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A RELATIONAL STUDY OF SELF-TAUGHT AND FORMALLY TRAINED MUSICIANS: TRENDS WITHIN MEMORY AND SOCIOECONOMIC FACTORS

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Abstract

It has been well documented that musicians perform better in memory tasks than non-musicians. The current study utilized self-taught musicians, formally trained musicians, and non-musicians, and focused on short-term memory (STM), musicianship, and SES factors to explore this finding. Do the memory benefits of musical training extend to self-taught musicians? First, we addressed musicianship amongst all groups using the Goldsmith's Musical Sophistication Index (GMSI), which contained subjective and objective measures. The subjective measure was a survey regarding the role of music in daily life. In the objective measures, participants completed tests of beat and melody perception. To measure STM, participants completed an audio-only and audiovisual serial recall task. A correlational analysis was run to view relationships among the five subjective measures with one another and with the GMSI general score. Another correlational analysis was run between the general score and objective tasks. Performance on the recall tasks was examined among all groups. Lastly, recall scores and objective measures were tested for any correlations. Through a regression analysis, memory was predicted by musical training, and further analysis showed a difference in memory scores between musician groups. However, no differences were found in SES or aptitude between musician types, as they were not significant predictors. The significant difference in our memory variable indicates that there could be important differences in the two methods of learning music, and this finding could have broader implications for communities and individuals without the means of learning through school or private lessons. However, further research is warranted before firm conclusions can be drawn.

Introduction

Music and other art programs are being cut in many schools in modern American education (Bowen & Kisida, 2019; Major, 2013). The trend is typically seen in schools in lower socioeconomic status (SES) communities (Elpus, 2020; Elpus & Abril, 2019). This trend is unfortunate as involvement in music training has been associated with academic achievement in areas such as mathematics and reading skills (e.g., Holochwost, 2017; Kraus et al., 2014; Young et al., 2014). Another considerable benefit associated with musical training is higher memory capacity and overall cognitive abilities as compared to those without musical training (e.g., Ding et al., 2018; Hansen et al., 2012; Ramachandra et al., 2012; Talamini et al., 2016). However, the causal direction of this association is still unknown. Regardless of whether the musical training causes the previously stated benefits, the availability of musical training should still be viewed as efficacious for lower SES communities. The associated benefits may either help lower SES children develop useful academic and life skills and/or it can support more motivated lower SES children to develop otherwise latent abilities (dos Santos-Luiz et al., 2015). One option that may be of use to lower SES communities is the encouragement of individuals to learn music on their own, in a self-taught manner.

There is very little research comparing self-taught musicians with formally trained musicians; however, one recent study examined the differences between self-taught and formally trained musicians' auditory processing ability. In this study, they found that formally trained musicians were more likely to detect smaller differences in musical deviations compared to self-taught musicians (Zendel & Alexander, 2020). Their study utilized ERP components, which are voltages recorded from the scalp when a change in neural or psychological processes are occurring (Kappenman & Luck, 2011). For the purposes of the current research, the most

relevant outcome of their study was seen in the results of the P600, an ERP component that reflects violations in language or inflection (Meltzer & Braun, 2013). Zendel and Alexander (2020) defined the violations as deviant music notes in a melodic discrimination task. The formally trained group had significantly higher P600 activation when an out-of-tune deviation was presented to them compared to the self-taught and non-musician groups. However, in the out-of-key condition (i.e., a larger difference than out-of-tune) both musician groups were significantly higher in P600 activation compared to the non-musician group. Based on prior research, an out-of-key condition was defined by a deviant note within a melody not in the tonal key of the melody, while an out-of-tune condition was when a deviant note is within the tonal key, but mistuned by less than a halftone (Peretz et al., 2009). While the goal of Zendel and Alexander's (2020) study was to identify the auditory processing performance of two different musician groups, and the authors did not focus on memory performance, it established relevant background information regarding self-taught musicians and the similarities and differences between different types of musical training relative to non-musicians.

Another recent study that investigated differences between self-taught musicians, formally trained musicians, and non-musicians was Talamini et al. (2022). The goal of this study was to investigate the role of music training in the vividness of mental imagery, both visual and auditory. In order to measure subjective feelings of vividness, they utilized the Vividness of Visual Imagery Questionnaire (Marks, 1973) and a new variation of that called the Vividness of Auditory Imagery Questionnaire. Other measures of interest for Talamini and colleagues included music aptitude and cognitive abilities. Music aptitude was measured using the short Profile of Music Perception Skills (Zentner & Strauss, 2017) and cognitive abilities through the Wechsler Adult Intelligence Scale (Wechsler, 2008). One other methodological detail of

importance to our study was the definition that they established for formally trained and self-taught musicians. Formally trained musicians were individuals who were "conservatory students, music school students, and/or professionals"; while self-taught were musicians that had fewer than 2 years of music lessons other than school, and also self-disclosed that they were unable to read music notation (Talamini et al., 2022, p. 4).

It was found that musicians, self-taught and formally trained, had higher vividness scores in auditory imagery than the non-musicians, but not in the visual imagery vividness scores. A secondary relevant finding was that there were differences in their musician groups in aptitude scores, such that the formally trained musicians scored higher than the self-taught musicians. These results are similar to Zendel and Alexander (2020) in the out-of-tune condition, who also indicated some advantages in formal training. The main finding of Talamini et al. (2022) has two larger implications for our study. Differences were observed in the aptitude measure based upon the type of music training. This finding provided validation of the inclusion of a self-taught group in order to investigate potential differences in methods of learning in research in general and specifically in the current research as well. The auditory processing abilities seen in the results of Talamini et al. (2022) and Zendel and Alexander (2020) showed the use of auditory stimuli as ideal in measuring musicians' abilities. In these studies, we saw that musicians had higher auditory functioning within multiple cognitive abilities (auditory processing and auditory imagery). Thus, the higher auditory cognitive abilities of musicians were utilized in our study to investigate the differences in the methods of learning music with the inclusion of auditory-based recall tasks.

SES and Musical Training

One complex issue in the literature is the idea that an association exists between musical training and SES. It may make sense that lower SES families cannot afford private lessons or that schools in lower SES communities cannot fund music programs, yet the literature on this topic is inconclusive. We have reported a sample of research in Tables 1 and 2 to illustrate this issue. Table 1 consists of studies that reported correlations between the measures of SES and musical training. In Table 2, studies were included that compared groups of musicians' and non-musicians' SES. From the inconsistencies found in both Tables regarding multiple factors such as methodology, type of sample, and sample sizes, we can confirm that the relationship between SES and musical training is still fairly unknown.

