INVOLUNTARY MUSIC IMAGERY: CONSCIOUS CONTENTS EXTENDING OVER TIME ELICITED BY SIMPLE MELODY

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by

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San Francisco, California

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CERTIFICATION OF APPROVAL

I certify that I have read Involuntary Music Imagery: Conscious Contents Extending Over Time Elicited by Simple Melody by Nathan Andrew White, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirement for the degree Master of Arts in Psychology, Mind Brain, and Behavior at San Francisco State University.

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Involuntary Music Imagery: Conscious Contents Extending Over Time Elicited by Simple Melody

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Percepts and urges often enter the conscious field involuntarily. The Reflexive Imagery Task (RIT) examines the manner in which high-level conscious contents enter the conscious field involuntarily. In the present study, subjects ($n = 48$, 40 female, M_{age} = 22.73 years old, SD_{age} = 4.86) were exposed to and learned four simple melodies. At test, subjects were instructed to follow along with the melody and to not continue in his or her head the melody when the melody stops short. It was revealed that participants were unable to suppress the continuation of the melody in his or her head on a majority of trials. There was a main effect of Stopping Point, but no main effect of Training.

I certify that the Abstract is a correct representation of the content of this thesis.

Ezequiel Morsella

Chair, Thesis Committee

5/21/2019

Date

PREFACE AND/OR ACKNOWLEDGEMENTS

I would like to take this opportunity to thank my mentors throughout my academic career, both past and present. Specifically, I would like to thank Dr. Ezequiel Morella for his mentorship and generosity during my time in the Action & Consciousness Lab and the Mind, Brain & Behavior program. The resources provided have undoubtedly aided my success and I am forever indebted. I would also like to thank my fellow lab members for their tireless support. Lastly, I would like to thank my parents for their unconditional support.

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Introduction

It has been demonstrated that active attempts to thwart involuntary music imagery, or earworms, are less successful than 'passive acceptance' (Beaman & Williams, 2010). Accordingly, these active attempts also tend to lead to more instances of the imagery (Beaman & Williams, 2010). These findings are consistent with Wegner's (1994) theory of ironic mental control. Additionally, perceptual experiences of silence in music have been demonstrated to be rated as more tense when followed by a lack of tonal closure (Margulis, 2007). A silence occurring in place of an expected continuation, progression, or resolution of a musical piece would be considered lacking tonal closure and thus be perceived as more tense than an appropriately placed silence. According to our review, a study has not experimentally manipulated the point in which a melody is stopped short (i.e., silence) and examined its effect on an individual's ability to thwart the continuation of a melody in his or her mind. Research regarding the subjective experience of a melody stopping short (before tonal closure) has been conducted, but according to our review of the literature, no study has experimentally manipulated the point in which a melody is stopped short (i.e., silence) and quantitatively measured the involuntary imagery thereafter. Additionally, to our knowledge, no study has used the Reflexive Imagery Task (RIT) to investigate imagery that extends over time (such as music) rather than a single, punctate instance of a single word or image.

To further the aims of the presented investigation, we employed the RIT because the paradigm was designed to investigate the manner in which urges, percepts, and high-level cognitions enter into consciousness involuntarily. In the original, most basic version of the RIT (Allen, Merrick, Wilkins & Morsella, 2013), subjects are presented with simple line drawings and instructed to not subvocalize the name of the drawings. A further variant of the paradigm (Cushing, Gazzaley & Morsella, 2017) instructed subjects pto both press a button whenever he or she experiences the subvocalization and to press a separate button if the subvocalization (e.g., "cat") rhymed with a word he or she was to hold in mind (e.g., "pat"). Accuracy on the rhyming task (>80% mean accuracy across trials) demonstrated that the RIT effect (involuntary subvocalization at the presentation of appropriate stimuli) is not an artifact of instruction. Detecting that a word rhymes with another requires the retrieval of the phonological form of the word, or at the very least, the retrieval of the coda of the word, and suggests subjects do indeed experience the involuntary imagery.

