

Does Chronotype explain Daily Timing of Music Behaviors?

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Abstract

We addressed how circadian rhythms influence daily musical activities of performing musicians, who exhibit fine temporal control. Music performances often occur in the evening and late at night; evidence suggests that composing musicians tend to be later chronotypes than non-composing musicians. However, chronotype and daily music-making in performing musicians have yet to be investigated. The current study examined chronotype in actively practicing and/or performing musicians and non-musicians, and whether it was related to the daily timing of music performance. To test influences of daily changes due to the global COVID-19 pandemic, disruptions to musical, athletic, social, and sleep habits were also measured. Performing musicians, active (practicing but non-performing) musicians, inactive musicians, and non-musicians, residing in Canada, completed a 7-day online daily activity and sleep diary in Summer 2020. There were more evening chronotypes than morning chronotypes in the sample. Active/performing musicians tended to be earlier chronotypes than all other groups. Musicians' chronotype, but not nightly sleep timing, predicted the time of day that musicians made music: Late chronotypes made music later in the day and early chronotypes made music earlier in the day. Music performance and practice amount decreased during the COVID-19 period, but the daily timing of these activities did not change. All participants reported later sleep onset during the COVID-19 period; the amount of social interaction decreased during the COVID-19 period, while exercise increased for some and decreased for others. No changes in the daily timing of exercise, social interaction, or morning wake-up were reported. These findings suggest that performing musicians may be slightly earlier chronotypes than non-performing musicians and non-musicians, despite music performances often occurring in the evening. Chronotype was related to the time of day of music-making independent of nightly sleep timing, suggesting that times of day for making music reflect an individual's circadian rhythm.

Keywords: chronotype, time of day, sleep, music performance, skilled motor performance, COVID-19

Introduction

Music performance is a complex task that requires precise, refined motor and cognitive skills. Music performances tend to occur in the evening, requiring musicians to be cognitively alert and motorically nimble at late hours. Thus, chronotype and time-of-day effects on cognitive and motor performance may be important factors that influence performing musicians. Performance on both motor tasks (Edwards et al., 2007; Moussay et al., 2002; Rossi et al., 2015) and cognitive tasks (Giampietro & Cavallera, 2007; Lehmann et al., 2013; Wright et al., 2002) have been shown to vary over 12h and 24h periods. The current study examines how musicians' chronotype and sleep timing relate to the daily performance of music.

To the best of our knowledge, only one study has compared musicians' chronotypes with those of non-musicians. Gjermunds et al. (2019) conducted an online survey to investigate chronotype differences between self-reported professional musicians and non-musicians. Although musicians tended to be slightly later chronotypes than non-musicians, this finding was constrained to composing musicians. Notably, Gjermunds et al. used the Morningness-Eveningness Questionnaire (MEQ; Horne & Ostberg, 1976), a qualitative assessment of chronotype that asks participants their time preferences for such things as waking up, going to sleep, and performing daily activities. In contrast, the Munich Chronotype Questionnaire (MCTQ; Roenneberg et al., 2003) provides a quantitative description of chronotype. Although the MEQ and MCTQ have been shown to produce similar chronotype evaluations (early bird versus night owl) (Roenneberg, 2015), the MCTQ has finer resolution by calculating chronotype from the midpoint of an individual's sleep period (Roenneberg et al., 2003). Finally, Gjermunds et al. did not report data on sleep patterns, social schedule constraints, physical activity levels, or light exposure which are known to influence sleep-wake timing (Roenneberg et al., 2003; Wright et al., 2013). A more complete investigation of musicians' chronotypes is thus needed to address remaining questions.

Although the relationship between music performance and circadian rhythms has yet to be further investigated, previous work suggests that motor performance may be influenced by time of day and chronotype. Moussay et al. (2002) measured cycling performance (pedal rate) at 5 time points in a single day between 06:00h and 22:00h, finding that pedal rates were slowest in the early morning and fastest in the early evening. Another study from Vitale et al. (2015) used actigraphy to compare the daily timing of physical activity in early, neutral, and late chronotypes (based on the MEQ). The peak activity time (14h32) for early chronotypes was about two hours earlier in the day than the peak activity time (16h53) for late chronotypes. Examining the influence of time of day on music performance, Koch and Fregin (2012) tested professional violinists' performance of a pre-learned piece of music across a 16-hour day. Trained raters provided subjective ratings of tempo fluctuations of the violinists' performances Slightly higher ratings of tempo fluctuations were given to the morning performances relative to the other times of day. Notably, Koch and Fregin (2012) did not report quantitative measures of observed temporal variability in the small sample of performers (N=6).