For example, Norton et al. (2005) found significant differences in SES between a group of musicians and non-musicians (as measured by parental education). Another finding from this study was that participants' scores of musical aptitude were significantly correlated with scores of auditory analysis ($r = .573$). Interestingly, this trend is commonly seen in the literature and demonstrates that musical training shows positive associations with language-related skills (Forgeard et al., 2008; Miendlarzewska & Trost, 2014; Milovanov et al., 2009; Moritz et al., 2013; Swaminathan & Schellenberg, 2020). However, within this area of the literature, it is important to note the differences in measuring SES. While many studies use a combination of parental education, and family income (typically yearly income), some studies only included one of these variables or decided to keep these variables separate. One such study that used only one of these factors is Jakobson et al. (2008). In this study, they found no significant differences between SES, as measured only by parental income, between musician and non-musician groups. In line with much of the known literature, Jakobson et al. (2008) found a positive association

Table 1. Studies measuring the correlation between measures of musical training and SES.

Authors	Year	Sample Size	Population	Correlation	Other Measures
Corrigall & Schellenberg	2015	170	Children (M = 8.6, SD = 0.8)	0.23**	Intelligence, personality
Corrigall & Trainor	2011	46	Children (*M* = 7.6, SD = 0.9)	0.22	Intelligence, auditory perception, reading ability
Degé et al.	2015	55	Children (M = 6.26, SD = 4.02 months)	0.091	Intelligence, working memory, reading ability, musical perception
dos Santos-Luiz et al.	2015	110	Early adolescence (Musicians: *M* = 11.76, SD = 0.44), (Non-musicians: M = 11.75, SD = 0.70)	0.33**	Intelligence, motivation
Okada & Slevc	2018	150	Undergraduates (*M* = 19.26, SD = 1.11)	-0.04	Executive function (updating, inhibition, shifting), musical sophistication
Swaminathan & Schellenberg	2018	84	Undergraduates (*M* = 19.1, SD = 2.1)	0.315*	Working memory, Short-term memory, intelligence, openness-to-experience
Swaminathan & Schellenberg	2020	91	Children (*M* = 7.84, SD = 1.19)	0.00	Musical expertise, intelligence, vocabulary ability
Swaminathan, Schellenberg, & Khalil	2017	133	Undergraduates (*M* = 19.1, SD = 2.2)	0.23*	Musical aptitude, intelligence
Swaminathan Schellenberg, & Venkatesan	2018	166	Undergraduates (*M* = 19.3, SD = 2.4)	0.23**	Short-term memory, working memory, music perception, reading ability
Vuvan et al.	2020	234	Undergraduate (*M* = 20.64, SD = 3.23)	0.06	Musical training, working memory, preference for musical complexity

** = p < .05; ** = p < 0.01*

between musical training and memory ability.

Another unique technique for measuring SES was used by dos Santos-Luiz et al. (2015). In this study, they asked participants about SES by combing parental education [i.e., (a) both had a basic education, (b) one parent had basic education and the other had secondary education].

Table 2. Studies comparing musician and non-musician groups

Authors	Year	Sample Size	Population	P-value (< .05)	Other Measures
Degé et al.	2009	45	Late childhood (*M* = 10, SD = 9 months)	Mother's education, p = .642; Father's education, p = .181	Intelligence, musical abilities, spatial reasoning, self-concept
Jakobson et al.	2008	36	Undergraduates (*M* = 19.0, SD = 1.5)	p = .30	Intelligence, vocabulary learning
Norton et al.	2005	70	Childhood (musicians: *M* = 6.6, SD = 0.8; non-musicians: *M* = 6.1, SD = 0.7)	p = .028*	Intelligence, audition perception,

Significant differences in SES between groups. * = $p < .05$

The study demonstrated a significant correlation between musical training and SES and added to the evidence that musical training is associated with academic achievement.

As a reminder that the literature is inconsistent on the association between SES and music training, Degé et al. (2015) found no association between music training (as measured by melody perception, pitch perception, rhythm perception, tone length perception, and meter perception) and SES. In this study, SES was measured with a 3-point scale for parental education: (0) no parent with a university degree, (1) one parent with a university degree, or (2) two parents with a university degree; thus, indicating the variability in measurement of the construct of SES. Degé et al. (2015) found that phonological awareness was associated with melody perception, rhythm perception, and tone length perception.

While the association between SES and musical training reported in the literature does vary, research done by Schellenberg and Swaminathan is of particular importance to our current study (e.g., Swaminathan et al., 2017; Swaminathan et al., 2018; Swaminathan & Schellenberg, 2018). In Swaminathan and Schellenberg (2018), it was found that musical training was associated with SES, general cognitive abilities (as measured by intelligence), and openness-to-experience (personality measure). An interesting finding in this study was that those with lower levels of cognitive abilities had higher musical competence (beat and melody perception) if they had musical training, while those with higher levels of cognitive abilities had higher musical competence regardless of musical training. This finding could provide support for the possibility of a more powerful effect of musical training in lower SES communities. This is due to lower SES communities tending to show lower levels of cognitive abilities compared to higher SES communities (Brito et al., 2017; Burhan et al., 2017; Larson et al., 2015; Paulus et al., 2021). However, in Swaminathan and Schellenberg (2018), a multiple regression model including SES as a predictor showed that SES did not account for a significant contribution in predicting musical competence among participants.

While some research by Swaminathan and Schellenberg showed a significant correlation between music training and SES, their own work does show an inconsistent story, reflective of the overall literature. Swaminathan and Schellenberg (2020) found that not only were SES and musical training not correlated but that the correlation was completely absent (see Table 1). In two of their studies, SES was measured by the mother's and father's highest level of education, as well as yearly family income (Swaminathan & Schellenberg, 2018; 2020). However, it should be noted that while SES was measured similarly, music abilities were not; furthermore, the participant samples were drastically different as well. In the 2020 study, they used the Montreal

Battery of Evaluation of Musical Abilities and in 2018 they used the Musical Ear Test; both tests used same-different judgments, however, due to the 2018 population being children the test was in the format of a video game rather than laboratory-based experimental stimuli. While there were procedural differences to note, the differences in the samples (children vs. undergraduate) seem to be especially significant. Interestingly, in the sample of children, participants were recruited from a metropolitan area, possibly reflecting larger diversity in SES. However, the correlation between SES and musical training was not significant. Meanwhile, in the sample of undergraduates from a university, which may restrict SES, a significant correlation was noted.

Swaminathan and Schellenberg's body of work focused on the relationship between musical abilities and non-musical factors. Of the non-musical factors they have observed, the most relevant to our study was the relationship between SES factors and musical abilities. As mentioned above, factors that are known to play a role in an individual's SES are the father's highest level of education, the mother's highest level of education, and the total parental income (Swaminathan et al., 2018). However, in one particular study, mother's education was the only factor that made a significant contribution in a model of SES predicting musical training (Swaminathan et al., 2017). Another finding from the work of Swaminathan and Schellenberg was the association found between SES and other cognitive abilities outside of memory, such as reading ability, intelligence, and personality (Swaminathan et al., 2017; Swaminathan & Schellenberg, 2020). Swaminathan and Schellenberg were careful to note that like memory, the other cognitive abilities may not be caused by musical training. It may be the case that higher levels of cognitive abilities influence a person to participate in music lessons.

