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Intelligence, Practice, Musical Ability, and Cognitive Complexity

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Abstract

This study addresses various factors that influence an individual’s level of cognitive complexity in the domain of music. Specifically, the links between intelligence, practice, musical ability, and musical cognitive complexity were assessed. It was hypothesized that higher intelligence, more hours of practice, and greater musical ability would predict greater musical cognitive complexity, and that intelligence, practice, and their interaction would predict greater musical ability. A total of 72 participants completed a questionnaire assessing number of hours practiced, musical experience, and intelligence. Additionally, they completed the repertory grid technique with musical elements in order to assess musical cognitive complexity. There was a significant positive correlation between intelligence and musical ability, a significant positive correlation between musical ability and musical cognitive complexity, and a significant positive correlation between practice and musical ability. Multiple regression results indicate that neither of the hypotheses were supported. Results are discussed in terms of implications that musical training may have for musical cognitive complexity.
Intelligence, Practice, Musical Ability, and Cognitive Complexity

When listening to the melancholy nocturnes of Chopin, or the improvised modal explorations of Miles Davis, it is difficult not to wonder how these musicians experienced music. Most people who attempt to play a musical instrument would agree that the acquisition of musical skill is no easy feat. It takes hours of practice just to develop the motor skills to accurately play one piece of music. It takes even more skill to artfully link a variety of notes into a cohesive composition that resonates with the listener. It seems only natural that individuals who developed their musical ability (through the understanding of scales, rhythms, chord progressions, and improvisation) would demonstrate greater musical cognitive complexity when compared to individuals who never developed the motor skills necessary to play a three-chord song. However, what role does intelligence play in this process and how might it interact with musical experience to enhance an individual's level of musical cognitive complexity? The focus of the present study is to explore the role of personal characteristics and musical experience as predictors of musical cognitive complexity.

The rationale for this study will be provided in three parts. The first section will address Personal Construct Theory as a foundation for understanding cognitive complexity. The following section focuses on variables that could potentially influence musical cognitive complexity, including intelligence, practice, and musical ability. The model for the current study will be presented in the third section.

**Personal Construct Theory**

Personal Construct Theory postulates that individuals differ in how they make sense of the world (i.e., how they construe) because people revise their perspectives based on what they experience (Experience Corollary, Kelly, 1955). Although there are many ways to analyze a
person’s intrinsic cognitive experience (e.g., fMRI studies, ERP signals), Personal Construct Theory (PCT, Kelly, 1955) has the capacity to assess how people make sense of their experience in a deep and meaningful way, tapping into idiosyncratic ways of thinking (Aldridge & Aldridge, 1996). Furthermore, PCT is capable of making predictions about an individual’s cognitive experience.

George Kelly (1955) suggested that individuals make sense of and give meaning to their experiences in a way that is similar to how a scientist conducts research. People create an idiosyncratic theoretical framework that allows them to anticipate events in terms of this system, known as a construct system in Personal Construct Theory. The core beliefs of individuals, their perspectives and biases, and the experiences that they have been through allow people to anticipate events. Humans are like scientists in that we develop hypotheses, or expectations from our theories, our personal construct system. We subject our expectations to testing, (e.g., if I do not speed, I will not get pulled over) and change our theory (e.g., if I do not speed and don't have a broken brake light, I will not get pulled over) when it does not apply. Furthermore, Personal Construct Theory posits that individuals have construct systems that allow them to make sense of the world. These constructs are bipolar in nature, such that the two labels can be placed at opposite ends of the spectrum (Dichotomy Corollary, Kelly, 1955).

In order to explore this personal construct system, Kelly (1955) developed the repertory grid technique. Kelly (1955) stated that a system of constructs is a type of conceptual grid where events can be analyzed in their psychological dimensions. Repertory grids are about constructs. Kelly (1955) defined a construct as a way that two or more things are similar and thereby different from a third; he utilized this definition in order to elicit constructs from individuals with the repertory grid. Three elements are presented to an individual; they are then asked to identify
how two of the elements are similar and different from a third. The participant then applies the opposing labels, e.g., “happy vs. sad”, thus resulting in a construct. This process is known as triadic elicitation. Originally, elements consisted of people (Kelly, 1955); however, since its inception, the use of different types of elements has expanded, including the use of art paintings and music pieces (Diamond, 1993; Hargreaves & Coleman, 1981; Gilbert, 1998).

The repertory grid technique has been validated through its ability to detect individual differences and is capable of detecting differences between individuals with varying degrees of musical experience (Gilbert, 1998; Thompson, 1988). Furthermore, it is capable of detecting differences between the creativity of individuals through the use of cognitive complexity (Quinn, 1980). This suggests that idiosyncratic ways of thinking are tapped with the repertory grid. One example of how constructs frame individuals' expectation for events can be found in music.

**Studies of PCT and Music.** The Experience Corollary, proposed in George Kelly's (1955) Personal Construct Theory, suggests that people who possess higher musical ability will make sense of music differently than individuals with lower or no musical ability, given that individuals with higher levels of musical ability revised their perspectives through continuous practice. The theory also posits that constructs are bipolar in nature, such that the two labels can be placed at opposite ends of the spectrum (Dichotomy Corollary, Kelly, 1955). This allows individuals to organize novel stimuli, including musical chords. An example of how constructs help individuals organize novel stimuli would be the construct major chord vs. minor chord. The C major, comprised of the notes C, E, G, is an example of a major chord. An example of a minor chord would be C minor, consisting of the notes C, E flat, and G. A musician who makes sense of music using the construct “major vs. minor chords” would be able to discern other major and minor chords that would not necessarily have C as their root note. That is, a musician who had
never heard the chord F minor before, but who utilizes the construct major chord vs. minor chord to make sense of music, would be able recognize that the novel stimulus F minor is not a major chord.

Several studies applied PCT to analyze how individuals with varying degrees of musical experience differ in how they make sense of music, including music therapists (Aldridge & Aldridge, 1996), music students (Gilbert, 1998), musicians and non musicians (Hargreaves & Colman, 1981), and experts (Thompson, 1998). These studies helped to develop predictions about how people make sense of music.

For example, it is important to know how music therapists make sense of music because of the potential impact it could have on a patient’s therapy. Aldridge and Aldridge (1996) used the repertory grid to understand how a music therapist, who was interested in how her patients developed their melodic playing, organized music with respect to the component of melody. The authors made the argument that the repertory grid is capable of eliciting deeper levels of idiosyncratic understanding that are not apparent in everyday life. Aldridge and Aldridge (1996) chose eight different melodies that were meaningful to the music therapist (two from Strauss, one each from Schostakowitch, Bach, Chopin, Janacek, Granados, and Dvorak). After selection of the musical pieces, called elements, three melodies were presented and the participant was asked which two are similar and which one is different, thus labeling the constructs at this point. Seventeen different constructs were elicited, including energetic vs. soft, indivisible vs. separable, balance vs. tension, closed vs. open, and coarse vs. tender. Her analysis of the constructs elicited from the repertory grid revealed that orientation (e.g., the construct, urge to move forward vs. holding back), forming (indifferent vs. arousing), feeling (deep vs. superficial), and musical (rhythmically uniform vs. turbulent melody) were important to how she construes
It is important to note, however, a major limitation of this study. There was only one participant; therefore, no comparisons between individuals with different levels of musical experience could be made. The authors would probably argue that the focus of the study was to explore how that particular music therapist made sense of music (given her role as a therapist) and to validate the repertory grid as a viable technique for undertaking such an exploration. Even though these limitations are present, the researchers provide evidence that the repertory grid can be used to assess how people make sense of music in a deep and meaningful way.