Considering the literature, it is hypothesized that, if given sufficient exposure to a melody, subjects will experience involuntary conscious contents that extend in time beyond the single-instance nature of previous experiments. It is also hypothesized that the stopping point of the melody presented ('three', 'five', and 'seven' verbal markers) will affect involuntary conscious content. In the present experiment, subjects listened to and learned four simple, novel melodies. Each melody was listened to either 10 times (minimal training) or 30 times (extended training). Each melody was accompanied by a voice singing the numbers 'one' to 'ten' in ascending order. Subjects were later presented with fragments of each melody. Each melody had a stopping point at the third, fifth, or seventh number. Subjects were instructed to not continue "in their head" the remainder of the melody. Subjects reported the number to which the melody continued "in their head" after the melody stopped short, thereby indicating whether they involuntarily continued the melody as music imagery. Subjects also reported the vividness of the imagery (Vividness) and rated how strong their urge was to complete the melody (Urge).

Method

Participants

San Francisco State University students ($n = 51$) participated for course credit. Of the 51 subjects, the data from three subjects were omitted from analysis (discussed below). The data from 48 subjects were included for the final analysis (40 female, $M_{age} = 22.73$, $SD = 2.86$). The involvement of human subjects in the present study was approved by the Institutional Review Board at San Francisco State University.

Stimuli and Apparatus

Instructions were presented on a 50.8 cm Apple iMac computer with a viewing distance of approximately 48 cm. PsyScope software (Cohen, MacWhinney, Flatt & Provost, 1993) was used to display instructions and record the data. All questions and instructions were written in a black 36-point Helvetica font. Four novel melodies were presented to subjects in a pair of JVC brand headphones (JVC HA-V570, Yokohama, Japan). The particular melodies were chosen as stimuli because of their novelty (designed to teach number counting from 'one' to 'ten'). A single melody was originally discovered and employed (Little Baby Bum – Nursery Rhymes & Kids Songs, 2015), and three melodies were created to resemble the original melody (see Appendix A). Accompanying each was a voice that counted along with the melody the numbers 'one' to 'ten' in ascending order. The voice was recorded separately and then edited with a music editing software program (Ableton AG, Berlin, Germany). The numbers allowed us to differentiate the melody into sections and allowed subjects to more easily communicate how many instances of the melody were involuntarily subvocalized. Piloting ($n = 11$) revealed that the melodies were previously unknown to independent judges from the sample population, which further secured their utility. The melodies were presented at 50% volume on the iMac computer. Two of the melodies were 7 s in length and two were 9 s in length.

Procedures

Each subject was run individually. All instructions were read aloud by the experimenter to the subject. Subjects were instructed that for the initial training section, for each melody, he or she is to listen to the melody carefully and follow along with the melody in their head, trying to learn the melody to the best of their ability. Subjects were informed that some melodies would be played more than once. Once having completed the training of one melody, subjects were then instructed he or she will be exposed to the same melody as in the previous section, but only a part of the single melody will be presented at a time. This was such that the melody effectively stopped at one of three prescribed points (at the verbal 'three', 'five', and 'seven' markers). Subjects were instructed, "Count along with the melody as in the previous section. When the melody stops, it is your task to NOT sing along 'in your head'. In other words, do not sing along 'in your head' the melody once the music stops". After the presentation of the target stimulus, subjects were asked, "if the melody did 'continue in your head', please indicate to which number the melody continued to. If the melody did not continue in your head, please type 'none'", to which he or she typed a number between 1 and 10 that indicates their response, or typing "none" if the melody did not continue in their head. Subjects were asked after the presentation of each melody also to respond to the questions, "how vivid was the melody you experienced?" and "how strong was the urge to complete/finish the melody in your head?". Once each fragment of the melody had been presented, the subject was asked to respond to the question, "how strongly do you feel you learned and can remember well the melody?". Training was manipulated such that two of the melodies were listened to a total of ten times (minimal training condition) and two of the melodies thirty times (extended training). Subjects repeated this process for each of the four different melodies. The four melodies were presented in random order.