Wright and Palmer (2020) tested 32 pianists' performance tempo of simple melodies at four times of day (08:00h, 12:00h, 16:00h, 20:00h). Although individual differences in performance tempo were consistent across the day, performance tempo was slower at the earliest testing session and pianists who were less alert in the morning tended to have the slowest melody performances. Performance tempo was not predicted by sleep duration the night before music performances, and pianists with different chronotypes did not systematically differ in their performance tempo. Van Vugt et al. (2013) found that night-owl pianists, measured by the

MCTQ, performed piano scales with more temporal stability in the evening (20:00h) while early-bird pianists performed piano scales more stably in the morning (08:00h). These findings suggest that music performance may be influenced by time of day and/or chronotype. The current study aimed to identify whether the daily timing of musicians' practice and performance behaviors are related to their chronotype.

Chronotype studies have also addressed the joint influence of biological and environmental factors such as training schedules on athletic performance in high-level athletes who often perform and train in the early morning. Kunorozva et al. (2017) compared chronotypes between South African professional rugby players and age-matched, low-physical activity controls. Based on the MEQ chronotype scores, they found more early birds in the professional rugby player group and more evening types in the control group. There was no relationship found between the chronotype scores and a biological marker of chronotype, the VNTR polymorphism of the Per3 gene, which had previously shown a relationship to chronotype such that individuals with one genotype variant tended to be early types and individuals with another genotype variant tended to be evening types (Kunorozva et al., 2012). Overall, this study provides evidence in favour of daily schedules (ex. morning practice times) potentially influencing the athlete groups' sleep-wake times, but no evidence that individuals with genetically-predisposed early chronotypes select into sports with early morning trainings. Henst et al. (2017) expanded on these findings by comparing chronotypes of South African marathon runners and low activity South African controls to Dutch marathon runners and low activity Dutch controls. Henst et al. (2017) found that the marathon runner groups had earlier chronotypes (based on the MEQ) than the control groups, and that South African marathon runners had earlier chronotypes than Dutch marathon runners. No differences were found between any groups in the VNTR polymorphism of the Per3 gene. However, across all groups, chronotype correlated with training time onset such that the earlier an individual's chronotype, the earlier their daily training times (Henst et al., 2017).

The relationship among daily schedules, activity patterns, and individuals' chronotype is particularly important to consider during the global coronavirus pandemic. Restrictions that affect leaving the home and interacting with others implemented in many countries can be expected to influence sleep-wake timing. Indeed, sleep-wake patterns of university students in the United States of America have shown alteration under coronavirus-related restrictions compared to pre-restriction times, with students sleeping longer during the COVID-19 period than during the pre-COVID-19 period (Wright et al., 2020). Leone et al. (2020) reported a similar lengthening of sleep on workdays during the COVID-19 period compared to the pre-COVID-19 period in the general population, as well as more frequent reports of later chronotypes during the COVID-19 period compared to the pre-COVID-19 period.

Daily musical activities have also been affected during the COVID-19 period. A large-scale survey conducted in the United Kingdom by Spiro et al. (2021) during the initial lockdown period (April-June 2020) found that musicians and other professional arts performers reported fewer performances, less teaching, composing, and directing, and a reduction in learning or practicing their artform during the COVID-19 period than before the COVID-19 period. Ferreri et al. (2021) also conducted a large-scale survey (primarily in Italy, Spain, and the United States of America) on changes in the amount of music listening and music production during the early (May-June 2020) COVID-19 period. Overall, they found an increase in music listening and singing as well as a decrease in music composition, but no change in instrument playing. These findings complement those of Cabedo-Mas et al. (2021) who surveyed participants in the general

Spanish population on their music activities during the COVID-19 period. More than 50% of respondents indicated they had not changed how much they played their musical instrument during the COVID-19 period compared to the pre-COVID-19 period; very few participants reported decreasing the amount of time they played their instrument. Carlson et al. (2021) surveyed the general Finnish population and found that individuals increased how frequently they listened to music but showed less uniform change in how often they made music. Notably, these studies did not track the sleep patterns or chronotype of respondents. This is important because chronotype and sleep are known to affect both motor (Van Vugt et al., 2013) and cognitive performance (Nilsson et al., 2005). To test the effects of those variables during COVID-19 on musicians' practice and performance activities, we assessed changes in sleep-wake timing and daily musical, social, and physical activity during and prior to the COVID-19 period.

