

Acquisition and Generalization of Pitch Probability Profiles

By

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Abstract

Krumhansl (1990) has proposed that our sense of tonality is based, in part, on the perception and internal representation of the hierarchies of pitch class salience in music. It has further been proposed that regularities in pitch patterns may be acquired through statistical learning. To further explore this proposal, we conducted two experiments in which musically untrained participants were exposed to tone sequences generated from one of two pitch profiles: Lydian or Hypophrygian. Tone sequences were randomly generated from event frequency profiles computed by Huron and Veltman (2006), with frequencies converted to probability of occurrence. Exposure trials consisted of 100 sequences generated from one mode for half the participants and from the other mode for the remaining participants. Sequences generated from the unexposed mode appeared in test trials only. Following the exposure trials, testing involved pairing exposed and unexposed tone sequences at each of three levels of distinctiveness. Versions of the tone sequences were constructed to be more or less distinctive following an algorithm described by Smith & Schmuckler (2004). In Experiment 1, participants were asked to record which pair member they preferred and in Experiment 2, participants were asked to record which pair member was more familiar. In both experiments, both groups received the same test pairs. Results of Experiment 1 indicated no preference for any tone sequence type. However, results of Experiment 2 revealed participants had acquired knowledge of the exposed pitch distribution, and were able to generalize to the more distinctive level. The findings support those of Loui, Wessel, and Hudson Kam (2010) in terms of a dissociation between recognition and preference. We suggest this may be due to methodology, stimulus-type and participant strategy. The findings also support Krumhansl (1990), as salient pitches appear to be important in the recognition of pitch probability profiles.

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CHAPTER 1

Introduction

Music is a complex form of communication. Theorists such as Meyer have suggested that "...musical styles are probability systems..." (Meyer, 1957, p.421), and that meaning and emotion in music arise from these probabilities in terms of violating or fulfilling expectations (Meyer, 1956). Since then, an increasing amount of research has explored the acquisition of rules in music (for review, see Rohrmeier & Rebuschat, 2012). In pursuit of understanding tonality, Krumhansl (1990) suggested a cognitive representation of key that may be acquired through statistical learning, however, relatively little research has looked at the acquisition of novel probability systems. The current paper addresses this issue and expands the investigation to look at limitations on the human ability to demonstrate acquisition of these representations.

A body of research on grammar learning has shown that we are able to learn the transitional probabilities in sequences relatively quickly (Saffran, Newport, Aslin, Tunick, Barrueco, 1997; Saffran, Johnson, Aslin, Newport, 1999). Saffran et al. (1999) developed "tone words" based on previous work with speech sounds, by combining tones into groups of three. Tone words were presented in a seven minute stream to participants without break, therefore creating transitional probabilities as some tones are more likely to follow each other than other tones. In the test phase, participants had to determine which of two tone words sounded more familiar. It was found that tone words that appeared in the presentation were more likely to be picked as familiar than tone words that did not; the authors argue that the statistical rules governing the novel system of tones seem to have been implicitly learned by the participants.

A number of studies have demonstrated musical rule knowledge using cross cultural designs (Castellano, Bharucha & Krumhansl, 1984; Krumhansl et al., 2000; Krumhansl, Louhivuori, Toiviainen, Jarvinen & Eerola, 1999; Krumhansl & Kessler, 1982). Castellano et al. (1984), studied North Indian melodies, called rags, which are made up of thāts (a large set of North Indian scales), and found participants who were familiar with the musical style were more sensitive to the statistical properties of the scales than Western listeners. Similarly, Krumhansl et al. (2000) demonstrated experts of North Sami Yoiks (a musical tradition of Finland) were more sensitive to its statistical properties than Western listeners. It has also been found that much of the statistical learning in music is largely unrelated to formal music training (for review see Bigand & Poulin-Charronnat, 2006), suggesting that we learn these statistical regularities mostly through passive listening. This idea is also evident in a growing number of studies that demonstrate musical rule learning through exposure to novel rule systems (Kuhn & Dienes, 2005; 2006; Loui, Wessel & Hudson Kam, 2010; Loui, 2012; Rohermeier, Rebuschat & Cross, 2011). Now the question becomes, what can be learned, and how.

In a notable study by Loui et al. (2010), participants were exposed to a novel musical rule system using the Bohlen-Pierce scale. This scale was put forth in the early 1970s by Heinz Bohlen and uses a 3:1 ratio of frequency in a tritave with 13 logarithmically equal divisions. The familiar Western music scale utilizes a 2:1 ratio of frequency in an octave of 12 logarithmically equal divisions. Therefore, the Bohlen-Pierce scale creates consonant sounding intervals that are different from Western music. Melodies were developed from a chord progression built on the Bohlen-Pierce scale using a finite state grammar (a rule system built on legal transitions between states).

Participants were tested for familiarity with melodies they heard during exposure, as well as with new melodies that were developed from the same musical system. In the first of two Experiments, participants were presented with five melodies repeated for 25 minutes. They found that they were only able to recognize these five melodies and not new ones, showing they did not learn the rules of the system. However, with an exposure time of 30 minutes and 400 melodies not repeated (Experiment 2), participants did learn the statistical regularities of the rule system as they found new melodies generated from the system more familiar than melodies generated from a different system. Interestingly, when participants were asked to rate their preference for the melodies, they only showed a preference for the exact melodies they heard in Experiment 1 and no preference was found in Experiment 2. This demonstrates a double dissociation between learning and preference. Based on the “mere exposure effect” (Zajonc, 1968), this is a rather unexpected finding, as the theory would predict if an item is rated as more familiar, it should also be rated as more pleasant. The general conclusion seems to rest in the mechanisms behind implicit learning; Loui (2012) suggests that the mechanisms underlying the mere exposure effect are likely different from those underlying the implicit learning nature of statistical learning.

Pitch Probability Profiles

Krumhansl (1990) suggested that our sense of tonality (the key of a melody or piece) is based, in part, on the perception and internal representation of the hierarchies of pitch class salience in music. Pitch class is simply the set of pitches without regards to different octaves. For example, pitch class C represents all Cs in all octaves. Therefore, there are twelve pitch classes representing each pitch in the chromatic scale. Pitches can

also be labeled in such a way as to generalize to all keys. That is, the tonic is the first note in the scale and the dominant is the fifth, regardless of the actual pitch. The hierarchy of pitch class salience is described such that the tonic is the most salient, followed by the members of the tonic triad (includes the third and fifth notes in the scale), then other diatonic pitches (notes found in the scale) and finally, non-diatonic pitches. While music theorists have had a description of this hierarchy for some time (for review, see Krumhansl, 1990), Krumhansl & Kessler (1982) quantified it using the probe tone method (a melodic (or chordal) context followed by a single tone that is rated for fit) and empirically defined the key profiles that have become quite familiar in current music cognition research. In this study (Krumhansl & Kessler, 1982), participants were presented with a context consisting of chords that would suggest a particular key, then heard a single tone and were asked to rate how well the tone fit with the preceding context. This method allowed them to average the ratings for each pitch class and create a key profile for both major and minor keys, both of which can be seen in Figure 1. The tones that “fit best” in these profiles lined up with the hierarchy described earlier.