After the completion of the experiment, subjects completed a series of funneled debriefing questions (procedures from Bargh & Chartrand, 2000). The debriefing questions were employed to assess whether subjects' data need removal from the final analysis. The series of questions can be found in Appendix B. Analysis of subjects' responses revealed that no data needed to be removed from the final analysis. Data from three subjects were ultimately omitted for final analysis, for reasons other than debriefing responses: two subjects received qualitatively different instructions than the other subjects, and one subject failed to respond for the entire session to the inquiry of how far the melody continue in his or her head, despite reporting vividness ratings.

Results

Proportion of the RIT Effect

The proportion of trials in which involuntary imagery (RIT effect) occurred across Training conditions and Stopping Point are presented in Table 1. Each of the means presented is significantly different from zero, *t*s $(47) > 6.90$, *p*s $< .0001$. A 2 x 3 within-subjects ANOVA, one factor being Training (Extended vs. Minimal) and the other factor being Stopping Point (Three, Five, or Seven), revealed a main effect of Stopping Point, $F\,(2, 47) = 12.36$, $p < .0001$, but no main effect of Training, $F\,(1, 47) = 1.62$, $p = .20$. There was no interaction between the two factors, $F\,(2, 47) = 1.07$, $p = .35$. A 1x4 ANOVA revealed there was no significant difference of the RIT effect between the four melody stimuli regardless of Stopping Point or Training, $F\,(3, 47) = .20$, $p = .90$.

Post-hoc analysis revealed that the RIT effect for Stopping Point Three was statistically different from Stopping Point Five, $t\,(47) = 5.01$, $p < .0001$, but not statistically different from Stopping Point Seven, $t\,(47) = .33$, $p = .74$. It was also revealed that Stopping Point Five was statistically different from Stopping Point Seven, $t\,(47) = 3.63$, $p < .001$. The RIT effect per Stopping Point across Training conditions can be found in Figure 2.

The RIT effect for Stopping Point Three ($M_{proportion} = 0.67$, $SE = 0.04$) and Stopping Point Seven ($M_{proportion} = 0.66$, $SE = 0.05$) across Training conditions are comparable to the proportions found in previous projects, in which the RIT stimuli consisted of images (e.g., 86% in Allen et al., 2013; 87% in Cho, Godwin, Geisler & Morsella, 2014; and 73% in Merrick, Farnia, Jantz, Gazzaley & Morsella, 2015).

Duration of Imagery

The mean Duration of Imagery (Duration) across Training conditions and Stopping Point are presented in Table 2. A 2 x 3 within-subjects ANOVA, one factor being Training (Extended vs. Minimal) and the other factor being Stopping Point (Three, Five, or Seven), revealed that the dependent variable of Duration did significantly differ between Stopping Point, $F(2, 47) = 3.46$, $p = .04$, but did not significantly differ between Training conditions, $F(1, 47) = .25$, $p = .62$. There was no interaction between the two factors, $F(2, 47) = .71$, $p = .62$.

Post-hoc analysis revealed that Duration for Stopping Point Three was statistically different from Stopping Point Five, $t(47) = -2.94$, $p = .005$, but not statistically different from Stopping Point Seven, $t(47) = 1.77$, $p = .08$. It was also revealed that Stopping Point Five was not statistically different from Stopping Point Seven, $t(47) = -.73$, $p < .47$. Mean Duration per Stopping Point across Training conditions can be found in Figure 3.

