Temporal Context-Specificity in Predictive Learning Produced with Visual, but not Musical, Primes

Catherine Woosley Luna

Follow this and additional works at: https://digitalcommons.wku.edu/theses

Part of the Cognitive Psychology Commons, Educational Psychology Commons, and the Music Commons

Recommended Citation
https://digitalcommons.wku.edu/theses/3036

This Thesis is brought to you for free and open access by TopSCHOLAR®. It has been accepted for inclusion in Masters Theses & Specialist Projects by an authorized administrator of TopSCHOLAR®. For more information, please contact topscholar@wku.edu.
TEMPORAL CONTEXT-SPECIFICITY IN PREDICTIVE LEARNING PRODUCED
WITH VISUAL, BUT NOT MUSICAL, PRIMES

A Thesis
Presented to
The Faculty of the Department of Psychological Sciences
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

By
Catherine Luna

May 2018
TEMPORAL CONTEXT-SPECIFICITY IN PREDICTIVE LEARNING PRODUCED BY
VISUAL, BUT NOT MUSICAL, PRIMES

Date Recommended 5/9/18

Sharon Mutter, Director of Thesis

Andrew Mienaltowski

Matthew Shake

Dean, Graduate Studies and Research  Date
ACKNOWLEDGEMENTS

I would like to thank the Graduate Council of Western Kentucky University’s Graduate School for granting funds necessary to support this research.

I would also like to thank those who collaborated on the formation and implementation of this research. Specifically, I would like to thank the current research assistants of the Cognition Laboratory of WKU: Kyle Luecke, Jessica Dukes, and Austin Willoughby. The dedication of each of the research assistants to accomplish the grinding details each day led to the successful completion of this study. I would also like to thank my thesis committee members who helped guide the vision of the current thesis: Dr. Andrew Mienaltowski, and Dr. Matthew Shake. Each of these professors contributed valuable time and intellect to the formation and ultimate completion of this thesis.

Finally, I would must extend the utmost of my gratitude to Dr. Sharon Mutter, my advisor and committee chair. She endlessly toiled alongside me as we strove to develop and understand each minute detail of the current thesis. I thank God for her patience and expertise as we struggled through this rigorous endeavor. The quality of the present thesis would not have been achieved without the individual contribution of each of the above mentioned contributors.
# TABLE OF CONTENTS

Abstract ........................................................................................................... vii

Chapter 1: Introduction ................................................................. 1

Chapter 2: Method ................................................................. 15

Chapter 3: Results .............................................................. 25

Chapter 4: Discussion ............................................................ 34

References ....................................................................................... 46

Appendix .......................................................................................... 55
LIST OF FIGURES

Figure 1. Predictive Judgments from Phase 1 and Phase 2 of Learning: Visual Prime.....28
Figure 2. Predictive Judgments from Phase 1 and Phase 2 of Learning: Music Prime.....28
Figure 3. Predictive Judgments from Phase 1 and Phase 2 of Learning: Both Prime……29
Figure 4. Mean Predictive Judgments at Test by Prime ………………………………30
Figure 5. Regression of Musical Expertise Predicting Test Predictive Judgments………33
LIST OF TABLES

Table 1. Mean Participant Characteristics...................................................... 15
Table 2. Experimental Design ........................................................................ 19
Table 3. Phase 3 Prime Predictive Judgments ................................................. 29
Table 4. Phase 1 Learning ANOVA ................................................................. 58
Table 5. Phase 2 Learning ANOVA ................................................................. 59
Table 6. Test Phase ANOVA .......................................................................... 60
Table 7. Frequency of Participant Awareness of Music by Condition ............... 61
Table 8. Frequency of Participant Musical Expertise by Condition .................. 61
Table 9. Simple Regression Table for Test Judgment Predicted by Musical Expertise .. 61
In this study we investigated whether a musical prime would produce a context-specificity effect in predictive learning. Participants were divided into six conditions of a spy-radio predictive learning task. The six conditions were comprised of a combination of three primes (i.e. visual, music, or both) and two learning phase groups (i.e. retrieve, default). The primes indicated the type of stimulus used to prime the temporal context for the test cue-outcome association. The learning phase groups indicated which temporal context would be primed. In the retrieve group, learning Phase 1 was primed; in the default group learning Phase 2 was primed. The presence of a temporal context-specificity effect was indicated by lower test predictive judgments for the test cue X in the retrieve group and higher test predictive judgments for this cue in the default group.

We hypothesized that all three types of primes would lead to a significant context-specificity effect. Furthermore, we hypothesized that the context-specificity effect would be strongest in the both prime condition because, with the presentation of both the visual and musical primes, participants would have more information about the learning phase temporal context to inform their test predictive judgment. The results partially supported the first hypothesis as there was a significant context-specificity effect with the visual prime. However, contrary to our hypotheses, we did not obtain a context-specificity effect with the music prime or both prime. Despite the lack of a context-specificity effect in the music prime condition, a relationship between participant musical expertise and
predictive judgment suggested that the music did have an effect on context-specificity in predictive learning.
CHAPTER 1

Introduction

All information is acquired in a context, whether that context is an emotional state, a physical surrounding, or a time. The influence of context on learning and memory has intrigued researchers for decades. When information becomes associated with its context during learning, it exhibits a “context-specificity effect” (Nelson, 2002). Specifically, the information or a response associated with the information is more accurately retrieved in the context where the information was acquired, than in a different context.

The operational definition of context varies depending on the topic of interest. Early memory research defined context as the physical environment surrounding an individual (Smith, 1979). However, context can also be considered in the broader sense as the incidental background related to the individual or the primary stimuli in a task (Smith, 1994). Incidental contexts are not explicitly stated by the researcher. Under these conditions, the context may not receive overt attention, but it can be implicitly associated with the primary stimuli to modify responses (Smith, 1994). This property was called “occasion setting” by Holland (1992), who suggested that when the context is reinstated, the context “sets the occasion” for an individual to produce the response associated with that context (Urcelay & Miller, 2014). The use of incidental contexts, therefore, allows researchers to covertly study the context-specificity effect using learning paradigms without explicit instruction.

The context-specificity effect has been extensively studied in memory and learning with visual stimuli, but it is insufficiently studied with auditory stimuli. There
are less than five studies, to this author’s knowledge, that investigate auditory context-specificity in learning with humans. The lack of research on the context-specificity of auditory contexts is particularly prominent with musical stimuli. Music provides a consistently activated, complex stimulus, unlike a pure auditory tone that either activates for a brief time or can be more easily ignored as white noise. The proposed research will consider how music might affect context-specificity effects in an associative learning paradigm.

**Context-Dependent Memory**

Research on the context-specificity effect in memory was first conducted using reinstatement paradigms. In a classic study of context-dependent memory (a term used to refer to the context-specificity effect exclusively in memory research), scuba divers learned a word list either under water or on land (Godden & Baddeley, 1975). The divers then recalled the word list either in the same environment as learned or in the other environment. Divers whose memory for the word list was tested in the same environment as learned (e.g., learn under water, recall under water) recalled more words than those in the different environment (e.g., learn under water, recall on land). This phenomenon was called the “environmental reinstatement effect” (Smith, 1979, p. 461), because the reinstatement of the learning environment led to an increase in recall. Likewise, the switch in the learning environment led to a decrease in recall. This showed that retrieval of information was dependent upon the reinstatement of the context.

Later research investigated how variations of context affected context-dependent memory. Some studies showed that reinstatement of the entire context was not always necessary to observe context-dependent recall. A simple cue to imagine the learning
environment led to the same results as the complete reinstatement of the environment (Smith, 1979). Recall accuracy increased when individuals were instructed to mentally picture the context, even though they were not in the physical environmental context from the learning phase. In recognition memory, the reinstatement effect extended beyond physical cues to semantic cues. When the semantic interpretation of a phrase was different at test than it was in the learning phase, then individuals recognized significantly fewer phrases (Light & Carter-Sobell, 1970). This replicated the effects of context-dependent memory, but extended the definition of context beyond a physical environment to the effect of semantic context on the interpretation of the to-be-remembered stimulus. These studies suggest that context can be defined broadly and that context-dependent memory can be influenced by a variety of contextual cues.

The majority of research on context-dependent memory has used recall or recognition tests and produced reliable, yet small, effect sizes (Smith & Vela, 2001). However, it is important to note that the environmental reinstatement effect does not always occur. In a follow-up investigation of the scuba diver study, Godden and Baddeley (1980) did not observe a significant effect of context-dependent memory with a recognition test instead of a recall test. Context-dependent memory may rely more heavily on whether the contextual cue is needed to help retrieve a memory than on the mere presence of context. In recognition, the target information is present and is the best cue, so contextual cues may not be necessary. Context-dependent memory was observed with a semantic recognition test because the meaning of the context cue at retrieval biased a different meaning for the target (Light & Cater-Sobell, 1970). See these reviews
for more information on the history of context-dependent memory (Isarida & Isarida, 2014; Smith, 2013).

**Context-Dependent Learning**

The context-specificity effect has been investigated in learning using an extinction paradigm. In extinction, a cue is not followed by the outcome with which it was originally associated. After responses to the cue decrease, reinstatement can be implemented by presenting a single trial where the cue is followed by the original outcome. While studying the extinction of conditioned responses in rats, Bouton found that both extinction and reinstatement can be context-specific (Bouton, 1994; Bouton & Bolles, 1979). If learning occurs in context A and extinction occurs in context B, then the subject will exhibit a reinstated response to the cue in context A. In fear conditioning paradigms, a cue from the extinction context presented in the reinstatement context leads to a decrease in responding (Dibbets, Havermans, & Arntz, 2008). Thus, a cue from the extinction context produces the response learned in that context. This effect occurs reliably in both animals (Bouton & Bolles, 1979; Bouton & Ricker, 1994; Harris, Jones, Bailey, & Westbrook, 2000) and humans (Dibbets et al., 2008; Labar & Phelps, 2005; Nelson, Lamoureux, & Leon, 2013).