The first aim of this study was to compare the chronotypes of musicians and non-musicians. The musicians were divided into non-musicians, inactive musicians, active (practicing) musicians, and performing musicians to further identify chronotype patterns. Based on the previous study (Gjermunds et al, 2019), we expected performing musicians to have the latest chronotype, as music performances often occur in the evening and late-night hours. The second aim was to investigate whether musicians' chronotypes were related to the daily timing of their music practice or performance. This was assessed by asking participants to complete a 7-day survey that collected information on their chronotype as well as daily sleep, musical, social, and physical activities. In line with Van Vugt et al. (2013) and Henst et al. (2017), we predicted that earlier chronotypes would practice or perform music earlier in the day and later chronotypes would practice or perform music later in the day. As a final aim, due to the on-going coronavirus pandemic and the social restrictions that accompany it, we assessed whether participants' sleep wake timing as well as music practice and performance, social interaction, and physical activity habits changed between the pre-COVID-19 period to the COVID-19 period.

Materials and Methods

Participants

We recruited 103 participants from within Canada to participate in this study, to reduce the influence of day length on sleep-wake timing at different latitudes. Recruitment took place between June and September 2020. Exclusion criteria included a diagnosed sleep or psychiatric disorder, current use of selective serotonin reuptake inhibitors (SSRIs) which are known to affect sleep architecture (Jindal et al., 2003), diagnosed hearing problems, participation in overnight shift work, or having taken a transcontinental flight in the 3 weeks prior to participating in the study. To be included in the study, participants needed to be between 18 and 35 years of age, inclusive. Five participants were excluded due to missing data; one participant was excluded due to reported sleep disturbances while participating in the study. This yielded a final sample size of 97. Participants' mean age was 21.66 years (SD = 3.18, range = 18-34, male gender = 18, female gender = 77, unspecified gender = 2). Ninety-five participants (97.9%) were located at latitudes between 42.31° N and 51.04° N (Southern Quebec, Ontario, Southern British Columbia, and New Brunswick) during their participation, and 2 participants (2.1%) were at latitudes north of 53.55° N (Northern Alberta) during their participation. Fifty-three participants (54.6%) were recruited from the McGill Psychology Participant Pool (SONA) and 44 participants (45.4%) were recruited from the general adult population within Canada. The study protocol was approved by the McGill Research Ethics Board (approval #197-1018).

Both musicians and non-musicians were recruited for this study. Participants were divided into four categories: Non-Musicians (NM), Inactive Musicians (IM), Active Musicians (AM), and Performing Musicians (PM). Participants classified as NM had 0 years of musical training and did not report performing, practicing, or composing any music. Participants classified as IM had at least 1 year of musical training but, similar to the NMs, did not report performing, practicing, or composing any music. The AM group included participants who had any number of years of musical training (including 0) and reported practicing or composing on a regular basis but not performing music. Finally, the PM group included participants who had any number of years of musical training (including 0) and who, in addition to practicing or composing music, reported either currently or typically (pre-COVID-19 period) performing music (see Table 1 for group demographic details).

Stimulus Materials

Three questionnaires were used in this survey study. A 7-day sleep diary from Carney et al. (2012) was adapted to collect daily information on sleep timing, exercise, social interaction, music-making activities, and alcohol/stimulant consumption (referred to collectively as the sleep and daily activity diary). The Munich Chronotype Questionnaire (MCTQ; 2015), which contains 32 questions on sleep and daily habits of exercise, work, and stimulant consumption, was used to determine participants' chronotype (see below). A Musical Background Questionnaire (MBQ) collected participants' musical instruction history, their preferred times of day to make music, the type of musical activities they engaged in (performing, practicing, composing), as well as changes in the daily amount and timing of their music-making, social interaction, physical activity, and sleep behaviors between the three months prior to the COVID-19 period and the COVID-19 period.

Study Design and Procedure

The study lasted for a total of 7 days during which participants received via email a daily link to an online survey hosted on Qualtrics. On Day 1, participants read a consent form, which included an understanding that their data would be anonymized. Participants indicated in writing their consent to participate in the study before completing the sleep and daily activity diary. The sleep and daily activity diary were then completed on each subsequent day of the study (Days 2-7). Participants were instructed to complete the sleep and daily activity diary within 1 hour of waking up in the morning. On Day 7, participants first completed the sleep and daily activity diary before completing the MCTQ and the MBQ. Days 1-6 of the study took approximately 5 minutes per day, and Day 7 took approximately 30 minutes. The total length of the study over the 7 days was approximately 1 hour. At the end of the study, participants received a debriefing form, and they either received course credit (n =44) or were compensated $10 for their participation (n = 53).

