9-6-2012

Violation of Expectation: Enemy to Musical Memory?

Jessica E.K. Buckland
Indiana University of Pennsylvania

VIOLATION OF EXPECTATION: ENEMY TO MUSICAL MEMORY?

A Dissertation

Submitted to the School of Graduate Studies and Research

in Partial Fulfillment of the

Requirement for the Degree

Doctor of Psychology

Jessica E. K. Buckland

Indiana University of Pennsylvania

August 2012

Indiana University of Pennsylvania

School of Graduate Research and Studies

Department of Psychology

We hereby approve the dissertation of

Jessica E. K. Buckland

Candidate for the degree of Doctor of Psychology

________________________ ____
Donald U. Robertson, Ph.D
Professor of Psychology, Advisor

________________________ ____
David J. LaPorte, Ph.D.
Professor of Psychology

________________________ ____
Susan T. Zimny, Ph.D.
Professor of Psychology

ACCEPTED

______________________________ ________________
Timothy P. Mack, Ph.D.
Dean
School of Graduate Studies and Research

Title: Violation of Expectation: Enemy to Musical Memory?

Author: Jessica E. K. Buckland

Dissertation Chair: Dr. Donald U. Robertson

Dissertation Committee Members: Dr. David J. LaPorte
Dr. Susan T. Zimny

Research has shown that expectation is an important part of music perception. Grouping effects create musical expectation. Musical expectation enables musical memory. Little research to date has explored the effect of violated musical expectations. This dissertation attempts to answer the question: Does violation of expectation in melodic contour affect musical memory? Subjects listened to six melodies, three of which contained a violation of melodic expectation and three of which did not. After hearing each melody, subjects were prompted to choose which of three phrases was contained in the just-heard melody. The dependent variable was comprised of: 1) whether or not the subject chose the correct phrase, and 2) the subject's confidence rating in his memory, which operationalized the strength of the effect. It was expected that subjects would have poor recognition memory and low confidence when the melodies contained a violated expectation. It was also expected that when asked to recognize the phrase containing the violation that subjects would be able to do so and would be confident in their memory in this condition. The results suggest that memory is hindered by violated expectations, but that subjects may not be aware that their memory is fallible. The effect was most pronounced in the phrase containing the target note, not the phrases before or after the violation as was hypothesized. It is possible that subjects were not actually using their memories to recognize the just-heard phrases. These results suggest that subjects created a mental map using musical expectation. Then, subjects used the mental map to calculate which of the three phrases was the most likely to have been in the previous melody rather than attempting to actually recognize the correct phrase. Subjects, in essence, reconstructed their memories of the melodies. In the case of the melodies containing violated expectation, their reconstructed musical memories were false. The implications for musical memory are addressed.

ACKNOWLEDGEMENTS

I dedicate this dissertation and research to my father, Dr. Jeffrey A. Kurland. He taught me from a young age to engage the world with a fierce curiosity and a scientific mind. He has believed in my work throughout graduate school—research and otherwise—never doubting I could succeed. This, of course, is one of the reasons I have succeeded.

I am deeply indebted and eternally thankful to my husband, Peter D. Buckland, M.M. for composing all of the musical pieces for this research. Without Peter's patience, skill, flexibility, and talent I would not have been able to do this research and it would not have been as much fun. Any other composer who collaborated on this work would have been paid yet he did this work with enthusiasm and without complaint. May we have many more years of collaboration, research and otherwise.

Every iota of this work owes a debt of gratitude to Dr. Don Robertson. His patience, kindness, and mentorship made it possible for me to complete not just this dissertation but all of graduate school. It has been my great honor and joy to know him. I am humbled by the time, advice, support, and affection he has given me. My relationship with him has been one of the most formative of my adult life.

TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Figures

CHAPTER I

INTRODUCTION

Music soothes, excites, pleases, and jolts. Its near-universal appeal and presence in the human experience suggests that it is an important part of living, of life. For decades, psychologists have been considering the function of music culturally, sociologically, psychologically, and cognitively. Helmholtz is credited with first attempting to systematically study music and music perception (Hallam, Cross, &Thaut, 2009). In 1919 Carl Seashore devised an apparatus to assess musical aptitude (Seashore, 1938). As research in the psychology of music evolved, the study of music perception has turned towards understanding how the brain hears, interprets, and remembers music. Many specific facets of music perception have been studied, including the phenomenon of musical expectation.

Researchers have documented how listeners' musical expectation affects music perception (Boltz, 1991; Boltz, 1993; Castellano, Bharucha, & Krumhansl, 1984; Cuddy, Cohen, & Miller, 1979; Deutsch, 1970; Huron, 2006; Meyer, 1956; Narmour, 1990; Krumhansl, 1991; Schmuckler, 1997; Snyder, 2002;). Musical memory is well-researched as well (Deutsch, 1999; Krumhansl, 1991; Peretz, 2003; Snyder 2002). Some research addresses the relationship between musical expectation and musical memory. Most of it suggests that musical expectation enhances musical memory (Boltz, 1991, 1993; Schmuckler, 1997; von Hippel, 2002). Little research addresses the effect of *violated* expectation on musical memory. The research that does examine this effect mainly documents that an effect exists: musical memory is hindered by violated expectations. But the specifics are not clear. Questions that remain relate to the strength of the detrimental effect; whether listeners are aware that their memories are fallible; whether the detrimental effect on memory varies depending on the position of the violated expectation; and why the effect occurs.

The current study investigates the effect of violated musical expectation on musical memory. Further, the study explores how recognition memory for different parts of a melody is affected by a violation of musical expectation. Below is a description of the relevant research literature. Music, the brain, and music perception are discussed. Also discussed are memory, its function, and musical memory specifically. Finally, an explanation of expectation in music—defined and explained—sets the stage for the experimental design.

Even at a very young age, the brain is beginning to recognize and process musical stimuli in an organized way. Music research by Trehub suggests that from an early age children have expectations of how melodies will continue (Trainor & Trehub, 1992). In her study, children under one year old were able to reliably detect deviations from a familiar melodic passage. Trehub notes that language begins to develop early in childhood as well. There is extensive research linking language and music (Justus & Hutsler, 2005; McDermott & Hauser, 2005; Patel, 2008; Schellenberg & Trehub, 1999; Trehub, Cohen, Thorpe, & Morrongiello, 1986). Steven Pinker suggests that music is an evolutionary spandrel he terms "auditory cheesecake" (Pinker, 1997, p.534). Pinker suggests that music is an interesting, enriching but evolutionarily useless by-product of language (Pinker, 1997). Mithen offers evidence suggesting that music preceded language (Mithen, 2006). Some research points to facets of musical perception that occur cross-culturally suggesting some innate ability and hardware (Burns & Ward, 1982, in McDermott & Hauser, 2005). The debate continues in the literature but there is research suggesting that music is perceived and processed in a way that is distinct from language and other stimuli.

According to Peretz, many different parts of the brain contribute to music perception. She cited the perception of pitch as one aspect of music which appears to be processed in the superior temporal gyrus and in parts of the frontal cortex (Peretz, 2003). Other parts of music perception are not as clearly localized. However, Peretz and her colleagues have shown that there are specific neural networks in the brain that perceive music (Griffiths, 2003; Peretz, 2003). Peretz has also shown that damage to some regions of the brain affects only music production and/or perception. Peretz's research on amusics corroborates the dissociation hypothesis, that language and music are localized in different places in the brain (Peretz, 2003; Peretz & Coltheart, 2003). This is further support for the theory that music is processed distinctly from language and other stimuli.

Research on brain function and structure suggests that although there is considerable dissociation between the parts of the brain which process musical stimuli and verbal stimuli, there is also some overlap. For example, the perception of prosody (the melodic feature of speech) is processed in the medial temporal lobes, one of the parts of the brain which processes musical stimuli (McMullen & Saffran, 2004). Even though there is some overlap, Peretz's (2003) research suggests that music is a specialized part of the human brain and experience. If music perception is specialized in the brain, musical memory may function differently than memory for language or other stimuli.

Memory

Research on memory, its mechanisms, and its components is extensive and complex. Debate exists in the literature between models used to represent the organization, analysis, storage, and mapping of memory. An extensive analysis of the research addressing models of memory is beyond the scope of this work. The function of memory and its application to music is relevant.

Lezak (2004) and others suggest that memory provides humans the ability to predict and anticipate events in their environment and to have expectations (Huron, 2006; Lezak, 2004; Snyder, 2002.). Expectation in this research is defined as: “a mental or corporeal ‘belief’ that some event or class of events is likely to happen in the future (Huron, 2006, p. 41).” The brain’s ability to generate expectation is an important part of memory because of its survival value. The ability to analyze and remember the world helps humans predict how the world will function and respond in the future. Memory, then, enables humans to act in adaptive and survival-promoting ways (Lezak, 2004). Memory allows humans to generate a model of how the world works which guides problem-solving. The model can be used to anticipate future events and guide behavior. Research suggests that there is a similar model at work in music perception and musical memory.

Because of the regularities of tones in Western music—such as the frequency of particular tones alone or with other tones—listeners develop a cognitive reference point or cognitive model that assists musical memory (Snyder, 2002). The model helps the listener determine what he is listening to and helps him generate expectations about the music. Memory, through exposure to stimuli, allows prediction of the next stimulus that will occur.

Music Perception and Musical Memory

A listener’s perception of music is created by the music’s structure and knowledge about music. Structure in music is created through melodic contour and grouping effects which in turn influence musical memory (Snyder, 2002). Melody—defined as meaningful sequences of sound (Patel, 2003)—is also known as melodic contour. Melodic contour is experienced as the up and down movement of a tone series. Musical memory is heavily based upon the listener's ability to perceive melodic contour

Huron (2006) and Krumhansl (1991) note interesting consistencies and patterns in melodic construction and perception (Huron, 2006; Krumhansl, 1991). Expectations are quickly generated by melodic contour. Listeners expect to hear certain patterns and trajectories of sound. The expectations are generated by both life-long exposure to music and by the immediately relevant piece of music.

Huron (2006) describes several properties of melodic contour that are reliably expected by listeners. One of these properties, pitch proximity, refers to a listener's expectation that the pitches[1] in a melody will be close together and that there will not be large jumps between pitches. Another property that listeners expect is step inertia. Step inertia is a property of melodic contour that generates the expectation that a melody will eventually descend in pitch, toward a resolution point. Listeners, even untrained non-musicians, expect this shape when listening to music (Huron, 2006).

Krumhansl has found that melodic contour is quickly and effectively encoded and remembered by subjects (Krumhansl, 1991). Subjects in Krumhansl's 1991 study readily recognized excerpts from a piece of music they had previously heard. Their recognition was not enhanced by repeated exposure to the composition. Subjects in the study were also able to distinguish these excerpts from novel musical pieces. This suggests that listeners are able to

---

[1] Pitch: "The location of a sound in the tonal scale, depending on the speed of vibrations from the source of the sound, fast ones producing a high pitch and slow ones producing a low. The rate of vibration per second is the note's 'frequency'" (Kennedy, 1985, p. 552).

consistently perceive and reliably remember sequences of pitch or rhythm. It is possible that this facilitates memory of melodic contour as well.

