

Can You Feel the Love Tonight...and Tomorrow?

An Experimental Examination of How Earworms are Created

An Honors Capstone

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In recent years, the growing literature on mental imagery has extended to musical experiences. Musical imagery can be defined as the persistence of a musical experience in the absence of direct sensory stimulation (Intons-Peterson, 1992). Numerous neuroimaging experiments have determined that brain stimulation while imagining music is similar to stimulation while actually hearing the music (e.g. Halpern & Zatorre, 1999).

Within the field of musical imagery resides a phenomenon known as involuntary musical imagery (INMI), a term describing the experience of a piece of music that comes unbidden into the mind and repeats outside of conscious control (Williamson et al, 2011). However, this phenomenon is not confined to a brief mental image, but may persist for extended periods of time, experienced in the sensation of “having a song stuck in your head.” This phenomenon has numerous aliases, including “stuck song syndrome” and “tune on the brain.” The more colloquial term “earworm” has arisen from the German word “ohrwurm” describing the same phenomenon. Because an operational definition of the occurrence has not yet been standardized, this phenomenon will henceforth be known as an earworm, which is the most general and least exclusive term to describe the experience.

One of the first formal studies of earworms was performed by Freya Bailes in 2007. 11 undergraduate music students participated, after indicating that earworms, or “tune on the brain,” often occurred. Using an experience-sampling method, Bailes contacted participants at random times during the day over the course of a week to determine whether participants were either hearing music or imagining music. Imagery episodes, or earworms, occurred most often while interacting with others, followed by while working. Participants indicated that they were often quite aware of imagined music, but not actively concentrating on it. The students also indicated that they would not rather imagine different music or no music at all.

In the first experimental induction of INMI, Liikkanen (2009) used an Internet survey to assess how earworms were created. He asked participants to complete written song lyrics, a variation of a standard method known as cued recall. They then completed a short filler task before being asked whether they had experienced any INMI relating to the cued recall procedure. On average, 58.35% of participants reported INMI from the cued songs, 15.75% reported INMI from other songs and 25.9% reported no INMI, a result that demonstrates the comparative ease with which INMI can be triggered by reading song lyrics.

In a study in Finland, Liikkanen (2011) assessed the earworm experience of 11,910 people through an Internet survey. Over 90% of respondents reported experiencing earworms at least once a week, and 33.2% retrospectively reported experiencing earworms every day. Significantly more women reported experiencing earworms every day. 63.2% of people reported that they did not find earworms annoying. The frequency of earworms reported decreased as people aged, even when controlling for music listening and musical activities.

Liikkanen focused on differences between musicians and non-musicians in earworm experience. He found that practicing music for more than one year dramatically increased earworm frequency. Overall, musicians tended to hear longer musical segments, but those who had practiced for more than ten years experienced far fewer than those who had practiced for less time. In terms of music exposure per day, listening to music and practicing music were both positively correlated with earworm frequency. Musicians were slightly over-represented in the sample.

Beaman and Williams (2010) executed two related studies. In the first, they used an opportunity sample of 103 mixed musicians and non-musicians. The participants were asked questions about their general experience with earworms. All of the respondents recognized the

experience, and generally reported experiencing lengthy earworms lasting periods of several hours or more. When participants were asked to list earworms they had experienced, the songs listed appeared almost unique to the individual.

Their second experiment was performed using daily diary method, in which 25 participants recorded their earworms in real time, as well as any precipitating causes and methods they employed to expel the earworm. Participants also reported the degree to which the earworm caused interference with activities or time wasting. The results of the daily diary method corroborated those of the first experiment, in which there was little overlap between subjects and little repetition. The daily diary results showed an average duration of 27.25 minutes, with the longest recorded earworm at 47 minutes. These results indicate that participants from the first study significantly overestimated earworm duration when responding retrospectively.