Vividness of Involuntary Imagery

The mean Vividness across Training conditions and Stopping Point are presented in Table 3. A 2 x 3 within-subjects ANOVA was conducted for Vividness, one factor being Training (Extended vs. Minimal) and the other factor being Stopping Point (Three, Five, or Seven). It was revealed that Vividness was significantly different across Stopping Point, $F\,(2, 47) = 7.32$, $p < .01$, as well as Training condition, $F\,(1, 47) = 5.15$, $p < .05$. There was no interaction between the two factors, $F\,(2, 47) = .12$, $p = .88$.

Post-hoc analysis revealed that within the Minimal Training condition, Vividness for Stopping Point Three was statistically different from Stopping Point Seven, $t\,(47) = 2.73$, $p < .01$, but not different from Stopping Point Five, $t\,(47) = .47$, $p = .66$. Additionally, Stopping Point Five was statistically different than Stopping Point Seven, $t\,(47) = 3.00$, $p < .01$. Within the Extended Training condition, Vividness for Stopping Point Three was statistically different from Stopping Point Seven, $t\,(47) = 2.65$, $p < .05$, but not statistically different from Stopping Point Five, $t\,(47) = .15$, $p = .88$. Additionally, Stopping Point Five was not statistically different from Stopping Point Seven, $t\,(47) = 1.97$, $p = .06$.

Reported Urge to Complete/Finish the Melody

The mean Urge rating across Training conditions and Stopping Point are presented in Table 4. A 2 x 3 within-subjects ANOVA was conducted for Urge, one factor being Training (Extended vs. Minimal) and the other factor being Stopping Point (Three, Five, or Seven). It was revealed that Urge was significantly different for Stopping

Point, $F(2, 47) = 12.53$, $p < .0001$, but not for Training, $F(1, 47) = 1.75$, $p = .19$. There was no interaction between the two factors, $F(2, 47) = .96$, $p = .37$.

Post-hoc analysis revealed that across the Training conditions, Urge for Stopping Point Three was statistically different from Stopping Point Seven, $t(47) = 4.56$, $p < .0001$, but not different from Stopping Point Five, $t(47) = -.45$, $p = .65$. Additionally, Stopping Point Five was statistically different than Stopping Point Seven, $t(47) = 4.64$, $p < .0001$. The mean Urge per Stopping Point across the Training conditions can be found in Figure 4.

Discussion

The present aim of the study was to explore whether involuntary imagery as elicited by previous RIT paradigms could be extended to dynamic music stimuli. By employing four simple melodies, it was revealed that both the mean proportion of the RIT effect and Duration differed as a function of the point at which the melody is stopped short, but not as a function of the amount of exposure in training. Specifically, stopping short the melody at the 'three' and 'seven' markers elicited comparable rates of imagery to previous RIT experiments. According to our review, this is the first study in which music stimuli was experimentally manipulated in the context of the RIT.

Considering the lack of statistical difference between the two Training conditions, the RIT effect for Stopping Point Three ($M_{\text{proportion}} = 0.67$, $SE = 0.04$) and Stopping Point Seven ($M_{\text{proportion}} = 0.66$, $SE = 0.05$) arose on a proportion of trials comparable to previous

RIT studies (e.g., 86% in Allen et al., 2013; 87% in Cho et al., 2014; and 73% in Merrick et al., 2015), studies in which visual stimuli were presented. The present findings suggest that the RIT effect is not limited to such visual stimuli. The current study also reveals that the RIT is fit to examine dynamic imagery that unfolds or elapses over time (i.e., music), in contrast to punctate imagery (i.e., the subvocalization of a single word).

In the present study, dynamic imagery was elicited involuntarily across varying manipulations of music stimuli. These findings are consistent with theories of consciousness that suggest the reflex-like manner in which contents arise is said to be 'encapsulated' (Fodor, 1983; Morsella, Godwin, Jantz, Krieger & Gazzaley, 2016). Encapsulation suggests that contents do not interact with one another once in conscious awareness, and that one is unable able to directly affect the mechanisms that generate contents. Miller (1962) notes that conscious awareness reflects the end products of these mechanisms. Encapsulation extends to action-related urges as well (Morsella, 2005).