Music, memory, and causality?

One study that does claim a causal link between music training and memory abilities is work by Kraus et al. (2014). In this study, the researchers followed 26 participants as they completed 2 years of formal musical training through the Harmony Project. The Harmony Project is an organization that provides musical training for low SES children in the Los Angeles area. In this program, students learn how to play an instrument of their choice, as well as develop musical skills such as pitch-matching, rhythm skills, instrument-specific techniques, and music theory. The students were also evaluated by the teachers in the Harmony project. The students were rated on the percentage that they attended class and on their level of class participation. These two evaluations (attendance and participation) were thought to reflect a student's motivation. The students also completed a reading assessment prior to beginning the classes and once after the 2-year period. The researchers used the Test of Oral Word Reading Efficiency (TOWRE; Torgesen et al., 1999) in order to establish reading skills. In this test students would read one list of words and one list of nonsense words aloud as quickly as they could for 45 seconds; the words read correctly from the words list and nonsense words list were totaled to create a reading fluency score.

Lastly, auditory evoked potential (AEP) data were gathered prior to the musical training and after the 2-year period. AEP is an EEG that is recorded after the participant was given an auditory stimulus; it is meant to reflect the auditory ability of an individual (Paulraj et al., 2015). Three subcortical activities were recorded: speech harmonics, response consistency, and spontaneous neural activity. Speech harmonics was defined as the average amplitude of the frequency, response consistency referred to the consistency of the frequency during the first half of the stimulus presentation compared to the second half, and spontaneous neural activity was

neuronal noise the participants were experiencing. The results showed that after music training, the level of engagement was associated significantly with the speech harmonics activity and response consistency. In other words, after the 2-year period, if a student was engaged in their musical training through attendance and participation, they had higher and more consistent neural encoding than those who engaged less with their music training. In their study, the researchers claimed that the increase in participants' speech encoding was due to the musical training the participants completed. The reasoning behind this thought was that the neural measures recorded before the music training were not a significant predictor of music class attendance and participation. One point to mention regarding this study was that measuring SES in this sample and correlating it with musical training provided evidence that musical training is not entirely a high SES characteristic. The data were collected from a group of children from a lower SES status who were exposed to formal training.

While the Kraus et al. (2014) study defended the view that musical training causes academic improvement in low SES students, there is evidence that musical training can preserve normal development not typically seen in low-income students (Lam, 2014; Slater et al., 2014). In work by Slater et al. (2014), low-income students were given music training through the Harmony Project and tested for reading ability. Their reading abilities were measured at two time points that were one year apart; the first time point was before the musical training had begun and the second point was one year after the onset of training. The results showed that the students' reading scores remained the same from time one to time two, whereas the control group (low-income students without musical training) had significantly declined in their reading scores at time two. Furthermore, students demonstrated differences in a speech processing speed test. In this test, the control group showed no differences between the two time points and the musically

trained group showed significant improvement at time two. Whether musical training helped improve cognitive abilities or helped them remain consistent, it seems that these effects are necessary for lower SES communities. This is because we see lower academic achievement in lower SES students and schools (e.g., Caro et al., 2009; Goodman et al., 2012; Thomson, 2018). If musical training could help improve these deficits, perhaps it should be considered more valuable for lower SES schools.

Interestingly, the improved cognitive abilities thought to be associated with musical training were referred to as being related to academic achievement (dos Santo-Luiz et al., 2015; Kraus et al., 2014; Slater et al., 2014). However, an argument could be made that these cognitive abilities are just as important in one's routine life rather than solely in an academic setting. Reading ability, speech processing speed, memory, and intelligence are all cognitive processes that an individual may use not only in academic success but in all manners of success (e.g., job market, relationships, etc.). If formal training is not available, one might ask if becoming a self-taught musician produces similar outcomes to formal training; specifically, can we observe similar improvement in the associated cognitive abilities. Becoming a self-taught musician may be a more viable option for lower SES individuals, as one does not need to pay someone for music lessons, nor rely on school programs.

Overall, it should be evident that SES and musical training may be related to one another, or they may not, and the story is incomplete. The issue becomes more complicated as we see that even within one's own research, results may vary across research projects. One key point from the existing literature does seem to be that musical training benefits those in lower SES communities. However, this cannot be assumed as a causal relationship. A reason for the uncertainty in the literature is the difference in results when conducting cross-sectional or

longitudinal designs. Another reason for the lack of causality is due to the specific benefits (i.e., memory, intelligence, language skills, etc.) of music training in lower SES communities still being explored in research, which is also the case in the literature pertaining to the link between memory performance and music training.

Musicians and Short-term Memory

While the subject of self-taught vs. formally trained is still an emerging topic, there is extensive existing literature regarding the association between musicians and memory abilities (Talamini et al., 2017). The existing literature has established an association between musicians and multiple types of memory; including short-term, long-term, and working memory (Aizenman et al., 2018; Dittinger et al., 2021; Talamini et al., 2016). In one study looking at the association between music and memory, musicians performed significantly better in short-term and working memory tasks compared to non-musicians (Talamini et al., 2016). In their study, musicians and non-musicians performed digit recall tasks in an auditory, audiovisual, and visual modality. In order to make comparisons between performance on short-term memory tasks and working memory tasks, they had participants perform the tasks in each modality with an articulatory suppression condition in which the participants had to repeat the syllable "la" as they performed the serial recall tasks. The results showed that musicians performed significantly better than non-musicians in the auditory and audiovisual recall, whether performing with or without suppression in the auditory task and only without suppression in the audiovisual condition. However, there was no difference between the groups in the visual recall task, regardless of the suppression condition.

There are two hypotheses to explore why musicians outperformed non-musicians in both the auditory and audiovisual recall tasks. The first is that music training may help integrate

information from multiple sensory modalities. This may be due to musicians' constant exposure and practice with auditory stimuli (Ramachandra et al., 2012). In our current study, musician rehearsal is crucial. The format of self-taught practices vs. formally trained practices may provide musicians with different levels of sensory integration. The second is that musicians have a stronger reliance on auditory modalities in general (Talamini et al., 2016). Previous research supports the second hypothesis (e.g., Talamini et al., 2022; Zendel & Alexander, 2020) because there is a large amount of evidence suggesting that musicians have better auditory processing than non-musicians.