Beaman and Williams' study sought to determine how earworms affected musicians versus non-musicians. The first study found no evidence that musicians experienced more than non-musicians. However, participants who considered music very important did report longer earworms, and found them more problematic. Beaman and Williams suggest that receptiveness to music, rather than musicians versus non-musicians, might be a more appropriate distinction.

Halpern and Bartlett (2011) performed a similar study, in which participants completed a survey about their earworm experiences and then kept a diary of their earworm experiences over the following two weeks. They found that the earworm frequency per person ranged from 2 to 57, with a median of 14, or 7 per week. They found that 85% of reported earworms were considered pleasant, a result consistent with the data from Beaman and Williams' study. Halpern and Bartlett suggest that this might be self-selecting: people expose themselves to music they

like and then replay it mentally, as the result of an unconscious process. Participants' recorded accounts suggested that once a particular earworm is evicted, it does not reappear on other days, which is also displayed in diarists from Beaman and Williams' study.

Williamson et al (2011) set out to determine specific types of contextual circumstances that facilitate the onset of an earworm. The BBC radio station "6 music" ran an advertisement encouraging listeners to call in if they had a song stuck in their heads at the time, reporting the song name, whether it was cued, and how long it had been stuck (n=2424). In a second method of data collection, participants filled out a questionnaire with basic demographic information, asking them to detail a recent earworm experience (n=1308). Their results indicated that both recent and repeated exposure to a song drastically increases its probability of returning as an earworm. Participants also indicated that mental triggers play a role in earworm formation. Williamson et al divided these associations into four categories- person, situation, word, and sound, based on the stimulus that provides the prompt.

Certain songs appear to possess intrinsic characteristics that make them more likely to become earworms. In examining data from their daily diary study, Halpern and Bartlett (2011) found that 96% of songs reported were familiar to the participants, and 83% of reported songs had lyrics. They also determined that 83% of the music reported was positive in valence. According to Stark and Wear's 2011 study, tonality and meter were other significant factors in determining which songs become earworms. For both musicians and nonmusicians, tonal music was remembered better than atonal music, and Stark and Wear assert that 25% of the variability in memory is accounted for by tonality. Music with a regular meter was remembered better than music with an irregular meter for both groups as well, and the authors state that meter accounts for 8% of the variability in memory.

Two test songs were chosen based on their adherence to the above criteria. Familiarity appears to be an important dimension in creating earworms, and thus it was necessary to choose songs that would be familiar to a large number of people. While various popular songs were considered, some interference from the radio or social events was possible. Therefore, current popular music was discarded as an option. Considering that the subject pool would be primarily undergraduate students, Disney songs were thought to be good candidates, as most of the participants would have heard them as children. In the interest of making the study as gender-neutral as possible, songs from *The Lion King* were chosen. “I Just Can’t Wait to be King” and “Can You Feel the Love Tonight” matched were thought to be the best known songs from the movie. Both songs have lyrics and are positive in valence. Additionally, they are both quite tonal and have distinct meters, making them ideal candidates for becoming earworms, according to the criteria from Halpern & Bartlett (2011) and Stark & Wear (2011).

Due to the lack of available research on the subject, a standard operational definition of an earworm has yet to be defined. Based on the data from studies by Beaman & Williams and Halpern & Bartlett, earworms vary greatly in length. It remains unknown whether the phenomenon of a song appearing in one’s head for a few seconds is fundamentally distinct from having a song actually stuck in one’s head for a longer period of time. In this experiment, a very broad definition of an earworm was used, encompassing both the brief sensation of a song “popping into one’s head” and the more extended sensation of a song that is stuck.

The intervention in Experiment 1 is based on the Zeigarnik effect, a theory asserting that incomplete tasks are remembered better than complete tasks (e.g. Zeigarnik, 1927; Savitsky, Medvec & Gilovich, 1997). In previous musical imagery studies (e.g. Halpern & Bartlett, 2011), participants recorded having only part of a song stuck in their heads. In more casual situations

where earworms are discussed, the experience of having only a part of a song stuck appears to be a very common experience. Based on both the Zeigarnik effect literature and these results, the experimenter hypothesized that playing only a part of a song might be an effective method of creating an earworm.