Snyder (2002) suggests that facets of melody such as the order of tones and how they are grouped gives important information to listeners. These facets enable perception, memory, and provide meaning to the music. Such facets are termed grouping effects and they delineate and define a melody. Further examination of the grouping effects—especially as they influence the perception of melody—offers a view of how music is encoded and remembered.

Grouping effects in music are caused by changes in one or more facets of musical expression, for example pitch, rhythm, articulation, or tempo. These groupings enable and enhance memory (Snyder, 2002). The boundaries that define groups of tones provide listeners with the overall features of a melody, define its contour, and force listeners to generate expectations about how the melody will continue or how it will change. The grouping effects provide guidance for the listener by conforming to or violating expectations.

Perceptual facets of music such as the grouping effects generate musical meaning. The listener perceives the facets of music, in part and in whole. This perception allows the listener to glean mood or have an emotional experience evoked by music. Carterette & Kendall (in Deutsch, 1999) describe meaning in music as analogous to meaning in language because both rely on discrete units (grouping effects in music and parts of speech in language) that when perceived together communicate meaning. Patel (2008) cites Nattiez's (1990) description of musical meaning. Nattiez suggests that: "…meaning exists when perception of an object/event brings something to mind other than the object/event itself" (Nattiez, 1990, p. 304, in Patel, 2008). Musical meaning could also be described as a listener's overall impression of a melody while perceiving it. Musical meaning is implied and communicated by musical structure and grouping effects.

Grouping effects offer the brain a way of organizing sensory data which aids musical memory. A listener's memory must be able to retain the elements of a musical phrase as a group (in a temporally accurate fashion) in order for the phrase to be interpreted correctly and for the phrase to offer meaning. It is important to note that these grouping effects interact and almost never occur in isolation.

Each phrase of musical stimuli is perceived not simply as a stand-alone player but rather as part of a whole musical grouping. Snyder (2002) suggests that the grouping effects of proximity, similarity, and continuity most profoundly affect musical memory.

The grouping effect of proximity refers to perceiving melodic and/or rhythmic events that are close together in time. For example, a series of notes played within a measure[2], temporally close to each other with no rests[3], are perceived and remembered as a group. The amount of time between notes in a measure is small compared to the amount of time between notes before and after a long rest (e.g., four measures of rest). Across an entire melody, the amount of time between notes changes. These changes demarcate the boundaries between groupings within the melody.

The second grouping effect, similarity, suggests that sounds that are similar tend to be included in a group and are remembered together. Similarity can be related to facets such as

[2] Measure: "…the time-content of notational space between one bar-line and the next, e.g. '2 beats in the bar'" (Kennedy, 1985, p. 455).
[3] Rest: "Musical silence" (Kennedy, 1985, p. 592).

timbre[4], loudness, duration (measured in quantities of measure or meter), articulation, and pitch interval[5]. Similarity of timbre suggests that notes played by trombones and trumpets would be grouped together and remembered as a unit more easily and effectively than would notes played by a xylophone and a string bass. Very loud notes might be grouped together, being perceived as an overall expression that is very different than a group of soft notes. Similarity implies consistency. When a previously consistent characteristic changes—such as loudness—the boundary of the grouping has been created.

Continuity, the third of Snyder's primitive grouping effects, suggests an extension of similarity and proximity. In proximity, the distance between notes dictates boundaries. In similarity, the differences between musical properties of notes dictate boundaries. The grouping effect of continuity suggests that a particular relationship between notes will continue. An example of continuity is the phenomenon of pitch proximity (Aarden, 2003 in Huron, 2006; Boomsliter & Creel, 1979, in Huron, 2006; Deutsch, 1979 in Huron, 2006). In Western music, notes temporally close are often close together in pitch, forming a pitch relationship. Pitch proximity refers to the listener's expectation that the relationship between future notes in the melody will continue, that the notes will be close in pitch. Continuity is a form of expectation, expectation of melodic contour. Expectation, defined as the belief that an event or class of events is likely to occur, implies a belief in continuity or discontinuity. For example, when listeners hear melodic contour that is downward-shaped, they expect the next notes will continue that downward trend (Huron, 2006). The three grouping effects, each alone and the three together,

---

[4] Timbre "Tone-colour; that which distinguishes the quality of tone or of one instrument or singer from another." (Kennedy, 1985, p. 732):
[5] Pitch interval or interval: "the difference in pitch in any two notes" (Kennedy, 1985, p. 352).

define a listener’s expectations of melodic contour. Without the grouping effects, listeners would not be able to generate expectations about music.

Expectation in Music

Expectation is experienced as anticipation of future musical events, trajectories, or directions and the belief that future events are likely. Both the music one is listening to in the moment and one’s musical experience across the lifespan influence one expects to hear. It is a listener’s expectations of melody, of continuity, and of patterns which generate meaning in music. Structure in music, including melodic expectation, helps facilitate listeners’ experience of music as narrative and meaningful.

Expectation and its role in music are documented in research and theory (Huron, 2006; Meyer, 1956; Narmour, 1990; Schmuckler, 1997). As noted above, Snyder’s grouping effects rely at least in part on expectation and its construction. Justus and Bharucha (2001) identify expectation as a major component of the aesthetically pleasing experience of music. Even music with which we are familiar can contain surprise and violated expectation and this can be enjoyable[6].

Meyer showed in his early work (1956) that listeners generate expectation, and can change those expectations, while they are listening to a piece of music (Meyer, 1956). Castellano, Bharucha, & Krumhansl (1984) tested the amount of time required for a listener to generate expectations. Their research suggests that the presentation of one tone is enough for rudimentary musical expectations to occur. As a melody continues, the listener’s expectations are further refined.

---

[6] For example, hearing a melody usually sung by one voice sung by many voices (perhaps in harmony) can intensify or alter the musical experience.

Narmour is credited with the first theory describing the role that expectation plays in music (Narmour, 1990). His Implication-Realization theory suggests that listeners have one of two perceptual experiences when listening to music. One perceptual possibility—the non-implicative melodic context—is that the melody does not guide a listener's expectations. Listeners have no expectations about future melodic direction and nothing is implied by the musical structure when melodic context is non-implicative (Huron, 2006). Alternatively, the facets and grouping effects of a melody could imply meaning for a listener. In this situation—termed an implicative melodic situation—a listener generates expectation about melodic contour and how a melody will continue or change (Huron, 2006). Researchers have investigated which facets of melody and rhythm create an implicative versus non-implicative melodic situation (Cudden & Lunney, 1995; Schellenberg, 1996, 1997; von Hippel, 2002). Among them are Snyder's grouping effects, described above (Snyder, 2002).

Research has documented the role of expectation in music and musical memory. Schmuckler (1997) described the nature of expectation in music as an important part of the theory and composition of music. He cited several studies showing that listeners clearly expect melodies to resolve in certain ways (Adachi, Purdy, & McKinnon, 1996; Cuddy & Lunney, 1995; Krumhansl, 1995; Schellenberg,). Schmuckler (1997) found that when melodies conform to expected composition rules (of tonality and expectation) that listeners are significantly better at recognizing the melodies. Boltz (1991, 1993) and Cuddy, Cohen, & Miller (1979) showed that when music conformed to standard musical expectations, listeners were better able to remember and recall novel music. Schumuckler's (1997) research, similar to others, asked subjects to rate how well a musical phrase "fit [the listener's] expectations of what was going to come at that point [in the melody] (Schmuckler, 1997, p. 295).” When expectations were met, musical memory was enhanced.

The research methods to date have relied on listeners’ ability to recall notes or complete melodies. These methods show clearly that expectation is an important part of music, melodic contour, and musical memory. Some research suggests that violation of expectation hinders musical memory. But no research has attempted to identify how strongly violated expectations affect musical memory. Research historically has compared simply whether or not subjects do or do not remember a part of a melody. No research to date has addressed which phrases of a melody are most affected by the violated expectation: Does the violation affect memory differently if the subject tries to remember music before the violation as opposed to after the violation? This question is unanswered by the current research.

Research Design

A two-factor experimental design was created to assess the effect of violated expectation on musical memory. The independent variables consist of target note status and phrase position. Target note status refers to whether the musical piece conforms to expectations or violates musical expectations. Phrase position refers to which part of the piece of music the listener attempts to recognize after presentation. Phrase position operationalizes the location of the violated expectation. Subjects attempted to recognize the phrase containing the violated expectation (target phrase), the phrase immediately before the target phrase (the before-phrase), or the phrase immediately following the target phrase (the after-phrase).

A straightforward choice for the dependent variable was memory, assessed by simple accuracy or inaccuracy. Subjects attempted to recognize just-heard melodic phrases (of various positions) which did or did not include violated expectations. In order to operationalize the memory effect beyond accuracy, another dimension was added to the variable: confidence rating. Confidence rating operationalized the strength of the memory effect, the degree to which memory was affected by the violated expectation. Listeners rated their confidence in their recognition memory on a Likert-scale. In order to combine the variables, memory accuracy was valenced as negative or positive (incorrect versus correct, respectively). The listener's rating was then assigned a positive or negative value based on the accuracy.

The continuous variable of confidence rating coupled with the categorical variable of accuracy allowed examination of the experimental effect in terms of strength of effect. Examining accuracy and confidence simultaneously provided a way to examine whether listeners were aware of the effect of violated expectation and whether the effect occurred within memory or due to another factor. Low confidence ratings coupled with poor recognition memory would suggest that the violated expectation affected musical memory and that that violated expectation had a large effect. High confidence ratings coupled with accuracy would confirm previous research suggesting that expectation informs musical memory.

It was expected that both a subject's ability to recognize a particular phrase and his confidence rating would depend upon an interaction between phrase position and target note status. Figure 1 shows a graph of the anticipated interaction effect.