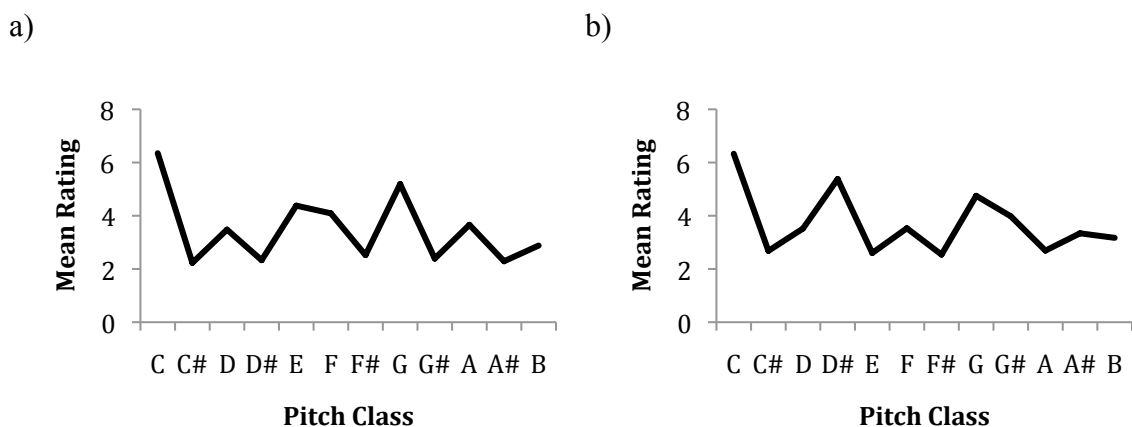


Figure 1. Key profiles generated from probe tone ratings, (Krumhansl & Kessler, 1982). a) Major b) Minor

These key profiles have also been found to be very similar to tonal distributions that were developed based on frequency of occurrence in classical music. Krumhansl (1990) correlated tonal distributions (taken from previous studies that counted frequencies of pitch classes (Youngblood, 1958; Knopoff & Hutchinson, 1983)), with the key profiles she derived in Krumhansl & Kessler (1982) and found high correlations between them (.887 for major and .858 for minor). Temperley (2007) also developed a key profile for his pitch model by counting the number of times each pitch class occurred in the pieces in the Essen Folksong Collection (a corpus of Western and Asian folksongs) and calculating the proportion of each pitch class to the total number of pitches. This distribution of pitch class lined up quite well with Krumhansl & Kessler's (1982) key profiles, thus supporting the idea that acquisition of these key profiles, and therefore the tonal hierarchy, may be attributed to statistical learning during exposure to our musical culture (Krumhansl, 1990). Thiesson & Erickson (2013) have suggested that there are two forms of statistical learning that are often grouped together in the literature: conditional and distributional statistical learning. The research discussed so far in this paper can fall into both categories, but of central importance to the current study, is distributional statistical learning. While conditional statistical learning is knowledge of the predictive relationships between events, distributional statistical learning is one that acquires knowledge about frequency, central tendency and variability. Therefore, acquisition of pitch probability profiles and pitch class saliency would fall into this specific form of statistical learning. While there is a great deal of evidence for statistical learning of musical rules in general (described previously), there does not seem to be any

direct evidence for acquisition of key profiles in terms of distributional statistical learning.

In this study, our question is whether people can learn the characteristics of a novel key profile (for the purposes of this study, this will henceforth be referred to as pitch probability profile) and generalize these characteristics to different levels of distinctiveness; that is, either an exaggerated or flattened version of the profile. We attempt to answer this question by exposing participants to novel tone sequences generated from a standard profile. Participants passively listen to these tone sequences, so any learning is assumed to be unintentional. We then ask participants implicitly in Experiment 1 (using a preference judgment) and explicitly in Experiment 2 (using a familiarity judgment) to recognize novel tone sequences generated from different versions of the exposed, standard distribution. Since this is a question of learning, it is important that we reduce the effect of previous music experience as much as possible. For this reason, we generated tone sequences using a novel rule system.

Tone sequence generation

In order to reduce the effect of experience with the rules of Western music, we selected medieval mode pitch profiles developed by Huron & Veltman (2006)¹. Non-musicians familiar with Western music are likely to be unfamiliar with this chant-style music. Two medieval mode pitch profiles (Lydian and Hypophrygian) were chosen since their profiles appeared the most different in structure from the major profile, and were considered “different” from each other in a variety of analyses performed by Huron & Veltman (2006) including Multi-Dimensional Scaling (MDS) where the two were found

¹ We’d like to thank Dr. Joshua Veltman for supplying us with the values used in these profiles.

to be far apart on the two-dimensions used and a cluster analysis where the two belonged mostly to different clusters.

These pitch profiles can be manipulated to create more and less distinctive versions. By raising the values in the profiles to an exponent, we change the absolute differences between pitch probabilities, without changing the basic pattern of the profile. After raising each value to the exponent, values must be returned to probabilities by finding the proportion of each value to the total of all pitches (this algorithm was taken from Smith & Schmuckler (2004)). If the exponent is between 0 and 1, the probability of highly probable pitches is decreased while that of less probable pitches is increased. This creates a flatter profile, but with the relative differences between pitches staying the same, therefore creating a less distinctive version of the original distribution. If the exponent is greater than 1, the probability of highly probable pitches is increased, while that of less probable pitches is decreased. This creates an exaggerated or more distinctive version of the original profile. Figure 2 displays the pitch classes found in each mode (those with a probability of 0 were not present in the tone sequences), as well as the profiles used in the generation of tone sequences. As seen in Figure 2, all profiles are oriented from C to B. Thus the final six groups of tone sequences that can be created from our model are: Standard Lydian, Lydian less distinctive, Lydian more distinctive, Standard Hypophrygian, Hypophrygian less distinctive, and Hypophrygian more distinctive.

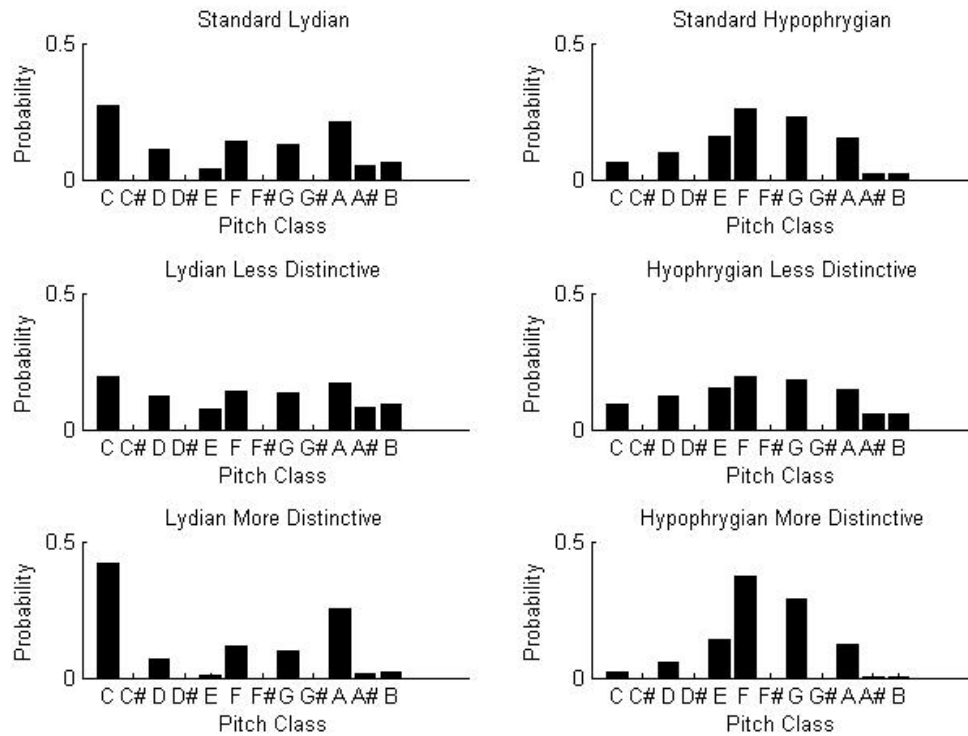


Figure 2. Pitch profiles of all six types of tone sequences. Standard probabilities for Lydian and Hypophrygian were taken from a corpus of Gregorian Chants (Huron & Veltman, 2006). Exponent for less distinctive profiles was .5 and exponent for more distinctive profiles was 2.

If we were to simply generate tone sequences by randomly choosing pitches from these pitch profiles, any two sequences may sound very different. For example, one sequence may be quite high in pitch with large leaps between tones, while another may be quite low in pitch without these large leaps. Since tone sequences are presented in pairs during the testing session (discussed later in the **Methods** section), the variability between tone sequences should be reduced as much as possible outside the domain of manipulation. To avoid this source of variability, we used Temperley's (2007, p. 48) pitch model to introduce melodic constraints to the tone sequences. The generative portion of this model creates melodies by randomly selecting pitches from a distribution.

This distribution is made up of 3 profiles: a proximity profile that keeps the distance between pitches relatively small, a range profile that keeps the melody in a relatively small range of pitches overall (however pitches could span over an octave), and a key profile that contains the frequencies of pitches, therefore determining the key of the melody. As mentioned previously, Temperley determined the parameters of these distributions using the Essen Folksong Collection, resulting in a model that generates melodies based on rules and probabilities of Western music. We replaced the key profile in Temperley's model with one of the six medieval mode pitch profiles described earlier, while keeping the proximity and range profiles the same. Therefore, not only can we create tone sequences that are novel to participants, the pitch frequencies behind these sequences will also be unfamiliar. It has been suggested that the musical constraints used in this study (taken from Temperley (2007)) may be universal characteristics of music (Dowling & Harwood, 1986; Schellenberg, 1997), suggesting that our tone sequences will be novel yet musical to participants. Samples of the six types of tone sequences can be found in Appendix A.