Schulze, Dowling, and Tillman (2012) showed further evidence that musicians tend to have higher short-term memory capacity than non-musicians. In Schulze et al. (2012) the stimuli were tonal, rather than a more typical span task as used in Talamini et al. (2016). Although the researchers stated that they were observing working memory while having participants complete an auditory tonal-based recall task, Schulze et al. (2012) is relevant to the current research question regarding musicians and memory in that a recall task is typically viewed as a tool for measuring short-term memory (Bopp & Verhaeghen, 2005; Woods et al., 2011). Participants in the Schulze et al. (2012) study were given recognition tasks with lengths of 5, 6, and 7 items; the items in this task were tones/notes in the C major scale for the tonal condition and random tones/notes not within the C major scale for the atonal condition. The participants had to listen to a set of tonal or atonal lists and then they were presented with a second set of tones of the same length. They then had to decide if the second list presented was the same or different from the first.

The results of Schulze et al. (2012) showed that both musicians and non-musicians had higher scores when the melodic sequence possessed tonal structure. More importantly for the

current study, while both groups performed significantly better in the tonal condition, the musician group performed better than the non-musician group at all list lengths. As mentioned above, Ramachandra et al. (2012) thought this type of finding may be due to musicians' exposure and practice with auditory stimuli. There was a similar conclusion drawn from both Schulze et al. (2012) and Talamini et al. (2016), indicating that musicians have higher short-term memory capacity compared to non-musicians for auditory stimuli rather than visual stimuli. Motivated by these findings, the stimuli used in the current study were auditory and audiovisual measures of memory.

Goldsmith Musical Sophistication Index

The current study focused on the potential interaction of SES with musician type, self-taught or formally trained, and there is an alternative to having dichotomous groups (musician vs. non-musician) seen in previous research designs. One approach is the Goldsmith Musical Sophistication Index (Gold-MSI; Müllensiefen et al., 2014). By using this index, an individual can be ranked on a continuous scale from low to high musical sophistication (Müllensiefen et al., 2014). The Gold-MSI is a reliable index that has been adopted by music psychology research in order to determine a person's musical sophistication (e.g., Baker et al., 2018). The Gold-MSI is a useful tool in our current study as it can determine the musical sophistication of all groups, regardless of musical training, professional experiences, or musical education.

The Gold-MSI is broken into two parts, utilizing objective and subjective tasks. The objective tasks are two music tests that determine the participant's ability to distinguish deviations in melody and rhythm. The melodic memory task was formerly a same-different discrimination task between two melodies. Participants were given two short melodies and they decided whether they were the same melody or two different melodies (Müllensiefen et al.,

2014). In the current and most recent version of the test, the melodic memory task is now referred to as the melody discrimination task (MDT). This updated version is an adaptive test that adjusts to the skills of the user as they complete the task (Harrison et al., 2017). In the MDT the participant is presented with three melodies, and the three melodies are identical in notation (phrasing, intervals, etc.); however, each melody is in a different tonal key. The target difference is that one of the melodies contains a deviant note (out-of-key). Similarly, the beat perception task also has an original and updated version. In the original version participants were presented with two identical melodies and each melody was accompanied by a metronome. Participants then had to decide which of the metronome tempos matched the tempo of the melody. In the updated beat perception task, called the computerized adaptive beat alignment task (CABAT), it is the same task as the original except that the difficulty adjusts to the user's skills (Harrison & Müllensiefen, 2018).

The subjective portion of the Gold-MSI is a self-report survey that aims to discover participants' musical involvement. It is broken down into 5 sub-scale factors and each factor contains 6-9 survey items. The first factor is titled "active engagement." Items contained in this factor are concerned with the individual's involvement with music in their daily life (Müllensiefen et al., 2014). Example items are: "what music events have you attended," "how much money have you spent on music," or "how much time do you spend listening to music." This factor may reveal whether there are any differences in the way self-taught and formally trained musicians spend their time with music outside of practice.

The second factor is "perceptual abilities." This factor deals with an individuals' ability to cognitively process music (Müllensiefen et al., 2014). Example items for this factor are: "can you spot a mistake in a performance," "can you identify musical genres," or "how well can you

judge others' beat performance." This factor may be useful in identifying musicality in nonmusical persons, such as DJs or dancers. These careers do spend a large amount of time listening to music without playing an instrument.

The third factor in the Gold-MSI is "musical training." This factor addresses many items that would be considered traditional in determining a formally trained musician. It focuses on things such as hours spent on practice, years spent on training, and possibly the most important item, whether the individual considers themselves a musician. Regarding this factor, it is expected that this may be the only factor to possess major differences between groups because musical training is the defining feature that separates the classification of self-taught and formally trained. That is not to say that self-taught musicians should be considered non-musicians, but that there are differences among the training tactics as compared to formally trained musicians, which have a more traditional teacher-student dynamic. Thus, this factor should have high scores in whether the participant "considers themselves a musician," regardless of the musician group, and a variety of scores with questions that are explicitly referring to the degree of formal training one has obtained.

The fourth factor is "singing abilities." This factor is meant to assess the participants' overall ability to sing (Müllensiefen et al., 2014). A few items within this factor are "can you sing a song back after hearing it a few times," "are you nervous to sing in public," or "can you sing harmonies with a familiar tune." This factor, similar to the second factor, may be useful in identifying musicality within the general population, which is the goal of the Gold-MSI (Müllensiefen et al., 2014; Zhang et al., 2020).

The final factor, factor five is titled "emotions." This factor measures participants' emotional connection to music (Müllensiefen et al., 2014). Items contained in factor five are

phrases such as “did this evoke memories,” “do you pick music that sends shivers down your spine,” or “how often does music evoke emotions.” This is an interesting factor because it seems to be skewed when surveying a young population such as college-aged individuals (Baker et al., 2018).

Since its creation, the Gold-MSI has been used in multiple studies to assess the musicality levels of participants (Küssner & Erola, 2019; Song et al., 2016; Straehley & Loebach, 2014; Zhang & Schubert, 2019). One vital paper in the current literature is the Baker et al. (2018) study in which their goal was to replicate and validate the original Gold-MSI study on a much smaller, pragmatic scale. The study was successfully replicated as the means and standard deviation among all five subscales and the overall scores in the Baker et al. study (2018) were similar to the Müllensiefen et al. study (2014). There are however two points recognized that should not be ignored. The first point is that all studies focusing on musical perception should include some test of memory capacity, intelligence, or any other confounding factor, as these tests can show that along with musical sophistication other factors may be at play (Baker et al., 2018). These confounding factors may have a unique influence on the outcome of any musical perception tests. Therefore, to determine a more accurate correlation it is important to understand the individual influence of confounding variables when testing for musical perception. The second point is that researchers should not bundle abilities together to form some singular latent variable and state this variable as the singular predictor variable (Baker et al., 2018). Considering the points mentioned in Baker et al. (2018) can help reduce noise in musical perception measurements, creating a more accurate picture of musical effects on the general population (Baker et al., 2018).