Going forward, limitations of the present approach should be addressed. Self-report measures by subjects are susceptible to various biases and can produce imprecise reports. That having been said, the RIT has reliably demonstrated that such reports hold valid as with the aforementioned rhyming RIT variant (Cushing et al., 2017). Secondly, the four melodies were not produced as to control for particular music qualities (e.g., key, tempo, melodic structure), variables which could unknowingly affect to the pattern of results displayed. Also, the placement of the three stopping points was selected to delineate the melodies into three meaningful sections and were done so across the four melodies as to feel natural for the listener, not specific to melodic structure. Future studies could benefit from controlling for these qualities to further explore the potential of music as a stimulus to investigate dynamic conscious contents that are activated across substantive periods of time.

Shortcomings having been addressed, the present study involving the manipulation of music stimuli both adds breath to the music cognition literature as well as the literature surrounding the RIT. Not only does the study provide evidence that consciousness, one of the biggest mysteries in science (Crick & Koch, 2003; Dehaene, 2014), can be studied experimentally, but also lends benefit to subfields of psychology including cognitive control, imagery, consciousness, and action. With our best aims we put forth this experiment as an investigation into the role of music imagery as a component of the wider phenomenon of dynamic conscious contents.

References

Ableton AG. *Ableton 9.* Berlin, Germany.

Allen, A. K., Wilkins, K., Gazzaley, A. & Morsella, E. (2013) Conscious thoughts from reflex-like processes: A new experimental paradigm for consciousness research. *Consciousness and Cognition,* 22:1318-31.

Bargh, J. A., & Chartrand, T. L. (2000). The mind in the middle: A practical guide to priming and automaticity research. In H. T. Reis & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 253 - 285). Cambridge, England: Cambridge University Press.

Beaman, C. P., & Williams, T. I. (2010). Earworms ('song stuck syndrome'): Towards a natural history of intrusive thoughts. *British Journal of Psychology, 101*(4), 637–653. https://doi.org/10.1348/000712609X479636

Cho, H., Godwin, C. A., Geisler, M. W., & Morsella, E. (2014). Internally generated conscious contents: Interactions between sustained mental imagery and involuntary subvocalizations. *Frontiers in Psychology, 5*. Retrieved from http://search.ebscohost.com.jpllnet.sfsu.edu/login.aspx?direct=true&AuthType=ip,cookie,url,uid&db=psyh&AN=2015-12850-001&site=ehost-live

Crick, F., & Koch, C. (2003). A framework for consciousness. *Nature Neuroscience, 6,* 1 - 8.

Cohen, J. D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavior Research Methods, Instruments, & Computers, 25*, 257 - 271.

Cushing, D., Gazzaley, A., & Morsella, E. (2017). Externally controlled involuntary cognitions and their relations with other representations in consciousness. *Consciousness and Cognition, 55*, 1-10.

Dehaene, S. (2014). *Consciousness and the brain: Deciphering how the brain codes our thoughts.* New York: Viking.

Fodor, J. A. (1983). *Modularity of mind: An essay on faculty psychology.* Cambridge, MA: MIT press.

[Little Baby Bum – Nursery Rhymes & Kids Songs]. (August 18, 2015). *Numbers song 1-10 | Part 2 | Nursery rhymes | Original song by littlebabybum!* [Video File]. Retrieved from https://www.youtube.com/watch?v=voCrQ1ebEdU&feature=youtu.be

Margulis, E. H. (2007). Silences in music are musical not silent: An exploratory study of context effects on the experience of musical pauses. *Music Perception*, *24*(5), 485–506. https://doi.org/10.1525/mp.2007.24.5.485

Merrick, C., Farnia, M., Jantz, T. K., Gazzaley, A., & Morsella, E. (2015). External control of the stream of consciousness: Stimulus-based effects on involuntary thought sequences. *Consciousness and Cognition: An International Journal, 33*, 217–225. https://doi-org.jpllnet.sfsu.edu/10.1016/j.concog.2014.12.014

Morsella, E. (2005). The function of phenomenal states: Supramodular interaction theory. *Psychological Review, 112,* 1000 – 1021.