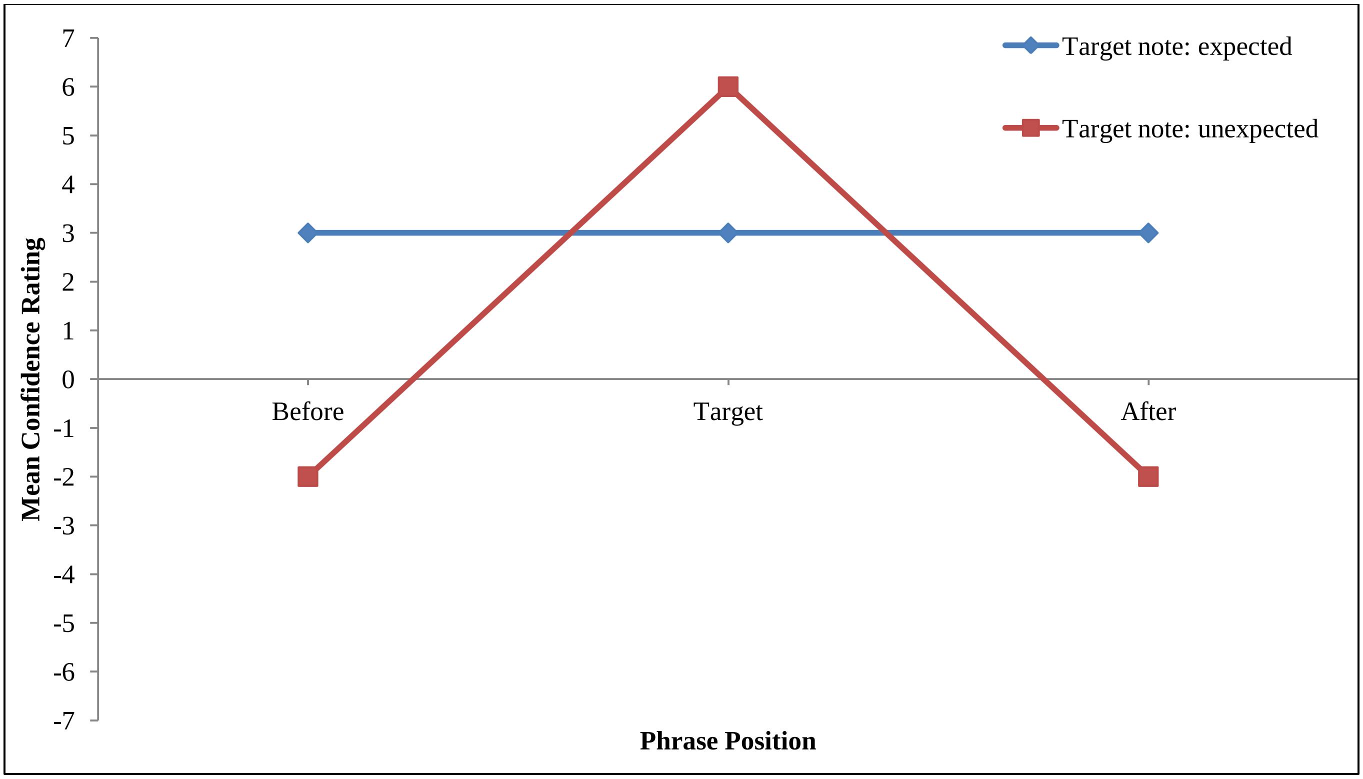


Figure 1. Hypothesized results suggesting that violated melodic expectation will detrimentally affect musical memory differentially depending on condition.

The hypothesis suggests that in the unexpected target note condition, subjects would be most confident and most accurate when attempting to recognize the target phrase. Memory was expected to be worst and confidence the lowest for the before and after phrases in the unexpected target note condition. In the expected target note condition, the hypothesis suggested that there would be no significant differences in memory or confidence across phrase positions.

It was also expected that the most reliably recognized stimuli would be the target phrase when the target note was unexpected. Not only would the listeners recognize the phrase but they would also be confident in their ability to do so. Subjects would hear an unexpected note, one which would disrupt memory for the third and/or fifth phrases, but that would be easily recognizable when presented again a few seconds later.

Based on previous research on musical memory and expectation, it seemed likely that memory for the before and after phrases would be detrimentally affected by the violated expectation. Inaccuracy coupled with low confidence ratings would offer insight into where, temporally, the memory interference occurred. It was unclear based on previous research where the disruption would occur. A violated expectation could interfere with stimuli before the violated expectation and then would prevent encoding in memory. This interference would be detected by low confidence and poor accuracy in the before-phrase condition. Alternately, the violation could interfere with complete binding of the stimuli after the violated expectation, detected by low confidence and poor accuracy in the after-phrase condition.

CHAPTER II

METHODS

This study examined two independent variables: phrase position (before, target, after) and target note status (expected or unexpected). Phrase position refers to which part of the melody the subject attempted to recognize. Before refers to the third phrase of the melody which immediately preceded the phrase containing the target note. The target refers to the fourth phrase and it contains the target note (whose status—expected or unexpected—is purview of the second independent variable). The after phrase refers to the fifth phrase, the one immediately following the target phrase. In the case of target note status, an expected target note does not deviate from the expected musical key. An unexpected target note deviates from the musical key.

The research on musical expectation suggests that neither devising expectation in melodic contour nor violating said expectation is difficult (Huron, 2006). More complex is systematically choosing how to test memory for melodic contour and how the memory might be disrupted when expectations are violated. Krumhansl and Shepard (Krumhansl & Shepard, 1979) created an influential form of operationalizing and testing the construct of expectation in music: the probe-tone method. In this type of experiment, listeners are asked to judge how well a particular tone fits in a melody or a chord based on expectations created by the stimuli. This methodology works well when simply detecting expectation in music. By itself, the probe-tone method did not offer the opportunity to test the effect of violated expectation on musical memory.

As described above, the structure and composition of music requires expectation. For this study, a trained composer generated melodies and musical phrases that easily met the musical expectations for a Western listener. These melodies were purely novel to all listeners and were created for this study alone. It was important to use novel melodies so that previous exposure to musical pieces did not influence memory. The melodies in this study are structurally similar to those in Patel's (2003) work.

Should the violated expectation be rhythmic or melodic? Almost all previous research in the area of musical expectation focuses on melody rather than rhythm; therefore, that precedent was followed. Further research should certainly add a rhythmic component.

The next sections of the Methods section describe the procedure and offer an in-depth explanation of the methods used to compose and structure the tasks.

Procedure

Each subject submitted to each of the six conditions (expressed here as phrase position-target note status): before-expected, before-unexpected, target-expected, target-unexpected, after-expected, and after-unexpected. Participants were presented with six different melodies and 18 musical phrases which were not contained in the six melodies (hereafter called foils). Melodies in this study are defined as meaningful sequences of sound (Patel, 2003). The particular methods in the melody and phrase construction are explained in-depth below. The melodies in the study are similar to each other and each one conforms to both basic and more complex musical parameters as do the 18 foils.

Before the actual tasks, participants heard detailed instructions about their tasks as participants. The subjects were instructed to read-along while they heard the instructions narrated to them. They also followed along with a demonstration of their task. Appendix A, Subject Instructions, shows the instructions which the subjects read and heard.

Participants were required, after hearing a melody, to identify which of three musical phrases they had just heard in said melody, a forced-choice task. Cuddy, Cohen and Miller (1979) used a similar task for testing musical recognition memory. Then, the participants rated how confident they were that they had chosen the correct phrase.

The participants heard six melodies, one at a time. After each melody, the participant was prompted: “That was the end of Melody [one, two, etc.]. Please choose which of the following three phrases was contained in the previous melody. Then be sure to indicate how confident you are that you have chosen correctly.” These instructions ensured that the participant knew her task.

After the above instructions the participants were presented with three phrases, One of the phrases was contained in the previous melody (the third, fourth, or fifth phrase termed the before phrase, the target phrase, and the after phrase, respectively). Two of the phrases were foils. Order presentation was counterbalanced using Latin Squares. Taking into account the levels of the independent variables and accounting for order effects, counterbalancing produced 36 different conditions. Two subjects were assigned to each condition in a repeated-measures design.

After making her choice, the participant rated how confident she was of her choice on a Likert-scale 1 (not at all confident) to 7 (extremely confident). Latin Squares were used to balance presentation of the stimuli, ensuring that across conditions for each melody, the correct response was offered to the subject in each of the three possible positions: first, second, or third compared to the foils.

Participants were presented six different melodies of six different timbres: piano, chimes, trumpet, clarinet, wooden flute, and violin. Each melody was presented in each of the timbres. The melodies were comprised of eight phrases. The fourth phrase of the melody contained a target note which was the last note of that phrase. The status of the target note was either expected or unexpected, depending on the condition. Each melody was presented in its expected and unexpected form, though a single subject heard three of the melodies at the expected level (target note expected) and three of the melodies at the unexpected level (target note unexpected). In the expected condition, the note's pitch was the dominant tone and conformed to musical expectations. In the unexpected condition, the note's pitch was unexpected and violated musical expectation. After hearing each melody, the participant was asked to choose which of three phrases was previously heard. Appendix B shows the Subjects' Response Form. The correct response—the phrase which actually was in the just-heard melody—was heard in one of three possible positions in the melody: the target phrase which contained the target note, the before phrase which immediately preceded the target phrase, or the after phrase which immediately followed the target phrase.

The dependent variable in this 2X3 repeated-measures design is a compilation of the participant's actual response and the participant's confidence rating of his response. The valence of the participant's confidence rating varies depending on the accuracy of his recognition response. For example, if the participant recognizes the correct phrase and rates his certainty as 6, then his score is 6 for that cell. If the participant does *not* recognize the correct phrase, and chooses one of the foils instead, and rates his certainty as 6, then his score for that cell is -6.

As a reliability check, the participants were asked to do the tasks again and to recall their previous responses. Appendix C shows the Reliability Check Instructions the participant both heard and read. This method offered a way to measure whether people were answering randomly or whether they were relying on their memory to recognize phrases. After doing the original task with the six melodies, the participants were given a new set of instructions. The participant was presented with the same stimuli—in the exact same order and with the same foils, but with different instructions. After hearing each melody the second time, the participant was prompted to recall (not recognize) which phrase she had chosen the first time she heard the melody: "Which of the three phrases did you choose the last time you heard Melody 1? Now that you hear Melody 1 again, which of the three phrases was contained in Melody 1?" Then the participant is prompted: "How confident are you that your choice is correct after hearing the melody a second time?" and to endorse her confidence that she has chosen correctly on this second choice. Appendix D shows the Subject Response Form for the reliability check.

Participants

Participants were obtained through the Subject Pool in the Psychology department at the Indiana University of Pennsylvania. Participants received one credit of research participation as required for the Introduction to Psychology classes. Participants disclosing diagnosed hearing loss or hearing problems were screened out of the study. Appendix E shows the Demographics Form the subjects completed. Appendix J shows the Informed Consent which subjects signed and Appendix K shows the Debriefing form.

Apparatus

The melodies were produced through Finale® (MakeMusic, 2007) composition software and played as electronic Musical Instrument Digital Interface (MIDI) files as Moving Picture Experts Group Layer-3 Audios (MP3's) using Windows® Media Player through Sony® brand Noise Canceling headphones (Model MDR-NC6). Each participant listened to the stimuli in a room alone while the administrator was outside the room, available to answer questions.. These apparatus ensured consistent presentation of the melodies and eliminated human error or expressiveness that could occur if the melodies were played on musical instruments.

Melody and Foil Construction

In order to ensure validity of the stimuli, I consulted previous research. I followed the research of Krumhansl and other leading music researchers (Deutsch, 1975, 1971; Huron, 2006; Juslin & Sloboda, 2001; Krumhansl, 1991; Patel, 2003; Snyder, 2002.) who have described in-depth the particular ways that composers create and listeners experience melody. Taking the research into account, I consulted Peter D. Buckland, a composer who holds a Master's Degree in Music Composition. Mr. Buckland composed all of the melodies and phrases. My goal was to ensure that the six melodies and the 18 foil phrases were sufficiently similar to compare. Ease of experimental manipulation was considered as well. The description below of the parameters of the musical stimuli explains how the construction maintains parsimony and ease of analysis for this study.

The melodies and phrases composed for this experiment are similar to the brief melodies that Patel (2003) previously used in his research. The melodies contain no chords or counterpoint[7]. The phrases composed as alternative response choices in the recognition trials (the foils) were composed to be similar enough to the phrases that actually constitute the melodies that they could be reasonably believed by a listener to have been contained in the just-heard melody. As such, they are in the same key and follow the same guidelines as the melodies. Each of the foils contains the same number of transitions, such that their overall contour was generally parallel.