Another study using the Gold-MSI found that the subscales (described previously) used in the survey portion are correlated with other relevant musical performance skills (Zhang et al., 2020). The researchers analyzed five musical performance skills: performing rehearsed music, sight-reading, playing from memory, playing by ear, and improvising. Each of these skills are useful for most western musicians, however, the importance of each skill may depend on the performance environment. That is, if one is more of a classical performer perhaps performing rehearsed music and sight-reading may be more important, as these skills are the foundation of music education in America today (Woody & Lehmann, 2010). The results from Zhang et al. (2020) showed that four out of the five (all but sight-reading) performance skills were significantly correlated with at least one of the subscale factors within the Gold-MSI. Active engagement correlated with playing by ear and improvising, perceptual abilities correlated with playing by memory, and musical training, singing abilities, and emotion correlated with performing rehearsed music (Zhang et al., 2020). Each performance skill analyzed in the study was significantly associated with the overall Gold-MSI score. The study showed that the subjective portion of the Gold-MSI is not only a good measurement of musical sophistication but also an accurate indicator of musical skill. The relationship with the largest magnitude with the overall Gold-MSI score was playing by ear. This finding suggested that playing by ear may be the most important skill in performing music and in one's degree of musical sophistication (Zhang et al., 2020). Future research could explore this topic of "playing by ear" and its relationship with type of musician (self-taught vs. formally trained).

Current Study

In this study, we investigated the relationship between musical training and SES, and the differences among the type of musician training. The unique approach of our study is the

inclusion of a scarcely researched group, self-taught musicians. From the limited literature, we can see that there is a difference between the two musical groups' cognitive abilities (Talamini et al, 2022; Zendel & Alexander, 2020). A formally trained musician in the context of our study is a musician that learned through means of an active teacher-student dynamic, whether that dynamic took place in the form of schooling or private lessons. A self-taught musician is an individual that learned music through means of unidirectional learning (sans direct feedback), that is, through online videos, by ear, or from reading instructional books. In this study we hypothesized that self-taught musicians would tend to be from lower SES communities, however, this method of learning will not lead to a reduction in the associated memory benefits or overall musicianship of the participants. We explored this question by measuring the musicianship of both musician groups by way of subjective and objective measures, and by attempting to obtain a sample of participants with a wide range of SES backgrounds.

Methods

Participants

Participants were students recruited through the Louisiana State University's (LSU) recruitment website, Sona. Students were surveyed at the beginning of the experiment if they classified themselves as self-taught, formally trained, or N/A (representing a non-musician).

Participants were recruited at two separate time points (see Figure 1 for a diagram of the recruitment process). One cohort of participants was recruited prior to August 2021 and returned for a second session after August 2021, while the second cohort of participants completed the entirety of the experiment in one session after August 2021. For those that completed the experiment in a two-session format, they were given extra/class credit through Sona for completing session 1 and a reward of $15 for their completion of session 2. The participants that completed the experiment in one session after August 2021 were given only extra/class credit through Sona.

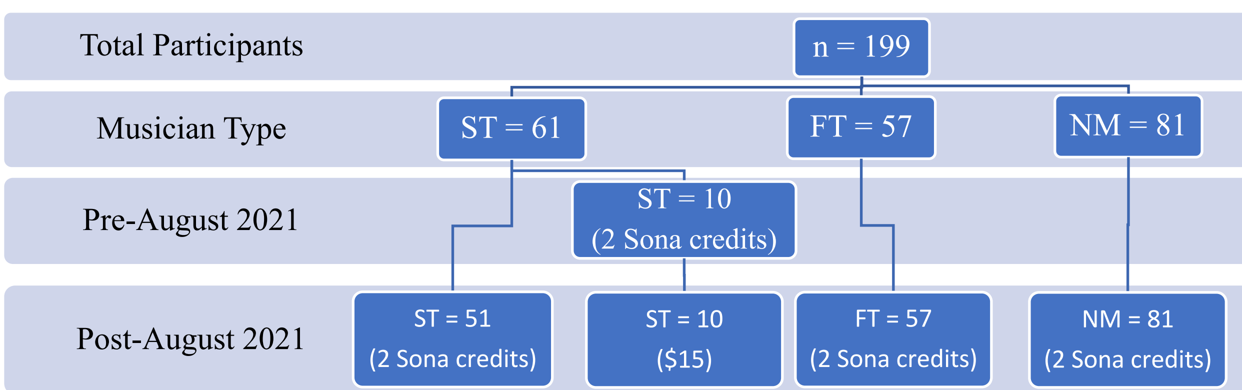

Figure 1. Timeline of participant inclusion, by musician type. ST = self-taught; FT = formally trained; NM = non-musician

Procedure

Participants completed the subjective task contained in the Gold-MSI (Müllensiefen et al., 2014). The subjective task was in the form of a survey that participants completed on Qualtrics (Qualtrics, Provo, UT). SES was a summed score of maternal education, paternal education, and family income. Parental education (for both mother and father) was measured on a 6-point scale ranging from (1) parent did not complete high school to (6) parent completed Doctoral degree. Family income was measured on a 5-point scale ranging from (1) < $10,000/year to (5) > $150,000/year, this range is modeled after the IRS tax brackets for the year 2020 (IRS, 2021).

Next participants completed two memory tasks: one auditory and one audiovisual. In the auditory memory task, the participant viewed a cross on a screen while a random series of digits (numbers 1-9) was read to them through headphones. After hearing the numbers, the participants saw a screen in which the numbers 1-9 were visually presented to them. Participants clicked the numbers in the order that they were presented. In the audiovisual memory task, the random digits were both visually presented and read to them. After the presentation, the procedure was the same as the auditory memory task. Participants viewed the numbers and had to click the numbers in the order that they appeared during the presentation. Both memory tasks started with a list length of 3 digits and gradually increased until the list length was 9 digits, with 3 trials of each length being presented. The scores of these memory tasks were then measured as a proportion correct by serial position, which provides partial credit as opposed to all-or-none scoring. The justification for using an auditory and audiovisual span task was based upon the evidence that suggested that musicians perform better than non-musicians for digit spans that were presented auditorily (e.g., Talamini et al., 2016). Lastly, participants completed the Gold-MSI objective tasks. The tasks measured beat perception and melody discrimination.

Materials

In the experiment, participants used Sennheiser HD 280 Pro headphones to complete the auditory/audiovisual memory tasks and the Gold-MSI objective music tasks. The memory tasks were presented on a website and study builder called lab.js (Henninger et al., 2020). The objective music tasks were presented on R using the package 'devtools', running both the MDT and CABAT (Harrison, 2021a; Harrison, 2021b; R Core Team, 2020; Wickham et al., 2021). The survey was a modified version of the Gold-MSI subjective task and was completed on Qualtrics (Qualtrics, Provo, UT).