Morsella, E., Godwin, C. A., Jantz, T. J., Krieger, S. C., & Gazzaley, A. (2016). Homing in on consciousness in the nervous system: An action-based synthesis. *Behavioral and Brain Sciences* [Target Article], *39,* 1 - 17.

Wegner, D. M. (1994). Ironic processes of thought control. *Psychological Review*, 101, 34 - 52.

Table 1. Mean proportion of trials in which the RIT effect arose across Training conditions (Minimal and Extended) and Stopping Point (three, five, and seven. Standard errors provided.

Proportion of the RIT Effect

	Three		Five		Seven	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
Min	.66	.05	.47	.06	.60	.05
Ext	.68	.05	.48	.06	.72	.06

Table 2. Mean duration of involuntary imagery across Training conditions (Minimal and Extended) and Stopping Point (Three, Five, and Seven). Standard errors provided.

Duration of Imagery

	Three		Five		Seven	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
Min	1.20	.20	1.00	.20	1.13	.14
Ext	1.38	.20	1.05	.20	1.29	.15

Table 3. Mean Vividness across Training conditions (Minimal and Extended) and Stopping Point (Three, Five, and Seven). Standard errors provided.

Vividness of Imagery

	Three		Five		Seven	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
Min	5.69	.26	5.77	.24	6.25	.22
Ext	6.15	.21	6.18	.25	6.58	.19

Table 4. Mean reported urge to complete/finish the melody across Training conditions (Minimal and Extended) and Stopping Point (Three, Five, and Seven). Standard errors provided.

Urge to Complete/Finish the Melody

	Three		Five		Seven	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
Min	4.36	.30	4.44	.33	5.08	.33
Ext	4.70	.29	4.44	.33	5.46	.31