Extinction training with humans has used predictive learning tasks. Predictive learning requires that participants learn the likelihood of a specific cue leading to the presence or absence of an outcome (i.e. cue-outcome associations). Extinction training occurs on trials within the predictive learning task when the cue is not followed by the expected outcome. The predictive learning paradigm allowed researchers to both analyze the fundamental conditioning processes involved in contextual learning and link the
animal extinction studies with human studies on context-specificity (Dibbets, Maes, Boermans, & Vossen, 2001). Because the cue-outcome associations are the primary focus of the task, all other stimuli are contextual cues. The context-specificity effect occurs when participants give lower predictive judgments for a cue-outcome association if the contextual cues that were present when the association was learned are absent at the test. Through the predictive learning paradigm, specific aspects of the contextual cues and/or the primary stimuli in the learning trials can be manipulated to establish consistent contributors to the context-specificity effect.

Context effects in extinction and predictive learning have been explained by the attentional theory of context processing (Rosas, Callejas-Aguilera, Alvarez, & Abad, 2006), which suggests that causing an individual to pay attention to context promotes associative binding between the primary cue-outcome associations and the context. Once this additional association with the context is formed, then the reinstatement of the context will produce the response formerly learned in that context or a higher level of performance on the task learned in that context. Causing an individual to pay attention to context can be accomplished by manipulating attributes of the learning environment. One of these attributes is ambiguity. For example, in extinction training, because the cues previously learned as strong cue-outcome associations are no longer followed by the outcome, the meaning of the cue becomes uncertain. The presence of ambiguity, or uncertainty, during learning causes subjects to pay more attention to the ambiguous cues (Hogarth, Dickinson, Austin, Brown, & Duka, 2008). In an attempt to disambiguate these cues, participants then shift their attention from the primary cue-outcome association to contextual cues that could potentially provide information about the outcome (Nelson et
Once one pays attention to context during learning, all of the information acquired in that context becomes context-specific (Rosas, Callejas-Aguilera, et al., 2006).

Partial reinforcement paradigms induce ambiguity through the use of reinforcement and extinction trials. In partial reinforcement a cue leads to the presence of the outcome equally as often as the absence of the outcome. Continuous reinforcement, its counterpart, exists when a cue consistently leads to the presence or consistently leads to the absence of the outcome. Partial reinforcement creates ambiguity, but continuous reinforcement is unambiguous (Rosas, Todd, & Bouton, 2013). By using partial and continuous reinforcement in predictive learning, the level of ambiguity and how much one attends to context in a predictive learning paradigm can be manipulated.

When contextual cues are associated with the primary cue-outcome association, then the presence of the contextual cues modulates the outcome response (De Houwer, 2014; Leon, Abad, & Rosas, 2008). This modulation occurs because the relational value of the contextual cues to the primary cue-outcome associations causes participants to selectively attend to the most informative attributes of contextual cues for predicting the outcome (George & Kruschke, 2012; Uengoer, Lachnit, Lotz, Koenig, & Pearce, 2013). As learning trials increase in unambiguous tasks, participants cease to attend to context (Leon, Abad, & Rosas, 2010, 2011). However, the general presence of ambiguity produces context-specificity for all information presented in a predictive learning task. Specifically, the presence of some ambiguous cue-outcome associations in the task leads to even unambiguous cue-outcome associations becoming context-specific (Rosas, Garcia-Gutierrez, et al., 2006; Rosas & Callejas-Aguilera, 2006). The informative value
of the context then allows participants to disambiguate all cue-outcome associations (Bouton, 1994).

**The Influence of Background Music**

Music is a complex stimulus that has captured the interest of scientists in fields ranging from cognition to human factors. The influence of background music has been studied in recognition memory (Proverbio et al., 2015), source memory (Ferreri, Bigand, & Bugaiska, 2015), verbal learning and memory (Ferreri, Aucouturier, Muthalib, Bigand, & Bugaiska, 2013; Ferreri & Verga, 2016), and task performance (Dalton & Behm, 2007). Perhaps the reason why music has attracted attention from so many types of research is its distinct combination of properties that ascribe it as a uniquely complex stimulus.

Hewitt (1977) proposed two aspects of contextual cues: extrinsic and intrinsic. Extrinsic contexts are contextual cues that the participant perceives outside of themselves, such as a visual or auditory stimulus. Intrinsic contexts refer to contextual cues within the participant, such as emotional states. Music has both extrinsic and intrinsic factors (Ferreri & Verga, 2016). Music has auditory and temporal properties that serve as extrinsic cues. The auditory component of music has been shown to facilitate memory after playing a couple of notes of a phrase, similar to tonal cues (McGee-Lennon, Wolters, McLachlan, Brewster, & Hall, 2011). The temporal component of music is unique amongst auditory stimuli. The perception and interpretation of music in working memory differs from that of other auditory stimuli, even speech (Berz, 1995). Although auditory tones exist within a temporal framework, the sequencing of music fills a temporal phase, giving meaning to each moment (Jones & Boltz, 1989). Music is
organized schematically in long-term memory by expectation of phrases (Berz, 1995). Event-related potential studies revealed that the brain anticipates tonal sequences, the basis of a musical phrase (Bendixen, Schroeger, & Winkler, 2009). The temporal predictability of musical dimensions, such as tempo, meter, and rhythm, attracts immediate attention when one of these expectations is violated (Boltz & Jones, 1989). This temporal expectation is particularly strong when participants are instructed to identify auditory targets as opposed to visual targets, suggesting that the temporal component of auditory signals outweighs the need for temporal structure in visual signals (Menceloglu, Grabowecky, & Suzuki, 2017).

Intrinsically, music evokes an emotional state in a listener. In a meta-analysis on background music, music was shown to have a positive effect on emotions (Kampfe, Sedlmeier, & Renkewitz, 2010). Musical stimuli in a major tonality have been shown to increase arousal and enhance performance on a variety of tasks (Thompson, Schellenberg, & Husain, 2001; c.f. Schellenberg & Weiss, 2013, for a review of the influence of music on cognitive abilities). The tempo of background music influences the speed at which participants complete a task; i.e., they complete a task more quickly when listening to music with a faster tempo than a slower tempo (Balch & Lewis, 1996; Kampfe et al., 2010). Furthermore, musicians and non-musicians respond to the presence of music differently. Musicians, who tend to approach musical stimuli more analytically, are potentially more distracted by the presence of music than non-musicians who simply experience an increase in affective arousal from the presence of music (Gold, Frank, Bogert, & Brattico, 2013).
**Music-dependent memory.** Research with both extrinsic and intrinsic aspects of contexts consistently lead to context-dependent recall (Unsworth, Spillers, & Brewer, 2011). Extrinsic factors between and within musical contexts facilitate music-dependent memory. Music-dependent memory was first observed by varying musical genres (Balch, Bowman, & Mohler, 1992; Smith, 1985). Smith (1985) began the research on music-dependent memory through manipulations similar to environmental reinstatement. He had one group of participants learn a word list while listening to classical music, while another group listened to jazz music. As with the environmental reinstatement effect in visual contexts, participants recalled more words when tested with the same musical context as their learning environment than when tested with the different musical context. This effect was replicated, even suggesting possible facilitating effects of music-dependent memory compared to the silent control conditions (Balch et al., 1992). The extrinsic factors of music-dependent memory were further expanded to include variations in musical tempo as separate contexts (Balch et al., 1992), indicating the versatility of musical contexts to produce the context-specificity effect.

The intrinsic factors of music were first manipulated to create mood-dependent memory in support of the mood-mediation hypothesis (Balch & Lewis, 1996). The mood-mediation hypothesis states that one’s mood can serve as a contextual influence on what is learned and the retrieval of the to-be-remembered stimuli. This was first discussed as a mood-congruity effect in learning and mood-state dependence in memory (Bower, 1981). The mood-congruity effect states that participants will learn information better if the information is congruent with their current mood. One study replicated this effect by using consonant or dissonant musical chords to prime participants before learning a
positive or negative word (Sollberger, Reber, & Eckstein, 2003). The mood-state dependence effect states that participants will more accurately retrieve information if they are induced into the same mood state as when the information was learned. Balch & Lewis (1996) found that participants recalled more words when the tempo of the musical context during learning (i.e. fast; slow) matched the mood described by a visual scenario at test (i.e. active mood; relaxed mood). This effect of music-dependent recall and mood was later replicated by manipulating the tonality of musical contexts (Mead & Ball, 2007).

Music-dependent memory has also been produced by abbreviated musical cues during a test. Musicons of as little as .5 seconds of a 20 second phrase facilitated memory retrieval for specific daily activities associated with each musical phrase (McGee-Lennon et al., 2011). Interestingly, one study found that when visual and auditory contextual cues were presented simultaneously, context-dependent recall memory was significantly better than when a single mode of contextual cue was presented (Stefanucci, O’Hargan, & Proffitt, 2007). These studies suggest that the occasion setting property of context extends broadly to variations of both musical form and task presentation to facilitate music-dependent memory.

**Music-dependent learning.** Predictive learning tasks consistently lead to information becoming context-dependent with visual stimuli, but this is not as well documented in tasks with auditory stimuli. Auditory tones are common stimuli in extinction training with animals (Bouton, 1994; Bouton & Bolles, 1979; Experiment 2, Bouton & Ricker, 1994). However, auditory tones in extinction training are typically accompanied by additional environmental contexts that could disambiguate cue-outcome
associations. One study in predictive learning manipulated the learning environment, so that only auditory tones were useful contextual stimuli. Dibbets et al. (2001) used a computer-based scenario in which participants learned an association between a geometric figure and a positive or negative outcome while one of two colors was presented on the computer screen background. Participants pressed a key on a computer keyboard to indicate if they predicted a plus sign or blank screen to follow the geometric figure. At test, increased response latencies for prediction when the learning context was switched suggested a context-dependent effect of the color of the computer screen. These results were replicated when using two auditory tones as the context of the figure-outcome associations suggesting that context-dependent effects in predictive learning are not confined to the visual modality. This study used simple auditory tones as contextual cues; the effect of the complex auditory stimulus of music has yet to be studied in context-dependent predictive learning paradigms.

Multiple studies have analyzed the effects of background music on other types of learning. In one study using a verbal learning paradigm, participants learned a word list while listening to music and learned another word list while in silence (Ferreri et al., 2013). Participants’ word recall was then tested in a silent room, and they showed higher recall accuracy for the word list learned while listening to music than the word list learned in silence. These results were replicated in a study investigating foreign language learning using musical and silent learning contexts (de Groot, 2006). These studies suggest that the presence of instrumental music does not hinder verbal learning, and may perhaps facilitate verbal learning. The greater recall accuracy for words learned in the musical context appears counter to the context-specificity effect. However, the presence
of a musical context is not an adequate comparison to the absence of a musical context as an explanation for context-specificity. A better manipulation should compare learning in at least two different auditory contexts. Though these studies use a musical context, they still do not investigate context-specificity for music.