Results

The goal of our current analyses was to investigate the relationship between SES and musician type, as well as to inspect the memory and aptitude differences by musician type. Our original criteria for the formally trained musicians were individuals that had received 5 or more years of musical training through school or private lessons, and 5 years or more of active performance/practice for self-taught musicians. These definitions were heavily influenced by Zendel and Alexander (2020). Upon further review, we found that those that met our criteria compared to those that had not met our criteria had no significant differences in musical aptitude scores (as examined using a *t-test*); therefore, the entirety of the sample was included in our analyses. The type of musician was justified by the participants' self-report.

A Pearson's correlation was calculated for pairs of every variable of interest. These variables included the five subjective subscales of the Gold-MSI, the general sophistication score, the two objective measures of the Gold-MSI, father's highest education, mother's highest education, parental income, and both recall task scores. The first Pearson's correlation matrix included all participant groups (Table 3). Within the first correlational analysis, the results shown were as expected: all five of the subjective task subfactors and the general score were positively associated with each other, our measures of SES were all positively associated with each other, our measures of memory were positively correlated, and the GMSI objective tasks were significantly correlated with each other. Interestingly, the melodic discrimination task was also significantly correlated with both memory measures, but the rhythm discrimination task was not. This pattern of relationships may be due to the required memory efforts from participants as they completed the melodic discrimination task, which was not required for the rhythm task.

Table 3. All Participants Correlation

	AE	PA	MT	SA	EM	GM	FSES	MSES	Income	MDT	CABAT	Aud
PA	0.42***											
MT	0.38***	0.39***										
SA	0.41***	0.53***	0.39***									
EM	0.62***	0.53***	0.31***	0.34***								
GM	0.65***	0.66***	0.78***	0.77***	0.53***							
FSES	0.04	-0.08	-0.02	0	-0.05	0						
MSES	-0.06	-0.08	-0.06	-0.1	-0.07	-0.1	0.48***					
Income	-0.02	0.05	0.02	0	-0.01	0.03	0.36***	0.33***				
MDT	0.22**	0.11	0.04	0.06	0.18*	0.09	-0.03	0.11	0.11			
CABAT	0.14*	0.05	0.07	0.03	0.04	0.09	0.13	0.13	-0.07	0.20**		
Aud	0.11	0.04	0.19**	0.04	-0.01	0.15*	0.01	0.11	0.15*	0.15*	0.02	
AudVis	0.08	0.04	0.16*	0.05	0	0.13	-0.03	0.12	0.14	0.23***	0.01	0.77***

*Pearson correlation for all variables of interest. *** = p < .001; ** = p < .01; * = p < .05. AE = active engagement; PA = perceptual abilities; SA = singing abilities; EM = emotion; GM = general musicianship; FSES = father's education; MSES = mother's education; Aud = Auditory; AudVis = Audiovisual*

A second Pearson's correlation was run with only the two musician groups included (Table 4). This musician-only correlation yielded similar results to our first correlation analysis. Within the second analysis both memory tasks showed significant positive correlations with parental income (Aud: r = .19; AudVis: r = .21), while the first correlation we saw parental income significantly correlated with only Aud (r = .15) but not AudVis (r = .14). We will return to this finding in the general discussion. Following the results of the musician-only correlations, aggregated variables were created when justified by significant positive correlations within the raw variables. A general SES variable was created from the individual measures of SES: father's education, mother's education, and parental income. A musical aptitude variable was created as both Gold-MSI objective measures were correlated. Lastly, a memory variable was created as both recall tasks were also significantly correlated. All aggregated variables were summations of the raw scores within each category. One final correlation matrix was completed with the two music groups. In this last correlational analysis, we examined the relationship between the music training subscale from the Gold-MSI subjective measure with all our previously aggregated variables (Figure 2). In this third correlational analysis, we found that the aggregated memory variable was positively correlated with the music training subscale (r = .21), SES (r = .21), and music aptitude (r = .21). No other significant correlations were present.

After examining the correlation matrices, we conducted a multiple regression with aggregated memory scores as the outcome variable. The predictor variables included were SES, music training, and music aptitude (Table 5). The overall model predicting memory was significant,

$F(3, 114) = 4.39$, $p = .006$, $R^2_{adj} = .08$. Music training was the only variable to significantly contribute to the model ($\beta = .204$, $p = .024$), while musical aptitude ($\beta = .15$, $p = .103$) and SES ($\beta = .18$, $p = .053$) did not contribute. Due to music training being the only significant predictor, analysis on the differences between memory scores and music training scores in our music groups was investigated. We found that the self-taught group (M = 1.48, SD = .24) scored significantly higher than the formally trained group (M = 1.38, SD = .26) in measures of memory, $t(116) = 2.27$, $p = .025$. We also found that formally trained musicians had significantly higher music training scores ($M = 29$, $SD = 7.52$) than self-taught musicians ($M = 25$, $SD = 6.74$), $t(116) = 3.05$, $p = .003$.

Table 5. Multiple regression model (Memory)

Variable	β	B	P
Aptitude	0.148	0.025	0.103
MT	0.204	0.007	0.024*
SES	0.176	0.016	0.053
Model			
R^2	0.104		
Adjusted R^2	0.08		
F (3, 114)	4.39		0.0058**

*Model predicting memory outcomes. ** = p < .01, * = p < .05. MT = music training, SES = socioeconomic status, Aptitude = music aptitude*

Table 4. Musicians Only Correlation

	AE	PA	MT	SA	EM	GM	FSES	MSES	Income	MDT	CABAT	Aud
PA	0.43***											
MT	0.19*	0.30***										
SA	0.33***	0.65***	0.34***									
EM	0.71***	0.46***	0.27**	0.37***								
GM	0.55***	0.73***	0.67***	0.80***	0.57***							
FSES	0.18	-0.14	-0.12	-0.01	-0.01	-0.02						
MSES	0.06	-0.13	-0.02	-0.16	-0.05	-0.09	0.45****					
Income	0.05	0.01	0	-0.01	0.01	0.02	0.33***	0.35***				
MDT	0.30**	0.09	0.05	0.12	0.18	0.13	0.02	0.11	0.16			
CABAT	0.24**	0.03	0.1	0.06	0.06	0.13	0.15	0.11	0.02	0.25**		
Aud	0.07	0.05	0.19*	0	-0.03	0.11	0.06	0.23*	0.19*	0.22*	0.1	
AudVis	0.05	0.07	0.20*	0.04	0	0.14	-0.02	0.17	0.21*	0.23*	0.01	0.78****

*Pearson correlation for variables of interest (only musicians are included). *** = p < .001; ** = p < .01; * = p < .05. AE = active engagement; PA = perceptual abilities; SA = singing abilities; EM = emotion; GM = general musicianship; FSES = father's education; MSES = mother's education; Aud = Auditory; AudVis = Audiovisual*