Gilbert (1998) provides evidence that individuals differ in how they make sense of music. The researcher, a music instructor at a school, was interested in the aesthetic development of her students, ages 9-18, and decided to analyze constructs elicited by music that they composed. It is interesting to note that the music samples used in this experiment were compositions from the children themselves, suggesting that any type of musical sample can be used in assessment. She divided the children into several groups in order to conduct a cross-sectional study. Her results indicate that different age groups use different types of constructs. For example, there was an increase in the use of constructs that could be categorized as “personal preference” (this was described as subjective judgments of music, including attitudes and preferences such as, good vs. bad), along with an increase in constructs that belonged to “artistic appraisal” (e.g., musical vs. non musical), for students between the ages of fourteen and sixteen. Those between the ages of sixteen and eighteen, on the other hand, had a similar number of constructs involving “aural perception” (e.g., in time vs. out of time) and “recognition” (e.g., drum vs. no drum). The “affective component” (how a certain song feels, e.g., happy vs. sad) of music also acquired greater importance, while constructs in the category of personal preference declined in number.
In essence, the researcher found that as students became older and gained more experience, the constructs they utilized changed. Gilbert (1998) states that these results are indicative of post-adolescent stage when an adolescent obtains the ability to synthesize information in a holistic way and to respond impartially, suggesting the acquisition of aesthetic knowing. It also suggests that differences in construal are present between individuals with varying degrees of musical experience. The types of constructs the music students used changed as they acquired more experience and became older.

Gilbert (1998) provides support for the idea that individuals differ in their construal of music. However, it is also possible that the students differed in their construal of music solely because of differences in age. Thus, a study that holds age constant but accounts for differences in experience is necessary.

Although these studies address how individuals make sense of music, no uniform method for analysis exists. Fransella (2004) suggests that researchers can create their own verbal categories for their own purposes, but this becomes problematic if all studies use different categories. Several researchers have chosen to apply the method of categorization in order to analyze the constructs elicited from their participants with the repertory grid (Aldridge, 1996; Gilbert, 1990; Thompson, 1998), but all the systems use different categories. It is therefore necessary that a system of classification be utilized that is more standardized. This would allow for prediction to be possible, as the same labels are applied universally. Hargreaves and Colman (1981) created this type of classification system.

Hargreaves and Colman (1981) provide a classification system that is capable of making predictions about the influence individual musical ability has on the construal of music. In order to assess musical experience, the participants were divided into three categories: no experience,
some experience, and experienced/practicing musician. Differences in constructs were assessed by creating different categories. Categorical constructs included those where participants classified music by its genre, such as “pop”, “rock”, or “jazz”. Objective-analytic constructs where those referring to the intrinsic qualities of the music, such as “fast”, “syncopated”, or “odd-time signature”. Objective-global constructs included those that refer to a musical piece as a whole while simultaneously paying attention to its intrinsic qualities, such as “religious”, “American”, or “twentieth century”. Affective constructs denote those of emotional value or evaluative response, such as “cheerful”, “weird”, or “mysterious”. Finally, Associative constructs associated music extragenerically, like “birds singing” or “the sea”.

Objective-analytic constructs were elicited most from participants with the most musical experience, whereas those with less musical experience mostly used affective constructs. This suggests that those with more musical experience construe music more analytically, while those with less musical experience construe music more affectively. Hargreaves and Coleman (1981) thus provided support for the claim that there are differences in how people make sense of music depending on their level of musical ability.

If individuals do indeed differ in how they make sense of musical because of their musical ability, then how do experts think about music? Thompson (1998) focused on adjudications (musicians who judge music competitions) in order to assess how experts make sense of music. Although these individuals are responsible for the outcome of music competitions, it is not clear how they arrive at their decisions. The author argues that the repertory grid can help clarify the way that adjudications come about their decisions. In order to assess how adjudicators judge musical performances, six different performances of a Chopin Etude were presented, all recordings from different pianists. The adjudicators listened to three
different pieces in consecutive order, and then continued by completing the repertory grid technique. In total, six constructs were elicited from each adjudicator, including tempo, rubato, form, pedaling, phrasing, right hand expression, and rhythm, suggesting that the repertory grid is capable of clarifying how adjudicators make sense of music. Of particular interest is that the results of Hargreaves and Coleman (1981) are consistent with the findings of Thompson (1998). Adjudicators, having extensive experience with music through their judging of competitions, produced only objective-analytical constructs. No associative, categorical, objective-global, or affective constructs were used by the adjudicators, suggesting that individuals with more musical experience do apply more objective-analytic constructs.

Collectively, these studies suggest that individuals differ in how they make sense of music, and that their experience with music influences how they perceive it, but how exactly does one measure these individual differences? The concept of cognitive complexity provides a way to analyze differences in an individual's subjective experience.

**Cognitive Complexity and Artistic Creativity.** Bieri (1955) introduced cognitive complexity, an objective method that analyzes the constructs elicited from individuals. Bieri (1955) stated that a system of constructs that is capable of differentiating highly among elements (in this case, musical excerpts) would be cognitively complex. A system that does not differentiate highly between elements would therefore be considered cognitively simple. Quinn (1980), applying the same method that Bieri (1955) used to analyze cognitive complexity, reported that creative writers who had published at least five works displayed a greater level of cognitive complexity, with people as elements, when compared to matched subjects without such experience. This suggests that individuals who are creative do display higher levels of cognitive complexity.
Further evidence suggests that students enrolled in an Arts and Science program display greater levels of conceptual complexity (Russell & Sandilands, 1973) than students enrolled in professional schools (e.g., medicine, law). However, these results have to be taken with caution, as the authors did not report what majors were included in the Arts and Science program, so it is not possible to know if the art or science majors lead to higher levels of conceptual complexity. Haller and Courvoisier (2010) also suggest that visual art students, when compared to other university students, displayed a greater level of personality complexity. Although this is not the same as cognitive complexity, this evidence suggests individuals involved in the arts exhibit higher levels of complexity.

The aforementioned results suggest that creative individuals demonstrate greater levels of cognitive complexity when compared to others (Quinn, 1980; Haller & Courvoisier, 2010). However, further research is necessary to establish whether these results will generalize to other creative domains, such as the musical domain and the cognitive complexity displayed by musicians, and to tease apart differences in complexity between individuals.

It is possible, however, that other factors also influence an individual's level of musical cognitive complexity. Intelligence and practice are two factors on which individuals demonstrate considerable variability. These factors could potentially predict levels of musical cognitive complexity.

