



The Leverhulme Trust

Investigating temporal and melodic features of involuntary musical imagery

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Outline

- Introduction & background
- Study 1: Tracking the tempo of INMI
- Study 2: Measuring melodic features of INMI

Involuntary musical imagery (INMI)

- A section of music that is **retrieved involuntarily** in the mind and **repeats** on a loop
- Also called “earworms”, “sticky tunes”, etc., will be referred to here as INMI
- One of the most common types of *involuntary semantic memories* (Kvavilashvili & Mandler, 2004)
- Experienced by $\approx 90\%$ of people (Liikkanen, 2012a)

Previous INMI research

- A large body of evidence has now accrued regarding the subjective experience, situational antecedents, evaluation, and behavioural reactions to INMI (e.g., Beaman & Williams, 2010, 2013; Halpern & Bartlett, 2011; Liikkanen, 2012a, 2012b; Williamson et al., 2012, 2014)
- Comparatively little research has examined the *musical content* of the INMI experience (e.g., tempo & melodic features)

Study 1: Tracking the Tempo of INMI in you

A new method for INMI research

- Aim: Obtain quantitative measurements of INMI tempo during everyday life
 - Participants tapped to the beat of their INMI with a wrist-worn accelerometer
- Combined this measure with traditional diary-based methods (e.g., Bailes, 2006, 2007)

Research Question 1

- **Investigate the precision of memory representations within INMI, specifically in terms of temporal veridicality**

Research Question 1

- Some participants subjectively report INMI to be a fairly authentic reproduction of the original music (Brown, 2006; Williamson & Jilka, 2013)
- *Deliberately* recalled musical memories are often highly veridical (Levitin & Cook, 1996)
- Involuntary *autobiographical* memories are often more specific and detailed than voluntary autobiographical memories (Berntsen, 1998; Mace, 2006; Schlagman & Kvavilashvili, 2008)
 - What about involuntary *semantic* memories?

Research Question 2

- **Investigate the relationship between INMI and concurrent affective state**

Research Question 2

- Some evidence that INMI interacts with mood state (Bailes, 2012; Williamson et al., 2012)
- Findings from perceived music research:
 - Positive relationships between tempo and arousal (Husain, Thompson, & Schellenberg, 2002; Jakubowski et al., 2014)
 - Major mode is associated with more positive emotional valence than minor mode (e.g, Dalla Bella et al., 2001; Husain et al., 2002)

Method

Design:

- Naturalistic study over the course of 4 days

Participants:

- N=17 (7 male), ages 20-34 years ($M = 24.6$)
- Reported experiencing INMI at least several times a day

Method



Materials:

- GeneActiv wrist-worn accelerometer to measure INMI tempo
- Paper diary
 - Filled in following each tapping period
 - Questions on time & date, song title, artist, & section, triggers of episode, last hearing of the song, mood assessment: Arousal and Positivity (Bailes, 2012; Sloboda, O’Neill, & Ivaldi, 2001)

Method

Procedure:

- Participants chose a 4-day period
- Experimenter provided a definition of INMI and instructions for the tapping procedure and diary booklet
- Participants asked to tap along to the beat of the music as closely as possible to what they heard in their head
- Examples of musical beat provided
 - Row row row your boat gent-ly down the stream _____

