the survey administered in the present study included fewer variables than Floridou et al.'s (2015) Study 3, a number of items could nevertheless be used to assess the convergent

Table 5. Nonparametric correlations: IMIS intercorrelations.

Variable	1	2	3	4	5	6	7
1. Earworm Frequency	–						
2. Section Length	.236**	–					
3. Episode Length	.225**	.155*	–				
4. IMIS Negative Valence	–.300**	–.176*	–.097	–			
5. IMIS Movement	.077	.051	.059	.076	–		
6. IMIS Personal Reflections	.091	–.024	–.012	.255**	.244**	–	
7. IMIS Help	.100	.103	.007	–.186*	.300**	.189*	–

Note. All reported correlations are nonparametric Spearman's correlations.
* = $p < .05$ (2-tailed). ** = $p < .01$ (2-tailed).

Table 6. Nonparametric correlations: Convergent correlations of IMIS items and subscales with selected MI and INMI survey items.

Variable	Age	Music listening	MI frequency	INMI frequency	INMI pleasant	INMI disturb
Earworm frequency (IMIS)	–.238**	.155*	.583**	.607**	.145	–.085
Section length (IMIS)	–.246**	.075	.185*	.201**	.226**	–.078
Episode length (IMIS)	–.094	.008	.178*	.272**	.110	–.118
Negative Valence	.059	–.007	–.226**	–.109	–.448**	.454**
Movement	–.072	.200*	.155*	.184*	.145	.010
Personal Reflections	–.007	–.045	.067	.056	.002	.251**
Help	–.027	.043	.058	.113	.273**	–.161*
IMIS item 5	–	–	–	–	–.422**	.421**

Note. All reported correlations are nonparametric Spearman's correlations. IMIS Item 5 = "The experience of my earworms is unpleasant." Music listening = Music listening frequency (survey). MI Frequency = Musical imagery frequency (survey). INMI frequency = Involuntary musical imagery frequency (survey). INMI pleasant = Pleasantness of INMI (survey). INMI disturb = Disturbing nature of INMI (survey).
* = $p < .05$ (2-tailed). ** = $p < .01$ (2-tailed).

and discriminant validity of the IMIS items and scores. Correlations between the IMIS subscales and these selected items are summarized in Table 6. Survey items addressing frequency of musical imagery (.583, $p < .001$) and INMI frequency (.607, $p < .001$) correlated strongly with the frequency of earworms as assessed by the IMIS, suggesting adequate levels of agreement amongst these frequency-related items. At the same time, the correlation between INMI frequency (survey) and earworm frequency (IMIS) was far from perfect - it reflected only 36.8% shared variance - which is noteworthy given that these terms are often used synonymously in the literature, most notably within the original IMIS itself. Furthermore, INMI frequency (survey) did not show the same strength and significance of associations with Negative Valence and Movement as these subscales had shown to earworm frequency (IMIS). In particular, the significant weak-to-moderate negative association between earworm frequency and Negative Valence ($-.3$, $p < .001$) was not evident in relation to the survey's INMI frequency item ($-.109$, $p > .05$); and there was a weak but significant positive correlation between the survey's INMI frequency item and the Movement subscale (.184, $p = .013$) that was entirely absent in the case of the correlation between earworm frequency and Movement (.077, $p > .05$). There were,

however, weak but significant positive associations between INMI frequency (survey) and both the IMIS's earworm section (.201, $p=.007$) and episode length scores (.272, $p<.001$), and these were consistent with the pattern of association between these scores and the IMIS earworm frequency item (.236, $p=.001$ and .225, $p=.002$ respectively).

The Negative Valence subscale showed appropriate, moderate, significant correlations with the survey items reflecting pleasantness ($-.448$, $p<.001$) and disturbance (.454, $p<.001$) associated with INMI experiences, thus providing evidence of convergent validity. The IMIS item that refers specifically to the unpleasantness of earworm experiences (Item 5) also correlated appropriately and significantly with the survey ratings of pleasantness ($-.422$, $p<.001$) and disturbance (.421, $p<.001$). Much weaker but still appropriate and significant correlations were found between the survey's disturbance item and both the Personal Reflections (.251, $p=.001$) and Help subscales ($-.161$, $p=.031$). Help correlated weakly but significantly with INMI pleasantness (.273, $p<.001$), suggesting that the helpfulness of earworms is associated with a general tendency to experience INMI as pleasant.

Music listening was weakly associated with earworm frequency (.155, $p=.048$) and *Movement* (.200, $p=.01$), but not with any other scores from the IMIS. There were negative correlations between the age of participants, earworm frequency ($-.238$, $p=.001$) and section length ($-.246$, $p=.001$), consistent with the predictions and results of Floridou et al. (2019a).