CHAPTER 2

Experiment 1

In the current experiment, we were interested in determining how well participants implicitly learn the six profiles previously mentioned, as well as if preferences for these profiles can develop. It was predicted that participants would prefer the tone sequences generated from the exposed distribution at all levels of distinctiveness.

Methods

Participants. 20 participants (14 female, 6 male) were recruited from Queen's University and were compensated \$15 for their time. No participant had more than five years of formal music training.

Stimuli. Stimuli were created in MATLAB 2007b. Each tone sequence consisted of 50, 300 ms tones that were made up of the first four harmonics, with the fundamental having the highest amplitude and decreasing at each harmonic (80%, 10% and 4% respectively), giving the tone a flute-like timbre. Each tone sequence could begin and end on any pitch, but to control for any first/last note effects of rule learning, all tone sequences were faded in and out. The fade-in initially involved a rapid increase of amplitude, reaching 80% of maximum amplitude by the 15th tone. The rate of increase then slowed, so that the increase was almost imperceptible, until the midpoint of the sequence was reached, at which point the amplitude coefficient hit the maximum of .25. In a symmetric fashion, the fade-out began slowly and then proceeded rapidly towards the end of the sequence. The sequences did not contain any rhythmic information in order to control for any effects this may have on predictability and liking. It is recognized that the rhythm x pitch interaction may play an important role in expectation generation (Pearce & Wiggins, 2006), which may affect learning. Therefore, it was decided that the simpler stimuli would be most appropriate for the first stage of this question.

Procedure. Participants were told in the beginning that there would be two phases: the first phase would involve listening to a number of melodies and rating some for pleasantness and the second phase would involve choosing between two melodies for

preference. Note they were never told phase two would be related to phase one and were not encouraged to memorize or intentionally attempt to learn anything during the first phase. Participants first completed a brief music questionnaire (see Appendix B) (including five questions pertaining to the music training and music listening indices of the Music USE Questionnaire (MUSE) (Chin & Rickard, 2012)), and then completed the interval test (task 3) of the Montreal Battery of Evaluation of Amusia (MBEA) (Peretz, Champod & Hyde, 2003). They were seated in a sound attenuated booth equipped with a computer and speakers. Participants were randomly assigned to either the Lydian or Hypophrygian group.

During exposure, participants listened only to tone sequences generated from their assigned distribution at the standard distinctiveness level. They were instructed to listen to the tone sequences, and told that they will be occasionally asked to answer questions about some of the tone sequences. First, participants rated 10 tone sequences for pleasantness (How pleasant did you find that melody?) on a 7-point likert scale, with 1 being highly unpleasant and 7 being highly pleasant (this scale (sometimes using 5-points) is common in much of the aesthetic and emotion research, for example, Blood & Zatorre (2001), Dellacharie, Roy, Hugueville, Peretz & Samson (2011), Koelsch, Fritz, Cramon, Muller & Friederici (2006), Menon & Levitin (2005), Salimpoor, Benovoy, Longo, Cooperstock & Zatorre (2009)). This question is essentially a guise to keep participants interested and motivated throughout exposure. Next, participants simply listened to a block of 20 tone sequences, followed by a block of 10 tone sequences for which participants were asked to rate each one as they did in the beginning. This block of

30 tone sequences continued three times for a total of 100 tone sequences (including the initial 10 rated tone sequences), which is approximately 25 minutes of exposure time.

Once exposure was completed, the testing phase began. Participants were presented with 30, two-alternative, forced choice items and were asked to choose which of the two tone sequences they preferred. There were three pair-types created by pairing tone sequences generated from exposed and unexposed distributions at each of the three levels of distinctiveness. There was ten of each pair-type making a total of 30 test items. All pairs were presented in a random order, and were arranged such that half were presented with the exposed item first and half with the exposed item second. By asking participants for preference, we hope to measure learning of these six pitch profiles in an implicit manner. We are also interested in how these preferences develop in their own right.

In order to avoid any additional, unwanted online learning of other tone sequence types during the testing presentations (it was believed this may be a problem, particularly because testing time was nearly as long as exposure time), intermittent “listening” trials were presented during the testing phase. The testing phase was broken into three groups of 10 items, with 20 of the standard level tone sequences presented between the three testing blocks. Participants were asked to simply listen to these tone sequences, as they were instructed in the exposure phase. These groups of 20 tone sequences were always from the standard exposed distribution in order to reinforce the previous exposure after presentation of the new tone sequence types during testing.

For both exposure and testing, new, random tone sequences were generated for each presentation. This means that every participant received different stimuli, but they

were all generated from the same models. This allows greater sampling from the tone sequence generation profiles, and reduces the influence of a possibly abnormal tone sequence if generated.

Results and Discussion

Results were scored according to two methods. The first sorted the data into the three pair-types that were then scored as percent correct, with correct defined as choosing the “exposed” item in the pair. Three independent t-tests comparing the two groups (Lydian and Hypophrygian) on percent correct at each pair-type revealed no significant differences between groups ($ps > .05$), therefore remaining analyzes were conducted by combining groups. Figure 3 shows the overall chance level of performance by participants at all pair-types. Three one sample t-tests were conducted (one at each pair-type) and all tests revealed participants did not score significantly above a chance level of 50% at any pair-type ($ps > .05$).

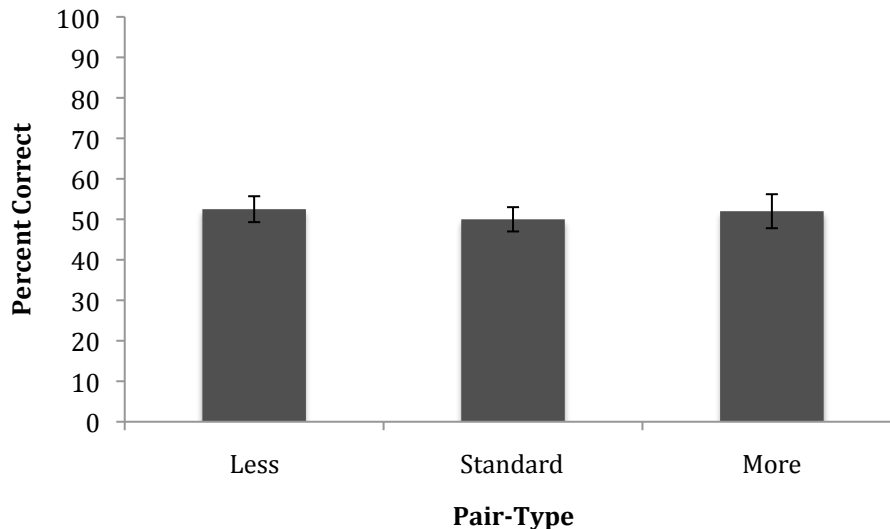


Figure 3. Average percent correct for each pair-type in Experiment 1. Error bars represent standard error of the mean. Correct was defined as choosing the exposed item in the pair. Note that the only tone sequences participants heard during exposure were those generated from the standard, exposed distribution.

The second scoring method looked at the pair-types including the different order of presentation and counted the number of times the exposed item was chosen in each pair-type. Order effect was analyzed using a 2 (order) x 3 (pair-type) repeated measures ANOVA. Figure 4 demonstrates the presence of an order effect at all pair-types such that participants tended to choose the more recent item they heard. There was a marginal main effect of order $F(1, 19) = 3.88, p = .064$, and no other significant main effects or interactions ($p > .05$).