Experiment 2 is based on the theory of overlearning, stating that practicing a task well beyond the point of initial mastery leads to automaticity (Krueger, 1929). In this case, participants are not required to learn a task, but the experimenters hypothesized that the effect could be generalized to overexposure. Previous studies (e.g. Halpern & Bartlett, 2011; Beaman & Williams, 2010) show that songs to which participants are repeatedly exposed tend to later return as earworms. The experimenter hypothesized that playing a song numerous times for a participant might increase its likelihood of becoming an earworm.

The foundations for Experiment 3 were based solely on effects found in casual conversation. The experimenter and several members of the lab team discovered on numerous occasions that talking about earworms actually resulted in an increased number of earworms. If a particular song was mentioned, that song tended to appear as an earworm relatively soon afterward. Therefore, the experimenter hypothesized that having a conversation in the lab about earworms while referencing particular songs could result in those songs becoming earworms.

Methods

Participants

Participants were recruited from American University campus through posted fliers and advertisements on Today@AU. They were offered 0.5 psychology credits for participation, and entry into a raffle for \$50, where odds were 1 in 20. They were primarily undergraduate students,

though one was a post-baccalaureate student and one had an indeterminate affiliation to the university. 19 participants were affiliated with AU music programs in an official capacity, and 14 others described themselves as performing or practicing regularly. 4 participants denied listening to music voluntarily. A total of 92 people participated, and 24 were omitted due to a failure to return data, leaving 68 participants. There were 43 females and 25 males included in the data.

Experiment 1

Participants ($n=24$) were informed that the study aimed to determine how the brain processes information presented musically. They were told there were multiple conditions of the study, and that their condition involved listening to two musical selections in the lab. After obtaining informed consent, the experimenter played the two test songs for the participant, one complete and one incomplete. The experimental and control songs were alternated between the two selections, as well as the order in which they were played. The entire control song was played, and approximately one minute of the test song was played. The test song was stopped in a place suggestive of the next words, i.e. “I just can’t wait to be—“. Participants were then instructed to keep track of songs that “popped into their heads” over the next week, starting as soon as they left the laboratory. Use of the word “earworms” or the phrase “song stuck in your head” was deliberately avoided. They were instructed to send a text message to the experimenter containing the name of any earworm they experienced, not only the test songs.

Experiment 2

Participants ($n = 24$) were also informed that the study aimed to determine how the brain processes information presented musically. They were told there were multiple conditions of the study, and that their condition involved listening to two musical selections in the lab, one only once and one multiple times. After obtaining informed consent, the experimenter played the two

test songs for the participant, the control song only once and the experimental song for approximately 15 minutes. The order and identity of the test song was alternated. Because the test song length differed by over a minute, one was played four times and the other five times. These participants were also instructed to keep track of songs that “popped into their heads” over the next week, starting as soon as they left the laboratory. They were instructed to send a text message to the experimenter containing the name of any earworm they experienced, not only the test songs.

Experiment 3

Participants ($n = 20$) were informed that they were participating in a study examining musical memory. All participants had a 7-minute conversation with the experimenter, and the content differed between the control and experimental conditions. In the control condition, participants were told they were going to have a short conversation about music. The experimenter asked questions from a pre-existing outline, about general musical tastes and experiences, as well as performances the participant had attended. The experimenter casually mentioned the phrase “The Lion King” in a non-musical context, usually discussing either the movie or the musical.

In the experimental condition, the experimenter disclosed details of the experiment, informing the participant that they were in a control condition of sorts. The experimenter outlined the procedure and aims of the other two experiments, making sure to mention the phrase “The Lion King” and the names of the test songs at least twice, in a specifically music-related context. The phrase “song stuck in your head” was mentioned on numerous occasions. The experimenter did not outline the hypothesis and aims for the third experiment. Participants were instructed to ask questions about the experimental procedure and data. Upon completion of the

conversation, these participants were also instructed to keep track of songs that became stuck in their heads over the next week, starting as soon as they left the laboratory. They were instructed to send a text message to the experimenter containing the name of any earworm they experienced.