**Individual Difference Factors**

**Intelligence.** The factors that are most likely to influence cognitive complexity (for musicians) are those that contribute to the acquisition of musical ability. Summation Theory (Ruthsatz & Detterman, 2008) proposes that the acquisition of musical expertise can be best understood through an analysis of various factors. Ruthsatz & Detterman (2008) suggest that the
acquisition of musical ability is the result of intelligence, practice, and musical aptitude. They conducted a study utilizing hierarchical multiple regression, with the variables of intelligence, practice, and musical aptitude used as predictors of musical expertise. Results indicate that each of these factors do indeed predict musical expertise (Ruthsatz & Detterman, 2008).

Other researchers also report relationships between intelligence and musical ability (Schellenberg, 2011a, 2011b; Hambrick & Meinz, 2011; Lynn, 1986), and some research even suggests that engagement with music enhances IQ (Schellenberg, 2004). The evidence presented by various researchers suggests that intelligence contributes to the acquisition of musical ability (Ruthsatz and Detterman, 2008; Schellenberg, 2011a, 2011b; Hambrick & Meinz, 2011; Lynn, 1986) and indicates that fluid intelligence could also be a predictor of cognitive complexity. Stakov (2000) proposes that there is a correlation between cognitive complexity and fluid intelligence, indicating that further exploration of the relationship is necessary.

**Practice.** Other research indicates that practice is a contributing factor to multiple cognitive abilities, including working-memory capacity and expertise. Neural imaging techniques (i.e., fMRI research) reveal that the superior temporal gyrus, the intraparietal sulcus, and several regions of the frontal cortex are activated when listening to music (Janata, Tillmann, & Bharucha, 2002). This suggests that multiple forms of working memory (e.g., attention, semantic processing, target detection, and motor imagery) are recruited by musical stimuli. Behavioral measures also suggest that musicians outperform non-musicians in visual, phonological, and executive memory, as well as exhibiting signs of faster updating of working memory, both in the visual and auditory domains (George & Coch, 2011). Thus, evidence suggests that musical practice influences working-memory.

Further evidence for the relationship between working-memory capacity and musical
training is provided by Wallentin, Nielsen, Friis-Olivarius, Vuust, and Vuust (2010). Participants completed the Musical Ear Test and the Digit Span Test. The Musical Ear Test is a measure which is capable of distinguishing between non-musicians, amateur musicians, and professional musicians. The Digit Span Test is a short term memory test. The researchers reported a significant positive correlation between musical ability and working memory capacity.

Further evidence suggests that there are other relationships between practice and cognitive abilities. Among the relationships between practice and cognitive abilities reported by researchers are pitch perception and phonological awareness (Tsang & Conrad, 2011), practice and visual-auditory ability (Moreno, Friensen, and Bialystock, 2011), and practice and reading comprehension (Corrigall and Trainor, 2011; Moreno and Besson, 2006). There is also a relationship between visual-motor skills and music training (Orsmond, 1997). This indicates that there is a relationship between various cognitive abilities and practice.

Several researchers also propose that practice is critical for the development of expertise in a domain, including the musical domain (Ericsson, Krampe, & Tesh-Romer, 1993; Howe, Davidson, & Sloboda, 1998; Ruthsatz & Detterman, 2008). Using a correlational design, Ericsson et al. (1993) found a relationship between the number of hours practiced and the ranking that instructors assigned musicians. More recently, Ruthsatz and Detterman (2008) reported that higher level musicians also had higher levels of accumulated practice time.

Collectively, this evidence suggests that there is a relationship between practice and various cognitive abilities, and that further exploration of what other cognitive abilities are related to practice (e.g., cognitive complexity) should be explored.

The Current Study

The current study proposes that intelligence, practice, and musical ability independently
contribute to an individual's level of musical cognitive complexity. Additionally, the interaction between intelligence and practice is expected to contribute to an individual's level of musical ability (See Figure 1). Specifically, it is hypothesized that

(1) greater intelligence, more hours of practice, and their interaction will predict higher levels of musical ability, and

(2) greater intelligence, more hours of practice, and greater musical ability will predict higher levels of musical cognitive complexity.

Figure 1

![Figure 1](image1)

Figure 2

![Figure 2](image2)
Method

Pilot Study

A pilot study was conducted with 7 participants from a California university through a Human Participant Pool (HPP). Participants received HPP credit for participating. The pilot study was conducted to see how long the study would take and if any modifications were necessary before the study was conducted. Participants completed a short form of Raven’s Progressive Matrices (Bors & Stokes, 1998), the repertory grid (Kelly, 1955), an assessment of the number of hours of musical instrument practice (Ericssons, 1993), and the Musical Ear Test (Wallentin et al., 2010). Results indicate that the mean of practice hours was 1585 ($SD= 1923.5$; range = 0 to 4756). The mean of intelligence scores was 3.6 correct answers, ($SD= 2.6$; range =0 to 8). The mean of musical ability scores was 68.3 correct answers ($SD = 5.9$; range= 57 to 76). Cognitive complexity scores had a mean of 35.2% ($SD =11.5$).

The planned methodology was to have a total of 21 constructs were elicited utilizing 21 elements. However, this method proved to be too time consuming; thus, the number of constructs was reduced to 8 and the number of elements to 12 (as suggested by Baldauf, Cron, & Grossenbacher, 2010, and Feixa, Moliner, Montes, Mai, & Neimeyer, 1992).
Since the practice form was modified from Ericsson's (1993) original work, there is no reliability coefficient for this measure. However, results of a pilot study indicated its validity, as individuals with more years of musical experience reported more hours of musical practice.

Participants

For the actual study, a total of 85 undergraduates were recruited from a California university through a Human Participant Pool (HPP). Participants received HPP credit for participation in the project. Both males and females participated and they did not have to be musicians in order to be included. All ethnic groups were included. The ethnicity of the participants consisted of Latinos (29.3%), whites (40.2%), American Indian (1.2%), Asian (13.1%), African American (3.6%), and multi-ethnic (8.3%). The average age of the participants was 22, with 66.7% females and 29.8% males. Thirty (42%) participants reported no musical practice, while thirty-nine (55%) reported musical practice. Fifteen individuals signed up to the study but did not complete any of the assessments and were not included in the rest of the analyses. The data of one participant was omitted, as the participant did not follow the instructions given in the beginning of the study. The total number of participants in this study was 71.

Measures

Intelligence assessment. General intelligence was assessed by a short version of Raven's Advanced Progressive Matrices (RAPM; Bors & Stokes, 1998). This assessment is a pattern recognition test that presents eight options. The participant has to select the choice that best fits the pattern. A total of 14 matrices were presented to the participant, with the first two used as examples. Scores represent the number of correct answer and can range from 0 to 12. The authors reported a mean of 7.01 ($SD = 2.56$) correct answers out of twelve problems for
university students, and a correlation of .92 between the full and short versions of the test, thereby demonstrating concurrent validity. For internal consistency, the authors reported a Cronbach's alpha of .73.