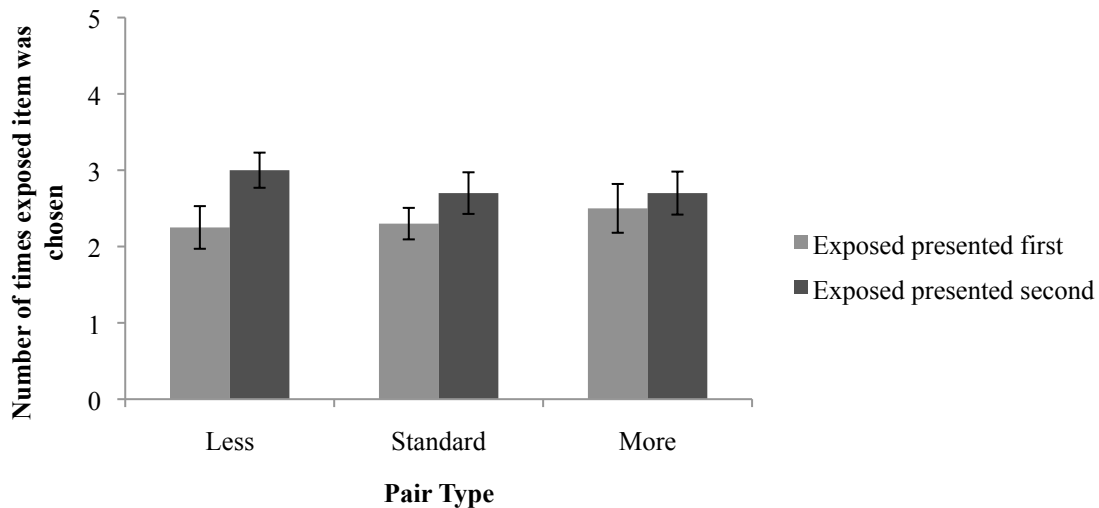


Figure 4. Average number of times the exposed item was chosen in each pair-type in Experiment 1, demonstrating an order effect. Error bars represent standard error of the mean. Note that the only tone sequences participants heard during exposure were those generated from the standard, exposed distribution. Exposed/unexposed here simply refers to the base distribution from which the levels of distinctiveness are drawn and whether participants were exposed to the standard version of that distribution.

Participant's responses on the music questionnaire can be found in Appendix C. There were no correlations between performance and MBEA score, years of formal music training, the items taken from the Music USE Questionnaire (MUSE) (Chin &

Rickard, 2012), education, gender or handedness at any level of pair-type ($.11 < r < .33$, $.16 < p < .66$).

Overall, results from Experiment 1 demonstrate that participants were unable to exhibit preferences for tone sequences generated from the distribution to which they were exposed, and were also unable to generalize any knowledge gained during exposure to the more or less distinctive versions of this distribution. With respect to the order effect found in Experiment 1, it seems likely that participants found this implicit task too difficult and simply chose the more recent item they heard.

CHAPTER 3

Experiment 2

Since results from Experiment 1 were not significant, it was deemed important to measure the learning more explicitly. Experiment 2 was designed to determine how well participants learned their assigned distribution, and how well they could generalize to the more and less distinctive distributions, using familiarity as a more explicit measure of learning.

Methods

Participants. 23 participants (15 female, 8 male) were recruited from Queen's University and were compensated \$15 for their time. No participant had more than five years of formal music training.

Stimuli. Stimuli were the same as Experiment 1.

Procedure. Procedure was the same as Experiment 1, except instructions for phase two were to choose which of the two tone sequences they found more familiar. Participants were told at the beginning that there would be two parts: the first phase

would involve listening to a number of melodies and rating some for pleasantness and the second phase would involve choosing between two melodies for familiarity. As in Experiment 1, in the beginning of the experiment, participants were not told phase two would be related to phase one and were not encouraged to memorize or intentionally attempt to learn anything during the exposure phase. However, once the exposure phase was complete, participants were told to base their familiarity judgment on what they heard in the first phase of the experiment.

Results and Discussion

Again, three independent t-tests comparing the two groups on percent correct at each pair-type revealed no significant differences between groups ($ps > .05$), therefore remaining analyzes were conducted by combining groups. Using the first scoring method from Experiment 1, Figure 5 shows that participants found the tone sequences generated from the exposed distribution more familiar than the tone sequences generated from the unexposed distribution at the more and standard distinctive pair-types, and to some extent, the less distinctive as well. This suggests that participants did learn the profile and could generalize to the more distinctive version, but seem to have found the less distinctive version more difficult. Three one sample t-tests were conducted (one at each pair-type) to compare performance to a chance level of 50%. At the more distinctive pair-type, participants performed significantly above chance, $t(22) = 5.24, p < .001$. At the standard distinctive pair-type, participants performed marginally above chance, $t(22) = 2.03, p = .054$. At the less distinctive pair-type, participants also performed marginally above chance, $t(22) = 1.88, p = .074$.

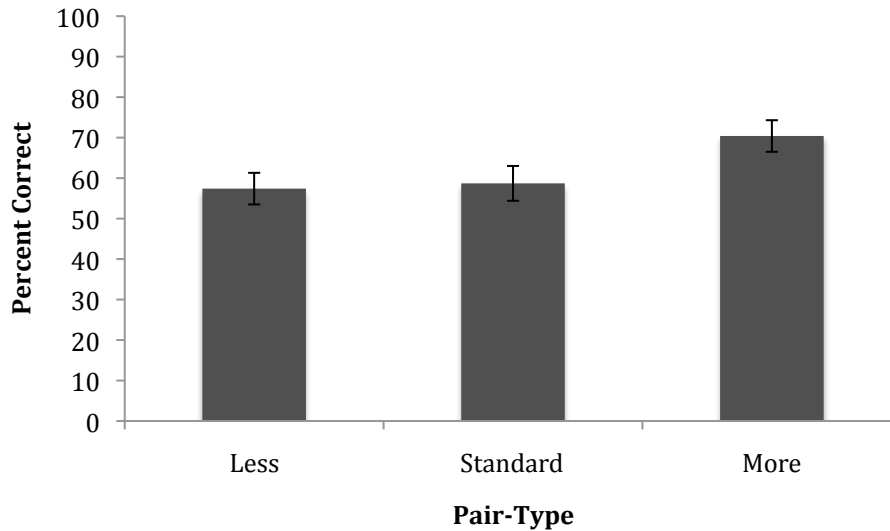


Figure 5. Average percent correct for each pair-type in Experiment 2. Error bars represent standard error of the mean. Correct was defined as choosing the exposed item in the pair. Note that the only tone sequences participants heard during exposure were those generated from the standard, exposed distribution.

Using the second scoring method from Experiment 1, a 2 (order) x 3 (pair-type) repeated measures ANOVA was conducted. As evident in Figure 6, the order effect was less prominent when participants performed better, that is, at the standard and more distinctive levels. There was a significant pair-type x order interaction, $F(2, 44) = 3.29, p = .047$. The order effect was then analyzed at each level of pair-type. At the less distinctive pair, there was a significant order effect, $t(22) = 2.55, p = .018$, such that the exposed item was chosen more often when it was presented first, than when it was presented second. There was no significant order effect at the standard or more distinctive pair-types, $p > .05$.

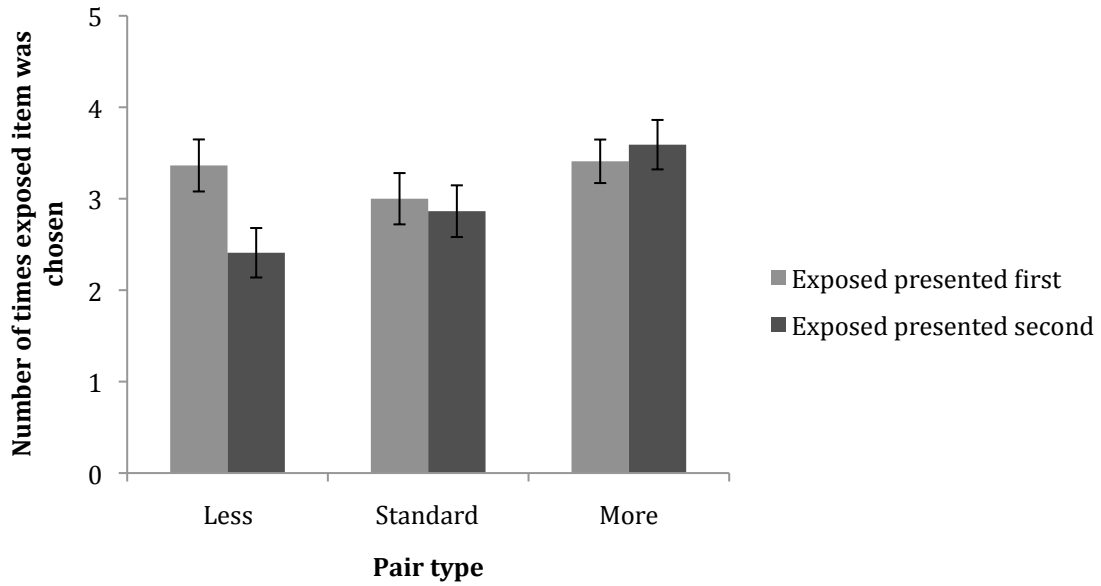


Figure 6. Average number of times the exposed item was chosen in each pair type in Experiment 2, with order effect. Error bars represent standard error of the mean. Note that the only tone sequences participants heard during exposure were those generated from the standard, exposed distribution. Exposed/unexposed here simply refers to the base distribution from which the levels of distinctiveness are drawn and whether participants were exposed to the standard version of that distribution.