Results

Song 1 refers to the test song “Can You Feel the Love Tonight,” and Song 2 refers to “I Just Can’t Wait to be King.” The designation (*) indicates the experimental condition.

Table 1: Incomplete Exposure to Test Songs

	Mean (Times appeared per week)	<i>p</i> -value	Significant
Song 1*	0.5	0.305082387	No
Song 1	0.666666667		
Song 2*	0.727272727	0.074092844	No
Song 2	1.25		

Self-reported frequency of earworm experiences (n=24) when participants were exposed to an incomplete version of a test song. Song 1 did not differ significantly in frequency between incomplete and complete trials (Mean = 0.5 and 0.67 times per week, respectively). Song 2 displayed a greater propensity for becoming an earworm when complete (Mean = 1.25 times per week versus 0.73 times when incomplete). This difference is relatively large, and the *p*-value approaches significance at .07.

Table 2: Overexposure to Test Songs

	Mean (Times appeared per week)	<i>p</i> -value	Significant
Song 1*	1.384615385	0.00088577	Yes
Song 1	0.2		
Song 2*	1.2	0.284542198	No
Song 2	1.692307692		

Self-reported frequency of earworm experiences (n=24) when participants were overexposed to a test song. Song 1 appeared as an earworm significantly more often when played multiple times (1.38 times per week versus 0.2 times when played once, $p < 0.001$). Song 2 did not display the

same trend; it appeared 1.2 times when played multiple times versus 1.69 times when played once. This difference was not significant.

Table 3: Experimental Conversation

	Mean (Times appeared per week)
Overall	0.266666667
Song 1	0.1
Song 2	0.6
Related Songs	0.1

Self-reported frequency of earworm experiences (n=10) when participants had a conversation with the experimenter about earworms. The means represent the total number of Lion King related earworms per week, number of times Song 1 appeared, number of times Song 2 appeared, and number of times any related Lion King song appeared.

Table 4: Control Conversation

	Mean (Times appeared per week)
Overall	0.133333333
Song 1	0
Song 2	0.3
Related Songs	0.1

Self-reported frequency of earworm experiences (n=10) when participants had a control conversation with the experimenter about music. The means represent the total number of Lion King related earworms per week, number of times Song 1 appeared, number of times Song 2 appeared, and number of times any related Lion King song appeared.

Table 5: T-test comparison of Experimental and Control Conversation Overall Means

Experimental overall mean	0.267
Control overall mean	0.133
p-value	0.174

A comparison of the overall means between groups that had control and experimental conversations. When participants discussed earworms with the experimenter, related songs appeared 0.267 times per week, compared to 0.13 times per week when they had a conversation about music. This difference is not significant.

Discussion

In this experiment, there was a surprisingly low data yield. Many participants came to the initial session and then failed to send any data from the next week. They received 0.5 credits simply for the initial session, so it is possible that they saw no personal gain in continuing the study. After the experimenter began emphasizing the importance of sending data particularly on the day of the experiment, the yield improved. Further, the experimenter began to emphasize that participants would not be eligible for the raffle if they failed to return any data.

Particularly in the early stages of the study, there were a significant number of participants that only sent the names of one or two earworms over the course of an entire week. Generally, these earworms were reported in the beginning of the week. Based on data from Liikkanen (2011) and Halpern & Bartlett (2011), it is unlikely that these people actually experienced so few earworms. It is more likely that they simply forgot to report them. Data from these participants was cautiously included in the data set.