Deutsch (1970) has also investigated musical memory, specifically for pitch. An important difference in these methods compared to Deutsch's is the nature of the violated expectation. Her research did not investigate whether or not listeners consciously detected changes in tones. The methods used here use tones and intervals that a listener does hear regularly whereas Deutsch's method used microtones. Microtones vary by less than a half step. Listeners rarely hear microtones in everyday listening. These methods used the tritone[8]. The target note was written as either the Dominant pitch (scale degree 5, which creates a half cadence) or the Neapolitan (flatted scale degree 2). The interval distance created by the tritone has historically been defined as dissonant (see footnote 9) and so is an operationalization of violated expectation according to tonal Western art music from the Middle Ages until the present.

The melodies and foils used in this study are found in Appendix F. Appendix F shows each of the six melodies, in their expected and unexpected forms as well as the foils used for each condition. There were several over-arching guidelines for the melodies and phrases. Each

---

[7] Counterpoint: "the combination of simultaneous parts or voices, each of significance in itself and the whole resulting in a coherent texture" (Kennedy, 1985, p. 166).

[8] The history of the tritone is interesting. "Difficult to sing, and in medieval times its use was prohibited. There was a saying, involving the Hexachord names for the notes, *Mi ontra fa diabolus est in musica,* 'Mi against fa is the devil in music,' hence the frequent use of the tritone in compositions to suggest evil." (Kennedy, 1985, p. 741).

melody and phrase was in a major key, harmonically diatonic, in 2/4 or 4/4 meter, and had no note shorter than a sixteenth note. Each of the six melodies followed parallel period form[9], the appropriate and accepted way to compose a short melody according to Peter D. Buckland, M. M. The melodies started and ended on the tonic of the scale to ensure that participants easily identified the key of the piece (Krumhansl, 1991). Perceiving the key of the piece ensured that the participants were able to detect violations of the key via the unexpected target note. Appendix G gives Peter Buckland's explanation of the composition rules he used when composing the foils for the target phrase.

In order to determine how violation of expectation in melodic contour affects musical memory, a 2 X 3 completely within-groups Analysis of Variance (ANOVA) was performed. The most important effect, with regard to the hypothesis, was an interaction effect. It was anticipated that memory accuracy would depend on which phrase was targeted and whether the target note was unexpected. It was anticipated that memory would be unreliable and confidence ratings low for the before and after phrases when the target note was unexpected. It was also anticipated that memory would be accurate and confidence ratings high for the target phrase in the unexpected target note condition.

[9] Parallel period form: "Two interdependent phrases that a form a larger unit or *period* are in *antecedent-consequent* relation…" (Aldwell and Schachter, 2002, pp. 147). They are parallel because they are the same size and each half of the period contains very similar melodic material.

CHAPTER III

RESULTS

The 2X3 within-subjects design included two independent variables: target note status (expected and unexpected) and phrase position (before, target, and after). Each subject submitted to two trials. For trial one, subjects listened to six melodies which correspond to the six conditions of the study: before-expected, before-unexpected, target-expected, target-unexpected, after-expected, and after-unexpected. In trial two, subjects heard the same six melodies presented in the same order with the same phrase positions and target note statuses counter-balanced.

The dependent variable was comprised of a subject's confidence in his accuracy at recognizing stimuli and his true accuracy. Subjects rated their confidence on a Likert-scale ranging from 1 (not at all confident) to 7 (extremely confident). Results were scored as positive when the subject chose the correct phrase and negative when the subject chose the incorrect phrase. The dependent variable was expressed as a positive or negative integer ranging from -7 to 7. If a subject recognized the correct phrase and rated his confidence as 6, his score for that trial would be 6. If he had not recognized the correct phrase and had rated his confidence as 6, his score for that trial would be -6. A mean of zero in any condition would suggest random responding by subjects.

The hypothesis predicted that there would be an interaction effect between target note status and phrase position, which would affect recognition memory and confidence rating. Specifically, it was predicted that an unexpected target note would detrimentally affect memory for the before or after phrase positions, but not necessarily the target phrase position. Not only would subjects have poorer recognition memory, but they would also be less confident in their memory. Figure 2 shows the frequency of response ratings and the distribution of accuracy.

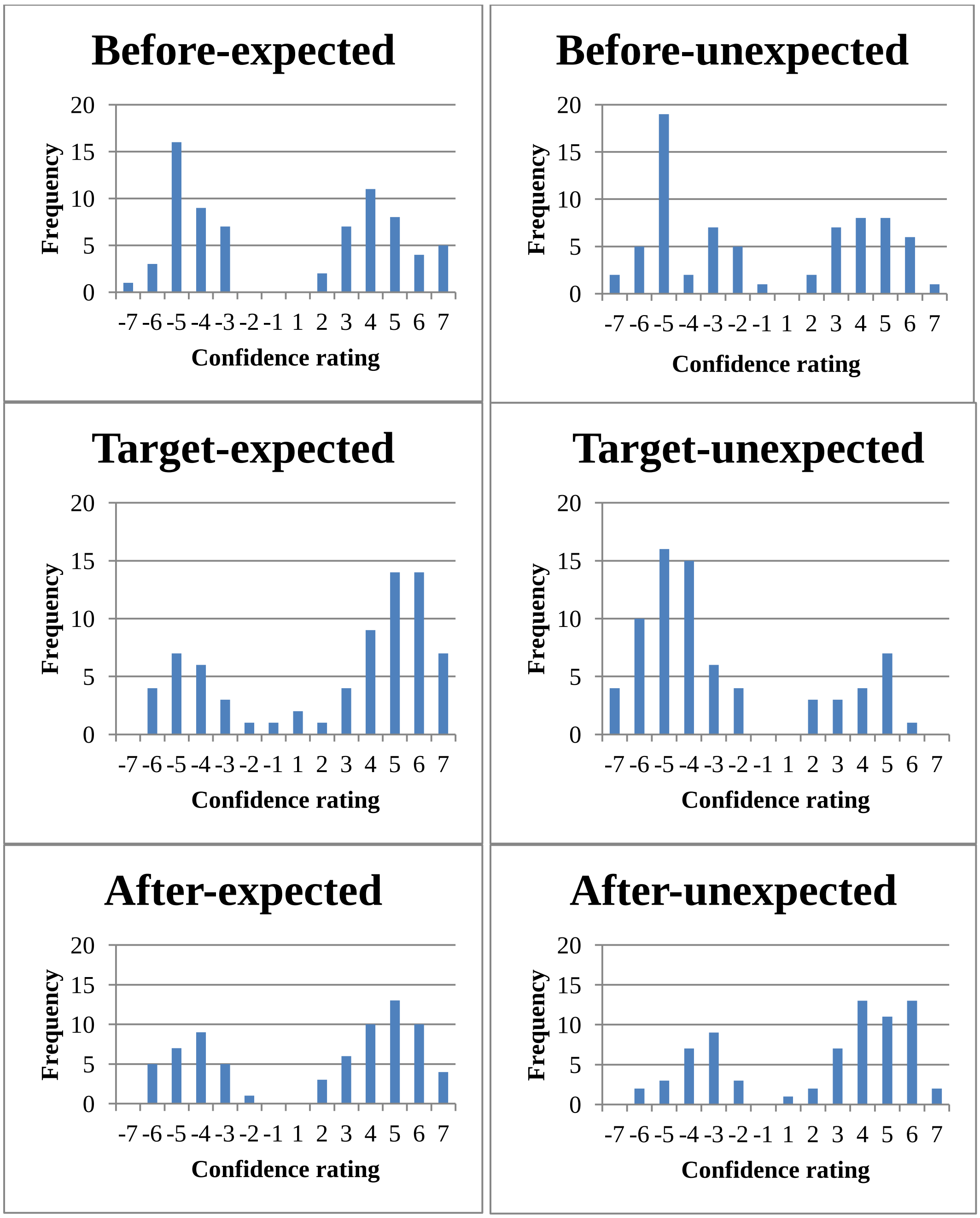


Figure 2. Frequency of each confidence rating by condition. Negative confidence ratings imply incorrect recognition memory. Positive confidence ratings imply accurate recognition memory.

The bimodal distribution of the dependent variable is evidence of negative kurtosis. Such a distribution suggests that the standard deviation is overestimated, so error terms would also be overestimated. This results in underestimated effect sizes. Partial eta-squared effect sizes in the results suggest a robust effect even in this underestimated case. Table 1 shows percentages of accurate recognition memory.

Table 1

Within-subjects Overall Means and Accuracy[10] *of Recognition, by Condition*[11] Mean confidence ratings within-subjects are highest and least accurate in the Unexpected-Target condition.

	Target Note Status					
	Expected			Unexpected		
Phrase Position	M (SD)	95% CI	Accuracy	M (SD)	95% CI	Accuracy
Before	.082 (4.71)	[-1.02, 1.18]	51%	-.53 (4.58)	[-1.60, .54]	44%
Target	2.19 (4.53)	[1.13, 3.25]	70%	-2.49 (3.96)	[-3.42, -1.57]	25%
After	1.36 (4.60)	[.28, 2.43]	63%	1.88 (4.11)	[.92, 2.84]	67%

That the accuracy results avoid the bimodal distribution problem suggests that in spite of kurtosis in the distribution, the results are significant and interpretable.

Target note status (expected versus unexpected) clearly affected how subjects rated their confidence and how accurate their recognition memory was. The effect was different than

[10] Where accuracy is percent correct
[11] N = 73

hypothesized. Rather than affecting memory in the after and before phrase positions, an unexpected target note differentially affected memory in the target phrase position.

When phrase position was before, subjects were correct 51% of the time in the case of an expected target note and correct 44% of the time when target note status was unexpected. Post-hoc Tukey's HSD suggest this difference is non-significant, $p<.09$. In the condition of after phrase position and target note status expected, subjects were correct 63% of the time. When the target note status was unexpected, they were correct 67% of the time. Post-hoc Tukey's HSD show this difference to be non-significant, $p < .13$. In the case of the target phrase position, subjects were correct in their choice of previously heard phrase 25% of the time when target note status was unexpected as opposed to 70% of the time when the target note status was expected. Post-hoc Tukey's HSD showed this difference to be significant at the $p < .01$ level.

Confidence ratings appear to have been affected by target note status. As Table 2 shows, subjects were more confident when the target note was expected, regardless of phrase position.

Table 2

Across Subjects' Mean Confidence Ratings by Condition. Across subjects, mean confidence ratings are highest in the Expected-Target condition.

	Target note status			
	Expected		Unexpected	
Phrase Position	M (SD)	95% CI	M (SD)	95% CI
Before	4.52 (1.23)	[4.24, 4.81]	4.37 (1.39)	[4.05, 4.69]
Target	4.79 (1.45)	[4.46, 5.13]	4.47 (1.31)	[4.16, 4.77]
After	4.59 (1.28)	[4.30, 4.89]	4.29 (1.35)	[3.97, 4.60]

Mauchly's Tests of Sphericity were non-significant. A 2 X 3 (Target Note Status X Phrase Position) completely within-groups Analysis of Variance (ANOVA) shows a significant interaction of the target note status and phrase position with a large effect size ($F(2, 73)=15.20$, $MSE = 273.40$, $p<.01$, partial eta-squared = .17). The means across conditions are shown in Table 1.