Participant’s responses on the music questionnaire can be found in Appendix C.

There were no correlations between performance and MBEA score, years of formal music training, the items taken from the Music USE Questionnaire (MUSE) (Chin & Rickard, 2012), education, gender or handedness at any level of pair-type ($.12 < r < .35$, $.10 < p < .60$).

Results from Experiment 2 demonstrate that participants did indeed learn the distribution they heard during exposure and were able to generalize this knowledge to a more distinctive distribution, and to some extent, the less distinctive distribution as well. It may be suggested that exaggerating the properties of the exposed distribution aided in

participant's explicit recognition, and as this performance increased, the order effect became less prominent.

CHAPTER 4

General Discussion

This series of experiments demonstrates that participants are able to acquire knowledge about an exposed profile, and are also able to generalize this knowledge to a more distinctive version of the profile and to some extent, a less distinctive version as well. However, this knowledge only seems to be demonstrated in an explicit task and not an implicit task.

The difference in the order effect found between the two experiments is a noteworthy finding. In general, when performance was poor, the order effect was more prominent, suggesting that when participants are less confident in their choice, they tend to consistently choose the same item number. Experiment 1 demonstrated that when participants performed at chance levels, they tended to choose the more recent item they heard. Experiment 2 demonstrated an order effect only at the less distinctive level, which was also the level with the lowest performance. While it is strange that this particular order effect is in the opposite direction from Experiment 1, it is still interesting that the effect is significant only at the level with poorest performance.

Distinctiveness

Experiment two demonstrated that participants actually performed better when tested with tone sequences generated from the more distinctive profile. This is quite intriguing, as participants were never actually exposed to this version of the profile until the testing phase. It seems that exaggerating the properties of the profile to which they

were exposed, actually aided in participant's recognition. There is evidence from face recognition research that exaggerating important aspects of a stimulus can help in recognition (for review, see Rhodes, 1996). Rhodes, Brennan & Carey (1987) employed a caricature generator that created faces by either exaggerating the differences from the norm (caricature) or reducing the differences from the norm (anticaricature). They found that caricatures of familiar faces were recognized more quickly than the original faces, which were recognized more quickly than the anticaricatures. Our results mimic this finding as participants performed best at the more distinctive level and worst at the less distinctive level. A number of studies have demonstrated similar facilitation of learning and recognition using caricatured (or more distinctive) images during exposure (Kaufmann & Schweinberger, 2012; Powell, Letson, Davidoff, Valentine & Greenwood, 2008) particularly during more difficult conditions (Dror, Stevenage & Ashworth, 2008; Rodriguez, Bortfeld, Rudomin, Hernandez & Gutierrez-Osuna, 2009). The finding that the use of more distinctive visual images can enhance learning and recognition, combined with the results from the current study, suggests the possibility of a common characteristic of perceptual processing in both the visual and auditory domains such that sensory stimuli may be partly processed using distinctive features.

To the best of our knowledge, until now, there was no direct evidence that novel key profiles could be learned. However, since we demonstrated participants' ability to learn a novel pitch profile through limited exposure, it is possible that the key profiles and tonal hierarchy described by Krumhansl & Kessler (1982) may be acquired through statistical learning during exposure over time as suggested by Krumhansl (1990). The results found here also support the theory of a tonal hierarchy of salience as participant's

performance increased when the more probable pitches were made increasingly salient; that is, in the more distinctive version of the profile. It is clear that salient pitches are important for recognition of pitch probability profiles. Therefore, supporting the theory that salient pitches are important for acquisition of these profiles, and, by association, tonal hierarchies

Towards an explanation of dissociation

Loui et al. (2010) demonstrated a double dissociation between familiarity and preference as described earlier. The results found here support this with a single dissociation. Both Loui et al. (2010) and the current study suggest a disconnect between the mechanisms involved in recognition and those involved in aesthetic evaluation of musical stimuli. Kuhn & Dienes (2005) found a dissociation between liking and recognition of rule-based musical stimuli as well, however the results were in the opposite direction. This is more similar to the classic mere exposure effect where participants demonstrate a liking for exposed stimuli without conscious recognition. In this study, participants were exposed to melodies that followed an inversion rule. Using the C major scale, all tones were numbered 1-7. A sequence of four tones was created, such as 1 7 5 1, and was then inverted by subtracting each number from 8, giving 7 1 3 7, which was then combined with the first sequence of tones, and therefore gave the tune 1 7 5 1 7 1 3 7, or C B G C B C E B. Participants were then presented with melodies that either followed the rule or did not and were asked to classify them according to grammaticality and then rate them on a liking scale. Results showed that participants liked the grammatical items more than ungrammatical items but did not perform above chance at the classification task. The difference in findings found here and in the present

study may be due to a number of methodological differences. The stimuli used in Kuhn & Dienes (2005) contained durational differences in the tones, therefore creating a rhythmic component and perhaps making them sound more musical than the tone sequences used in the present study and in Loui et al. (2010). This may have caused them to be simply more pleasant in the first place. Another important difference is the length of the test melodies. Kuhn & Dienes (2005) used melodies that were eight tones in length while the present study used 50 tones in each tone sequence. These longer sequences could have prevented preferences from developing by not allowing holistic processing and forcing an analytic strategy. This will be discussed further below. It has been shown that less exposure (Bornstein, 1989), with instruction to memorize the exposure items (Newell & Bright, 2003), can increase the strength of the mere exposure effect. Both of these criteria were met in Kuhn & Dienes (2005) but not in the current study or Loui et al. (2010).

The next question is why is there a dissociation at all. Clearly it is possible for participants to perform both implicit and explicit tasks when it comes to grammar learning. In fact, the term “structural mere exposure effect” (for review, see Newell & Bright, 2001) has been coined to represent the finding of increased liking for items that are grammatically similar to items that were previously exposed. Numerous studies involving letter strings from artificial grammar learning research have demonstrated both an increase in liking and recognition for grammatically similar items after exposure (Forkstam, Elver, Ingvar, & Petersson, 2008; Gordon & Holyoak, 1983; Helman & Berry, 2003; Manza & Bornstein, 1995; Newell & Bright, 2001; Whittlesea & Wright, 1997; Zizak & Reber, 2004), therefore, demonstrating no dissociation in the visual domain. To the best of our knowledge, only one study of the structural mere exposure

effect using visual stimuli found the same results as the current study (recognition without preference). Participants were exposed to a finite state grammar involving unfamiliar Japanese or Chinese characters, as well as when using moderately familiar keyboard symbols (Zizak & Reber, 2004). The authors suggest that the structural mere exposure effect is dependent on the a priori familiarity of the stimuli such that the more familiar the items are to participants going into the experiment, the more likely the structural mere exposure effect will occur. It is possible that the present stimuli were too abstract for participants. Kuhn & Dienes' (2005) melodies may have been viewed as more familiar, particularly due to the simple rhythmic characteristics that were added, which may have allowed the effect to come through. Bornstein (1989) demonstrated in a meta-analysis that abstract paintings, drawings and matrices were the only stimulus-types to not show a reliable classic mere exposure effect. It is possible then, that there is something special about art-related stimuli in terms of developing appreciation. Abstract artwork may be viewed as too unfamiliar, and it may be more difficult to demonstrate a liking, or preference effect using this kind of stimuli. Perhaps the current study's stimuli fell into this category and resulted in a lack of preference.