Discussion

To the best of the authors' knowledge, this study represented the first use of the Involuntary Musical Imagery Scale in the multicultural, multilingual, and musically diverse context of South Africa. In a sample that included more than 50% of participants with home languages other than English, evenly balanced between musicians and non-musicians, but with predominantly women participants, the IMIS demonstrated psychometric characteristics consistent with those reported by its authors, Floridou et al. (2015). The rotated factor structure for the scale, and the resulting subscale structures, followed exactly the pattern of that reported in Floridou et al.'s (2015) Study 2. Unfortunately, comparisons to the factor analytic results of Jue et al.'s (2020) study in mainland China were not possible because these authors added and removed items from the original IMIS, and subsequently found a factor solution with two novel dimensions, interpreted as Spare cognitive capacity, and Mind-wandering.

Internal consistency reliabilities for the Negative Valence, Movement, Personal Reflections, and Help subscales were all above .84, consistent with or higher than the alphas reported by the test authors, and higher than three of four alphas reported by Cotter et al. (2016). While some significant differences were noted between broad home language categories (English vs. other than English), these had weak effect sizes, and provide no obvious basis for suspecting linguistic bias. These results provide encouraging evidence of the robustness of the IMIS for cross-cultural use in a range of cultural, linguistic, and musical settings.

Intercorrelations between the IMIS subscales were consistent in terms of direction, effect size, and significance with those reported by Cotter et al. (2016). In terms of intercorrelations with the earworm frequency, section length, and episode length items, Negative Valence correlated negatively with average earworm frequency, section length, and episode length. The same negative trend was evident in Negative Valence correlations with MI and INMI frequency items, suggesting that participants experiencing more and longer earworms over longer periods of time tended to associate their experience with less negative valence (i.e., affect). This result appears consistent with studies indicating that INMI tends to be experienced positively (Beaman & Williams, 2010; Beaty et al., 2013; Floridou & Müllensiefen, 2015; Halpern & Bartlett, 2011;

Hyman et al., 2015). This is in contrast to the corresponding correlations as reported by Floridou et al. (2015), which were all positive and very weak or near zero, and those reported Cotter et al. (2016) between Negative Valence and the IMIS section and episode length items, which were also positive and very weak. These inconsistent findings warrant further investigation.

IMIS items and subscales demonstrated mostly expected and appropriate patterns of convergent validity with relevant items from the larger survey. This was especially evident in the case of the Negative Valence subscale, which correlated well with items tapping the pleasantness/unpleasantness and disturbing character of INMI. Weaker but also expected patterns of association were observed between these INMI items and the Personal Reflections and Help scales respectively.

While IMIS earworm frequency correlated strongly with self-reported INMI frequency, this strong correlation (.607) nevertheless reflects only 36.8% shared variance between these items, despite INMI and earworms frequently being treated as synonymous terms. INMI frequency also failed to show the same pattern of associations with the IMIS subscales, at least in the cases of Negative Valence and Movement. Taken together, this suggests that self-reports of musical imagery frequency may vary depending on the definitions provided and, specifically, that use of the term *earworm* may have different and specific connotations for respondents compared to the more general term *involuntary musical imagery*. This issue will be explored in greater detail in future research, for example, engaging with Cotter et al.'s (2019) dimensional approach to MI. It is possible that observed discrepancies between reported INMI and earworm frequencies might be an artefact of this study, perhaps because the IMIS was the last instrument in an online survey taking 20 minutes or more to complete that had already asked questions about musical imagery and involuntary musical imagery. Nevertheless, replication of these trends might suggest that the IMIS would be better understood, utilized, and renamed as an earworm scale, best suited to researching the earworm as a specific subtype of musical imagery, with characteristics that might not be shared by other musical imagery phenomena, including INMI as it is conceived more generically. Future research should also consider the appropriateness of earworm-focused measures of INMI, given the concerns raised by Williams (2015) and Cotter et al. (2019) about using the terms earworms and INMI interchangeably when earworms represent only one type of INMI.

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Supplemental material

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Notes

1. "Do you have a tune stuck in your head? This experience is also known as involuntary musical imagery (INMI) or 'having an earworm.' An earworm is a short section of music that comes into your mind without effort (it is involuntary; i.e. it comes even though you did not have any intention to retrieve or remember the music) and then repeats by itself spontaneously (i.e. without you consciously trying to replay the music) at least once, on a loop. It may have words or it may just be a melody or a rhythm." (Floridou et al., 2015, p. 29. See also 1.5 in the Supplementary Materials)
2. Wikipedia identifies the Global North as including the United States, Canada, most Western European countries, Israel, Singapore, South Korea, Taiwan, Japan, Australia, and New Zealand ("North-South divide in the world", 2020, December 10).

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