For this study, intelligence scores ranged from 0 to 12, with a mean of 5.48 ($SD=2.57$) correct answers. It should be noted that only 1 participant received a score of 0, suggesting this individual found the assessment difficult or did not try to complete the it to the best of his or her ability. Two participants scored a 1 on the assessment, the next lowest score in the range. Included is a histogram of the intelligence data (Figure 8). These scores were significantly lower than the reported population mean of 7.01, $t(70)=-5.02, p>.001$. Cronbach's alpha was .70 for this measure.

**Practice assessment.** In order to assess musical practice, a questionnaire was developed based on the work of Ericsson (1993). In order to assess number of hours they have practiced, participants were asked to first indicate at what age they started playing their instrument and whether or not they received formal music instruction (e.g., private music lessons, music theory courses offered at school). Participants were then asked to estimate the number of hours they practiced per week over their lifetime. The number of practice hours was used as their practice score.

Practice hours ranged from 0 to 12208, with a mean of 1197.22 hours practiced ($SD=2319.28$). The median score was 130 practice hours. The modal response was zero, as forty-two percent of the participants reported 0 hours of practice. Included is a histogram of the practice data (Figure 7).

**Musical Ability Assessment.** The Musical Ear Test (Wallentin et al., 2010) was used to assess musical ability. This test consists of 104 recordings (52 pairs of melodic phrases played...
on a piano and 52 pairs of rhythms played with a wood block) on which participants judge whether or not two musical phrases are identical. Half of the pairs are identical trials and half are different. The melodic session contains 3-8 tones played at 100 bpm (beats per minute), with 20 in the major key and 7 in the minor key. The test takes 18 minutes to complete. The Musical Ear Test was selected because it is capable of distinguishing musicians from non-musicians.

Wallentin et al. (2010) reported mean scores of correct answers for non-musicians (67.8%, $SD = 6.1$), amateur musicians (78%, $SD = 6.0$), and professional musicians (87.5%, $SD = 4.6$) and a Cronbach alpha of .85 for the test. A correlation between The Imitation Test and the Musical Ear Test ($r = 0.89$) suggest that the measure shows convergent validity. The score entered was the total number of correct answers from the 104 trials.

For this study, musical ability scores ranged from 51 to 85, with a mean of 68.59 correct answers ($SD=8.07$). Cronbach's alpha for the melody portion of the test was .70, .76 for the rhythm portion, and .75 for the two portions combined.

**Cognitive complexity assessment.** To assess musical cognitive complexity, the repertory grid (Kelly, 1955) was used. This technique is comprised of two components: provided elements and elicited constructs. The elements that were used in this study were twelve twenty-five second-long musical excerpts from a variety of musical styles. Excerpts from rock, jazz, classical, Indian music, Latin American music, rap and hip hop were each played for a total of twelve music clips. Three musical excerpts were presented together as a triad, and participants were asked to specify how two of the elements are similar and the third one different. For example, a participant who is presented with Chopin's “Funeral March”, “Happy Birthday”, and “Feliz Navidad” could potentially indicate that the Funeral March is sad and that the other two songs are happy. The construct elicited by these three songs would be: sad vs. happy. The
participant then rates all of the musical elements on a five point Likert scale (1=sad, 5=happy). In this example, the participant would be likely to indicate that “Happy Birthday” and “Feliz Navidad” are both a 5 on the sad vs. happy continuum, whereas the “Funeral March” is a 1.

The participant was then presented with another combination of the three songs (e.g., “While My Guitar Gently Weeps”, “Happy Birthday”, and “Feliz Navidad”). Once again, the participant was asked to indicate how two of them are similar and how the other is different. The participant might indicate that “While My Guitar Gently Weeps” is in a minor key, whereas “Happy Birthday” and “Feliz Navidad” are in a major key. The participant then ranks all the songs using the semantic differential technique, resulting in a 1 (minor key) for “While My Guitar Gently Weeps” and a 5 (major key) for the two other songs. Participants were presented with 12 sets of 3 musical excerpts. Next, the participant provided ratings (1-5) for each of the musical samples on every elicited construct. A 3 on the scale indicated that the musical excerpt does not fit under the construct. This triadic elicitation resulted in 8 constructs.

To assess musical cognitive complexity using the structure of the repertory grid, a Principal Component Analysis was conducted utilizing the program WebGrid (http://repgrid.csusm.edu/). This analysis results in a percentage, with lower scores on the first component indicating higher levels of cognitive complexity. Construct systems that highly differentiate between elements can be considered cognitively complex (Bieri, 1955). For this study, musical cognitive complexity scores ranged from 28.70% to 71.70%, with a mean of 44.96% ($SD = 9.52\%$).

**Procedure**

Once participants agreed to participate, an internet link with a questionnaire (which included demographic questions, The Music Use Questionnaire, and the practice assessment)
Results

Preliminary Analyses

For the preliminary analyses, the distributions of the data were inspected, descriptive statistics calculated (e.g., mean, standard deviation), and zero order correlations were examined. Idiographic analyses were conducted to explore differences between participants based on their level of practice and musical ability.

Assumptions. The assumptions of normal distribution, linear relationships, homoscedasticity, and independence of observations were checked. In order to check the assumption of normal distribution, Q-Q plots were assessed. All measures were normally distributed, except for the practice assessment, which was positively skewed and had a floor effect. Included is a histogram of the practice data (Figure 7). Therefore, the practice data was transformed using a square root transformation. The rest of the analyses were conducted using the transformed practice data. Low tolerance, ranging from .26 to .83, indicates the regression analyzing intelligence, practice, and their interaction as predictors of musical ability did not meet the assumptions of absence of multicollinearity. In order to address this issue, the transformed
practice variable was centered. This did not change the low tolerance, so the uncentered results are reported.

The second regression, which analyzed whether intelligence, practice, and musical ability are predictors of cognitive complexity, resulted in a Tolerance ranging from .82 to .90, suggesting that the assumption of absence of multicollinearity was met. However, given the non-normal distribution of the practice assessment revealed by the Q-Q plot, this test also did not meet the assumption of normal distribution of the data.

**Zero-order correlations.** Zero-order correlations were calculated. These results indicated that intelligence \((r(69) = .26, p < .05)\) and practice \((r(67) = .31, p < .05)\) were significantly correlated with greater musical ability. There was also a significant negative correlation between musical ability and musical cognitive complexity \((r(66) = -.29, p < .05)\), which was expected, given that lower cognitive complexity scores indicate higher levels of cognitive complexity.

There was no significant relationship between intelligence and musical cognitive complexity, \(r(66) = -.048, p > .05\). Given the non-normal distribution of the practice assessment, a nonparametric statistic was used to analyze the possible bivariate relationships between the major variables of interest. Results indicate a bivariate relationship between intelligence and practice \((\rho = .27, p < .05)\), practice and musical ability \((\rho = .42, p < .05)\), practice and cognitive complexity, \((\rho = -.28, p < .05)\).

**Hypothesis Testing**

There were two planned analyses: one in relation to musical cognitive complexity, and one addressing musical ability and its correlates.

**Hypothesis 1.** Intelligence and practice, along with their interaction, were expected to predict musical ability. In order to assess this hypothesis, multiple regression was used, with
intelligence, practice, and their interaction entered into the first step.