It may be that auditory stimuli are processed differently than visual stimuli in terms of statistical learning. Conway & Christiansen (2005) have demonstrated that statistical learning in the auditory domain has a quantitative advantage over visual and tactile statistical learning as participants performed better when presented with tone sequences than when presented with visuo-spatial patterns or tactile patterns. They further demonstrated qualitative differences in the three senses where auditory memory relied more on end portions of the sequences. There is also evidence that musical

memory may be different in some ways from memory for other types of stimuli. A number of studies have demonstrated that explicit memory for music seems to be more sensitive to changes in surface structures (such as timbre) than implicit memory (Halpern & Mullensiefen, 2008; Peretz et al., 1998; Warker & Halpern, 2005), which is opposite to verbal memory where implicit tests rely more on perceptual memory than explicit tests (Roediger, Weldon, Stadler, & Riegler, 1992). Furthermore, the irrelevant speech effect (the finding that background speech sounds played during exposure presentations decreases test performance) has been shown in visual statistical learning studies (Neath, Guerard, Jalbert, Bireta & Surprenant, 2009), but not in the statistical learning of tone sequences (Collett, 2011 (unpublished Undergraduate thesis)) The fact that music and audition present contrasting results in memory and learning research suggests that it is possible that this finding of dissociation may be more common in musical stimuli, however, much more research is needed to draw any conclusions.

Strategies for Recognition and Preference

It has been shown that familiarity judgments tend to use analytic strategies whereas attitude judgments tend to use non-analytic strategies (Whittlesea & Price, 2001; Willems, Dedonder & Van der Linden, 2010). An analytic strategy can be described as picking apart details and features of the stimulus while a non-analytic strategy can be described as looking at the item as a whole. It seems plausible then that due to the complex nature of the statistical rules being learned during exposure and the fact that the test items were in fact novel items, an analytic strategy was required to recognize the appropriate tone sequences. In addition to this, the tone sequences used during the testing phase were quite long, and a holistic appraisal of the sequence may have been next to

impossible. It may also be difficult to analyze music in this holistic manner, as it is highly temporal. Therefore, in Experiment 1, when participants were asked to evaluate their attitude towards the tone sequences, they may have employed a non-analytic strategy that failed to recognize the correct item. However, when asked in Experiment 2 to judge familiarity, they employed an analytic strategy that succeeded in recognizing the correct items. One may begin to wonder then, how we develop preferences for our favorite kinds of music. It is possible that preferences may develop with longer exposure time, or shorter test sequences as this may cause the recognition to become easier and suggest a more holistic appraisal. On the other hand, it has been suggested that less exposure may be superior when inducing the mere exposure effect (Bornstein, 1989). Clearly, much more research is needed to explain the development of preferences in music.

It may be suggested in the current study that participants were expecting phase two of the experiments to be related to phase one, and so were employing a more conscious, analytic strategy during exposure to learn something about the tone sequences they heard. However, assuming expectations were the same in both Experiments 1 and 2 (instructions were the same for both at the beginning of each experiment, except for the preference/familiarity difference), this would not explain the difference in results for the two experiments (the dissociation discussed previously). It is possible that this assumption is incorrect, however current research in our lab suggests that if expectations about phase two are removed from the exposure phase, results remain dissociated. As well, most research on the structural mere exposure effect asks participants to attempt to memorize strings during exposure and still finds evidence of learning in both implicit and explicit tasks (Forkstam et al., 2008; Gordon & Holyoak, 1983; Helman & Berry, 2003;

Kuhn & Dienes, 2005; Kuhn & Dienes, 2006; Manza & Bornstein, 1995; Newell & Bright, 2001; Whittlesea & Wright, 1997; Zizak & Reber, 2004).

Conclusion

Overall, the results from this set of experiments demonstrate an impressive ability to not only acquire knowledge of a pitch probability profile, but also to generalize this knowledge to similar profiles. While this learning was only demonstrated in an explicit task and not an implicit task, the results support previous findings and suggest some very exciting areas for future research in musical rule learning.

References

- Bharucha, J., & Krumhansl, C. L. (1983). The representation of harmonic structure in music: Hierarchies of stability as a function of context. *Cognition*, *13*(1), 63-102. doi: 10.1016/0010-0277(83)90003-3
- Bigand, E., & Poulin-Charronnat, B. (2006). Are we "experienced listeners"? A review of the musical capacities that do not depend on formal musical training. *Cognition*, *100*(1), 100-130. doi: 10.1016/j.cognition.2005.11.007
- Blood, A. J., & Zatorre, R. J. (2001). Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proceedings of the National Academy of Sciences of the United States of America*, *98*(20), 11818-11823. doi: 10.1073/pnas.191355898
- Bornstein, R. F. (1989). Exposure and affect: Overview and meta-analysis of research, 1968–1987. *Psychological Bulletin*, *106*(2), 265-289. doi: 10.1037/0033-2909.106.2.265
- 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. doi: 10.1037/0096-3445.113.3.394
- Chin, T., & Rickard, N. S. (2012). The music USE (MUSE) questionnaire: An instrument to measure engagement in music. *Music Perception: An Interdisciplinary Journal*, *29*(4), 429-446. doi: 10.1525/mp.2012.29.4.429

- Collett, M. (2011). *Irrelevant speech effects and statistical learning of tone sequences*.
Unpublished Undergraduate Thesis, Department of Psychology, Memorial
University of Newfoundland, St. John's, Canada.
- Conway, C. M., & Christiansen, M. H. (2005). Modality-constrained statistical learning
of tactile, visual, and auditory sequences. *Journal of Experimental Psychology:
Learning, Memory, and Cognition*, 31(1), 24-39. doi: 10.1037/0278-7393.31.1.24
- Dellacherie, D., Roy, M., Hugueville, L., Peretz, I., & Samson, S. (2011). The effect of
musical experience on emotional self-reports and psychophysiological responses to
dissonance. *Psychophysiology*, 48(3), 337-349. doi: 10.1111/j.1469-
8986.2010.01075.x
- Dowling, W. J., & Harwood, D. L. (1986). *Music cognition*. Orlando: Academic Press.
- Dror, I. E., Stevenage, S. V., & Ashworth, A. R. S. (2008). Helping the cognitive system
learn: Exaggerating distinctiveness and uniqueness. *Applied Cognitive Psychology*,
22(4), 573-584. doi: 10.1002/acp.1383
- Forkstam, C., Elwer, A., Ingvar, M., & Petersson, K. M. (2008). Instruction effects in
implicit artificial grammar learning: A preference for grammaticality. *Brain
Research*, 1221, 80-92. doi: 10.1016/j.brainres.2008.05.005
- Gordon, P. C., & Holyoak, K. J. (1983). Implicit learning and generalization of the "mere
exposure" effect. *Journal of Personality and Social Psychology*, 45(3), 492-500. doi:
10.1037/0022-3514.45.3.492

- Halpern, A. R., & Müllensiefen, D. (2008). Effects of timbre and tempo change on memory for music. *The Quarterly Journal of Experimental Psychology*, *61*(9), 1371-1384. doi: 10.1080/17470210701508038
- Helman, S., & Berry, D. C. (2003). Effects of divided attention and speeded responding on implicit and explicit retrieval of artificial grammar knowledge. *Memory and Cognition*, *31*(5), 703-714. doi: 10.3758/BF03196109
- Huron, D., & Veltman, J. (2006). A cognitive approach to medieval mode: Evidence for an historical antecedent to the Major/Minor system. *Empirical Musicology Review*, *1*(1), 33-55.
- Kaufmann, J. M., & Schweinberger, S. R. (2012). The faces you remember: Caricaturing shape facilitates brain processes reflecting the acquisition of new face representations. *Biological Psychology*, *89*(1), 21-33. doi: 10.1016/j.biopsycho.2011.08.011
- Knopoff, L., & Hutchinson, W. (1983). Entropy as a measure of style: The influence of sample length. *Journal of Music Theory*, *27*(1), 75-97. doi: 10.2307/843561
- Koelsch, S., Fritz, T., v. Cramon, D. Y., Müller, K., & Friederici, A. D. (2006). Investigating emotion with music: An fMRI study. *Human Brain Mapping*, *27*(3), 239-250. doi: 10.1002/hbm.20180