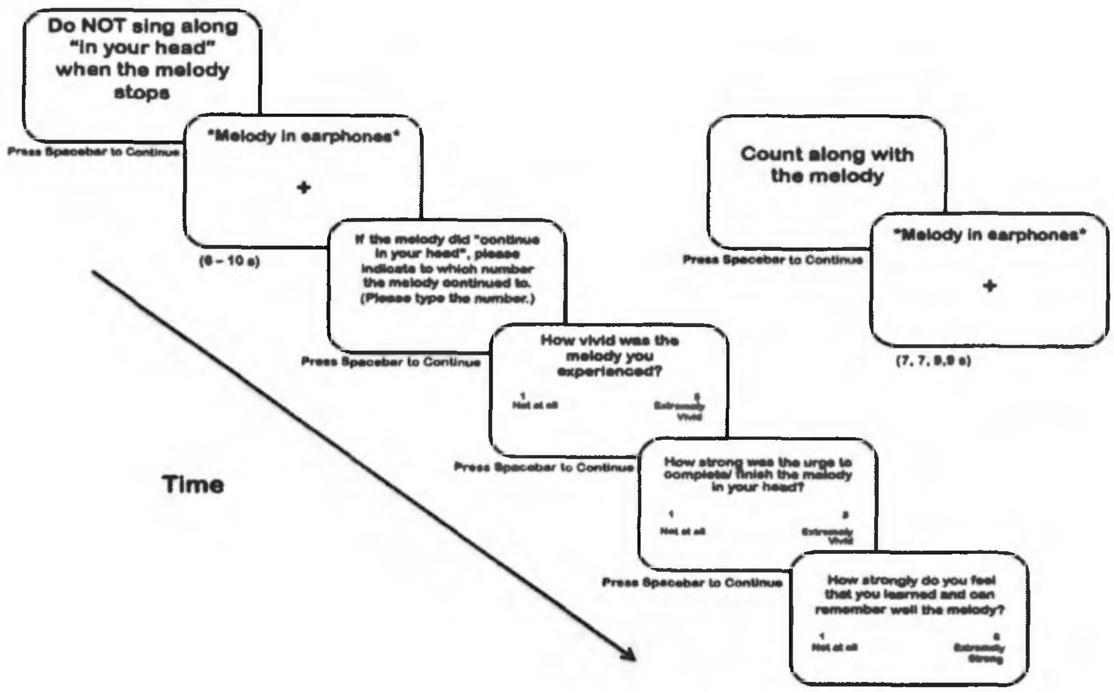

Figure 1: Schematic of a trial sequence

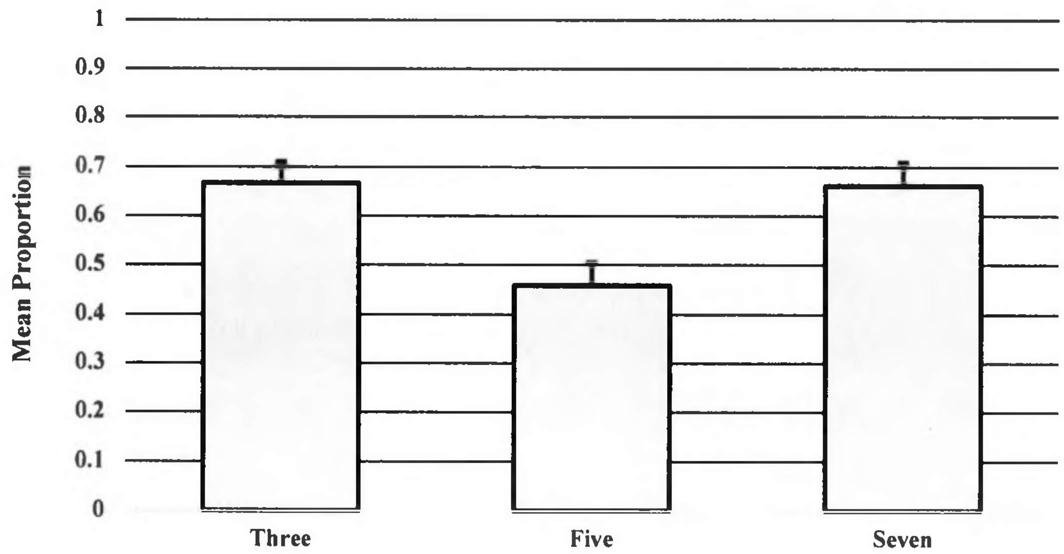

Figure 2: Mean proportion of trial in which the RIT effect arose per Stopping Point across Training conditions. Error bars indicate *SEs*.