A study on reinforcement learning manipulated the affective influence of a musical context in a probabilistic learning task (Gold et al., 2013). They found an increase in reaction time to the learned cue-outcome association when participants listened to self-defined pleasurable music instead of neutral music. However, there was no test of the learned associations’ context-dependency on music type. In all of these studies, context was manipulated during learning, but there were no tests for associations formed between the to-be-remembered stimuli and distinctive musical contexts. Thus, no research has investigated the influence of music on the context-specificity effect in predictive learning.

**Present Study**

The goal of the present study was to determine whether participants use a music prime to retrieve the temporal context of cue-outcome associations in a context-specific predictive learning paradigm. We investigated this question by adapting a predictive learning task developed by Matute and colleagues (Matute, Lipp, Vadillo, & Humphreys, 2011; Pineño, Ortega, & Matute, 2000). During this task, participants were told to imagine they were on a mission to rescue refugees and supplies from a ramshackle building and transport them to a safe house. To accomplish this mission, participants must use colored light cues on a spy-radio to discern if a transport road will be safe or dangerous. In Phase 1, cue X (e.g., red) was followed by a negative outcome and cue A
(e.g., blue) was followed by a positive outcome. In Phase 2, however, cue X was followed by a positive outcome and cue B (e.g., yellow), a novel cue, was followed by a negative outcome. Participants were primed in Phase 3 with cue A or cue B followed by the respective outcome. Then, in a test trial, they reported the expected outcome of X. Participants reported a negative outcome for X when primed by the Phase 1 cue A, and a positive outcome for X when primed by the Phase 2 cue B. The results indicated a context-specificity effect for the test cue X. Matute et al. (2011) explained their results by stating that the visual cue prime activated the temporal context of Phase 1 or Phase 2. Once the temporal context was activated, participants were able to retrieve the appropriate cue X-outcome association for the test.

To address the present research question concerning music, we adapted the spy-radio task of Matute and colleagues (2011) by adding different music selections to each phase. One piece of music served as P1M in Phase 1 and another piece of music was P2M in Phase 2. The visual light cue X led to a negative outcome in Phase 1 and a positive outcome in Phase 2. In Phase 3, participants were primed with either the visual cue A of Phase 1 or cue B of Phase 2, the music of Phase 1 or Phase 2, or both the visual light cue and the music of Phase 1 or both of Phase 2. The visual light cue prime replicated the spy-radio testing procedure used by Matute et al. (2011). The music selections were presented for 4 seconds in the music prime conditions. The brief presentation of the priming musical stimulus in Phase 3 was considered sufficient exposure because 3 sequential chords have been shown to be an effective prime (Sollberger et al., 2003) and musicons of 0.5 seconds effectively facilitate memory retrieval (McGee-Lennon et al., 2011). The both primes resembled a typical trial from
Phase 1 or Phase 2 with the presentation of the appropriate visual light cue and music from each learning phase. After the Phase 3 prime trial, participants made predictive judgments on the outcome of the test cue X in the absence of any music or feedback.

We hypothesized that all priming conditions would lead to a context-specificity effect. The visual light cue priming conditions should replicate the temporal context effects found by Matute and colleagues (2011). Specifically, the predictive judgments at test should reflect the cue-outcome association appropriate for the primed phase. There should be lower predictions for X when primed by a Phase 1 stimulus, whereas there should be higher predictions for X when primed by a Phase 2 stimulus. The music alone priming conditions address our primary research question. We hypothesize that the music prime would produce the same context-specificity effect observed with the visual cue prime. Finally, we hypothesized that the priming condition of both the visual cue and music would produce a stronger context-specificity effect than either of the single priming cues by activating both modalities (c.f. Stefanucci et al., 2007).
CHAPTER 2

Method

Participants

Ninety-six (16 participants per group) undergraduate students of Western Kentucky University were recruited via the university’s online study board. The sample was mostly female (69.8%) and of a white ethnicity (74.2%). Exclusion criteria included color-blindness, hearing deficits, and under 18 years of age. Color-blindness was an exclusion criterion because all visual cues in the experimental task could only be differentiated by color. Hearing deficits were an exclusion criterion because musical contexts were essential to the purpose of the study. Participants were screened for both exclusion criteria through study board. Additional screening for color-blindness (by Ishihara’s Tests for Colour Deficiency – Concise Edition) occurred in the Cognition Laboratory upon arrival for the study. One participant failed to pass Ishihara’s Tests for Colour Deficiency – Concise Edition, received compensation for half an hour of participation and was dismissed from the study. Up to five study board credits, depending on the amount of time a participant required to complete the study, were granted to each participant as compensation. Biographical characteristics and cognitive data are presented in Table 1.

Table 1. Mean Participant Characteristics (Standard Deviation)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>96</td>
</tr>
<tr>
<td>Age (years)</td>
<td>19.56 (1.70)</td>
</tr>
<tr>
<td>Education (years)</td>
<td>13.05 (1.14)</td>
</tr>
<tr>
<td>Ishihara</td>
<td>10.94 (0.22)</td>
</tr>
</tbody>
</table>
### Advanced Vocabulary

<table>
<thead>
<tr>
<th>Test</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Vocabulary</td>
<td>9.97 (4.94)</td>
</tr>
<tr>
<td>Reading Span</td>
<td>2.53 (1.18)</td>
</tr>
<tr>
<td>DS substitution</td>
<td>80.34 (12.22)</td>
</tr>
<tr>
<td>DS incidental learning</td>
<td>22.83 (4.55)</td>
</tr>
<tr>
<td>CAL # forgotten</td>
<td>4.5 (2.67)</td>
</tr>
<tr>
<td>CAL # perseverations</td>
<td>2.25 (2.28)</td>
</tr>
</tbody>
</table>

**Note.** Standard deviations are in parentheses. Ishihara = Ishihara’s Test for Colour Deficiency – Concise Condition (Isshinkai Foundation, 2006); Advanced Vocabulary (Ekstrom, French, & Harman, 1979); Reading Span (Salthouse & Babcock, 1991); DS = Digit Symbol (Wechsler, 1997); CAL = Conditional Associative Learning (Levine, Stuss, & Milberg, 1997).

### Design and Stimuli

This study used a 2 (Group: Retrieve vs. Default) × 3 (Prime: Visual vs. Music vs. Both) between-subjects design. Specifically, six conditions were defined. For the retrieve group, the conditions were: Retrieve Visual (RV), Retrieve Music (RM), and Retrieve Both (RVM). For the default group, the conditions were: Default Visual (DV), Default Music (DM), and Default Both (DVM). The dependent variable was predictive judgments of visual cues leading to a safe or unsafe road. The predictive judgments were made using a rating scale with 21 buttons ranging from 0 to 50. Participants were pseudo-randomly assigned to one of the six experimental conditions.

The experimental task was an adaptation of the spy-radio task developed by Matute and colleagues (Matute et al., 2011; Pineño et al., 2000). The spy-radio task was programmed on a Macintosh computer using the software SuperLab Pro 5.0. In the task,
participants were asked to imagine that they were soldiers for the United Nations. Their mission was to save a group of refugees and supplies from a building. In order to save the refugees and supplies, participants were to send the refugees and supplies on safe roads. Safe and dangerous roads were identified by colored lights on the spy-radio. Participants must learn to decipher the light cue-outcome associations in order to save as many refugees and supplies as possible.

The experimental design is diagramed in Table 2. The spy-radio task had three phases followed by a test. The first and second phases were identical except in the meaning of the cue-outcome associations. In Phase 1, the cue-outcome associations of X- and A+ were presented 10 times each. The cue-outcome associations of F1- and F1+ were presented five times each. In Phase 2, the cue-outcome associations of X+ and B- were presented 10 times each. The cue-outcome associations of F2- and F2+ were presented 5 times each. All trials were randomly presented within a phase. The third phase only contained one trial that was manipulated to prime the appropriate learning phase of the correct test cue-outcome association. The test phase contained one trial in which participants gave predictive judgments of the expected outcome of the light cue X.

Visual cues (i.e. the lights on the spy-radio) indicated the outcome of a safe (+) or dangerous (-) road in a trial. The colors red, blue, and yellow were counterbalanced as the light cues X, A, and B. A was continuously reinforced with a positive outcome of a safe road in Phase 1. B was continuously reinforced with a negative outcome in Phase 2. The meaning of the outcome of X changed depending on the phase. In Phase 1, X was continuously reinforced with a negative outcome; however, in Phase 2, X was continuously reinforced with a positive outcome. The colors green and purple served as
the light cues of F1 and F2, respectively. F1 only appeared in Phase 1, and F2 only appeared in Phase 2. F1 and F2 were partially reinforced, so that in half of the trials F1 and F2 led to positive outcomes and in half of the trials F1 and F2 led to negative outcomes. This partial reinforcement of F1 and F2 was added to induce ambiguity within the two learning phases (Rosas et al., 2013). Ambiguity causes one to attend to context (Callejas-Aguilera & Rosas, 2010; Rosas, Callejas-Aguilera et al., 2006). By inducing ambiguity immediately into the learning paradigm in both Phase 1 and Phase 2, participants should attend to contextual cues beyond the primary light cue-outcome associations.