Regression results with the transformed practice data suggest that practice made significant contributions to musical ability ($\beta=.511$, $t(67)=2.3$, $p<.05$, $R^2=.17$, $F(3,65)=4.52$, $p<.05$), but intelligence ($\beta=.174$, $t(67)=1.41$, $p>.05$) and the interaction of intelligence and practice ($\beta=-.21$, $t(67)=-.89$, $p>.05$) did not.

**Hypothesis 2.** Intelligence, practice, and musical ability were expected to predict musical cognitive complexity. This hypothesis was tested by using multiple regression. Regression results suggest that musical ability, $\beta=-.26$, $t(64)=-1.41$, $p>.05$, intelligence, $\beta=.09$, $t(64)=.70$, $p>.05$, or practice $\beta=-.19$, $t(64)=-1.4$, $p>.05$, did not explain a significant portion of the variance in cognitive complexity, $R^2=.12$, $F(3,62)=2.94$, $p<.05$.

**Idiographic Data Analysis.** Idiographic data analyses were conducted to explore differences in construing based on participants’ practice hours and musical ability, this allowing to go beyond just asking whether or not there are differences between individuals. Idiographic data analysis allows for a more in depth analysis of the data given that we can explore the differences in the types of constructs that individuals use. Figure 3 represents the construct system of an individual with a higher level of musical ability and higher level of musical cognitive complexity, as the participant scored one standard deviation above the mean in both measures. The labels developed by Hargreaves and Colman (1981) were applied to analyze the labels of the constructs provided by the participant. The participant exhibited the constructs “alternative vs. rhythmic”, “modern vs. not modern”, “hip-hop vs. Latin roots”, “slow rock vs. heavy rock”, “classic hip hop vs. rock”, “slower vs. upbeat”, “mellow vs. fast”, and “metal vs. soothing”. Of the constructs used, the first five can be categorized as objective-global constructs, or constructs that refer to a musical piece as a whole, e.g., their genre. The construct
“slower vs. upbeat” can be categorized as an objective-analytic construct, as it refers to the intrinsic qualities of the music, such as their tempo or key signature. It is interesting that the constructs “metal vs. soothing” and “mellow vs. fast” could be classified as objective or affective, given that “metal” and “fast” are objective descriptions of the musical piece, while “soothing” and “mellow” are affective, as they are an emotional response or evaluation of the piece. These constructs will be denoted as objective-affective, as they consist of both objective and affective bipolar ends. In summary, this individual with a higher level of musical ability and musical cognitive complexity displayed only two constructs with an affective component, with six being of the objective nature, suggesting that he or she construes music technically.

Figure 4 represents the construct system of an individual with a lower level of musical ability and lower level of musical cognitive complexity, as the participant scored one standard deviation below the mean in both assessments. This participant used the constructs “heavy vs. flows”, “mellow vs. soothing”, “tranquilized vs. ecstatic”, “calm vs. excitement”, “tribal vs. chilled”, “higher beat vs. cruising”, “rocky vs. hip”, and “slowed down vs. upbeat”. The first four constructs can be categorized as affective constructs, or those of emotional value or evaluative response of the qualities of the music, as they describe the affective responses or qualities of the musical excerpts, e.g. “calm vs. excitement”. The constructs “tribal vs. chilled” and “higher beat vs. cruising” can be categorized as objective-affective constructs, as the bipolar ends consist of both affective, i.e., “chilled” and “cruising”, and objective, i.e., “tribal” and “higher beat”, components. The construct “rocky vs. hip” is an objective-global construct, i.e., a construct related to the genre or type of music. Finally, the construct “slowed down vs. upbeat” can be categorized as an objective-analytic construct. In summary, this individual with lower musical ability and lower musical cognitive complexity displayed more constructs with an
affective component, specifically, four affective constructs and two objective-affective constructs, suggesting he or she construe music more subjectively.

Figure 5 (219) represents the repertory grid of an individual that reported no practice time but exhibited a higher level of musical cognitive complexity. This individual used the constructs “different melody vs. similar rhythm”, “predominately guitar vs. predominately drums”, “slower tempo vs. upbeat”, “has lyrics vs. no lyrics”, “energizing vs. soothing”, “classical vs. modern”, “head bobbing vs. rock”, “good quality recording vs. poor quality recording”. The first four constructs can be categorized as objective-analytic constructs, or those pertaining to the intrinsic qualities of the song. The construct “energizing vs. soothing” can be categorized as an affective construct, as it pertains to an affective evaluation of the musical excerpt. The remaining three constructs can be categorized as objective-global constructs, given that they pertain to the musical excerpt as a whole, e.g., “rock vs. head bobbing”. In summary, this individual with higher musical ability used a total of seven constructs with an objective component, and only one affective construct, suggesting he or she is more technical in the analysis.

Figure 6 represents the repertory grid of an individual who reported more practice hours, and exhibited a higher level of musical cognitive complexity, scoring one standard deviation above the mean in both measures. The participant used the constructs “hip hop vs. jazz”, “classical vs. alternative rock”, “punk vs. soft rock”, “screamo vs. rock”, “Indian based vs. piano”, “easy listening vs. Latin based”, “percussion vs. jazz-rock”, “pop rock vs. smooth rock”. In summary, this individual utilized only objective-global constructs, as the constructs pertain to the genre and global assessment of the musical excerpts as a whole, suggesting that he or she is more technical in the analysis.

Discussion
This study focused on the relationship between various cognitive abilities. It was hypothesized that intelligence, practice, and their interaction would predict levels of musical ability, and that intelligence practice, and musical ability would predict levels of musical cognitive complexity. Intelligence and practice were related to musical ability, and practice and musical ability were related to musical cognitive complexity. Results indicated that although these variables were related at the bivariate level, multiple regression analyses did not support either hypothesis.

**Musical Ability and Correlates**

**Intelligence and Musical Ability.** Although there were no associations at the multivariate level, results at the bivariate level indicate a significant relationship between intelligence and musical ability. This suggests that highly intelligent individuals will also demonstrate high levels of musical ability. Several researchers have reported the relationship between intelligence and musical ability (Ruthsatz & Detterman, 2008; Schellenberg, 2011a, 2011b). It is possible that the two cognitive abilities are related because they both rely on working-memory capacity, that is, the amount of information an individual can process in their working memory (Wallentin et al., 2010).

Previous researchers have reported a relationship between intelligence and working-memory capacity (Ackerman, Beier, & Boyle, 2002; Redick, Unsworth, Kelly, & Engle, 2012; Conway, Cowan, Bunting, Therriault, Minkoff, 2002) and a relationship between musical ability and working memory capacity (Wallentin et al. 2010). The relationship found in the current study between intelligence and musical ability could potentially stem from an individual’s level of working memory capacity. If true, it suggests that the amount of information an individual is able to process could potentially influence the individual’s level of musical ability, along with
their intelligence. For example, consider pieces of music that musicians play. Musical pieces require the individual to retain various pieces of information for the song to be performed eloquently, including the timing when playing notes, length of different phrases, sight reading when required, and the dynamics present in a particular piece. The influence that working-memory capacity could have on musical ability would perhaps be most prevalent in individuals who perform improvised music. This type of musician needs to perceive, retain, and perform various musical tasks when they spontaneously create music. They have to make sense of novel information, including time signature, rhythm, key signature, key changes, and time changes, and adapt to them at a moment’s notice.