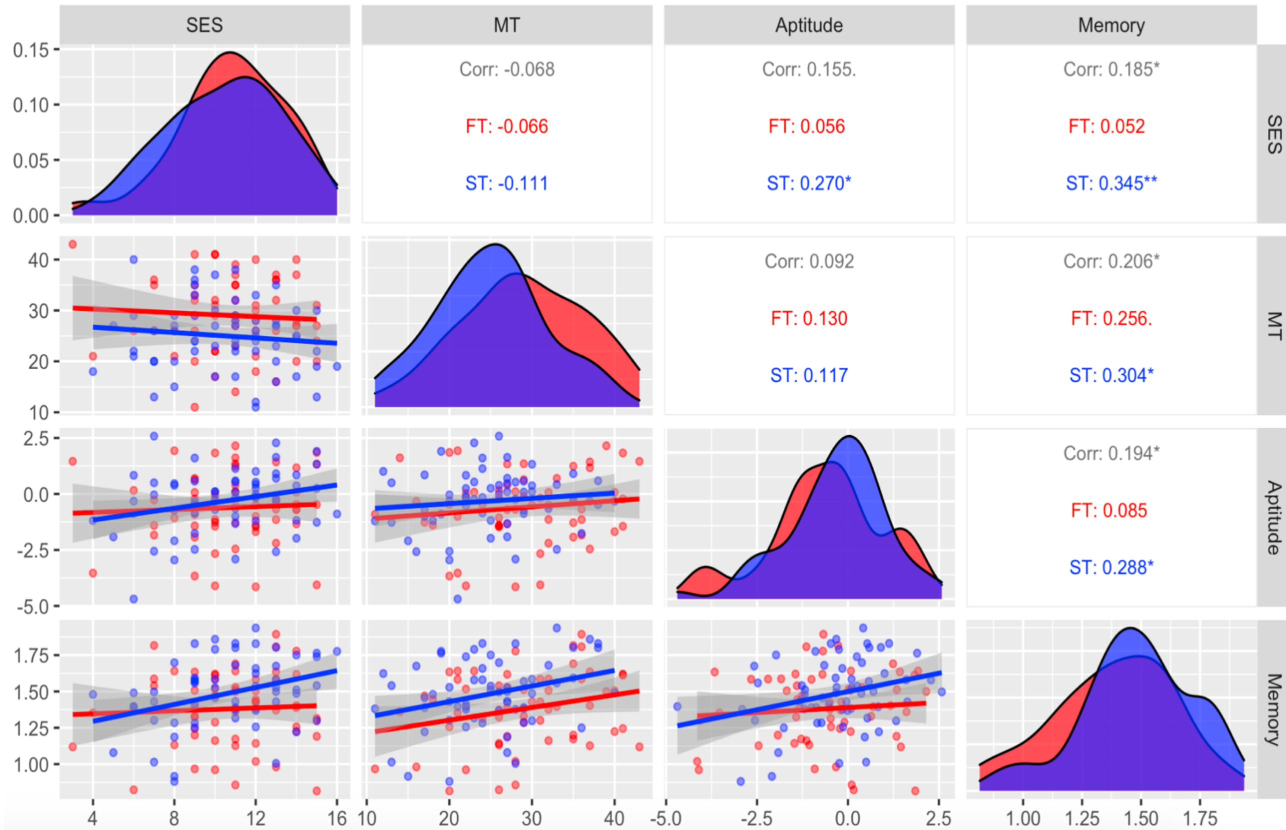

*Figure 2. Aggregated Variables. Scatterplots (lower half), distributions (diagonally), and correlations (upper half) between pairs of variables presented both for the sample of musicians and then divided by the self-report of whether they were formally trained or self-taught musicians. * = p < .05. MT = music training, SES = socioeconomic status, Aptitude = music aptitude, Corr = overall correlation, FT = formally trained, ST = self-taught.*

General Discussion

In order to establish a relationship between musician type and SES, we examined self-taught and formally trained musicians on measures of SES. We used audio and audiovisual recall tasks as measures of memory and determined differences in our musician groups by analyzing any relationships between music training scores and recall task scores. Gold-MSI objective tasks were used to ascertain differences between self-taught and formally trained musicians. Lastly, the musical training subfactor from the Gold-MSI subjective measure was used as a representation of musician groups. We found significant relationships between music training and memory scores, but not in SES or musical aptitude. Overall, our hypothesis was not supported by our results.

The nature of the items within the Gold-MSI music training subscale are formatted for those that have received formal training according to our definitions of the two groups (Müllensiefen et al., 2014). Because of subscale design, we used music training as a proxy for our two musician groups in our regression analysis; we anticipated that self-taught musicians would contribute lower scores than formally trained musicians. Indeed, this is what we found. Formally trained musicians scored significantly higher in music training than self-taught musicians. While the Gold-MSI is a continuous measure, it may still be sensitive enough to detect differences in the method of training a person has experienced, which can be useful for future research in this area.

Within the current sample of participants, music training and SES did not have any significant correlations. This lack of a significant relationship suggested that those from lower SES communities were just as likely to be formally trained as those from higher SES communities. This also adds evidence to the uncertain point of whether music training is related

to one's SES (see Table 1). However, this may be an issue in our data collection. The data included in this study were solely from LSU psychology undergraduates. Populations of this kind tend to be part of the WEIRD problem in psychology, that is to say, that majority of psychology data are from individuals that are: white, educated, industrialized, rich, and from democratic countries (Henrich et al., 2010). Further data collection for a broader range of SES will be required to make any further claims regarding the relationship between SES and other variables. Overall, the hypothesis that self-taught musicians will be from lower SES communities was unsupported as there were no distinct differences in SES scores among musician type (see Figure 2).

We found a significant and positive correlation between the aggregated variables for SES and memory. Some previous research has suggested that there is an existing positive relationship between these two variables (Brito et al., 2017; Swaminathan & Schellenberg, 2020; Degé et al., 2015). Interestingly, in our study, we hypothesized an opposite effect, but no firm conclusions can be made regarding our hypothesis. Self-taught musicians were not found to be lower in SES than formally trained musicians. Therefore, we cannot assume that the hypothesized lower SES self-taught musicians were able to remedy lower memory abilities commonly seen in lower SES communities as a result of their music training.

While we saw an overall significant correlation between music training and memory, we then chose to perform additional analysis to better understand this finding. Using the musical training subscale of the Gold-MSI provided important information about the musicians' experiences; however, given the paucity of published research using formally trained and self-taught musicians, and given the differences in how these groups have been defined, we conducted two exploratory follow-up analyses. We chose to use a t-test based upon self-

identified training methods, and we saw significant differences in memory scores between musician groups. This finding was in the opposite direction of what we anticipated. We did predict that being self-taught would not affect a musician's memory scores, yet we found these differences. This outcome indicates that there could be differences in the methods of learning, or also potentially in motivation. These results may give rise to the differences in the associated memory benefits. One possible reason could be due to the rehearsal effects we see in formally trained musicians (Ramachandra et al., 2012; Talamini et al., 2016). Formally trained musicians, typically, learn a piece of music, rehearse that piece, and eventually memorize it. With the small amount of research on self-taught musicians' practice habits, it is unclear whether or not they engage in these same memory strengthening exercises. Yet the current study indicated that self-taught musicians scored higher than those with formal music training. The reasoning for this may be due to motivation differences present in our musician groups. We will return to our thoughts on motivation in music training later in this section.