The musical selections indicated the phase of the task. Headphones connected to the computer played the music throughout the task. The musical selections were classical and jazz pieces that have been used in previous research (Smith, 1985). One selection was an excerpt from the classical piece, Mozart’s Concerto No. 24 in C Minor for Piano and Orchestra. The other selection was an excerpt from the jazz piece, “People Make the World Go Around,” by Milt Jackson. The volume of the selections was normalized at 89 dB using the software MP3Gain (Proverbio et al., 2015). Each selection began at the onset of the piece and was cut at the end of a musical phrase at about 45 seconds. The musical excerpts continuously looped throughout their respective phase. The two musical excerpts were counterbalanced across the two phases. Participants listened to either the classical or jazz excerpt in Phase 1 (P1M) and the other musical excerpt in Phase 2 (P2M).
Table 2. *Experimental Design*

<table>
<thead>
<tr>
<th>Group</th>
<th>Learning</th>
<th>Prime</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phase 1</td>
<td>Phase 2</td>
<td>Phase 3</td>
</tr>
<tr>
<td>Retrieve</td>
<td>X-, A+, F1-, F1+</td>
<td>X+, B-, F2-, F2+</td>
<td>A+, or P1M, or P1M/A+</td>
</tr>
<tr>
<td>Default</td>
<td>X-, A+, F1-, F1+</td>
<td>P1M</td>
<td>X+, B-, F2-, F2+</td>
</tr>
</tbody>
</table>

*Note.* The Retrieve and Default groups differ by source of the Phase 3 cues, either cues from Phase 1 or Phase 2. The outcomes of each trial are represented by + (safe) and – (dangerous). The letters X, A, B, F1 and F2 indicate visual light cues. P1M indicates the music from Phase 1. P2M indicates the music from Phase 2. All groups received one test trial on the light cue X.

A single learning trial consisted of three screens. Diagrams of the screens are shown in Appendix A. The first screen was an inter-trial interval that showed the spy-radio in the center of the screen with no light. In the upper center of the screen, in 36-point font, read the phrase, “Traveling to the next outpost.” The duration of the inter-trial interval was randomized between 3 and 6 seconds with an average of 4 seconds. The second trial screen was a stimulus screen. The phrase from the inter-trial interval screen was erased. The spy-radio remained in the same position and a colored circle (the light cue) appeared super-imposed on the spy-radio. A rating scale ranging from 0 to 50 in increments of 5 appeared at the bottom of the stimulus screen. This screen remained until the participants selected a button on the rating scale to indicate how many refugees and supplies they wished to place on the truck. The background of the stimulus screen and the inter-trial interval screen was an orange colored desert road with a truck traveling down the road. The third trial screen was a feedback screen. The message on the feedback screen varied depending on the trial’s pre-determined outcome. For positive trials, the message read, “This road was SAFE! Number of people and supplies SAVED.” For
negative trials, the message read, “Oh no! This road was MINED. Number of people and supplies lost:” The number that the participant picked from the rating scale appeared under the text on the feedback screens. The background of the feedback screen was a tan antique map. The feedback screen remained for 3 seconds before proceeding to the next inter-trial interval screen.

The primary manipulation of the spy-radio task occurred in Phase 3, during which a single trial primed the response for the test. The Phase 3 manipulations were divided by group and prime for a total of six possible conditions. The first division was by the retrieve group or the default group. In the retrieve group, all cues presented in Phase 3 were from Phase 1. Specifically, participants either saw the visual light cue A+ of Phase 1, heard the music of Phase 1, or both. The Phase 3 primes of the retrieve group should then cause the participants to give lower predictive judgments to cue X on the test rating scale because cue X was followed by a negative outcome in Phase 1. In the default group, all cues in Phase 3 were from Phase 2. Participants either saw the visual light cue B- of Phase 2, heard the music of Phase 2, or both. The Phase 3 primes of the default group should cause the participants to give higher predictive judgments to cue X in the test phase because cue X was followed by a positive outcome in Phase 2. All Phase 3 trials were the length of one trial from the previous phases. For the visual prime, no music played. For the music prime, the stimulus screen appeared for 4 seconds, but the visual light cue never appeared on the spy-radio. For the both prime, the visual light cue and music appeared in the same manner as experienced previously in the appropriate phase.

The final phase was the test phase. In the test phase, participants in all conditions completed one trial with cue X. No music played during the test. There was an inter-trial
interval screen before the test stimulus screen, but no feedback was given after participants made their response.

**Procedure**

The study was approved by the Human Subjects Review Board of Western Kentucky University. Participants completed the experiment one at a time in the Cognition Laboratory. All tasks were administered by a trained research assistant of the Cognition Laboratory.

Upon entering the Cognition Laboratory, participants read and signed the informed consent document. Next, the researcher administered Ishihara’s Tests for Colour Deficiency – Concise Edition to the participant. If the participants did not pass this test, they were dismissed from the Cognition Laboratory. If the participants passed this test, they proceeded with the experiment. The participants then filled out a Biographical and Health Questionnaire with items of a demographic (i.e. ethnicity, level of education, social-economic status) and health (i.e. medical history, current medications) focus.

Next, the participants began the spy-radio task. They sat in front of the computer and read the instructions to themselves as the researcher reads the instructions aloud. The full instructions are listed in Appendix B. After reading the instructions, the researcher demonstrated the task in a practice trial. The practice trial was identical to a learning trial, except it used a white light cue instead of a color. The researcher pointed out the spy-radio, light cue, and rating scale to the participants. Then participants put on a set of headphones for a volume check. A C4 tone played through the headphones. Once the participants were comfortable with the volume, they were instructed not to change the
volume of the headphones for the remainder of the task. The researcher then clicked the center button on the rating scale, “25,” to continue to the practice trial feedback screen. The practice trial feedback screen stated positive feedback for the trial. After the practice trial ended, the researcher allowed the participants to ask questions, and then the researcher exited the room.

When the participants finished the spy-radio task, their awareness of the music’s relationship with the cue-outcome associations was assessed by questioning if they noticed anything about the experimental task. The experimenter asked the participant, “Did you notice anything about the task?” If the participant said, “Yes,” the experimenter probed further by asking for specific details and for further elaboration. If the participant said, “No,” the experimenter did not probe further.

Participants then completed a series of tasks assessing their musical experience and cognitive abilities. The order of the tasks was: the Helsinki Inventory of Music and Affective Behavior (Gold et al., 2013), the WAIS Digit Symbol Substitution and Incidental Learning (Gerontol, 1978), Reading Span (Daneman & Carpenter, 1980), Advanced Vocabulary (Ekstrom, French, Harman, & Dermen, 1976), and Conditional Associative Learning (Levine, Stuss, and Milberg, 1997). Upon completion of the individual differences tasks, the researcher read a debriefing statement to the participants. Finally, the researcher compensated and dismissed the participants.

**Measures**

**Ishihara’s Tests for Colour Deficiency – Concise Edition.** This version of Ishihara’s tests consists of 14 color plates (11 number plates, 2 line plates, 1 control of
nothing). Only the number plates are scored. Participants pass the test if they get 10 out of 11 number plates correct (Isshinkai Foundation, 2006).

**Helsinki inventory of music and affective behavior (HIMAB).** This is a five-section questionnaire that measures musical expertise, exposure, and use (Gold et al., 2013). See Appendix E for the entire HIMAB questionnaire. The first section, “Musical Training,” contains 9 fill-in-the-blank items. The second section, “Listening to Music,” contains 4 items using a seven-point scale and a five-point ranking scale. The third section, “Music Consumption,” contains 2 items using a seven-point scale. The fourth section, “Uses of Music,” contains 15 items using a seven-point scale. The fifth section, “Music-Directed Attention Scale,” contains 13 items in which participants circle if they agree or disagree with the statement. An example item is, “When I study for an exam, music playing in another room distracts me. (Agree or Disagree).” A final page was added to assess participants’ arousal induced by the musical selections of the experimental task (c.f. Greene, Bahri, & Soto, 2010).

**WAIS digit symbol substitution test (DSST) and digit symbol incidental learning (DSIL).** This is a standardized test commonly used in the aging literature to measure speed of processing and working memory (Wechsler, 1997). The participants must complete at least four rows of matching the symbol and number association. Then the participants complete two incidental learning procedures in which they recall as many of the symbol-number associations as they can.

**Reading span.** This test is a computerized procedure in which the participant must read a sentence aloud and answer a question pertaining to it, while remembering the
last word in the sentence. It tests working memory capacity (Salthouse & Babcock, 1991).

 Advanced vocabulary. This vocabulary test is standardized and common in the aging literature to examine verbal knowledge. It consists of two parts, each with 18 matching vocabulary items (Ekstrom et al., 1976).

 Conditional associative learning (CAL). The CAL is a standardized procedure commonly used in the aging literature to examine frontal lobe deficits and flexibility of associative learning (Levine et al., 1997). It requires participants to learn the association between a key symbol and one of four patterns.
CHAPTER 3

Results

Learning Criteria

Preliminary analyses were conducted to ensure that all participants included in the final analyses adequately learned the cue-outcome associations in Phase 1 and Phase 2. Based on the learning criteria imposed by Matute et al. (2011), we defined adequate learning within a phase as higher average ratings for the final two cues followed by a positive outcome, than for the final two cues followed by a negative outcome. Specifically, in Phase 1, the final two presentations of cue A+ must have a higher average rating than the final two presentations of cue X-. In Phase 2, the final two presentations of cue X+ must have a higher average rating than the final two presentations of cue B-. This criterion did not include ratings for filler cues, which were ambiguous in their expected outcome. The data for eight participants (2 in DV, 1 in DM, 2 in RM, 3 in RVM) were eliminated from the analyses due to failure to meet the learning criteria. These eight participants were replaced with eight participants who met the learning criteria.

Learning Phases

A 2 (Group) X 3 (Prime) X 3 (Cue) X 10 (Trial) ANOVA was conducted on the data for each learning phase to analyze participants’ cue-outcome discriminations for the visual cues across trials. See Figure 1 for a graph of the learning data for the visual prime conditions, Figure 2 for the music prime conditions, and Figure 3 for the both prime conditions. The target cue X was analyzed as Cue 1; cues A and B were analyzed as Cue 2. The filler cues, F1 and F2, were collapsed over outcome type within each phase and analyzed as Cue 3. Five participants (2 DV, 1 DM, 1 DVM, 1 RM) had one or more data
points missing due to participant error and across the five participants, there were a total of 17 missing data points out of a total of 5,760 data points. These data points were interpolated by averaging the data for the specific cue and trial over all participants, and inserting this mean for the missing data point.

In Phase 1 there was a significant three-way Prime X Cue X Trial interaction, $F(36, 1620) = 1.82, MSE = 1998.46, p = .00, n^2_p = .04$. See Appendix C, Table 4, for the Phase 1 learning omnibus ANOVA results. It was not expected that responses to learning trials would differ between conditions because the conditions were identical until the Phase 3 prime. Further analysis of this interaction revealed that all prime conditions had significant Cue X Trial interactions, Visual: $F(18, 558) = 22.16, MSE = 1842.04, p = .00, n^2_p = .42$; Music: $F(18, 558) = 14.01, MSE = 2142.18, p = .00, n^2_p = .31$; Both: $F(18, 558) = 14.38, MSE = 1987.86, p = .00, n^2_p = .32$. The visual prime had a larger interaction effect size than the music prime or both prime, however, this difference is of little importance because all three prime conditions show clear discrimination performance as displayed in Figures 1, 2 and 3. Specifically, as learning trials increased, the positive cue-outcome associations (e.g., A+) resulted in higher predictive judgments, whereas the negative cue-outcome associations (e.g., X-) resulted in lower predictive judgments.