When viewed in this manner, it is easier to decipher a relationship between intelligence and musical ability. Intelligence allows an individual to interpret information in the environment and adapt to it as necessary (Sternberg, 1985), similar to how musical ability allows an individual to adapt to the changes found in music, especially those present in improvised music playing. Perhaps these two cognitive abilities are related because individuals who exhibit high levels of intelligence and musical ability are able to adapt more quickly to novel information, and what allows them to adapt more quickly is their working-memory capacity.

**Practice and Musical Ability.** Other variables are also related to musical ability, including practice. Regression results indicate that practice predicts levels of musical ability, explaining about 18% of the variance in musical ability scores. As people refine their skills in the musical domain through practice, they acquire higher levels of musical ability. This is consistent with Kelly’s (1955) Experience Corollary, as it suggests that people revise their perspectives based on what they experience. As individuals practice more, they revise their construct systems, as it allows them to more easily manipulate their musical instruments through
the development of motor and auditory skills. By revising their construct systems, they are able to differentiate between scales, key signatures, and time signatures, elements that are important for the mastering of a musical instrument. A useful approach to exploring how this reshaping occurs is to examine individuals’ level of cognitive complexity and how it relates to musical ability.

**Cognitive Complexity and Correlates**

**Musical Ability, Practice, and Cognitive Complexity.** Individuals with higher levels of musical ability and more hours of practice on a musical instrument exhibited higher levels of musical cognitive complexity, as suggested by the negative correlation between musical cognitive complexity scores and musical ability scores (given that lower cognitive complexity scores indicate higher levels of musical cognitive complexity), and the positive correlation between musical cognitive complexity and practice hours reported. Higher scores indicate that the construct system is more interrelated and suggests that people find more similarities between the different musical pieces, which indicates a lower level of cognitive complexity. Individuals with higher levels of musical ability and who practiced more hours on a musical instrument exhibited higher levels of musical cognitive complexity because they differentiate between musical stimuli much more so than individuals with lower levels of musical ability. It indicates that individuals with varying degrees of musical ability perceive music in a fundamentally different way. Those who have higher levels of musical ability exhibit higher levels of cognitive complexity because that is what is required for them to successfully play an instrument. For example, musicians have to pay attention to time signature, key signature, syncopation, and modulation of key to successfully play a song. This type of musical knowledge is technical and would be expected of someone who exhibited higher musical ability and who reported more
practice hours on a musical instrument. Individuals with lower musical ability or who never practiced a music instrument, however, would not need to rely on these types of technical constructs because their interaction with music is more casual, as they only listen to it, therefore using constructs related to how music makes them feel (Hargreaves & Colman, 1981).

This was supported after a qualitative data analysis of several repertory grids revealed a difference in the types of constructs people use. When comparing Figure 3 (representing the construct system of an individual with a higher level of musical ability and higher level of musical cognitive complexity), to Figure 4 (representing the construct system of an individual with a lower level of musical ability and lower level of musical cognitive complexity), the individual with lower musical ability and lower musical cognitive complexity displayed more constructs with an affective component, specifically, four affective constructs and two objective-affective constructs, whereas the individual with a higher level of musical ability and musical cognitive complexity displayed only two constructs with an affective component. This suggests that individuals with varying degrees of musical experience not only exhibit different levels of cognitive complexity, but also use different types of constructs; those with lower levels of musical ability use more affective constructs, whereas individuals with higher levels of musical ability use more objective constructs. The participant with a lower level of musical ability only used two objective constructs, whereas the individual with a higher level of musical ability used a total of six. The higher level of musical cognitive complexity displayed by the participant with a higher level of musical ability indicates that he or she was also better at differentiating between musical stimuli, as the individual teased apart minute differences, when compared to the individual with a lower level of musical cognitive complexity, who found more similarities in the musical excerpts.
Similarly, individuals with more hours practiced on a musical instrument displayed a more technical analysis. For example, when comparing Figure 4 (which represents the construct system of an individual with low musical cognitive complexity and no practice hours) to Figure 6 (representing the repertory grid of an individual who reported more practice hours and exhibited a higher level of musical cognitive complexity), the individual with no practice hours used two constructs with an objective component and six with an affective component, as opposed to the individual with more practice hours, who used only objective-global constructs. Once individuals have acquired enough practice, they are able to discern the technical structure of a song, including its rhythmic components and chords progression. These types of constructs are not as readily available to individuals with lower levels of practice because they do not need them, given that they do not play musical instruments.

These results support those of Hargreaves and Colman (1981), who reported that individuals with higher levels of musical ability used more objective constructs, and those of Quinn (1980), who reported higher levels of musical cognitive complexity for creative writers. This suggests that individuals with higher levels of musical ability have higher levels of musical cognitive complexity and that they are able to construe music in a more complex and differentiated way when compared to individuals with lower levels of musical ability. The results suggest that individuals with a higher level of artistic ability will exhibit higher levels of cognitive complexity in their specific domain.

Kelly (1955) provides an explanation for the pattern of responses displayed by participants. He stated that constructs that are easily verbalized indicative higher cognitive awareness, as opposed to those that are not easily verbalized, which are lower in cognitive awareness. This suggests that individuals who displayed a higher level of cognitive complexity
also displayed a higher level of cognitive awareness of music, given that they more easily utilized constructs that were directly associated with music. Those with lower levels of cognitive complexity were less cognitively aware of music, as they used more constructs that related to emotions. Potentially, higher levels of cognitive complexity, which is related to an individual's practice time and level of musical ability, could result in higher cognitive awareness. The question arises as to whether or not these increases in cognitive awareness would be domain specific. For example, would cognitive complexity in music transfer to another domain such as mathematical ability or working-memory capacity? If an individual increases his or her level of cognitive awareness and cognitive complexity through practice in a specific domain, it could potentially increase levels of cognitive complexity and cognitive awareness in a distinct, but similar cognitive ability. This would suggest that cognitive abilities are very interrelated, depending on one another to function optimally, similar to how a clock relies on the interaction of its components to function properly.

**Intelligence and Cognitive Complexity**

Although this study revealed a relationship between musical ability, practice, and cognitive complexity, no significant relationship was found between intelligence and musical cognitive complexity. This is of particular concern given that it was hypothesized that intelligence would predict musical cognitive complexity. Results of this study indicate that the two cognitive abilities are independent of one another. This may be due to the fact that intelligence is a highly heritable trait (Trzaskowski, Yang, Visscher, & Plomin, 2013) and therefore a more innate cognitive ability, whereas the level of musical cognitive complexity people display is much more malleable, as suggested by Kelly’s (1955) Creativity Cycle. It appears as if two different influences are underlying the two cognitive abilities, specifically,
those of nurture vs. nature.