Results & Discussion

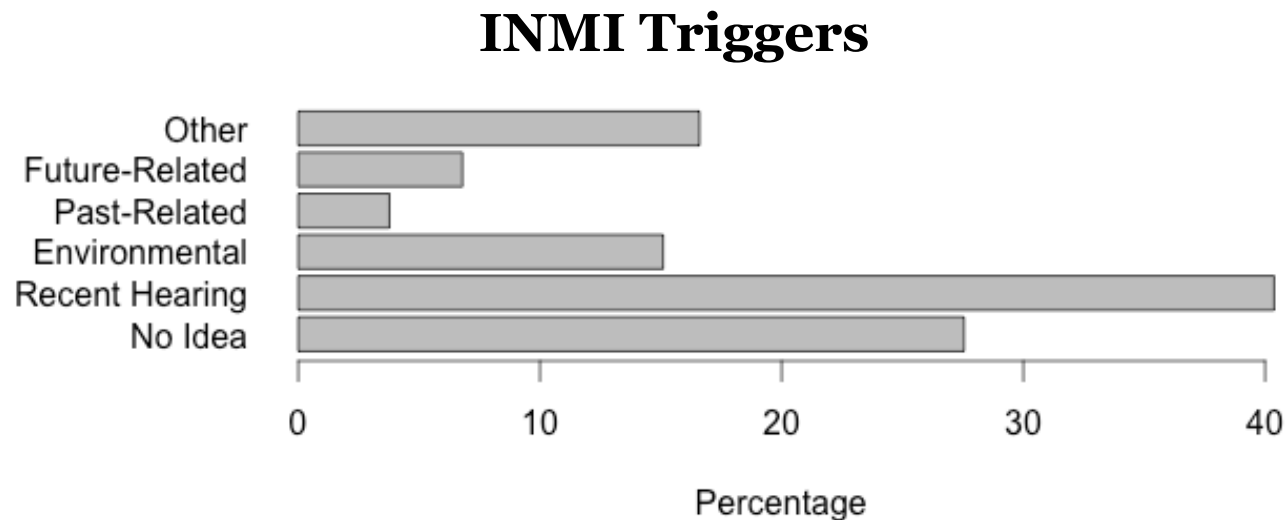


Descriptive Statistics:

- 275 INMI episodes in total
 - 7-32 INMI episodes per participant, 0-10 episodes per day
- 182 unique songs
 - Only 1 song repeated across 2 participants
 - Corroborates previous findings on the idiosyncratic nature of INMI (e.g., Beaman & Williams, 2010; Williamson & Müllensiefen, 2012)

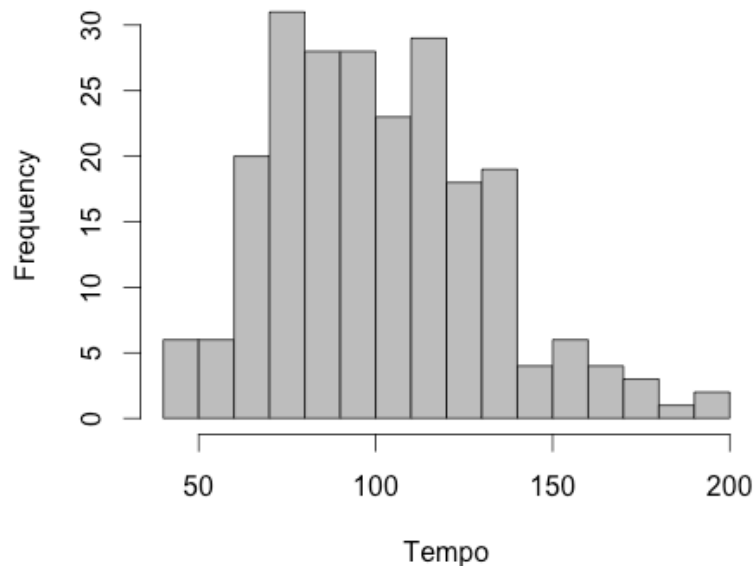
Results & Discussion

- 16.2% of songs experienced as INMI had been heard less than 1 hour ago, 40.0% of songs hadn't been heard in over 1 week
- Data on INMI triggers similar to previous questionnaire-based research (Williamson et al., 2012)



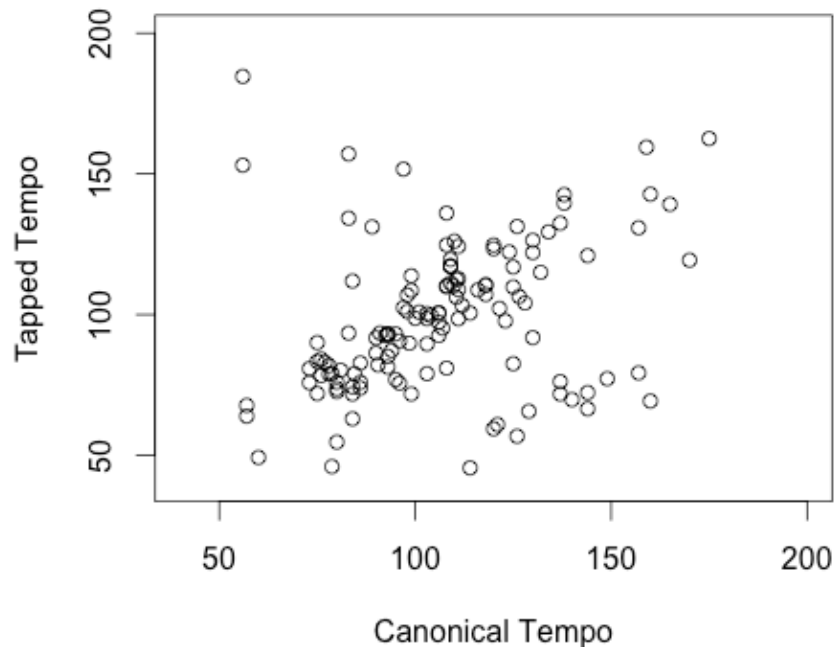
Results & Discussion

- 228 INMI episodes with usable tempo data
- INMI tempi ranged from 42.0- 196.5 bpm ($M=100.9$, $SD=29.9$)