In Phase 2 of learning the only significant interaction was Cue X Trial, $F(18, 1620) = 40.24, MSE = 2486.79, p = .00, n^2_p = .31$. See Appendix C, Table 5, for the Phase 2 learning omnibus ANOVA results. The Cue X Trial interaction suggests that all participants acquired the correct discriminations between the positive (e.g., X+), and negative (e.g., B-) cue-outcome associations as the trials of Phase 2 increased. The lack of any significant interaction or main effect with prime or group indicates that all
conditions were equivalent in learning throughout Phase 2. This further reduces the possibility that systematic differences between the conditions during Phase 1 learning could have influenced the test results.

Phase 3 was a single trial intended to prime the appropriate X cue-outcome association expected for the test (i.e. X- in the retrieve group, or X+ in the default group). Participants in the music prime conditions did not record any predictive judgments during Phase 3 because the music played without the presentation of a cue on the spy-radio. Participants did record predictive judgments in the visual prime and both prime conditions during Phase 3. The means of these predictive judgments are shown in Table 3. A 2 (Group) X 2 (Prime: Visual, Both) ANOVA was conducted to analyze the Phase 3 predictive judgments. There was a significant 2-way interaction of Group X Prime, $F(1, 60) = 7.49, MSE = 190.15, p = .01, n_p^2 = .11$. Further analysis of this interaction isolated group. There was no significant difference between Phase 3 predictive judgments of the visual and both primes for the default group, $F(1, 30) = 0.96, MSE = 78.53, p = .33, n_p^2 = .03$. However, there was a significant simple main effect of prime for the retrieve group, $F(1, 30) = 12.76, MSE = 301.76, p = .00, n_p^2 = .29$, indicating that the Phase 3 predictive judgments were greater for the both prime than for the visual prime.
Figure 1. Mean Predictive Judgments from Phase 1 and Phase 2 of Learning: Visual Prime (Phase 1: Phase 2)

Figure 2. Mean Predictive Judgments from Phase 1 and Phase 2 of Learning: Music Prime (Phase 1: Phase 2)
Figure 3. Mean Predictive Judgments from Phase 1 and Phase 2 of Learning: Both Prime

(Phase 1: Phase 2)

Table 3. Phase 3 Prime Predictive Judgments

<table>
<thead>
<tr>
<th>Phase 3 Prime</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (S.E. Mean)</td>
</tr>
<tr>
<td>DV-</td>
<td>.437 (.328)</td>
</tr>
<tr>
<td>DM</td>
<td>-----</td>
</tr>
<tr>
<td>DVM-</td>
<td>3.5 (3.12)</td>
</tr>
<tr>
<td>RV+</td>
<td>4.06 (2.23)</td>
</tr>
<tr>
<td>RM</td>
<td>-----</td>
</tr>
<tr>
<td>RVM+</td>
<td>26 (5.72)</td>
</tr>
</tbody>
</table>

Test Phase

The ratings for target cue X in the test phase were analyzed for the six experimental conditions in a 2 (Group) x 3 (Prime) ANOVA. See Table 3 for mean test predictive judgments, and Figure 4 for a graph of the test results. See Appendix C, Table 6, for the test omnibus ANOVA results. To show the context-specificity effect, the predictive judgments of cue X in group retrieve should be significantly lower than the predictive judgments of cue X in group default. There was a significant main effect of
group, \( F(1, 90) = 13.72, MSE = 407.95, p = .00, \eta^2_p = .13 \), showing that participants in the retrieve group gave significantly lower predictive judgments to cue X at the test than participants in the default group. However, there was also a significant interaction of Group X Prime, \( F(2,90) = 3.45, MSE = 407.95, p = .03, \eta^2_p = .07 \). To further analyze the interaction, prime was isolated. There was a simple main effect of group in the visual prime condition, \( F(1,30) = 26.59, MSE = 279.86, p = .00, \eta^2_p = .47 \); however the simple main effects of group were not significant in the music prime condition, \( F(1,30) = .59, MSE = 523.57, p = .45, \eta^2_p = .02 \), or the both prime condition, \( F(1,30) = 1.58, MSE = 420.43, p = .22, \eta^2_p = .05 \). This suggests that the significant main effect of group was driven primarily by the visual prime condition.

Figure 4. *Mean Predictive Judgments at Test by Prime*
Awareness and Musical Expertise

Participant awareness of the relationship between the musical selections and visual cues was assessed upon completion of the experimental task. Awareness was coded as follows: Yes+ (participant explicitly stated that the music was associated with specific colors cues), Yes (participant explicitly stated that the music switched during the task), No (participant did not mention or differentiate the musical selections). Two participants (1 DM, 1 DVM) did not provide awareness data, so they were not included in the awareness analyses. See Appendix D, Table 7, for the frequency distribution of participant awareness by condition.

Data on participant musical expertise was gathered to determine if it was related to participant awareness of the music or accuracy of test results in the conditions with music primes. Musical expertise was coded as an ordinal variable (1: No experience; 2: 1-2 years; 3: 3-6 years; 4: 6+ years). These rankings are consistent with the categories established by Korsakova-Kreyn & Dowling (2014), which indicate that the greatest musicianship variance is found between the 1-2 years rank and the 6+ years rank. Two participants (1 DV, 1 DVM) did not provide musical expertise data, so they were not included in musical expertise analyses. See Appendix D, Table 8, for a frequency distribution of participant musical expertise by condition.

The researchers were interested in three primary questions concerning awareness and musical expertise. First, we were interested in whether musical expertise predicted awareness of the music. We hypothesized that participants with greater musical expertise might be more aware of the music. A chi-square test of independence showed that
musical expertise was not significantly related to awareness, $\chi^2(6, N = 92) = 8.39, p = .21$.

Second, we asked if group or prime was related to awareness. We hypothesized that the retrieve group and the music prime would be related to awareness of the music because the music would be most important at test for these conditions. A chi-square test of independence showed that neither group, $\chi^2(2, N = 94) = 5.36, p = .07$, nor prime was significantly related to awareness, $\chi^2(4, N = 94) = 9.00, p = .06$.

Third, we wondered whether awareness or musical expertise was related to test predictive judgments. We hypothesized that as participants’ awareness or musical expertise increased, their test predictive judgments would become more accurate in the music prime and both prime conditions. We first examined the relationship between awareness and overall test predictive judgments within each group using linear regression analysis. This regression analysis was not significant for either group, Default Group: $R^2 = .01, p = .52$; Retrieve Group: $R^2 = .00, p = .88$. We then examined the relationship between musical expertise and predictive judgments within each group. See Table 7 for all regression coefficients. Musical expertise was not a significant predictor of test predictive judgments in the default group, $R^2 = .03, p = .26$. However, musical expertise explained a significant proportion of the test predictive judgment variance in the retrieve group, $R^2 = .11, p = .02$. The regression equation was as follows:

$$\text{Predictive Judgment} = 20.68 + -.33\text{ME}$$

Thus, as musical expertise increased, the predictive judgments of the test cue, X-, decreased for the retrieve group. See Appendix D, Table 9, for the results of the regression on the test predictive judgments for each condition.
To further explore the significant relationship for the retrieve group, we ran separate regression analyses for each prime condition in the retrieve group (i.e., RV, RM, and RVM). The regression lines for these analyses are displayed in Figure 5. Musical expertise explained a significant proportion of the test score variance in the RM condition, \( R^2 = .25, p = .04 \). The regression equation was as follows:

\[
\text{Predictive Judgment} = 33.61 + -.51\text{ME}
\]

Musical expertise did not significantly predict test predictive judgments in the RV condition (Predictive Judgment = 11.32 + -.25ME, \( R^2 = .06, p = .35 \)) or in the RVM condition (Predictive Judgment = 14 + -.13ME, \( R^2 = .02, p = .63 \)). Thus, as musical expertise increased, test predictive judgments for X- decreased only in the RM condition. This finding is of particular interest because the RM condition was also the only condition in which participants had to use the music to retrieve the correct test predictive judgment for X- from Phase 1.

Figure 5. Regression Lines of Musical Expertise Predicting Test Predictive Judgments for the Retrieve Group Primes
CHAPTER 4

Discussion

In this study we investigated whether a musical prime would produce a context-specificity effect in predictive learning. Participants were divided into six conditions of a spy-radio predictive learning task. The six conditions were comprised of a combination of three primes (i.e. visual, music, or both) and two prime phase groups (i.e. retrieve, default). The primes indicated the type of stimulus used to prime the temporal context for the test cue-outcome association. The learning phase groups indicated which temporal context would be primed. In the retrieve group, learning Phase 1 was primed; in the default group learning Phase 2 was primed. The presence of a temporal context-specificity effect was indicated by lower test predictive judgments for the test cue X in the retrieve group and higher test predictive judgments for this cue in the default group. We hypothesized that all three types of primes would lead to a significant context-specificity effect. Furthermore, we hypothesized that the context-specificity effect would be strongest in the both prime condition because, with the presentation of both the visual and musical primes, participants would have more information about the learning phase temporal context to inform their test predictive judgment. The results partially supported the first hypothesis as there was a significant context-specificity effect with the visual prime. However, contrary to our hypotheses, we did not obtain a context-specificity effect with the music prime or both prime. Despite the lack of a context-specificity effect in the music prime condition, a relationship between participant musical expertise and predictive judgment suggested that the music did have an effect on context-specificity in predictive learning.
Learning

Participant learning performance reflected accurate discrimination of the cue-outcome associations of each learning phase. As trials increased, the mean predictive judgments for each positive and negative cue-outcome association approached the rating scale extremes. Specifically, predictive judgments for A+ of Phase 1 and X+ of Phase 2 approached 50 as the trials increased. Similarly, predictive judgments for X- of Phase 1 and B- of Phase 2 approached 0 as the trials increased. The predictive judgments for the filler cues, F1 and F2, of each phase remained below 25 for the duration of the spy-radio task. This was expected because of the ambiguous nature of these cues. The filler cues were added to each learning phase to induce an immediate state of ambiguity in Phase 1 that would encourage participants to pay attention to the context (e.g., Rosas, Callejas-Aguilera, et al., 2006). This pattern of discrimination replicated the learning results of Matute et al. (2011).