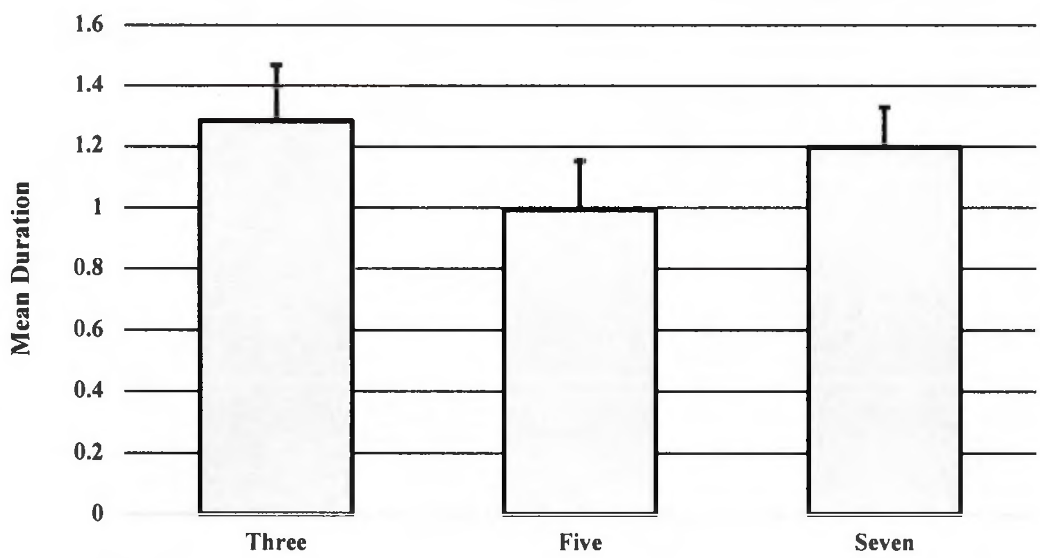

Figure 3: Mean Duration of involuntary imagery per Stopping Point across Training conditions. Error bars indicate *SEs.*

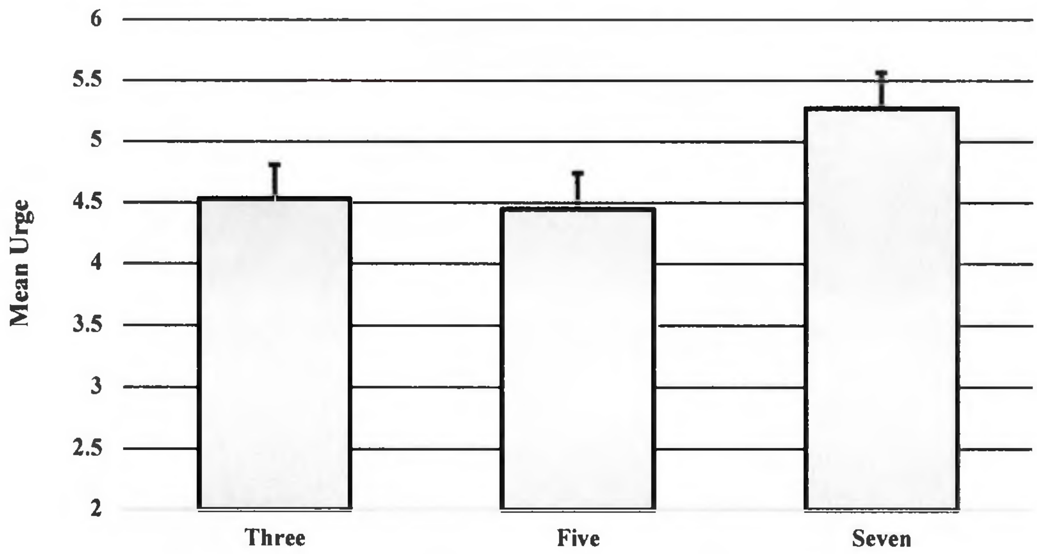

Figure 4: Mean Urge rating per Stopping Point across Training conditions. Error bars indicate *SEs.*

Appendix A

Melody 1 (original)

1	2	3	4	5	6	7	8	9	10
D	D	A	A	G	A	F#-E	E	E	A

Melody 2

1	2	3	4	5	6	7	8	9	10
E	C,C	D	A	B	C	A	A	B	C,C,C

Melody 3

1	2	3	4	5	6	7	8	9	10
E	E	D	C#	C	C	B-A	G-F	E	D

Melody 4

1	2	3	4	5	6	7	8	9	10
C-A	E-D	C	E-F	G	G-B	B	A	B	C,C,C

Note, dashes (-) between notes indicate a slide

Appendix B

1. Please indicate your age and gender
2. What do you think the purpose of this experiment was?
3. What do you think this experiment was trying to study?
4. Did you have a strategy and/or goal in completing this experiment?
5. Was there anything that interfered with your performance on the task?