Figure 3 illustrates the significant interaction effect graphically. This effect was clearly different than the hypothesized interaction effect (see Figure 1 in the Introduction). In the before phrase condition there were no significant differences in confidence ratings whether the target note status was unexpected or expected (post-hoc Tukey's HSD $p < .09$) and recognition memory was reliably wrong.

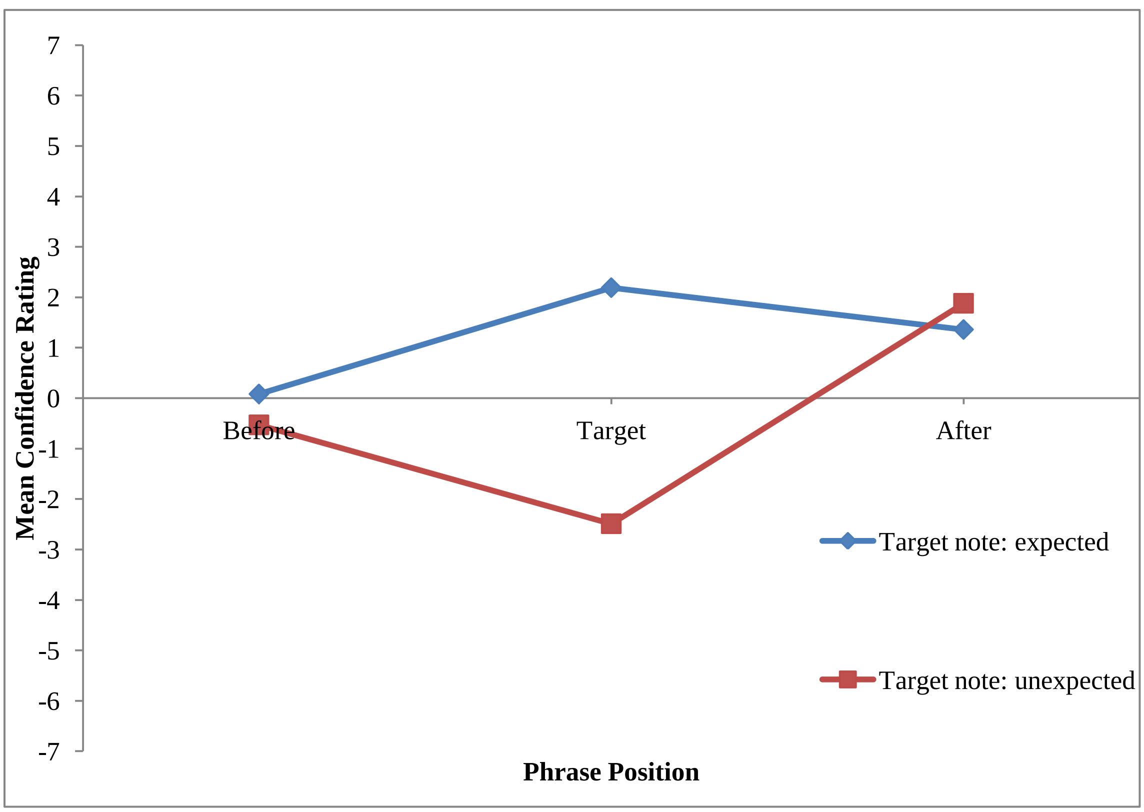


Figure 3. Graph of within-subjects' means. Memory was least accurate confidence highest in the Unexpected-Target condition.

There were no significant differences in the case of the after phrase position, in contrast to the hypothesis. Recognition memory accuracy was positive and confidence ratings were nearly equivalent whether target note status was unexpected or expected (post-hoc Tukey's HSD $p < .13$).

Only in the target phrase position were there significant differences caused by target note status, contrary to the hypothesis. Subjects were most confident regarding their ability to recognize the correct phrase when attempting to recognize the target phrase position, regardless of target note status. Figure 2 shows that the magnitude of confidence is nearly identical. Although the subjects were most confident in both of these cases, the effect of unexpected target note status was large and subjects were reliably incorrect. Post-hoc Tukey's HSD shows a significant difference between ratings in the two conditions, $p<.01$.

In order to examine the reliability of the experimental effect, subjects completed Trial 2 immediately following completion of Trial 1. Appendix H shows the summary table for Trial 2. Appendix I shows the intercorrelations for Trial 1 and Trial 2. As shown in Table 3, subjects accurately recalled their choice of phrase previously heard 84.2% of the time across conditions.

Table 3

Trial 2: Accuracy of Phrase Recall. Accuracy refers to the percentage listeners' correct recall in Trial 2 of their previous phrase choice in Trial 1.

	Target note status	
Phrase Position	Expected	Unexpected
Before	87.7%	91.8%
Target	83.6%	75.3%
After	86.3%	80.8%
	Grand mean	84.2%

A 2 X 3 X 2 (target note status X phrase position X trial) completely within-subjects ANOVA shows a reliable experimental effect. There is no significant main effect or interaction effect for time of trial. The correlation matrix calculated between Trial 1 and Trial 2 show positive correlations for each of the factors.

Overall, the results suggest that violated expectation in melodic contour affects recognition memory in a measurable and distinct way.

CHAPTER IV

DISCUSSION

To investigate how violated expectation affected musical memory, subjects were presented with melodies containing target notes which violated the subjects' musical expectations. Subjects then tried to recognize one phrase they had actually just heard from two foil phrases which they had not, in actuality, heard. Then they rated their confidence in their choice. The dependent variable indicated whether or not the subject recognized the correct phrase. It also gave information about the strength of the effect. Positive versus negative confidence ratings operationalized the effect of the violated expectation.

Based on the literature, two predictions were tested. The first was that listeners would both consciously hear and notice the unexpected note. It seemed likely that their attention would be drawn to the difference in expected contour. If listeners were conscious of hearing a violated expectation, it seemed likely that when they heard the phrase with the violated expectation, they would remember and recognize it. Further, it seemed likely that they would be quite confident in their ability to recognize the correct phrase. In Schmuckler's 1997 research, he postulated that it was possible that strongly violated expectations could be reliably remembered as a result of the von Restorff effect (Schmuckler, 1997; von Restorff, 1933). The von Restorff effect suggests that two stimuli that do not a match a background (such as unexpected notes in an expected melody) are more easily remembered than stimuli that match the background (such as notes that follow expectations) (von Restorff, 1933 in Schmuckler, 1997). In the case of the von Restorff effect, it is the *actual violation* that is recognized and remembered, corresponding to the target note in this study.

The second prediction was that a violated expectation would affect musical memory in the before and after phrases. As noted in the introduction, Huron and others have found that listeners reliably expect particular directions of pitch and standard grouping effects in melodies (Huron, 2006; Krumhansl, 1990; Snyder, 2002; von Hippel, 2002). Expectations are an integral part of music perception and they enhance memory for groupings and melodies. The violation of expectation would hinder listeners' ability to effectively encode and remember the music. Previous research did not suggest whether stimuli before or after a violated expectation were more likely to be affected by the violation. Instead, previous research had focused on notes immediately surrounding the violation. The methods of this study allowed examination of recognition memory at different places in the melody, namely the before and after phrase. The findings are startling in some ways and unsurprising in other ways. As the results clearly show, violated expectation detrimentally affected musical memory but there was a more complex story.

Memory was less reliable, overall, when the target note was unexpected compared to expected. The effect was statistically significant in the case of the target phrase but not in the case of the before or after phrases. An unexpected target note detrimentally affected memory in the before and after phrases as well, but not to the same degree.

In the before-phrase condition, memory was still accurate even when the target note was unexpected. However, listener confidence was lower when the target note was unexpected. Listener confidence was lower in the before-phrase condition than it was in the target or after phrase conditions, no matter the status of the target note.

In the after-phrase condition, memory was unreliable when the target note was unexpected but reliable when the target note was expected. Confidence ratings in the after-phrase condition were lower than in the target-phrase condition and higher than those in the before-phrase condition.

Looking at these results through the lens of Snyder's grouping effects the facet of proximity becomes salient. Proximity suggests that notes temporally near each other will be remembered and encoded together. This could give some insight into why the target phrase was most detrimentally affected by the violated expectation. It could be that the violated expectation prevented the subjects from encoding that phrase as a whole, coherent group and so they did not recognize it later. The note was unexpected and was in a phrase. Therefore the whole phrase that contained the target note was not encoded correctly. The violated expectation made the phrase more random, less ordered, more difficult to recognize. This does not explain the confidence rating however. Of the six conditions, means were second highest in the target phrase-unexpected target note condition and were considerably higher than those in the before and after conditions.

As Figure 3 shows, the largest effect size of violation of expectation was detected in the target phrase-unexpected target note status condition. Subjects were reliably wrong and remarkably confident in their incorrect choice. Subjects appear to have been unaware that their memory was poor in this condition. Yet, the target note seems to have left a memory trace and a strong effect upon memory, namely hindering it. Across the other conditions, the effect of the memory disruption appears consonant with the subjects' confidence ratings. In the before and after phrase conditions, subjects were less confident when the target note was unexpected and tended to be inaccurate in their memory, suggesting that the subjects knew their memories were not reliable. This was not the case for the target phrase. It could be that subjects were not relying solely on their memories to choose the correct phrase. They may have used a mental map that was inefficient when expectations were violated.

Expectation: Creating a Mental Map to Guide Memory?

Huron (2006) describes the use of statistical probability that listeners use to anticipate the future direction and structure of melodies. Pitch proximity is one example of how listeners take probability into account when creating expectations. The expectation of pitch proximity suggests that listeners take into account the pitches they have just heard and the intervals between those pitches. Then they generate a mental map of the most likely pitches to follow. Listeners calculate what is most probable to come next based on what they just heard. In most cases, the most probable pitch to follow is one close to the previous one, creating a small pitch interval. In this study, subjects may have used a similar probability-based mental map to guide their choices and enable their memory. Grouping effects and musical expectation may have helped the subjects create the mental map. They may have used the mental map to determine which of the three phrases (the phrase that was actually heard or the two foil phrases) was most likely to fit in the previous melody instead of simply using recognition memory to identify the actual phrase they just heard. If this mental map was effective, then subjects would be able to reliably choose the correct phrase. When the target note was expected, this map seems to have been effective and subjects were able to reliably choose the correct phrase. The mental map appears to have been fallible when the target note was unexpected.

To a listener, the probability of a violated expectation was low. This assumption partly shaped the listener's mental map. When attempting to successfully perform a memory task, it is conceivable that a listener would choose a more common, more probable, and expected phrase than one that has a low probability in musical experience (the unexpected target phrase). The incorrect choice for the study—one of the two foil phrases which *did* follow melodic expectations—felt correct to the subjects because it followed musical syntax and grouping effects. When the target note was unexpected, it is possible that listeners were still using the mental map to make their choice. Subjects may have cognitively replaced the unexpected phrase with the one that accurately followed expectations. They chose the phrase that was logical based on their mental map. In effect, listeners may have been expressing their confidence in their abilities to recognize expected melodic contour rather than actually expressing confidence in memory.