In Phase 1, the rate of learning differed by prime. Specifically, all participants acquired the cue-outcome discriminations, but the participants in the visual prime condition displayed somewhat better discrimination. In Phase 2, all participants learned to discriminate the cue-outcome associations for the positively and negatively reinforced cues equally well. The discrimination of cue X from a negative outcome in Phase 1 to a positive outcome in Phase 2 was of particular importance because the test results are based upon the accurate discrimination of the outcome of cue X depending on the learning phase.

The better discrimination by the visual prime participants in Phase 1 may suggest a systematic difference in participants’ rate of learning for the three prime conditions,
which could weaken the interpretation of the context-specificity effects in the test results. For example, better discrimination by participants in the visual prime condition might lead to lower test predictive judgments for the retrieve group. However, this would not affect interpretations of the test results because the context-specificity effect is derived from a difference between the test predictive judgments of the default and retrieve groups, not simply the test predictive judgments of the retrieve group. Moreover, the similar levels of learning displayed in Phase 2 across all prime conditions reduces concern about the Phase 1 differences in predictive judgments.

The prime manipulation was presented in Phase 3. This was the first point at which the conditions differed. The retrieve group received a single priming trial from Phase 1. The default group received a single priming trial from Phase 2. No prediction responses were recorded during this trial for participants in the music prime conditions because only the music was presented. Participants’ predictive judgments were recorded for the priming trial in the visual and both prime conditions. In the default group, there was no difference between the both prime condition and the visual prime condition in participants’ predictive judgments. This was not surprising given that the default group essentially received a continuation of Phase 2. For participants in the both prime of the default group, there was no change when the task left Phase 2 and entered Phase 3. For participants in the visual prime condition of the default group, when the task shifted from Phase 2 to Phase 3, the music was removed, but the visual cue-outcome association could easily be retrieved from the previous phase.

In contrast to the default group, there was a difference between the Phase 3 predictive judgments for the visual and both prime conditions in the retrieve group.
Specifically, participants in the visual prime condition gave lower predictive judgments to cue A+ than participants in the both prime condition. This suggests that presentation of the visual cue A without the music from Phase 1 led to weaker retrieval of the cue-outcome association for cue A+, than presentation of both the visual cue and the music. This may be a context effect. Previous literature suggests a change in contextual information can lead to a decrease in predictive judgments (Callejas-Aguilera & Rosas, 2010; Dibbets et al., 2001). The decrease in predictive judgments displayed in the RV condition could be due to the sudden absence of the music, which could be considered an auditory context change from music to silence. This decrease in predictive judgments in response to a context change is discussed further below.

**Test**

The test results were of most importance to the hypotheses of this experiment. Contrary to our hypotheses, the findings suggested that the visual prime, but not the music prime or the both prime, produced a context-specificity effect. This context-specificity effect was revealed by higher predictive judgments for the test cue X in the default group than in the retrieve group. Interestingly, the highest predictive judgments for any default group and the lowest predictive judgments for any retrieve group were observed with the visual prime. This finding replicates and extends previous research using visual stimuli to prime the temporal context of cue-outcome associations (Matute et al., 2011). Moreover, we obtained the visual prime context-specificity effect using a modified spy-radio task with ambiguous filler cues and a predictive judgment rating scale, further supporting the external validity of the effect. However, the lack of context-specificity for the music prime and both prime contrasts with previous research showing...
that auditory (Dibbets et al., 2001) and bimodal context switches (Stefanucci et al., 2007) can produce context-specificity effects.

The significant context-specificity effect in the visual prime condition can be explained by the Rescorla-Wagner (R-W) model (Rescorla & Wagner, 1972). The R-W model proposes that context can form hierarchical associations with primary cue-outcome associations. In this study, the three prime conditions introduced separate methods to prime the temporal context of one of the two learning phases. The temporal context of Phase 1 formed a hierarchical association with the visual cue-outcome associations (e.g., A+, X-, F1+-) of Phase 1. The temporal context of Phase 2 formed a hierarchical association with the visual cue-outcome associations (e.g., B-, X+, F2+/) of Phase 2. Each prime condition was meant to activate the temporal context of a learning phase. For example, in the visual prime conditions, the visual cue-outcome association, A+, should activate the Phase 1 temporal context for the retrieve group, whereas the visual cue-outcome association, B-, should activate the Phase 2 temporal context for the default group (Matute et al., 2011). In the music prime conditions, the music, P1M, should activate the Phase 1 temporal context for the retrieve group, whereas the music, P2M, should activate the Phase 2 temporal context for the default group. In the both prime conditions, the visual cue-outcome associations and the music should activate their respective temporal contexts. The activation of the temporal context would then modulate the expected outcome for the test cue X. The context-specificity effect displayed by the test predictive judgments of participants in the visual prime conditions supports this explanation.
Unlike the visual prime conditions, the hierarchical association of the R-W model cannot fully explain the lack of a context-specificity effect in the music prime and both prime conditions. Like the visual cue-outcome associations, the music was present in the temporal space of each learning phase and should have primed the appropriate temporal context and modulated test predictive judgments. However, music did not lead to the strong context-specificity effect produced by the visual cues. It is possible that the visual cues may have been more salient than the music. Participants had to interact with each visual cue-outcome association during learning. On the contrary, the music was a passive stimulus present during each phase, which may have not attracted enough attention during learning to sufficiently activate the appropriate temporal context for the test. In fact, the results suggest that music was only sufficiently salient to participants with musical experience.

Musical expertise predicted test predictive judgments in the retrieve group, primarily in the RM condition. The RM condition was the only condition that required participants to use the music to retrieve the temporal context for the appropriate test cue-outcome association. Although the DM condition was similar, participants could give the most recent correct predictive judgment of X instead of using the music prime to retrieve the Phase 1 temporal context. The music prime was also not necessary in the RVM and DVM conditions because participants could use the visual cue to prime the appropriate temporal phase. In the RM condition, as musical expertise increased, participant’s predictive judgments for the test cue decreased, which was appropriate because the Phase 1 cue-outcome association was X-. In fact, the test predictive judgments of the musical experts (i.e. participants with six or more years of musical experience) in the RM
condition were similar to the test predictive judgments for participants in the visual RV condition, suggesting that for music experts the music prime retrieved the temporal context of Phase 1 and modulated their test predictive judgments. Previous research suggests musicians and non-musicians process music differently (Gold et al., 2013). The finding that only participants with six or more years of musical experience were able to use the music prime suggests that musical expertise is important when prediction is dependent upon music priming hierarchical associations involving temporal context. However, musical expertise may not be important when other cues can prime the temporal context for these associations, as in the visual prime and both prime conditions. The inclusion of musical expertise in future studies may reveal sub-groups who systematically vary in their learning of associations involving musical stimuli.

The stronger temporal context-specificity effect in the visual prime conditions than the music and both prime conditions could also have been due to the opportunity participants had to learn the irrelevance of the music during the Phase 3 priming trial. Specifically, in the priming trial, the RV condition was characterized by the presence of the A+ visual prime and the absence of the Phase 1 music, and the DV condition was characterized by the presence of the B- visual prime and the absence of the Phase 2 music. Participants in the RV condition and the DV condition gave predictive judgments and then received feedback on the actual outcome. Importantly, participants in the RV condition learned that the Phase 1 visual prime, A+, remained the same in the absence of the music. Likewise, participants in the DV condition received feedback that the music was irrelevant to the Phase 2 visual prime, B-. Thus, at test participants in the RV condition gave the test cue X a low predictive judgment as in Phase 1, and participants in
the DV condition gave the test cue X a high predictive judgment as in Phase 2. This difference produced the large context-specificity effect observed for the visual prime.

Participants in the music prime and both prime conditions never had the opportunity to learn that the presence of music was irrelevant to the test. The first time that the music was absent for the music prime and both prime conditions was at the onset of the test trial. The lack of a context specificity effect for the music prime conditions could be due to the absence of music during the test. The DM condition was characterized by the continued presentation of the Phase 2 music prime and the absence of the visual prime during the Phase 3 prime trial. The RM condition was identical except that the music prime was from Phase 1. Participants in the music prime conditions could only rely upon the music prime to retrieve the temporal context and accurately predict the test cue X outcome. The sudden removal of the music at test introduced a novel auditory context, which may have induced a state of uncertainty. For example, in the RM condition, the test predictive judgments for cue X were more similar to the predictive judgments for the ambiguous cues than to the low predictive judgments for cue X in the final learning trials of Phase 1. The uncertainty shown in participants’ test predictive judgments suggests that they believed the presence of the music was relevant to the previously learned cue-outcome associations. If the music from Phase 1 continued to play during the test, there might have been less uncertainty about the expected outcome of cue X. On the other hand, the extent of this uncertainty may have been conditional upon participants’ musical expertise as suggested by the evidence that the music prime alone was effective for participants with multiple years of musical experience.
The absence of a context-specificity effect in the both prime conditions could also be due to the abrupt removal of the music at test. The participants in the RVM condition experienced their first absence of the music during the test. Although the predictive judgments for the Phase 3 prime suggests participants shifted the temporal context from Phase 2 to Phase 1, this was followed by the unexpected removal of the music during the test. At the test, participants’ predictive judgments decreased appropriately, but this was only slightly less than their predictive judgments for the ambiguous cues. In the DVM condition, there was no interruption in the task between Phase 2 and Phase 3.

Additionally, no retrieval of prior contextual information from Phase 1 was necessary to give an accurate, high predictive judgment to cue X at the test. Despite this, there was a dramatic average decrease in the predictive judgment to cue X from 40 in the last trial of Phase 2 to 20 in the test trial. It is likely that the sudden absence of the music during the test trial made the participants uncertain about the expected outcome for cue X, leading them to reduce their predictive judgments (Callejas-Aguilera & Rosas, 2010, Experiment 2). Again, this uncertainty suggests the participants of the both prime conditions believed that the presence of the music was relevant to the cue-outcome associations. Perhaps, if the music had remained during the test, the both prime conditions may have exhibited a context-specificity effect.