Cognitive complexity can be changed based on what an individual experiences (Experience Corollary, Kelly, 1955), thus suggesting that one can nurture a construct system to become more cognitively complex. Kelly (1955) suggested that this is possible through the Creativity Cycle, which begins with loose construing, or a construct system that is less interrelated, and ends in a system that is more intercorrelated, or tight construing. It seems that it would be advantageous for people to be able to change and adapt their level of cognitive complexity to fit what they have experienced, as it suggests that learning is taking place.

The nature side of the argument can also help to explain why intelligence and cognitive complexity may not be related. Spearman (1904) proposed that intelligence consists of two factors: general, or “g”, and specific, or “s”, intelligence. General intelligence, the nature component, allows an individual to adapt to novel situations in various domains, whereas specific intelligence is particular to one domain, such as the musical domain. Raven's Progressive Matrices (1998), the measure used in this study, were developed to measure general intelligence. It is possible that the two cognitive abilities are not related because one measures “g”, whereas the other, the repertory grid, measures “s”. This would help to explain why musical cognitive complexity is related to musical ability (two abilities that pertain to the musical domain), but not to general intelligence. The relationships found in the study, and those that were not found, specifically the lack of relationship between intelligence and musical cognitive complexity, suggest that the measures of the study may have tapped into the two factors of intelligence proposed by Spearman (1904). This has important implications concerning the use of the repertory grid in future research. When coupled with a measure that quantifies general intelligence, the repertory grid could help measure an individual's level of specific intelligence,
as the results of this study suggest that higher levels of cognitive complexity indicate higher levels of “s” intelligence in a particular domain. It would be interesting to explore whether these results would generalize to other domains, including other arts and the sciences.

It is also possible that the two cognitive abilities are not related because cognitive complexity reflects how individuals perceive and construe their surroundings, which can change with experiences, whereas general intelligence could instead potentially reflect an ability to adapt to one's surroundings (Sternberg, 1985). It would be interesting to explore whether the construct system of a highly intelligent individual would more quickly become more cognitively complex through musical training, when compared to individual with a lower level of intelligence. Exploring this relationship could help to clarify the relationship between intelligence and cognitive complexity.

Limitations and Strengths

A major limitation of this study was the non-normal distribution of the practice variable. Nearly half of the participants reported 0 hours of practice. It was expected that this variable would be more normally distributed, but it seems that not everyone has practiced musical instruments. A second limitation of this study was that participants were asked to retrospectively account for the total number of hours practiced on a musical instrument. This method, which relies on the memories of participants, could be prone to errors and miscalculations, and perhaps influenced the reported hours of some participants. Finally, this study is correlational in nature; therefore, questions about the direction of causality cannot be addressed. For example, we cannot answer whether intelligence causes increased musical ability, or whether musical ability causes increases in intelligence.

Despite these limitations, there are several strengths in this study. For example, excerpts
of actual songs from varying music genres were used in order to assess musical cognitive complexity. This allowed for documentation of constructs that were directly related to the domain of interest. Furthermore, these constructs were participant generated, instead of being developed by the researcher, thus allowing for a more in depth analysis of idiosyncratic differences between participants. Another strength of the study is that it is high in external validity. The relationships found in the study were not manipulated, allowing for more generalizable conclusions when compared to experiments.

**Summary**

The results of the study suggest that there are many relationships between musical ability and other cognitive abilities, including intelligence, practice, and cognitive complexity. Musical ability is related to how an individual makes sense of music, so much so that a person with high musical ability thinks about music more technically and with more complexity.

**Future Studies**

The results of the study bring forth several questions for further exploration. It would be interesting to explore the direction of causality in the musical ability and musical cognitive complexity relationship. An experimental design would be capable of addressing this question. Participants could complete the repertory grid technique in the beginning of the study, complete an intervention that provides them with musical training, and then complete a post-test to measure if their level of musical cognitive complexity changes due to the intervention. This would require a longitudinal design, given that it would take the participant some time to obtain some knowledge of their instrument. Participants could be recruited from an undergraduate population that is receiving musical training for the first time in a university course. This longitudinal design would also be capable of addressing the methodological weakness present in
the current study: the practice assessment. Instead of relying on the memories of how many hours the participants have practiced in the past, they could fill out a daily diary with the number of hours they practiced. The intervention of music lessons would also help to address the non-normal distribution of the practice assessment found in the current study, as its skewed distribution was due to a large number of individuals without any practice hours. The intervention would ensure that the population of interest would actually have practice hours on an instrument.

Future studies should also address the idiographic qualities of the repertory grid, as this information can prove very useful in defining the types of constructs that the population uses to construe music. It is interesting that a brief qualitative analysis of the data resulted in a trend where individuals with higher levels of musical ability use more objective constructs when compared to individuals with lower musical ability, who used more affective constructs. It would also be interesting to explore whether music training affects other cognitive abilities, including mathematical intelligence and working memory capacity. This would allow researchers to explore the extent that musical abilities can impact other cognitive abilities, as results of this study indicate various relationships are present.

**Conclusion**

Results of the study indicate that intelligence and practice are related to musical ability, and that musical ability and practice are related to musical cognitive complexity. These results suggest that the cognitive abilities of an individual are interrelated, potentially to the point that in order to function optimally, they need to interact with each other. The various relationships reported suggest that intelligence and practice work together and contribute to an individual’s musical ability, and that musical ability and practice work together and contribute to an
individual’s level of cognitive complexity. It is plausible that these cognitive abilities interact in a manner similar to how the components of clocks work together in order to function properly, suggesting that an observable human behavior, like musical ability and cognitive complexity, is the result of various cognitive abilities working together and interacting, for example, intelligence and practice or auditory and motor functions, to produce such complex behaviors. This suggests that musical ability could potentially influence an individual’s level of intelligence, although it would be necessary to explore these relationships further through experimental designs so questions of causality could be addressed. If musical ability does have an impact on an individual’s intelligence, this would suggest that music training could have a deep impact in an individual’s life in non-musical domains, including academic performance in the classroom. It is also possible that increases in one cognitive ability, like musical cognitive complexity, could increase levels of a similar but distinct cognitive ability, for example, intelligence or mathematical cognitive complexity. These speculations would have to be explored experimentally, however. In conclusion, musical ability impacts how an individual makes sense of music, so much so that a person with high musical ability thinks about music more technically and with more complexity.
References


Figure 3

Percentage variance in each component
1: 31.0%  2: 23.8%  3: 15.9%  4: 10.9%  5: 10.0%  6: 4.9%  7: 2.4%  8: 1.1%
Figure 4

Percentage variance in each component:
1: 60.3%  2: 23.1%  3: 7.8%  4: 3.8%  5: 2.3%  6: 1.6%
Figure 5

Percentage variance in each component
1: 35.8%  2: 24.8%  3: 14.8%  4: 11.3%  5: 7.7%  6: 3.2%  7: 1.8%
Figure 7

Histogram

Mean = 1197.22
Std. Dev. = 2319.278
N = 69
Figure 8

Histogram

- Mean = 6.48
- Std. Dev. = 2.588
- N = 74

Frequency

Intelligence
Appendix A

Musical Experience

Consent Form

Invitation to Participate
Rafael Ayala, a graduate student in the Master’s program in General Experimental Psychology at California State University San Marcos (CSUSM) is conducting research to investigate music perception.