Possible Links to Language: Garden-path Sentences

As noted in the Introduction, there is research to suggest that there is overlap in music and language processing. Comparisons between language and music are evident in the research (Patel, 2008). Sentences and phrases in language have been likened to parts of music. Snyder states that:

> …grouping boundaries provide the detailed features of the melodic and rhythmic contour of a phrase…These boundaries can take the form of leaps in pitch interval, changes in duration, loudness, articulation, tone color, and so on. Roughly parallel phenomena can be found in the grouping units of language. A sentence consists of phrases, separated from other phrases by pauses, like musical phrases; each phrase consists of words, which are like melodic and rhythmic groupings; and each word consists of phonemes, which cohere like the individual notes of a grouping (p. 38, Synder, 2002).

Expectation is an important part of both music and language perception. Research suggests that expectancy in language affects the comprehension of language (McRae, Hare, Elman, & Ferretti, 2005; Meng & Bader, 2000; van Gompel, Pickering, Pearson, & Jacob, 2006). McRae et al. (2005) found that nouns generate expectations for verb forms. Specifically, they describe "typical events" for verbs. The readers' expectations of the "typical events" are generated by the nouns which come before the verbs. The noun generates expectations about which verb will be semantically correct in the sentence and which verb will generate meaning. This suggests that similar to music, the structure of a sentence generates expectation and meaning. van Gompel et al. (2006) suggest that understanding of sentences is heavily based on the listener's ability to use expected structure based on syntactic knowledge and expectation. This is quite similar to melodic expectations. Violated language expectations might affect language comprehension and memory in a similar way that violated expectation affects music perception and musical memory.

Violated expectation in language research is operationalized by the use of garden-path sentences. Garden path sentences are so-called because they lead a listener down an expected path of grammar and comprehension, but do not follow the expected form (e.g., *The old man the boat.*). van Gompel et. al (2006) found that after working with garden-path sentences, subjects prompted to write novel sentences tended to write more ambiguous ones. This would suggest that violated expectation of syntax affects language production.

Other researchers have found that garden-path sentences affect readers' comprehension of the sentences and inhibit understanding (Christianson, Hollingworth, & Halliwell, 2001; Ferreira & Henderson, 1991; Ferreira, Christianson, & Hollingworth, 2001;).

Ferreira et al. (2001) investigated how garden-path sentences affect reader comprehension and reader-rated confidence in comprehension. Subjects in one experiment cited by Ferreira et al. 2001 (Christianson, et al., 2001, in Ferreira et al., 2001) were asked Yes or No questions to determine if they had comprehended garden-path sentences. Subjects then rated their confidence that they answered the question correctly. The researchers found that readers were confident in their abilities to understand a garden-path sentence, even when they were incorrect. Readers showed the worst comprehension when the ambiguous part of the garden-path sentence was long. Readers were still confident that they understood the sentence, as confident as when they correctly understood the sentence. This is very similar to the finding in this study that listeners were confident in their memory even when their memory was wrong. In both cases, subjects appeared unaware of the effects of a violated expectation.

An important limitation to this comparison regards what cognitive process is being assessed in these studies. In the studies cited above (Christianson et al., 200; Ferreira et al. 2001; Ferreira & Henderson, 1991; van Gompel et al., 2006), language comprehension is the focal construct. In this work, it is musical memory that is assessed. Expectation is a major part of musical grouping effects. It enables musical memory. Syntax in language is also influenced by expectation and expectation enables comprehension of language. But the comparison is not perfectly analogous. Further research that more specifically addresses the effect of violated expectation in language memory might offer insight into the mechanisms at work in musical memory as well. The link is not perfect, the analogy not clear cut, but it is interesting nonetheless.

The McGurk-MacDonald effect suggests another potential link between linguistic and musical phenomena. The McGurk-Macdonald effect (1976) describes the phenomenon in which being presented with auditory stimuli of the syllable “/ba/” dubbed over the lip movements of a speaker mouthing the syllable “/ga/” resulted in a listener reporting that the actual syllable he heard or saw was “/da/ (McGurk & MacDonald, 1976). In the 1976 study, researchers found that when the auditory and visual stimuli were separated (presented with just the lip movements or just the auditory syllable), listeners were able to recall the correct syllable. Their findings suggest that peoples’ reconstructions of auditory memory are fluid and change based on context. It is possible that there is an analogous phenomenon at work in this study. It could be that the violated expectation in the target phrase interfered with the listener’s encoding of the musical stimuli in a fashion similar to the McGurk-MacDonald effect.

Musical Memory as Reconstruction

This study attempted to study the construct of expectation and its effect on melodic memory. It was expected that violating musical expectations would detrimentally affect memory. The results bear this out: When musical expectations are violated, musical memory suffers. But more seems to be at work. The function of musical expectation may be entwined with musical memory. Rather than being one of many facets of music perception that contributes to musical memory, expectation in music may serve to enable a listener to construct and reconstruct memory for melodies.

Memory is notoriously reconstructive. Humans assume their memories function like cameras, capturing details and experiences as they were and are. This is often not the case. Roediger & McDermott (1995) had subjects attempt to remember lists of words that were related (e.g., pillow, night, blanket). Subjects were then prompted to recall those words. Subjects often generated words that were not on the list but that would have logically been related to the words that were actually on the list (e.g., sleep). In their study, subjects were confident that the spontaneously generated words were actually on the list. This false memory recall effect is termed the Deese-Roediger-McDermott paradigm in some research (e.g., Watson, McDermott, & Balota, 2004) and has been documented and replicated. It seems similar to the effect detected in this study. Listeners appear to have constructed false memories of what musical phrases they actually heard. Their recollections were influenced by the melodic expectations of the musical pieces such that when they heard a violated expectation, they rejected it as an impossible part of their memory. If the violated expectation was impossible, the listener would then be left to construct the actual event in his own memory and so would construct and recognize a *false* musical event.

The results of this study suggest that, like other forms of memory, musical memory is reconstructive. Subjects may not have relied wholly on their memories of the actual melodies they had just heard. Instead they seem to have reconstructed the *most likely* melodic events based on their expectations and the musical stimuli. Using a mental map based on musical expectation, they created memories that seemed likely. They seem to have relied on these reconstructed memories to guide them as they attempted to recognize the musical phrases. The subjects had no reason to believe that their mental maps were fallible or that their expectations would not be realized and so they were remarkably confident in their reconstructed—and incorrect—memories.

The results of this study suggest that remembering music may be less conscious that it seems. If this is true, then music is experienced in a gestalt way. Rather than just being a series of met expectations or appropriate groupings, it could be that music is experienced more deeply and its meaning is generated through reconstruction and participation by the listener.

Limitations and Further Research

Some refinement of the methods of the study could more specifically identify where the memory disruption occurred. The operationalization of the violated expectation in this study is a note that is a tritone away from the expected note. This may have been so unexpected that subjects interpreted the note as an actual error in the experiment. It is impossible to know if the subjects ignored the seemingly anomalous note and attempted to correct the mistake by choosing the phrase that had a higher probability of following their expectations.

These methods ask listeners to recall musical excerpts they heard relatively recently. It could be interesting in future research to manipulate the span of time between original presentation of the music and the recollection attempts. It is possible that the effect of reconstructed memory would be even greater in this case or it would perhaps be detectable in other conditions, not just Target-Unexpected. It is also possible that the experimental effects would fade.

Further research could look at the memory effect when the violations are less overtly detectable, when they are closer in tonal proximity as in Deutsch (1970). It could be useful to use several phases of tonal proximity. This could give a sense of the threshold at which violation of expectation affects memory. It would be possible to determine when a subject experiences an unexpected target note as a violated expectation versus an anomaly or error in the experiment.

This might make it easier to identify whether memory is actually affected by the violation, whether it is the subject's mental map of expectation which is affected, or if both are affected.

Applying the paradigms of false recall and false memory to musical memory research may also be fruitful. Research investigating the phenomenon of false memory in music would give insight into whether musical memory is influenced by probability and expectation or whether other processes are at work.

There is still plenty of room for research comparing music and language. Research investigating how garden-path sentences affect memory for their content might give insight into the results of this study.

The research on musical expectation has focused on melodic expectation. It is quite easy to operationalize this violation: change a tone. But rhythm needs to be examined more thoroughly. It is likely that violating rhythmic expectations produces different effects from violated melodic expectations. This study suggests that melodic musical processing may be more unconscious than overt but it isn't clear whether this is the case for rhythm as well.

Conclusion

Expectation plays a major role in music perception. It shapes how listeners hear and experience music. The role expectation plays is so crucial to perception that its violation hinders musical memory. The inhibitory effect is evident even if the listener is not aware of it. The results of this study suggest that expectation affects more than just music perception: It is a crucial part of musical memory. Further, these results suggest that musical memory is reconstructive. False musical memory appears to be a real phenomenon.

REFERENCES

Aarden, B. (2003). *Dynamic melodic expectancy* (Unpublished doctoral dissertation). Ohio State University, Columbus, OH.

Aldwell, E., & Schachter, C. (2002) *Harmony and voice leading, third edition.* New York, NY: G. Schirmer, Associated Music.

Boltz, M. (1993). The generation of temporal and melodic expectancies during musical listening. P*erception & Psychophysics*, *53*, 585-600.

Boltz, M. (1991). Some structural determinants of melody recall. *Memory & Cognition*, 19, 239-251.

Boomsliter, P. C., & Creel, W. (1979). Prestimulus perceptual activity in perception of tone in musical sequences. *Journal of Acoustical Society of America, 65*(1), S123.

Burns, E. M., & Ward, W. D. (1982). Intervals, scales, and tuning. In D. Diana (Ed.), *The psychology of music* (pp. 241-269). San Diego, CA: Academic Press.

Carterette, E. C., & Kendall, R. A. (1999). Comparative music perception and cognition. In D. Deutsch (Ed.), *The psychology of music, second edition* (pp. 725-791). San Diego, CA: Academic Press

Castellano, M. A., Bharucha, J. J., & Krumhansl, C. L. (1984). Tonal hierarchies in the music of North India. *Journal of Experimental Psychology: General, 113*(3), 394-412.

Christianson, K., Hollingworth, A., Halliwwell, J., & Ferreira, F. (2001). Thematic roles assigned along the garden path linger. *Cognitive Psychology, 42,* 368-407.

Cuddy, L. L., Cohen, A. J., & Miller, J. (1979). Melody recognition: The experimental application of musical rules. *Canadian Journal of Psychology*, *33,* 148-157.

Cuddy, L. L., & Lunney, C. A. (1995). Expectancies generated by melodic intervals: Perceptual judgments in melodic continuity. *Perception & Psychophysics*, *57*, 451-462.

Deutsch, D. (1999). *The psychology of music*, *second edition.* San Diego, CA: Academic Press.

Ferreira, F., Christianson, K., & Hollingworth, A. (2001). Misinterpretations of garden-path sentences: Implications of sentence processing and reanalysis. *Journal of Psycholinguistic Research*, *30*(1), 3-20.