Limitations and Future Directions

The major limitation of this study was also one of its most unique attributes, specifically using various methods of priming the temporal context to study the context-specificity effect in predictive learning. Matute et al. (2011) successfully obtained a temporal context-specificity effect with this priming procedure. We replicated their
results in our visual prime conditions (RV vs. DV) after changing various aspects of the procedure (i.e., the predictive judgment rating scale, ambiguous filler cues, musical selections). However, this temporal priming procedure did not lead to context-specificity effects using either a music prime (RM vs. DM) or both primes together (RVM vs. DVM). If one were to solely analyze the music prime conditions, it could be argued that music does not serve as an adequate prime for the temporal context-specificity effect. Yet, the both prime condition, which included the visual prime, also did not produce the context-specificity effect.

Examining the effect of a music prime on temporal context-specificity should not be abandoned, however. It may be informative to further examine the impact of musical expertise in music priming of temporal context. The relationship between musical expertise and test predictive judgments in the RM condition suggests that a music prime may be too subtle for musical novices to detect and use, but not musical experts who are more sensitive to music. Additionally, presenting the music at test while using a priming procedure may make the music more salient for novices to detect and use. Therefore, future research should investigate whether a significant context-specificity effect can be obtained with a music prime in a group of musical experts, or with novices when the music is presented during the test.

As noted above, the absence of the music during the test likely introduced a novel auditory context. This novelty confounds the temporal priming procedure and prevents the comparison of these priming conditions to previous studies in priming temporal context-specificity. Further research is needed to investigate the effect of a music context in predictive learning using the traditional context-specificity methodology in which
musical contexts are either the same or switched during the test. This type of research has been done with simple auditory tones (Dibbets et al., 2001), but no research has investigated musical context-specificity in this way. Using this method would allow the inclusion of additional context switches, which might strengthen the context-specificity effect by drawing more attention to the specific relationships of the cue-outcomes associations with each context (c.f., Callejas-Aguilera & Rosas, 2010; Dibbets et al., 2001).

Finally, it has been suggested that cross-modal priming (i.e. auditory music priming visual test stimulus) is less efficient than intra-modal priming (i.e. visual cue priming visual test stimulus) which primes the direct association for the test stimulus (Bower, 1996). Perhaps, the visual prime was more robust because the test cues were visual stimuli. If the test cues were auditory stimuli, perhaps the music prime would increase in its effectiveness. Research in fear conditioning has produced auditory, cross-modal context-specificity by giving participants a short auditory cue at test to induce retrieval of the extinction context (Dibbets et al., 2008), but this has not been achieved with musical contexts. Future research could explore intra-modal musical context-specificity by using music primes with auditory stimuli as the to-be-learned cue-outcome associations as well as cross-modal context-specificity by using a visual prime with musical cue – outcome pairs.

Conclusions

In conclusion, the significant context-specificity effect shown by the group difference in test predictive judgments for the visual prime replicates previous research (Matute et al., 2011). However, we did not obtain a significant context-specificity effect
for either the music prime or the both prime conditions. It is possible that the visual prime
was more salient than the music prime and that visual context-specificity effects are
simply more robust than musical context-specificity effects. The relationship between
musical expertise and the music prime provides some evidence for this. Before accepting
this conclusion, however, the methodological differences among the prime conditions,
such as the salience of the music compared to the visual cues and the possible uncertainty
introduced by the sudden absence of music during the test, must be further explored.
Future research testing musical experts with the priming procedure and presenting the
music during the test will reveal possible specifications for circumstances that may
produce a musical context-specificity effect in predictive learning.
References


Appendix A

Experimental Task Screen Examples

Stimulus Screen Example.

Feedback Screen Example.

Oh no! This road was MINED.
Number of people and supplies LOST:

25
Appendix B

Spy-radio task instructions

“Imagine that you are a soldier for the United Nations. Your mission is to rescue a group of refugees and supplies that are hidden in a ramshackle building.

You have several trucks for rescuing the refugees and supplies. Your job is to place them on the trucks. You will do this by selecting a number on a rating scale of refugees and supplies that you wish to place on the truck. You will be rewarded a point for each refugee and supply box saved. You must gain as many points as possible!

“However, your mission will not be as simple as it seems. The enemy has placed deadly mines on some roads. If the truck hits a mine, it will explode and all passengers and supplies will be lost. You will lose a point for each passenger and supply box lost.

Fortunately, the colored lights on the SPY-RADIO will indicate the state of the road.

“At first, you will not know what each colored light of the SPY-RADIO means. However, as you gain experience with the lights, you will learn to interpret what they mean.

Thus, we recommend you:

1) Place more people and supplies in the truck the more certain you are that the road will be safe.

2) Place fewer people and supplied in the truck the more certain you are that the road will be mined.
“The experimenter will first demonstrate your mission in a practice trial. Then you will complete the main task. To make the task more enjoyable, some parts of the task will be accompanied by music and other parts will not.

Do you have any questions concerning your mission?

“This is an example of a trial screen. In the center of the screen you see the SPY-RADIO with a light on. At the bottom of the screen there is a rating scale. You will click a number on the rating scale indicating how many refugees and supplies you wish to put on the truck.

Now please put on the headphones. You may adjust the volume according to your comfort level. Please do not adjust the volume of the headphones for the remainder of the task.

“As you saw from the feedback screen. That road was safe and you saved 25 people and supplies. Do you have any further questions?

You will now begin your mission. Good Luck!”
Appendix C

*Results Section Phase 1 and Phase 2 Learning and Test Phase ANOVA Tables*

Table 4. *Phase 1 Learning ANOVA* (*p < .05*)

<table>
<thead>
<tr>
<th>Effect</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>( \eta^2_p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cue *</td>
<td>2</td>
<td>301620.136</td>
<td>567.095</td>
<td>.00</td>
<td>.863</td>
</tr>
<tr>
<td>Cue X Group</td>
<td>2</td>
<td>462.914</td>
<td>.87</td>
<td>.421</td>
<td>.010</td>
</tr>
<tr>
<td>Cue X Prime</td>
<td>4</td>
<td>1122.936</td>
<td>2.111</td>
<td>.081</td>
<td>.045</td>
</tr>
<tr>
<td>Cue X Group X Prime</td>
<td>4</td>
<td>1008.259</td>
<td>1.896</td>
<td>.113</td>
<td>.040</td>
</tr>
<tr>
<td>Error (Cue)</td>
<td>180</td>
<td>531.869</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial *</td>
<td>9</td>
<td>1553.122</td>
<td>11.617</td>
<td>.00</td>
<td>.114</td>
</tr>
<tr>
<td>Trial X Group *</td>
<td>9</td>
<td>276.572</td>
<td>2.069</td>
<td>.030</td>
<td>.022</td>
</tr>
<tr>
<td>Trial X Prime</td>
<td>18</td>
<td>148.15</td>
<td>1.108</td>
<td>.339</td>
<td>.024</td>
</tr>
<tr>
<td>Trial X Group X Prime</td>
<td>18</td>
<td>152.776</td>
<td>1.143</td>
<td>.305</td>
<td>.025</td>
</tr>
<tr>
<td>Error (Trial)</td>
<td>810</td>
<td>133.699</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cue X Trial *</td>
<td>18</td>
<td>5120.334</td>
<td>46.118</td>
<td>.00</td>
<td>.339</td>
</tr>
<tr>
<td>Cue X Trial X Group</td>
<td>18</td>
<td>79.115</td>
<td>.713</td>
<td>.801</td>
<td>.008</td>
</tr>
<tr>
<td>Cue X Trial X Prime *</td>
<td>36</td>
<td>201.545</td>
<td>1.815</td>
<td>.002</td>
<td>.039</td>
</tr>
<tr>
<td>Cue X Trial X Group X Prime</td>
<td>36</td>
<td>106.907</td>
<td>.963</td>
<td>.532</td>
<td>.021</td>
</tr>
<tr>
<td>Error (Cue X Trial)</td>
<td>1620</td>
<td>111.026</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>1382.050</td>
<td>2.156</td>
<td>.146</td>
<td>.023</td>
</tr>
<tr>
<td>Prime</td>
<td>2</td>
<td>1389.129</td>
<td>2.167</td>
<td>.120</td>
<td>.046</td>
</tr>
<tr>
<td>Group X Prime</td>
<td>2</td>
<td>120.104</td>
<td>.187</td>
<td>.829</td>
<td>.004</td>
</tr>
<tr>
<td>Error</td>
<td>90</td>
<td>641.106</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5. *Phase 2 Learning ANOVA* (*p < .05*)

<table>
<thead>
<tr>
<th>Effect</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>$\eta_p^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cue *</td>
<td>2</td>
<td>307724.540</td>
<td>452.377</td>
<td>.00</td>
<td>.834</td>
</tr>
<tr>
<td>Cue X Group</td>
<td>2</td>
<td>205.463</td>
<td>.302</td>
<td>.740</td>
<td>.003</td>
</tr>
<tr>
<td>Cue X Prime</td>
<td>4</td>
<td>473.631</td>
<td>.696</td>
<td>.595</td>
<td>.015</td>
</tr>
<tr>
<td>Cue X Group X Prime</td>
<td>4</td>
<td>1206.622</td>
<td>1.744</td>
<td>.136</td>
<td>.038</td>
</tr>
<tr>
<td>Error (Cue)</td>
<td>180</td>
<td>680.239</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial *</td>
<td>9</td>
<td>3465.407</td>
<td>23.294</td>
<td>.00</td>
<td>.206</td>
</tr>
<tr>
<td>Trial X Group</td>
<td>9</td>
<td>87.825</td>
<td>.590</td>
<td>.806</td>
<td>.007</td>
</tr>
<tr>
<td>Trial X Prime</td>
<td>18</td>
<td>160.434</td>
<td>1.078</td>
<td>.369</td>
<td>.023</td>
</tr>
<tr>
<td>Trial X Group X Prime</td>
<td>18</td>
<td>128.257</td>
<td>.862</td>
<td>.626</td>
<td>.019</td>
</tr>
<tr>
<td>Error (Trial)</td>
<td>810</td>
<td>148.769</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cue X Trial *</td>
<td>18</td>
<td>5559.787</td>
<td>40.243</td>
<td>.00</td>
<td>.309</td>
</tr>
<tr>
<td>Cue X Trial X Group</td>
<td>18</td>
<td>79.905</td>
<td>.578</td>
<td>.917</td>
<td>.006</td>
</tr>
<tr>
<td>Cue X Trial X Prime</td>
<td>36</td>
<td>151.551</td>
<td>1.097</td>
<td>.319</td>
<td>.024</td>
</tr>
<tr>
<td>Cue X Trial X Group X Prime</td>
<td>36</td>
<td>132.711</td>
<td>.961</td>
<td>.536</td>
<td>.021</td>
</tr>
<tr>
<td>Error (Cue X Trial)</td>
<td>1620</td>
<td>138.155</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>263.320</td>
<td>.335</td>
<td>.564</td>
<td>.004</td>
</tr>
<tr>
<td>Prime</td>
<td>2</td>
<td>981.400</td>
<td>1.249</td>
<td>.292</td>
<td>.027</td>
</tr>
<tr>
<td>Group X Prime</td>
<td>2</td>
<td>1154.436</td>
<td>1.469</td>
<td>.236</td>
<td>.032</td>
</tr>
<tr>
<td>Error</td>
<td>90</td>
<td>785.797</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6. Test Phase ANOVA (*p < .05)