Results & Discussion

- RQ1: The temporal veridicality of INMI
- 132 INMI episodes for songs that exist in canonical versions



Results & Discussion

- Correlation between tapped and canonical tempo: $r = .77$ ($p < .001$)
- On average, tapped tempo deviated from the canonical tempo by 10.8% ($SD = 10.8\%$)
- 77.4% of songs were recalled within 15% of the canonical tempo
- Songs heard aloud within the past week were not recalled more veridically than those heard less recently, $W = 1399$, $p = .19$

Results & Discussion

- INMI was recalled at a fairly veridical tempo
- Parallels studies of deliberately recalled music (Levitin & Cook, 1996)
 - Tempo of voluntary musical imagery deviated on average from original recordings by 17.3% (Jakubowski et al., 2014)
 - In the present study, INMI tempo deviated on average from the original recording by 10.8%
- No effect of recency of hearing a song on the veridicality of tempo recall in INMI

Results & Discussion

- RQ 2: Interactions between INMI & affective state
- Linear mixed effects model fitted with Arousal and Positivity as predictors of INMI tempo
 - Significant positive effect of Arousal ($t = 2.78, p = .01$)
 - No effect of Positivity
- Binomial mixed effects model with Arousal and Positivity as predictors of INMI mode
 - No significant effects

Results & Discussion

- Arousal was a significant positive predictor of INMI tempo
 - Suggests parallels to perceived music (Edworthy & Waring, 2006; Husain, Thompson, & Schellenberg, 2002; North & Hargreaves, 2000)
 - Role of INMI in mood regulation?
- Positivity did not predict INMI mode
 - Perhaps mode is a less salient feature of INMI
 - Felt emotion versus perceived emotion

Study 2: Measuring the Melody of INMI in you

Melodic Features of INMI

- “Why does this particular song get stuck in my head?”
 - Recent exposure (Liikkanen, 2012b; Williamson et al., 2012)
 - Familiarity (Byron & Fowles, 2013)
 - Features of the melody? (Finkel, 2010; Williamson & Müllensiefen, 2012)
- Aim: to reveal any common underlying patterns of melodic features of tunes frequently named as INMI

Method

- Collated responses from 3,000 participants to an online survey that asked for their most recent and most frequent INMI tune
- A subset of these songs was taken that:
 - Had been in the UK charts
 - Had a corresponding high-quality MIDI transcription in Geerdes music database
 - Were reported by at least 3 people

Method

- From this subset, INMI tunes were matched to a “control group” of non-INMI tunes (never reported in the survey) based on their recency, popularity, artist, and genre using a matching algorithm (‘Matching’ package in R; Sekhon, 2011)
- This resulted in a dataset of 100 INMI tunes and 100 non-INMI matched tunes

Method

- The melodic line of the MIDI file for each INMI and non-INMI tune was extracted
- Computed 83 statistical features to describe the melodic content of each melody using FANTASTIC (Müllensiefen, 2009)
 - Includes summary and corpus-based features
 - Examples: p.range, dens.p.range

Results

- Three statistical techniques were employed to classify INMI versus non-INMI tunes based on their melodic features
 - Random forest (Breiman, 2001)
 - Partial least squares regression (Wold, Ruhe, Wold, & Dunn, 1984)
 - Elastic net (Zou & Hastie, 2005)

Results

- After cross validation, only the random forest was able to classify INMI tunes above chance level (classification accuracy= 62.5%)
- This model used three melodic features as predictors of INMI quality....
- These three features will be revealed at the 5 pm “Guess the Earworm” activity, where you will be invited to try to perform better than the computer algorithms at classifying INMI vs. non-INMI tunes

Summary

- Melodic features can be used to (somewhat) predict the propensity of a tune to become INMI
- However, extra-musical factors (recency, personal associations) will likely always play a role as well

Thank you!

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