Ferreira, F., & Henderson, J. M. (1991). Recovery of misanalyses of garden-path sentences. *Journal of Memory and Language*, *30*(6), 725-745.

Fodor, J. (1983). *Modularity of the mind.* Cambridge, MA: Massachusetts Institute of Technology Press.

Hadley, C. B., & MacKay, D. G. (2006). Does emotion help or hinder immediate memory? Arousal versus priority-binding mechanisms. *Journal of Experimental Psychology, 32*(1), 79-88.

Hallam, S., Cross, I., & Thaut, M. (2009). *Oxford handbook of music psychology*. Oxford, UK: Oxford University Press.

Hick, W. E. (1952). On the rate of gain of information. *Quarterly Journal of Experimental Psychology, 4,* 11-26.

Huron, D. (2006) *Sweet anticipation.* Cambridge, MA: Massachusetts Institute of Technology Press.

Hyman, R. (1953). Stimulus information as a determinant of reaction time. *Journal of Experimental Psychology, 45,* 423-432.

Ilie, G., & Thompson, W. F. (2006). A comparison of acoustic cues in music and speech for three dimensions of affect. *Music Perception, 23,* 319-329.

Juslin, P. N., & Laukka, P. (2003). Communication of emotions in vocal expression and music performance: Different channels, same code? *Psychological Bulletin, 129*(5), 770-814.

Juslin, P. N., & Laukka, P. (2004). Expression, perception, and induction of musical emotions: A review and questionnaire study of everyday listening. *Journal of New Music Research, 33*(3), 217-238.

Juslin, P. N., & Sloboda, J. A. (2001). *Music and emotion: Theory and research.* Oxford, UK: Oxford University Press.

Justus, T., & Hutsler, J. J. (2005). Fundamental issues in the evolutionary psychology of music: Assessing innateness and domain specificity. *Music Perception, 2* (1), 1-27.

Kennedy, M. (1985). *The oxford dictionary of music.* Oxford, UK: Oxford University Press.

Kensinger, E. A., & Corkin, S. (2003). Effect of negative emotional content on working memory and long-term memory. *Emotion, 3*(4), 378-393.

Kinder, A., & Shanks, D. R. (2003). Neuropsychological dissociations between priming and recognition: A single-system connectionist account. *Psychological Review, 110*(4), 728-744.

Krumhansl, C. L. (1991). Memory for musical surface. *Memory & Cognition, 19*(4), 401- 411.

Krumhansl, C. L. (1995). Music psychology and music theory: Problems and prospects. *Music Theory Spectrum, 17*, 53-80.

Lezak, M. D. (2004). *Neuropsychological assessment, fourth edition.* New York, NY: Oxford University Press.

MakeMusic. (2007). *Finale 2008*. Eden Prairie, MN: MakeMusic.

McDermott, J., & Hauser, M. (2005). The origins of music: Innateness, uniqueness, and evolution. *Music Perception, 23*(1), 29-59.

McGurk, H., & MacDonald, J. (1976). Hearing lips and seeing voices. *Nature, 264,* 746-748.

McMullen, E., & Saffran, J. R. (2004). Music and language: A developmental comparison. *Music Perception, 21*(3), 289-311.

McRae, K., Hare, M. L., Elman, J .L., & Ferretti, T. (2005). A basis for generating expectancies for verbs from nouns. *Memory and Cognition, 33*, 1174-1184.

Meng, M., & Bader, M. (2000). Ungrammaticality detection and garden path strength: Evidence for serial parsing. *Language and Cognitive Processes, 15*(6), 615-666.

Meyer, L. (2001). Music and emotion: Distinctions and uncertainties. In P. Juslin & J. Sloboda (Eds.), *Music and emotion: Theory and research* (pp. 341-360). Oxford, UK: Oxford University Press.

Meyer, L. B. (1956). *Emotion and meaning in music*. Chicago, IL: University of Chicago Press.

Mithen, S. (2006). *The singing neanderthals.* Cambridge, MA: Harvard University Press.

Narmour, E. (1990). *The analysis and cognition of basic melodic structures: The implication-realization model*. Chicago, IL: University of Chicago Press.

Nattiez, J. J. (1990). *Music and discourse: Toward a semiology of music* (C. Abate, Trans.). Princeton, NJ: Princeton University Press.

Patel, A. N. (2003). A new approach to the cognitive neuroscience of melody. In I. Peretz & R. Zatorre (Eds.) *The cognitive neuroscience of music* (pp. 325-345). New York, NY: Oxford University Press

Patel, A. N. (2008). *Music, language, and brain.* Oxford, UK: Oxford University Press.

Peretz, I. (2003). Brain specialization for music: New evidence from congenital amusia. In I. Peretz & R. Zatorre (Eds.), *The cognitive neuroscience of music* (pp. 192-203). Oxford, UK: Oxford University Press.

Peretz, I., & Coltheart, M. (2003). Modularity of music processing. *Nature Neuroscience, 6*, 688-691.

Peretz, I., & Zatorre, R. (2003). *The cognitive neuroscience of music.* Oxford, UK: Oxford University Press.

Pinker, S. (1997). *How the mind works.* New York. NY: W.W. Norton.

Roediger, H. L., & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*(4), 803-814.

Schellenberg, E. G. (1996). Expectancy in melody: Tests of the implication-realization model. *Cognition, 58*, 75-125.

Schellenberg, E. G. (1997). Simplifying the implication-realization model. *Music Perception, 14* (3), 295-318.

Schellenberg, E. G., & Trehub, S. (1999). Culture-general and culture-specific factors in the discrimination of melodies. *Journal of Experimental Child Psychology, 74,* 107-127.

Seashore, C. (1938). *Psychology of music.* New York, NY: McGraw-Hill.

Snyder, B. (2002). *Music and memory: An introduction*. Cambridge, MA: Massachusetts Institute of Technology Press.

Tillman, B., Bharucha, J. J., & Bigand, E. (2003). Learning and perceiving musical structures:

Further insights from articficial neural networks. In I. Peretz & R. Zatorre (Eds.), *The cognitive neuroscience of music* (pp. 109-123). Oxford, UK: Oxford University Press.

Trainor, L. J., & Trehub, S. E. (1992). A comparison of infants' and adults' sensitivity to Western musical structures. *Journal of Experimental Psychology, 18*(2), 394-402.

Trehub, S., Cohen, A., Thorpe, L., & Morrongiello, B. (1986). Development of the perception of musical relations: semitone and diatonic structure. *Journal of Experimental Psychology: Human Perception and Performance, 12,* 295-301.

van Gompel, R. P. G., Pickering, M. J., Pearson, J., & Jacob, G. (2006). The activation of inappropriate analyses in garden-path sentences: Evidence from structural priming. *Journal of Memory and Language, 55*(3), 335-362.

von Hippel, P. (2002). Melodic-expectation rules as learned heuristics. In C. Stevens and D. Burnham, G. McPherson, E. Schubert, & J. Renwick (Eds.), *Proceedings of the 7th international conference on music perception and cognition.* Sydney, Australia: Causal Productions.

von Restorff, H. (1933). Uber die virkung von bereichsbildungen im spurenfeld. *Psychologie Forschung, 18,* IVi-Mi.

Watson, J. M., McDermott, K. B., & Balota, D. A. (2004). Attempting to avoid false memories in the Deese/Roediger-McDermott paradigm: Assessing the combined influence of practice and warnings in young and old adults. *Memory & Cognition, 32*(1), 135-141.

Appendix A
Subject Instructions.

INSTRUCTIONS

Please listen carefully to the following directions. You may read along below. If you have any questions, please ask the administrator. You may also keep this instruction sheet as a guide.

You will hear six brief musical melodies. Each melody is followed by a pause and three short musical phrases. Your task is to identify which of the three short phrases was contained in the previous brief musical melody

Then, you will rate how confident you are that your choice is correct. The rating will be a 7 point scale. 1 indicates that you are not at all confident that you have made the correct choice. 7 indicates that you are extremely confident that you have made the correct choice.

For example, if you simply did not hear the melody that was played and are ***purely guessing*** you would circle 1. Do not circle 1 if you would consider your answer a good guess or a bad guess. ***Choosing 1 indicates that you are blindly guessing*** for your response. Alternatively, choosing 7 on the scale indicates ***100% certainty*** in your response. Only circle 7 if you are ***extremely confident*** that you have chosen the correct phrase from among the three.

Let's do an example.

Listen carefully to the melody and the three musical phrases that follow.

Most people would choose the first phrase because it is the one that most sounds like it was contained in the previous melody. Now you would rate how confident you are that you are correct.

Please consider if the volume of the music is OK. If it is not and you would like it to be louder or softer, please let the administrator know.

Now we will begin with the tasks.

Appendix B
Subject Response Form

MELODY 1
Which of the following was contained Melody 1?
_____1st phrase _____2nd phrase____3rd phrase

How confident are you that you have made the correct choice?
1 2 3 4 5 6 7
Not at all confident. **Extremely confident.**

MELODY 2
Which of the following was contained Melody 2?
_____1st phrase _____2nd phrase____3rd phrase

How confident are you that you have made the correct choice?
1 2 3 4 5 6 7
Not at all confident. **Extremely confident.**

MELODY 3
Which of the following was contained Melody 3?
_____1st phrase _____2nd phrase____3rd phrase

How confident are you that you have made the correct choice?
1 2 3 4 5 6 7
Not at all confident. **Extremely confident.**

MELODY 4
Which of the following was contained Melody 4?
_____1st phrase _____2nd phrase____3rd phrase

How confident are you that you have made the correct choice?
1 2 3 4 5 6 7
Not at all confident. **Extremely confident.**

MELODY 5
Which of the following was contained Melody 5?
_____1st phrase _____2nd phrase____3rd phrase

How confident are you that you have made the correct choice?
1 2 3 4 5 6 7
Not at all confident. **Extremely confident.**

MELODY 6
Which of the following was contained Melody 6?
_____1st phrase _____2nd phrase____3rd phrase

How confident are you that you have made the correct choice?
1 2 3 4 5 6 7
Not at all confident. **Extremely confident.**

Appendix C
Reliability Check Subject Instructions.

You have just listened to and responded to 6 melodies. Now, you will hear each of these same 6 melodies for a second time. This time, you will have **2 tasks** to complete after hearing each melody. You will hear the melody played again and then you will again hear the three phrases.

First, you need to indicate which of the three phrases you chose as your response the last time you heard the melody.

Second, you need to choose which of the three phrases you think is correct when you hear each melody NOW, the second time. It may be that your choices the first and second time are different. They may also be the same.

Next, you will rate how confident you are that this second time you have chosen the correct phrase.

Please note: You are rating your how confident you are of your choice after the second listening of the melody, so your rating only refers to this second choice.

If you do not understand these instructions, please pause the music and ask the administrator for assistance.

Appendix D

Subject Response Form for Reliability Check.

MELODY 1

Which of the three phrases did you choose the last time you heard Melody 1?
_____1st phrase _____2nd phrase____3rd phrase

Now that you hear Melody 1 again, which of the three phrases was contained in Melody 1?

_____1st phrase _____2nd phrase____3rd phrase

How confident are you that your choice is correct after hearing the melody a second time?