<table>
<thead>
<tr>
<th>Effect</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>$\eta_p^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group*</td>
<td>1</td>
<td>5596.76</td>
<td>13.719</td>
<td>.00</td>
<td>.132</td>
</tr>
<tr>
<td>Prime</td>
<td>2</td>
<td>218.885</td>
<td>.537</td>
<td>.587</td>
<td>.012</td>
</tr>
<tr>
<td>Group X Prime*</td>
<td>2</td>
<td>1408.823</td>
<td>3.453</td>
<td>.036</td>
<td>.071</td>
</tr>
<tr>
<td>Error</td>
<td>92</td>
<td>407.953</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix D

Results Section Awareness and Musical Expertise Frequency and Regression Tables

Table 7. Frequency of Participant Awareness of Music by Condition

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Yes</th>
<th>Yes+</th>
<th>Total</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>DV</td>
<td>9</td>
<td>6</td>
<td>1</td>
<td>16</td>
<td>1 (No)</td>
</tr>
<tr>
<td>DM</td>
<td>11</td>
<td>4</td>
<td>0</td>
<td>15</td>
<td>1 (No)</td>
</tr>
<tr>
<td>DVM</td>
<td>10</td>
<td>2</td>
<td>3</td>
<td>15</td>
<td>1 (No)</td>
</tr>
<tr>
<td>Total (Default)</td>
<td>30</td>
<td>12</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RV</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>16</td>
<td>1.5</td>
</tr>
<tr>
<td>RM</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>16</td>
<td>1 (No)</td>
</tr>
<tr>
<td>RVM</td>
<td>7</td>
<td>2</td>
<td>7</td>
<td>16</td>
<td>2 (Yes)</td>
</tr>
<tr>
<td>Total (Retrieve)</td>
<td>25</td>
<td>11</td>
<td>13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8. Frequency of Participant Musical Expertise by Condition

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Total</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>DV</td>
<td>4</td>
<td>1</td>
<td>6</td>
<td>4</td>
<td>15</td>
<td>3 (3-6 years)</td>
</tr>
<tr>
<td>DM</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>16</td>
<td>3 (3-6 years)</td>
</tr>
<tr>
<td>DVM</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>15</td>
<td>3 (3-6 years)</td>
</tr>
<tr>
<td>Total (Default)</td>
<td>11</td>
<td>3</td>
<td>16</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RV</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>16</td>
<td>2 (1-2 years)</td>
</tr>
<tr>
<td>RM</td>
<td>8</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>16</td>
<td>1.5</td>
</tr>
<tr>
<td>RVM</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>16</td>
<td>1.5</td>
</tr>
<tr>
<td>Total (Retrieve)</td>
<td>20</td>
<td>11</td>
<td>6</td>
<td>11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9. Simple Regression Table for Test Predictive Judgment Predicted by Musical Expertise, Isolating Condition (*p < .05)

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>R²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>DV</td>
<td>.500</td>
<td>5.066</td>
<td>.027</td>
<td>.001</td>
<td>.010</td>
</tr>
<tr>
<td>DM</td>
<td>-9.06</td>
<td>4.38</td>
<td>-.484</td>
<td>.234</td>
<td>4.279</td>
</tr>
<tr>
<td>DVM</td>
<td>1.903</td>
<td>6.653</td>
<td>.079</td>
<td>.006</td>
<td>.082</td>
</tr>
<tr>
<td>RV</td>
<td>-2.652</td>
<td>2.733</td>
<td>-.251</td>
<td>.063</td>
<td>.942</td>
</tr>
<tr>
<td>RM*</td>
<td>-8.689</td>
<td>3.944</td>
<td>-.507</td>
<td>.257</td>
<td>4.854</td>
</tr>
<tr>
<td>RVM</td>
<td>-1.532</td>
<td>3.123</td>
<td>-.130</td>
<td>.017</td>
<td>.241</td>
</tr>
</tbody>
</table>

61
Appendix E

**H.I.M.A.B.**

A. Musical Training

1. Have you learned to play an instrument or been in a choir? (circle) YES or NO

   If you answered “NO,” please continue to the “Listening to Music” section.

   i. How many years have you taken instrumental or singing lessons? ______________________________________________________

   ii. How old were you when you started learning an instrument (including voice)? ________________________________

   iii. If you learned to play an instrument (including voice) and then stopped, how old were you when you stopped? _______________

2. Are you, or were you a professional musician or music student? (circle) YES or NO

   If you answered “NO,” please continue to question #3.

   i. What was your main instrument? Did you play other instruments? ______________________________________________________

   ii. How many years have you played/did you play music professionally or as a student? ________________________________

3. Currently, how much time per week do you practice or play one or more instruments or sing? ________________________________

4. Which of the following describes you the best? (Write in or circle one or more musical styles that best describes your musicianship).
B. Listening to Music

1. How often do you actively listen to music (without doing something else at the same time)? (Circle one below)
   - Never
   - Once per year
   - Once per month
   - 2–3 times per month
   - Once per week
   - 2–3 times per week
   - More often (How many hours per week?)

2. How often do you listen to music passively (e.g., while you are cleaning, etc.)? (Circle one below)
   - Never
   - Once per year
   - Once per month
   - 2–3 times per month
   - Once per week
   - 2–3 times per week
   - More often (How many hours per week?)

3. Please evaluate how important music is in your daily life. (Circle a number)
   - Not at all important
   - Very Important
4. Please rank these musical genres from 1 to 5 in order of your preference. (1 being favorite and 5 being least favorite).

Pop ________
Jazz ________
Rock ________
Folk ________
Classical _____

C. Music Consumption

Using the scale below, please indicate how frequently you engage in each of the following activities. Please write a number after each activity.

Very rarely 1 —— 2 —— 3 —— 4 —— 5 —— 6 —— 7 Very often

i. I purchase or download music... ______
ii. I attend musical concerts or recitals... ______

D. Uses of Music

Using the scale below, please indicate the extent to which you agree or disagree with each of the following activities. Please write a number after each activity.

Strongly disagree 1 --- 2 --- 3 --- 4 --- 5 --- 6 --- 7 Strongly agree
1. Listening to music really affects my mood. ________________
2. I am not very nostalgic when I listen to old songs I used to listen to. _____
3. Whenever I want to feel happy I listen to a happy song. ________________
4. When I listen to sad songs I feel very emotional. _________________
5. Almost every memory I have is associated with a particular song. _____
6. I often enjoy analyzing complex musical compositions. ____________
7. I seldom like a song unless I admire the technique of the musicians. ____
8. I don’t enjoy listening to pop music because it’s very primitive. ______
9. Rather than relaxing, when I listen to music I like to concentrate on it. ___
10. Listening to music is an intellectual experience for me. ______________
11. I enjoy listening to music while I work. ____________________________
12. Music is very distracting so whenever I study I need to have silence. ___
13. If I don’t listen to music while I’m doing something, I often get bored. __
14. I enjoy listening to music in social events. _________________________
15. I often feel very lonely if I don’t listen to music. ____________________

E. Music-Directed Attention Scale

These questions regard listening to music at a medium volume. For each sentence, choose the answer that is more relevant to your experience.

Respond quickly, according to the first decision that comes to your mind.

1. When I eat out, music playing in the background is of no importance to me. (Agree or Disagree)
2. I turn off my music and go out only after the piece of music I’m listening to has finished. (Agree or Disagree)

3. When I have a difficult mathematics task to do, music disturbs me. (Agree or Disagree)

4. Background music diverts my attention from what another person is saying to me. (Agree or Disagree)

5. I don’t mind if I have to stop a piece of music halfway through. (Agree or Disagree)

6. When I eat, inappropriate music disturbs me. (Agree or Disagree)

7. When I hear someone else’s music playing through his/her earphones, I can detach myself from the music if I want. (Agree or Disagree)

8. When I have to write an essay, I do it with the music on. (Agree or Disagree)

9. Even when I am concentrating on something, I like to have the music on. (Agree or Disagree)

10. In a conversation, I can be distracted by music playing in the background. (Agree or Disagree)

11. When I study for an exam, music playing in another room distracts me. (Agree or Disagree)

12. When I hear music, I find it hard not to listen to it attentively. (Agree or Disagree)

13. I am more effective when I study in silence than with the music on. (Agree or Disagree)
Musical Response

Instructions: Please call the experimenter. After the experimenter plays a musical selection, please rate your emotional reactions to each selection.

Classical Music

A. My level of arousal induced by the classical music selection:

“relaxed”                      “neutral”

“alert/energized”

0  1  2  3  4  5  6  7  8  9  10

B. My mood induced by the classical music selection:

“negative”                      “neutral”

“positive”

0  1  2  3  4  5  6  7  8  9  10

Jazz Music

A. My level of arousal induced by the jazz music selection:

“relaxed”                      “neutral”

“alert/energized”

0  1  2  3  4  5  6  7  8  9  10

B. My mood induced by the jazz music selection:
<table>
<thead>
<tr>
<th>&quot;positive&quot;</th>
<th>&quot;negative&quot;</th>
<th>&quot;neutral&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>