- Krumhansl, C. L., Louhivuori, J., Toiviainen, P., Jarvinen, T., & Eerola, T. (1999). Melodic expectation in finnish spiritual folk hymns: Convergence of statistical, behavioral, and computational approaches. *Music Perception, 17*(2), 151-195.
- Krumhansl, C. L. (1990). *Cognitive foundations of musical pitch*. New York: Oxford University Press.
- Krumhansl, C. L., & Kessler, E. J. (1982). Tracing the dynamic changes in perceived tonal organization in a spatial representation of musical keys. *Psychological Review, 89*(4), 334-368. doi: 10.1037/0033-295X.89.4.334
- Krumhansl, C. L., Toivanen, P., Eerola, T., Toiviainen, P., Järvinen, T., & Louhivuori, J. (2000). Cross-cultural music cognition: Cognitive methodology applied to north sami yoiks. *Cognition, 76*(1), 13-58. doi: 10.1016/S0010-0277(00)00068-8
- Kuhn, G., & Dienes, Z. (2005). Implicit learning of nonlocal musical rules: Implicitly learning more than chunks. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*(6), 1417-1432. doi: 10.1037/0278-7393.31.6.1417
- Kuhn, G., & Dienes, Z. (2006). Differences in the types of musical regularity learnt in incidental- and intentional-learning conditions. *The Quarterly Journal of Experimental Psychology, 59*(10), 1725-1744. doi: 10.1080/17470210500438361
- Loui, P. (2012). Learning and liking of melody and harmony: Further studies in artificial grammar learning. *Topics in Cognitive Science, 4*(4), 554-567. doi: 10.1111/j.1756-8765.2012.01208.x

- Loui, P., Wessel, D. L., & Hudson Kam, C. L. (2010). Humans rapidly learn grammatical structure in a new musical scale. *Music Perception: An Interdisciplinary Journal*, 27(5), 377-388. doi: 10.1525/mp.2010.27.5.377
- Manza, L., & Bornstein, R. F. (1995). Affective discrimination and the implicit learning process. *Consciousness and Cognition*, 4(4), 399-409. doi: 10.1006/ccog.1995.1047
- Menon, V., & Levitin, D. J. (2005). The rewards of music listening: Response and physiological connectivity of the mesolimbic system. *Neuroimage*, 28(1), 175-184. doi: 10.1016/j.neuroimage.2005.05.053
- Meyer, L. B. (1956). *Emotion and meaning in music*. Chicago: University of Chicago Press.
- Meyer, L. B. (1957). Meaning in music and information theory. *The Journal of Aesthetics and Art Criticism*, 15(4), 412-424. doi: 10.2307/427154
- Neath, I., Guérard, K., Jalbert, A., Bireta, T. J., & Surprenant, A. M. (2009). Irrelevant speech effects and statistical learning. *The Quarterly Journal of Experimental Psychology*, 62(8), 1551-1559. doi: 10.1080/17470210902795640
- Newell, B. R., & Bright, J. E. H. (2001). The relationship between the structural mere exposure effect and the implicit learning process. *The Quarterly Journal of Experimental Psychology*, 54A(4), 1087-1104. doi: 10.1080/713756009
- Newell, B. R., & Bright, J. E. H. (2003). The subliminal mere exposure effect does not generalize to structurally related stimuli. *Canadian Journal of Experimental*

Psychology, 57(1), 61-8. Retrieved from

<http://search.proquest.com.proxy.queensu.ca/docview/200362058?accountid=6180>

Pearce, M. T., & Wiggins, G. A. (2006). Expectation in melody: The influence of context and learning. *Music Perception*, 23(5), 377-405. Retrieved from

<http://search.proquest.com.proxy.queensu.ca/docview/222225488?accountid=6180>

Peretz, I., Champod, A. S., & Hyde, K. (2003). Varieties of musical disorders: The montreal battery of evaluation of amusia. *Annals New York Academy of Sciences*, 999(1), 58-75. doi: 10.1196/annals.1284.006

Peretz, I., Gaudreau, D., & Bonnel, A. (1998). Exposure effects on music preference and recognition. *Memory & Cognition*, 26(5), 884-902. doi: 10.3758/BF03201171

Powell, J., Letson, S., Davidoff, J., Valentine, T., & Greenwood, R. (2008). Enhancement of face recognition learning in patients with brain injury using three cognitive training procedures. *Neuropsychological Rehabilitation*, 18(2), 182-203. doi: 10.1080/09602010701419485

Rhodes, G. (1996). *Superportraits: Caricatures and recognition*. Hove, East Sussex, UK: Psychology Press.

Rhodes, G., Brennan, S., & Carey, S. (1987). Identification and ratings of caricatures: Implications for mental representations of faces. *Cognitive Psychology*, 19(4), 473-497. doi: 10.1016/0010-0285(87)90016-8

- Rodríguez, J., Bortfeld, H., Rudomín, I., Hernández, B., & Gutiérrez-Osuna, R. (2009). The reverse-caricature effect revisited: Familiarization with frontal facial caricatures improves veridical face recognition. *Applied Cognitive Psychology, 23*(5), 733-742. doi: 10.1002/acp.1539
- Roediger, H. L., Weldon, M. S., Stadler, M. L., & Riegler, G. L. (1992). Direct comparison of two implicit memory tests: Word fragment and word stem completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*(6), 1251-1269. doi: 10.1037/0278-7393.18.6.1251
- Rohrmeier, M., & Rebuschat, P. (2012). Implicit learning and acquisition of music. *Topics in Cognitive Science, 4*(4), 525-553. doi: 10.1111/j.1756-8765.2012.01223.x
- Rohrmeier, M., Rebuschat, P., & Cross, I. (2011). Incidental and online learning of melodic structure. *Consciousness and Cognition, 20*(2), 214-222. doi: 10.1016/j.concog.2010.07.004
- Saffran, J. R., Johnson, E. K., Aslin, R. N., & Newport, E. L. (1999). Statistical learning of tone sequences by human infants and adults. *Cognition, 70*(1), 27-52. doi: 10.1016/S0010-0277(98)00075-4
- Saffran, J., Newport, E., Aslin, R., Tunick, R., & Barrueco, S. (1997). Incidental language learning: Listening (and learning) out of the corner of your ear. *Psychological Science, 8*(2), 101-105. doi: 10.1111/j.1467-9280.1997.tb00690.x

- Salimpoor, V. N., Benovoy, M., Longo, G., Cooperstock, J. R., & Zatorre, R. J. (2009). The rewarding aspects of music listening are related to degree of emotional arousal. *PLoS One*, *4*(10), e7487. doi: 10.1371/journal.pone.0007487
- Schellenberg, E. G. (1997). Simplifying the implication-realization model of melodic expectancy. *Music Perception: An Interdisciplinary Journal*, *14*(3), 295-318.
- Smith, N. A., & Schmuckler, M. A. (2004). The perception of tonal structure through the differentiation and organization of pitches. *Journal of Experimental Psychology: Human Perception and Performance*, *30*(2), 268-286. doi: 10.1037/0096-1523.30.2.268
- Temperley, D. (2007). *Music and probability*. Cambridge, Mass.: MIT Press.
- Thiessen, E. D., & Erickson, L. C. (2013). Beyond word segmentation: A two-process account of statistical learning. *Current Directions in Psychological Science*, *22*(3), 239-243. Retrieved from <http://cdp.sagepub.com/content/22/3/239.abstract>
- Warker, J. A., & Halpern, A. R. (2005). Musical stem completion: Humming that note. *The American Journal of Psychology*, *118*(4), 567-585. doi: 10.2307/30039086
- Whittlesea, B. W. A., & Wright, R. L. (1997). Implicit (and explicit) learning: Acting adaptively without knowing the consequences. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *23*(1), 181-200. doi: 10.1037/0278-7393.23.1.181

- Whittlesea, B. A., & Price, J. (2001). Implicit /explicit memory versus analytic/nonanalytic processing: Rethinking the mere exposure effect. *Memory & Cognition*, 29(2), 234-246. doi: 10.3758/BF03194917
- Willems, S., Dedonder, J., & Van der Linden, M. (2010). The mere exposure effect and recognition depend on the way you look! *Experimental Psychology*, 57(3), 185-192. doi: 10.1027/1618-3169/a000023
- Youngblood, J. E. (1958). Style as information. *Journal of Music Theory*, 2(1), 24-35. doi: 10.2307/842928
- Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology*, 9(2), 1-27. doi: 10.1037/h0025848
- Zizak, D. M., & Reber, A. S. (2004). Implicit preferences: The role(s) of familiarity in the structural mere exposure effect. *Consciousness and Cognition*, 13(2), 336-362. doi: 10.1016/j.concog.2003.12.003

Appendix A: Samples of the six tone sequence types

Lydian



Hypophrygian



Lydian Less Distinctive



Hypophrygian Less Distinctive



Lydian More Distinctive



Hypophrygian More Distinctive



Appendix B: Music Questionnaire

Acoustics Laboratory Questionnaire

1. What gender do you most identify with? _____
2. What is your first language? _____
3. Are you right handed? (Please circle your answer) Yes No
4. Do you have normal hearing? Yes No
5. What is your highest level of education?
 - A) Some High School
 - B) High School
 - C) Some Post-Secondary
 - D) Post-Secondary degree/diploma
 - E) Some Graduate studies
 - F) Graduate degree
6. Can you recognize your favourite songs if the lyrics are not present?
 - A) Yes- I can usually recognize a song from the tune alone
 - B) No- I usually require the lyrics in order to recognize a song
7. When you sing, do you sometimes sing “out of tune”- that is, sing wrong notes?
 - A) No
 - B) Yes, and I can tell when I am out of tune
 - C) Yes, but I cannot tell when I am out of tune unless someone else tells me
8. Do you consider yourself to be tone deaf?
 - A) Yes
 - B) No
9. What are your favorite styles/genres of music? (ex. Rock, pop, classical, etc.)