In the overexposure experiment, Song 1 appeared an average of 1.38 times per week when overexposed, compared with 0.2 times when played only once. The p-value is significant on the .01 level, indicating that the intervention effectively increases Song 1's propensity to become an earworm. Song 2, when overexposed, did not display the same trend. It appeared as an earworm 1.2 times per week when overexposed, and 1.69 times when not overexposed. The p-value was 0.28, which is not significant. This result indicates that the number of times Song 2 is played does not affect its likelihood of becoming an earworm. In both the experimental and control conditions, it appears as an earworm relatively frequently compared to Song 1, indicating that it could be considered "catchier" in general. Song 2 also matches the specific criteria for "catchy" songs (Halpern & Bartlett, 2011; Stark & Wear, 2011). It may be tentatively concluded

that for catchy songs, the number of times played is irrelevant to their likelihood of becoming an earworm.

The results for the Incompleteness experiment did not match the experimenter's hypothesis, that an incomplete song would be more likely to appear as an earworm. Song 1 appeared an average of 0.5 times per week when incomplete, and 0.67 times per week when complete. This result, combined with the data from the overexposure experiment, indicates a direct relationship between the amount of time the song was played and its likelihood of becoming an earworm. Again, Song 2 displayed a different trend. It appeared 0.72 times per week on average when incomplete, and 1.25 times when complete. While the p-value is not quite significant on the 0.05 level ($p = 0.07$) these results do display a distinct trend. It appears that even for a very catchy song, one minute was not a sufficient amount of time to produce an earworm.

In future studies, different results may be obtained if a longer section of the song is used. Both songs had fairly long instrumental introductions, and although the first verse of both songs was played, the song segment stopped before finishing the chorus. In both songs, the chorus is the best-known section. If the chorus was finished and the song stopped in a suggestive place in the second rendition of the chorus, the song may appear as an earworm more often.

Primacy and recency effects did not appear to affect the frequency of the earworms. The order of the songs was alternated in both Experiment 1 and Experiment 2 to determine whether more earworms resulted from the most recent songs heard. There were no significant differences in earworm based on when the song was originally played in either Experiment 1 or Experiment 2. This result adds credence to the theory that differences in earworm appearance result primarily from the intervention.

During the data collection process, participants were instructed to text the experimenter the name of any song that came into their minds, not only test songs. As in other studies, these lists were highly individual, though showed some common threads. Numerous popular songs appeared on multiple lists, as well as Christmas songs in the holiday season. One notable tendency was other songs from the Lion King appearing on participants' lists in addition to the test songs. Songs such as "Hakuna Matata," "The Lion Sleeps Tonight," and "Circle of Life" appeared relatively often. It is unlikely that these songs would become earworms due to random chance, because they appeared far more often than other Disney songs that are arguably just as catchy. Upon later inquiry, many participants could not recall precisely which songs had been played in the lab, but distinctly recalled that they were from the Lion King. These results suggest that a DRM paradigm may be a factor in earworm generation, which fits with Williamson et al's (2011) observation of mental triggers as causative factors in creating earworms.

The intervention in Experiment 3 appeared to be at least partially successful. Participants experienced Lion King songs as earworms 0.267 times per week when they were explicitly discussed, compared to 0.133 times when they were not discussed explicitly. Although this difference was not significant, the results may be clarified with a larger number of participants. In both cases, "I Just Can't Wait to be King" appeared to be more likely to appear as an earworm than "Can You Feel the Love Tonight" and any other Lion King songs, even when only the name was mentioned.

In future studies, more revealing results may be found if the data collection process in Experiment 3 is altered. In most cases, participants who experienced a Lion King song as an earworm did so within an hour of completing the study. However, other participants experienced the song as an earworm days later. Emphasis on reporting the test songs as earworms

immediately following the study may produce a more useful data set. Because some participants still experience test song earworms after a longer period of time, the overall length of the experiment should remain the same.

As this is a first step into experimentally generated earworms, the hypotheses tested here require further research and development. The elusive nature of earworms makes it difficult to accurately assess their appearance, and a more exact process should be developed through further research. Earworms may yet prove to be another pathway into the human subconscious.

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