Description of Procedures
In this session, you will be asked to complete a computerized survey, taking between 15-20 minutes to complete. Subsequently, you will be asked to come into the lab in order to complete the study.

Risks
This study is designed in such a way as to pose little or not risk to participants. You may terminate your participation in this study at any time.

Confidentiality
Your survey responses will be kept confidential, available only to the research team for analysis purposes. These responses will not be in any way linked to your consent form. Consent forms will be locked in a safe place. Only the research team will view or analyze the information provided. In order to ensure anonymity, you will be assigned a unique Assigned Participant Number (APN). Your name will not be associated with the data.

Voluntary Participation
Your participation is entirely voluntary, and you may withdraw at any time. There is no penalty for withdrawing from the study.

Benefits
By completing this survey and arriving on time to your appointment, you can receive up to 8 HPP credits. At the end of the study, you will have the opportunity to join a mailing list concerning future updates on the study’s results.

Questions
If you have any questions about this study, please contact Rafael Ayala (951-834-7305, ayala029@cougars.csusm.edu) or Dr. Spencer McWilliams (smcwill@csusm.edu). If you have any questions about your rights as a research participant, please contact CSUSM’s Institutional Review Board at 760-750-4099.

1. Do you agree to participate in this study?
   - Yes
   - No

PLEASE NOTE THAT BY CONTINUING TO THE NEXT PAGE YOU AGREE TO PARTICIPATE IN THE STUDY.

2. Please enter your Assigned Participant Number (APN):

   APN: [Blank]
3. Gender:
   - Female
   - Male

4. Age:
   [ ] Age

5. What is your ethnicity (choose the category with which you most closely identify)?
   - [ ] American Indian/Alaskan Native
   - [ ] Asian/Pacific Islander
   - [ ] African American/Black
   - [ ] Hispanic/Latino/Latina
   - [ ] White
   - [ ] Multiracial (belonging to more than one ethnic group)
   - [ ] Other (please specify):

6. What was your major?
   [ ]

7. What is your GPA?
   [ ] 4.0 or above
   [ ] 3.6 - 4.0
   [ ] 3.1 - 3.5
   [ ] 2.6 - 3.0
   [ ] 2.1 - 2.5
   [ ] 2.0 or below

8. What is your approximate average household income?
   [ ] $0-$24,999
   [ ] $25,000-$49,999
   [ ] $50,000-$74,999
   [ ] $75,000-$99,999
   [ ] $100,000-$124,999
   [ ] $125,000-$149,999
   [ ] $150,000-$174,999
   [ ] $175,000-$199,999
   [ ] $200,000 and up

9. Are you:
   [ ] Left-handed
   [ ] Right-handed
   [ ] Ambidextrous

10. What is your native language?
    [ ]

11. Are you bilingual/multilingual?
    [ ] Yes
    [ ] No
12. If so, what languages? (Please specify if you can speak/read/write the language).
Example:
Spanish (speak/read/write)
English (speak/read/write)
Portuguese (read)

13. Are your parents currently involved with music in any way (sing, play an instrument, avid listeners, etc.)?
   Yes
   No

14. Are you tone deaf?
   Yes
   No
   Somewhat
   Don't know

15. Do you have absolute pitch?
   Yes
   No
   Don't know

16. On average, how often do you listen to music?
   Less than once a week
   1-2 times a week
   3-4 times a week
   5-6 times a week
   More than 5 times a week

17. On average, how many hours do you PURPOSELY listen to music a day (as opposed to music in teh environment that you have no control over, such as music in cafes or stores)?
   Less than 1 hour per day
   1-2 hours per day
   3-4 hours per day
   5-6 hours per day
   More than 6 hours per day

18. Have you played/did you play a musical instrument (includes singing, practice, and performance)?
   No
   Yes, I've played a music instrument for ___ years

   Number of years
   ___
19. At the peak of your interest, how many hours per day did you play/practice the music instrument (includes singing)?

I played/practiced _______ hours per day

(please fill in the hours of practice)

20. How long since you last regularly played a music instrument (includes singing, practice, and performance)?

- Less than a week ago
- Less than a month ago
- Less than a year ago
- Between 1 and 5 years ago
- Between 5 and 10 years ago
- More than 10 years ago

21. What is the highest level of FORMAL music training you have received?

- None
- Elementary school music classes
- Middle school music classes
- High school music classes
- University undergraduate training, Conservatory of music
- Postgraduate training

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

- None
- Self-taught (no formal training)
- Private (individual) music classes
- Group music classes

23. If you agree with the statement, check “Agree”. If you strongly disagree with the above statement, check “Strongly Disagree”.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not applicable to me</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
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<tbody>
<tr>
<td>Music is often a source of inspiration for me</td>
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<td>I often play challenging pieces</td>
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<td>There is a greater connection with my friends when we like the same music</td>
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<td>Music provides me with a good pace for exercising</td>
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<td>Music often takes away tension at the end of the day</td>
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<td>I often listen to new compositions</td>
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<td>I often look forward to attending music practices with my friends</td>
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<td>Certain type of music helps me think</td>
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<td>Mastering this piece of music gives me greater recognition as a performer</td>
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<td>Having similar tastes in music often helps me relate better to my peers</td>
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<td>Dance is an expression of my feelings</td>
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<td>I often listen to music when I'm feeling down</td>
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<td>I often get recognition from my friends from playing in the band</td>
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<td>I am able to make more friends when we like the same type of music</td>
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<td>Listening to music while exercising often helps me exercise for longer</td>
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<td>Specific types of music make me feel better</td>
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<td>Being able to improve while playing music gives me a great sense of satisfaction</td>
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</tbody>
</table>
### Practice Example

<table>
<thead>
<tr>
<th>Year</th>
<th>Age/Life Event</th>
<th>Estimated Practice</th>
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<tbody>
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<td>1987</td>
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<tr>
<td>1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>Started playing guitar (self-taught)</td>
<td>3 hours per day x 5</td>
</tr>
<tr>
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<td>played guitar</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>played guitar</td>
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</tr>
<tr>
<td>2002</td>
<td>played guitar</td>
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</tr>
<tr>
<td>2003</td>
<td>played guitar</td>
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</tr>
<tr>
<td>2004</td>
<td>played guitar</td>
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</tr>
<tr>
<td>2005</td>
<td>played guitar (started theory courses, started band)</td>
<td>2 hours per day x 5</td>
</tr>
<tr>
<td>2006</td>
<td>played guitar (theory courses, jazz ensemble, band)</td>
<td>2 hours per day x 5</td>
</tr>
<tr>
<td>2007</td>
<td>played guitar (jazz ensemble, band)</td>
<td>1 hour per day x 5</td>
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<tr>
<td>2008</td>
<td>played guitar</td>
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<tr>
<td>2009</td>
<td>played guitar</td>
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<tr>
<td>2010</td>
<td>played guitar</td>
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<tr>
<td>2011</td>
<td>played guitar</td>
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</tr>
<tr>
<td>2012</td>
<td>played guitar</td>
<td>1 hour per week</td>
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</tbody>
</table>
Appendix B