10. On average, how often do you listen to music in a week?
 - A) Less than once a week
 - B) 1-2 times a week
 - C) 3-4 times a week
 - D) 5-6 times a week
 - E) More than 6 times a week

11. On average, how many hours do you **purposely** listen to music a day (as opposed to music in the environment that you have no control over (e.g., music in cafes, stores)?

- A) Less than 1 hour per day
- B) 1-2 hours per day
- C) 3-4 hours per day
- D) 5-6 hours per day
- E) More than 6 hours per day

12. How many years of training have you had on voice or an instrument? (If you have studied more than one instrument or voice, report years for the *one* instrument or voice that you studied for the longest amount of time)

- A) Less than one year
- B) 1-4 years
- C) 5-8 years
- D) 8-10 years
- E) Over 10 years

13. How would you rate your music training experience?

1-----2-----3-----4-----5-----6-----7-----8-----9-----10
(Negative) (Neutral) (Positive)

14. What is the highest level of formal music training you have received?

- A) None
- B) Primary (Elementary) school music classes
- C) Secondary (High) school lessons
- D) Tertiary (University) undergraduate training, Conservatory of music or master classes
- E) Postgraduate training, or advanced overseas training

15. What other type of music training did you receive?

- A) None
- B) Self-taught (no formal training)
- C) Private (Individual) music classes / tuition
- D) Group music classes / tuition

16. Have you completed RCM (or equivalent such as Conservatory Canada) music examinations?

- A) No
- B) Yes, I have completed up to Grade for Theory and Performance/Practical (please fill in the highest Grade you have completed)

Thank you for your participation!

Appendix C: Music Questionnaire Results

Experiment 1

Question Number	Number/Proportion of Responses
1	14 <i>Female</i> , 6 <i>Male</i>
2	16 <i>English</i> , 4 <i>Other</i>
3	19 <i>Right-Handed</i>
4	20 <i>Yes</i>
5	1 <i>B</i> , 15 <i>C</i> , 1 <i>D</i> , 2 <i>E</i> , 1 <i>F</i>
6	20 <i>A</i>
7	2 <i>A</i> , 14 <i>B</i> , 4 <i>C</i>
8	20 <i>B</i>
9	18% <i>Pop</i> , 7% <i>Hip-Hop</i> , 29% <i>Rock</i> , 46% <i>Other</i>
10	1 <i>A</i> , 3 <i>C</i> , 4 <i>D</i> , 12 <i>E</i>
11	8 <i>A</i> , 5 <i>B</i> , 3 <i>C</i> , 2 <i>D</i> , 2 <i>E</i>
12	7 <i>A</i> , 13 <i>B</i>
13	1 <i>2</i> , 4 <i>3</i> , 2 <i>4</i> , 4 <i>5</i> , 4 <i>6</i> , 2 <i>7</i> , 2 <i>8</i> , 1 <i>10</i>
14	1 <i>A</i> , 10 <i>B</i> , 8 <i>C</i> , 1 <i>D</i>
15	6 <i>A</i> , 3 <i>B</i> , 9 <i>C</i> , 2 <i>D</i>
16	16 <i>A</i> , 2 <i>Preliminary</i> , 1 <i>Grade 4</i> , 1 <i>Grade 6</i>

Note: Results are based on all 20 participants. Question number in column 1 refers to the questions on the Music Questionnaire in Appendix B. Column 2 contains the values in Arabic, followed by the response options for that question in bolded italics. All values are raw counts except question 9 which presents the proportions of the most commonly mentioned styles/genres.

Experiment 2

Question Number	Proportion of Responses
1	15 <i>Female</i> , 8 <i>Male</i>
2	19 <i>English</i> , 4 <i>Other</i>
3	19 <i>Right-Handed</i>
4	20 <i>Yes</i>
5	20 <i>C</i> , 1 <i>D</i> , 1 <i>E</i> , 1 <i>F</i>
6	22 <i>A</i> , 1 <i>B</i>
7	4 <i>A</i> , 14 <i>B</i> , 5 <i>C</i>
8	20 <i>B</i> , 3 <i>C</i>
9	25% <i>Pop</i> , 11% <i>Country</i> , 21% <i>Rock</i> , 43% <i>Other</i>
10	2 <i>C</i> , 7 <i>D</i> , 14 <i>E</i>
11	6 <i>A</i> , 11 <i>B</i> , 3 <i>D</i> , 2 <i>E</i> , 1 <i>N/A</i>
12	7 <i>A</i> , 15 <i>B</i> , 1 <i>N/A</i>
13	1 <i>I</i> , 2 <i>2</i> , 1 <i>3</i> , 4 <i>4</i> , 3 <i>5</i> , 2 <i>6</i> , 2 <i>7</i> , 2 <i>8</i> , 5 <i>9</i> , 1 <i>N/A</i>
14	1 <i>A</i> , 11 <i>B</i> , 9 <i>C</i> , 1 <i>D</i> , 1 <i>N/A</i>
15	7 <i>A</i> , 5 <i>B</i> , 5 <i>C</i> , 5 <i>D</i> , 1 <i>N/A</i>
16	20 <i>A</i> , 2 <i>Preliminary</i> , 1 <i>Grade 2</i> , 1 <i>Grade 6</i> , 1 <i>N/A</i>

Note: Results are based on all 23 participants, however one participant did not answer page 2 of the questionnaire and so their responses for questions 11-16 were marked N/A. Question number in column 1 refers to the questions on the Music Questionnaire in Appendix B. Column 2 contains the values in Arabic, followed by the response options for that question in bolded italics. All values are raw counts except question 9, which presents the proportions of the most commonly mentioned styles/genres.

Appendix D: General Research Ethics Board Approval



August 03, 2012

Miss Meghan Collett
Master's Student
Department of Psychology
Queen's University
Kingston, ON K7L 3N6

GREB Ref #: GPSYC-571-12; Romeo # 6007226
Title: "GPSYC-571-12 Relating Predictability to Music Preference"

Dear Miss Collett:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled "GPSYC-571-12 Relating Predictability to Music Preference" for ethical compliance with the Tri-Council Guidelines (TCPS) and Queen's ethics policies. In accordance with the Tri-Council Guidelines (article D.1.6) and Senate Terms of Reference (article G), your project has been cleared for one year. At the end of each year, the GREB will ask if your project has been completed and if not, what changes have occurred or will occur in the next year.

You are reminded of your obligation to advise the GREB, with a copy to your unit REB, of any adverse event(s) that occur during this one year period (access this form at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Adverse Event Report). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example you must report changes to the level of risk, applicant characteristics, and implementation of new procedures. To make an amendment, access the application at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Amendment to Approved Study Form. These changes will automatically be sent to the Ethics Coordinator, Gail Irving, at the Office of Research Services or irvingg@queensu.ca for further review and clearance by the GREB or GREB Chair.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Yours sincerely,

A handwritten signature in black ink that reads "Joan Stevenson".

Joan Stevenson, Ph.D.
Professor and Chair
General Research Ethics Board

cc: Dr. Lola Cuddy and Dr. Nikolaus Troje, Faculty Supervisors
Dr. Leandre Fabrigar, Chair, Unit REB
Janessa Shorrock, Dept. Admin.