1	**2**	**3**	**4**	**5**	**6**	**7**
Not at all confident.						**Extremely confident.**

MELODY 2

Which of the three phrases did you choose the last time you heard Melody 2?
_____1st phrase _____2nd phrase____3rd phrase

Now that you hear Melody 2 again, which of the three phrases was contained in Melody 2?

_____1st phrase _____2nd phrase____3rd phrase

How confident are you that your choice is correct after hearing the melody a second time?

1	**2**	**3**	**4**	**5**	**6**	**7**
Not at all confident.						**Extremely confident.**

MELODY 3

Which of the three phrases did you choose the last time you heard Melody 3?
_____1st phrase _____2nd phrase____3rd phrase

Now that you hear Melody 3 again, which of the three phrases was contained in Melody 3?

_____1st phrase _____2nd phrase____3rd phrase

How confident are you that your choice is correct after hearing the melody a second time?

1	**2**	**3**	**4**	**5**	**6**	**7**
Not at all confident.						**Extremely confident.**

MELODY 4
Which of the three phrases did you choose the last time you heard Melody 4?
_____1st phrase _____2nd phrase____3rd phrase

Now that you hear Melody 4 again, which of the three phrases was contained in Melody 4?

_____1st phrase _____2nd phrase____3rd phrase

How confident are you that your choice is correct after hearing the melody a second time?

1	2	3	4	5	6	7
Not at all confident.						**Extremely confident.**

MELODY 5
Which of the three phrases did you choose the last time you heard Melody 5?
_____1st phrase _____2nd phrase____3rd phrase

Now that you hear Melody 5 again, which of the three phrases was contained in Melody 5?

_____1st phrase _____2nd phrase____3rd phrase

How confident are you that your choice is correct after hearing the melody a second time?

1	2	3	4	5	6	7
Not at all confident.						**Extremely confident.**

MELODY 6
Which of the three phrases did you choose the last time you heard Melody 6?
_____1st phrase _____2nd phrase____3rd phrase

Now that you hear Melody 6 again, which of the three phrases was contained in Melody 6?

_____1st phrase _____2nd phrase____3rd phrase

How confident are you that your choice is correct after hearing the melody a second time?

1	2	3	4	5	6	7
Not at all confident.						**Extremely confident.**

Appendix E

Demographics Form

Questionnaire

1. Age: ___________

2. Gender: _____ Male _____Female

3. What is your class standing? ____

4. What is your Major? ____

5. Are you a:

    ___ vocalist
    ___instrumentalist
    ___ both.
    ___ neither.

6. If you are a vocalist and/or instrumentalist, how many performances have you been involved with during the past four years? If you are not a vocalist or performer, please go to number 7.

    ___0
    ___1-5
    ___6-10
    ___ 10 or more.

7. Do you have any hearing problems or hearing loss? If so, please briefly describe below.

____

____

____

____

Appendix F
Melodies and Foils

Melody 1

Melody 2

Measure 3 - Foil 1

Measure 3 - Foil 2

Measure 4 - Foil 1/Unexpected

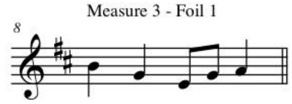
Measure 4 - Foil 2/Median

Measure 5 - Foil 1

Measure 5 - Foil 2

Melody 3

Measure 3 - Foil 1



Measure 3 - Foil 2

Measure 4 - Foil 1/Unexpected

Measure 4 - Foil 2/Median

Measure 5 - Foil 1

Measure 5 - Foil 2

Melody 4

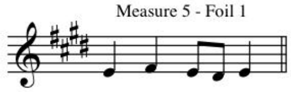
Measure 3 - Foil 1

Measure 3 - Foil 2

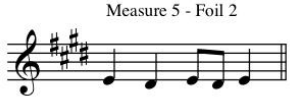
Measure 4 - Foil/Unexpected

Measure 4 - Foil 2/Median

Measure 5 - Foil 1



Measure 5 - Foil 2



Melody 5

Measure 3 - Foil 1

Measure 3 - Foil 2

Measure 4 - Foil1/Unexpected

Measure 4 - Foil 2/Median

Measure 5 - Foil 1

Measure 5 - Foil 2

Melody 6

Measure 3 - Foil 1

Measure 3 - Foil 2

Measure 4 - Foil 1/Unexpected

Measure 4 - Foil 2/Median

Measure 5 - Foil 1❊

Measure 5 - Foil 2

Appendix G

Peter Buckland's Explanation of Measure Four Foil Composition

The foils for the target phrase work in the following manner:

1. The listener heard one of two versions of the measure when they listened to the melody in its entirety; they heard measure four conclude on scale degree 5 (the dominant and what is termed the "expected" harmonic goal in this paper) or a flatted scale degree 2 (the "Neapolitan" or what has been termed the "unexpected" harmonic goal in this paper).
2. For the recognition section, the listener heard three versions of measure 4; they heard measure 4 conclude on scale degree 5 (the dominant and what is termed the "expected" harmonic goal in this paper), the flatted scale degree 2 (the "Neapolitan" or what has been termed the "unexpected" harmonic goal in this paper), and also scale degree 3 (the median chord). The other two notes were always foils to the other one. The Neapolitan and the median acted as foils to the dominant and the dominant and the median acted as foils to the Neapolitan simply because they are not the same. The median note was chosen because it is harmonically equidistant from the Neapolitan and the dominant. It is 3 half-steps below the dominant (a minor third in the major key) and 3 half-steps above the Neapolitan (an augmented second in the major key scheme).

For example, Melody 1 is in the key of C major. Measure 4 ends on the pitch G when the target note status is expected. The foils composed and shown with Melody 1end on D-flat (the Neapolitan pitch) and on E (the median pitch which is a minor third below the dominant pitch G and an augmented second above the Neapolitan pitch D-flat). Were the unexpected version shown, the foils would be G (the dominant) and E (the median).

Appendix H

Summary Table of Trial 2[12]

Factor	Df	Mean Square	F-value	Significance Level	Partial Eta-squared
Position	2	376.27	11.63	<.01	.14
Mean Square Error Position	144	32.35			
Target	1	543.49	20.00	<.01	.22
Mean Square Error Target	72	27.04			
Trial 2	1	5.59	.39	.53	.01
MSE Trial 2	72	14.33			
Position X Target	2	428.67	15.41	<.01	.18
Mean Square Error Position X Target	144	27.82			
Position X Trial 2	2	16.47	1.20	.30	.02
Mean Square Error Position X Trial 2	144	13.68			
Target X Trial 2	1	.07	.01	.94	<.01
Mean Square Error Target X Trial 2	72	12.11			

[12] N = 73

Position X Target X Trial 2	2	7.62	.65	.53	.01
Mean Square Error Position X Target X Trial 2	144	11.81			

Appendix H (continued)

Summary Table for Trial 2

Factor	F-value	df	Mean Square	Significance level	Partial Eta-Squared
Target	20	1	543.49	.01	.22
Position	11.63	2	376.27	.01	.14
Trial 2	.39	1	5.59	.53	.01
Position X Target	15.41	2	428.67	.01	.18
Position X Trial 2	1.20	2	16.47	.30	.02
Target X Trial 2	.01	1	.07	.94	<.01
Position X Target X Trial 2	.65	2	7.62	.53	.01

Appendix I

Intercorrelations for Trial 1 and Trial 2[13]

	BE2	BU2	TE2	TU2	AE2	AU2
BE	**.51****[14]	-.13	.04	**.36****	.18	-.15
BU	**-.25***	**.31***	-.06	-.03	-.06	.12
TE	-.07	-.13	**.52****	-.03	-.10	**.29***
TU	.03	.05	**.37****	**.41****	-.04	.14
AE	-.02	-.09	-.09	-.02	**.32****	.18
AU	-.09	**-.25***	-.08	-.09	.11	**.30***

[13] N = 73
[14]* Correlation significant at .05 level (2-tailed).
** Correlation significant at .01 level (2-tailed).

Appendix J
Informed Consent.

Informed Consent Form

You are invited to participate in this research study. The information contained on this form is meant to inform you and help you decide if you consent to participation in the study. If you have further questions, do not hesitate to ask. You are eligible to participate because you are a student in Psychology 101 at Indiana University of Pennsylvania (IUP).

The purpose of this study is to examine how memory for music might change depending on the nature of that music.

Risks and Benefits There are no known risks associated with this study. You may find the experience interesting.

Compensation Participation in this study will provide you with credit toward your research participation requirement for Psychology 101 class.

Your participation in this study is **voluntary**. You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with the investigators or IUP. Your decision will not result in any loss of benefits to which you are otherwise entitled. If you choose to participate, you may withdraw at any time by notifying the researcher or informing the person administering the test. Upon your request, to withdraw, all information pertaining to you will be destroyed. If you choose to participate, all information will be held in strict confidence and will have no bearing on your academic standing or services you receive from the University. The information obtained in the study may be published in scientific journals or presented at scientific meetings but your identity will be kept strictly confidential.

If you are willing to participate in this study please sign the statement below and return it to the person administering the survey. When you complete the study, you will be given an information sheet that will provide you with contact information if you wish to receive results of the study and with referral sources should you like to receive counseling in the unlikely even that any issues or concerns arise from your participation.

Principal Investigator
Mrs. Jessica Buckland
Doctoral Student
Psychology Department
G19 Uhler Hall
Indiana, PA 15705
Phone: 724-357-4705
Email: tkjm@iup.edu

<u>This project has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (Phone: 724-357-7730).”</u>

VOLUNTARY CONSENT FORM

I have read and understand the information on the form and I consent to volunteer to be a subject in this study. I understand that my responses are completely confidential and that I have the right to withdraw at any time. I have received an unsigned copy of this Informed Consent Form to keep in my possession.

Name (PLEASE PRINT) ____

Signature ____

Date___________________________

Email Contact ____

Appendix K

Debriefing Form.

Subject Debriefing

Department of Psychology

The following information is offered in order to inform you of the purpose of the study and to provide you with referrals for further support or information.

The study in which you participated was designed to examine how negative emotional arousal affects musical memory. There has been research that has found that negative emotional arousal has a deleterious effect upon verbal memory. I aim to investigate whether the effect of negative emotional arousal is the same for musical memory. In some of the musical samples you heard, there were notes that sounded wrong. These wrong notes were meant to be jarring and somewhat uncomfortable to hear. I intended for them to feel negative emotionally. In the other musical samples you heard, there were no notes that sounded wrong. I will examine if there is a difference in peoples' memory for previously heard music depending on whether they heard a wrong note or note.

If you are interested in receiving the results of this study please contact the principal investigator:

Jessica Buckland, M.A.
Doctoral Student
G19 Uhler Hall
1020 Oakland Avenue
Indiana, PA 15705
tkjm@iup.edu.

If you would like to discuss any concerns or discomfort or receive counseling feel free to contact the following agencies.

IUP Student Counseling Center: 724-357-2621

Indiana County Guidance Center: 724-465-5576

This research is sponsored by the Indiana University of Pennsylvania Department of Psychology. The principal investigator is Jessica Buckland and the co-investigator is Dr. Donald U. Robertson.