We found that music aptitude and music training were not correlated when examining only the musicians (Figure 2). This finding is promising for our hypothesis, as we did state that being self-taught would not affect an individual's overall musicianship. The limited research on self-taught musicians shows similar outcomes in certain circumstances (Zendel & Alexander, 2020). In out-of-key melodic discrimination tasks, the musician groups were found to be comparable. In contrast, some evidence does support that there is a difference (Talamini et al., 2022). However, we cannot interpret this outcome with full confidence for two reasons. Firstly, our music aptitude variable was not the entirety of one's musicianship but consisted only of melodic and rhythm discrimination. As mentioned before the Gold-MSI contains both objective and subjective measures and was designed to create a global measure of musical sophistication,

broadly defined. Secondly, our sample size consisted of only students taking psychology classes at a major state university. In order to further examine this point within a more representative sample, motivations of the individuals who participated in this sample must be taken into account. One way of reporting this in future studies could be the inclusion of musical-career-oriented individuals or those with higher levels of musical training. This goal could be accomplished by recruiting individuals that play music for a living or students who are majoring in music. This is unlike our current sample as many no longer played their instruments or started playing as hobbyists.

Furthermore, there was no association found between SES and musical aptitude. This could potentially provide evidence for our hypothesis. We hypothesized that being from a lower SES community would not play a role in a person's overall musicianship. As musical aptitude is one aspect of musicianship, the results seem to trend in favor of our hypothesis in this regard. This is not a novel finding as previous research has shown that there does not seem to be a relationship between the two variables (Degé et al., 2015; Swaminathan et al., 2017). The literature has shown that musical competence is closely related to musical aptitude, yet even this variable has not been consistently predicted by SES (Swaminathan & Schellenberg, 2018). However, as mentioned previously, the aptitude scores require further expansion in that more musically-driven individuals should be included.

In our multiple regression model, the full model was significant (SES, music training, and musical aptitude) with memory scores as the outcome (multiple $R^2 = .104$; adjusted $R^2 = .08$). SES did not make a significant contribution to the model; this is most likely due to the non-significant differences between our musician groups. The low variability in our SES data did not allow us to support SES as a significant predictor of memory scores, which contradicted previous

findings (Brito et al., 2017; Degé et al., 2015; Swaminathan & Schellenberg, 2020). Music training was the only predictor variable to make a significant contribution, therefore establishing that some differences in music training affect the predicted memory ability. Musical aptitude also did not contribute to the model. We may have restricted the range of this variable by including only our musicians in our model and excluding the non-musicians in the sample. With the finding that there were no differences in aptitude in our musician groups, a future regression analysis may be necessary to include our non-musicians. This could potentially show that the presence of music training overall could predict memory abilities, which would be consistent with the previous literature and was supported by the relationships of these variables in the correlational analyses including the whole sample.

Our measures of subjective musicianship, through the use of the Gold-MSI, further validated the measure as all subfactors remained positively and significantly correlated with each other. These subjective measure results were present when including non-musicians and when including only musicians. The significant correlations were consistent with previous research as the literature does show evidence that as one's music training increases so does one's memory ability, those from lower SES areas experience lower memory abilities (the inverse is true), and as memory increases so does one's musical aptitude (e.g., Degé et al., 2009; Degé et al., 2015; Swaminathan & Schellenberg, 2020). These results are in line with previous data suggesting that individuals from lower SES communities experience lower cognitive abilities (i.e., Swaminathan & Schellenberg, 2020).

In both of our correlation analyses, we observed significance among multiple variables that could have interesting implications. Firstly, we see significance between our measures of musical aptitude and the active engagement subfactor. This may indicate that those who make

music part of their regular daily life, outside of musical training, could show signs of enhanced musical ability. Interestingly, one would assume this to be the case for perceptual abilities as ear training is heavily encouraged in formal training settings, but we saw no such correlation (Karahan, 2014; Wang, 2022). Secondly, when examining the variables at the raw level, before aggregating them, we saw that parental income was significantly correlated to our measures of memory. In our first correlation, we did see a non-significant relationship between parental income and our audiovisual measure. However, the non-significance in this particular situation may be of little concern as there was only a one-point difference with the significant relationship in our auditory-only measure. The practical implications of this still indicate a relevant trend in the association between parental income and memory abilities. While this finding is closely related to the main interest of this study, the curious outcome is that we only see a relationship between one of our SES variables and both of our memory variables. Our musician-only analysis indicated a relationship between mother's education and the auditory recall task. Furthermore, we then saw an overall significant correlation when these variables were aggregated. This may suggest that income is a more reliable indicator of SES as it is the only variable within our SES measures that was seen to consistently show a relationship with memory; however, future research is needed with a range of participants who are not attending a university. This finding also suggested that newer measures of SES may be necessary for future studies as more reliable indicators of an individual's true SES, such as self/parent occupation and subjective feelings of one's own SES (Conger et al., 2021; Ming et al., 2021).

In sum, we found that there were differences in memory scores and music training, depending on the method one learns; self-taught musicians scored higher on the memory tasks but demonstrated lower scores in music training. Music training was the only significant

predictor of memory performance in the regression model. These differences in music training were able to predict memory outcomes, but aptitude and SES were not able to predict memory. Future projects should expand on analyzing a wider range of SES and musically-driven individuals to explore more robust differences in methods of learning music and the possible implications of the method of learning to those from a wide range of SES communities.

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Vita

Matthew N. Jimenez was born in Canoga Park, California in 1994. After graduating high school in 2012, Matthew joined the workforce as a certified nursing assistant. It was not until 2017 that Matthew had decided that his passion was in psychology, and therefore started attending College of the Canyons. At College of the Canyons, Matthew graduated as valedictorian of his class with an A.A. in Psychology in 2018. After receiving his A.A., Matthew transferred to the University of California, Davis where he received his B.A. in Psychology in 2020. At UC Davis, Matthew worked as a research assistant in the Janata Lab under Dr. Petr Janata and Dr. Ben Kubit where they studied musical memory. Upon graduating in 2020, Matthew started working with Dr. Emily Elliott as a graduate student in the Elliott Attention Recall and Sounds lab at Louisiana State University. Matthew intends to receive his Master's in August of 2022, and he will then continue working with Dr. Elliott to pursue his Ph.D.