Data Analysis

To derive a chronotype score for each participant, we calculated the midsleep point from the MCTQ using participants' self-reported typical sleep onset and wake-up times on free (non-work) days. As individuals may sleep longer on non-work days to compensate for sleep loss on workdays (commonly weekdays) for which they have imposed early social schedules (Wittman et al., 2006), we used Roenneberg et al.'s (2004) formula to derive a corrected midsleep time (MSF_{sc}) for each participant:

$$MSF_{sc} = MSF - .5*(SD_F – (5*SD_W + 2*SD_F)/7), \tag{1}$$

where MSF is the uncorrected midsleep time on free days, SD_F is the self-reported sleep duration per night on free days, and SD_W is the self-reported sleep duration per night on weekdays. This equation generates a value in hours and minutes (ex. 04:00h) denoting the corrected midsleep point (MSF_{sc}). As per Roenneberg et al. (2003), participants with an MSF_{sc} of 04:00h or earlier were categorized as early chronotypes, participants with an MSF_{sc} between 04:01h and 05:00h were categorized as neutral chronotypes, and participants with an MSF_{sc} of 05:01h or later were categorized as late chronotypes. For statistical analyses, we converted all MSF_{sc} scores to minutes past midnight (ex. 04:00h = 240 min). Chronotype was calculated for 93 participants, as 4 participants failed to answer the questionnaire fully (their data was excluded from chronotype analyses).

Daily self-reported sleep onset times from the 7-day sleep and activity diary were used to assess whether nightly sleep onset time predicted self-reported music practice or performance time the following day. For example, if a participant reported practicing or performing music on a Wednesday (outcome), their self-reported sleep onset time Tuesday night was used as a predictor. As not all participants who were considered active or performing musicians made music during the week of the study, this resulted in pairs of data (Sleep Onset Time and Music Practice or Performance Time) for 32 participants. As sleep timing should be less variable within an individual than between individuals, we constructed a random intercept, fixed-slope multi-level model (using the *lmer* function from the *lme4* and *lmerTest* packages and the *r2mlm* function in R) with individuals as the level-2 clustering variable and their sleep onset times as the level-1 variable.

Both parametric and non-parametric tests were used to assess differences in chronotype between the groups. Non-parametric chi-square tests were used to test changes in music-making, social interaction, exercise, and sleep behavior from the pre-COVID-19 period to the COVID-19 period. All assumptions were met for parametric tests.

Results

Chronotype Differences and Musicianship

We first assessed whether the musicianship groups differed in age, as age is known to influence chronotype. A one-way ANOVA on age by Musicianship (NM, IM, AM, PM) did not show a significant effect (F (3,93) = 1.04, p = .38), suggesting the groups did not differ systematically in age (see Table 1).

[Table 1 here]

We tested whether the distribution of early ($MSF_{sc} \leq$ 04:00h), neutral (MSF_{sc} between 04:01h and 05:00h), and late ($MSF_{sc} \geq$ 05:00h) chronotypes, determined by the MCTQ, differed across the musicianship groups. As shown in Figure 1, a 3x4 chi-squared test on the distribution of individuals by Chronotype (Early, Neutral, Late) and Musicianship (NM, IM, AM, PM) indicated a significant main effect of Chronotype (χ^2 = 9.74, p = .008) and no other main effects or interactions. The majority of participants (48%) were late chronotypes, as expected for this age population. There was, however, a pattern of more early chronotypes in the PM group (40%) than in the other groups (NM = 19%, IM = 11%, AM = 27%).

[Figure 1 here]

Next, we compared differences among individuals in midsleep point. Figure 2 shows each participant's sleep midpoint (based on the MCTQ); performing musicians (PM) tended to show earlier midsleep points and non-musicians (NM) tended to show later midsleep points. A one-way ANOVA on midsleep point (minutes past midnight) by Musicianship (NM, IM, AM, PM) did not show a significant effect of Musicianship (F (3,89) = 1.16, p = .33). As the AM and PM groups both contained musically-active participants, we conducted a follow-up analysis to compare current musicians (participants from the AM and PM group) against all others (participants from the NM and IM groups). A one-way ANOVA on Midsleep Point by Musician

Status (Currently active musicians, Others) was not significant (F (1,91) = 3.54, p = .06), although musicians tended to have an earlier midsleep point (Active Musician mean minutes past midnight = 289.23; Non-musician mean = 321.02).

[Figure 2 here]

Daily Timing of Motor Activities

Daily musical and athletic activity, including practicing and performing start times and exercise onset times, were collected from the 7-day sleep and daily activity diary; practice and performance values were combined in the music activities analyses. A median start time (Music Onset Time) for musical activity was generated for each participant who reported practicing and/or performing music on at least one day in the week (N = 35, 83% of all participants in the AM and PM groups). Similarly, a median start time (Exercise Onset Time) for athletic activity was generated for each participant who reported exercising at least one day in the week (N = 84, 90% of all participants in the AM and PM group). When multiple practice, performance, or exercise times were reported in a single day, the median value was taken for that day and individual.

To determine whether the times of day of musical activity were related to musicians' chronotype, a simple correlation was conducted between the median Music Onset Time (in minutes past midnight) and individuals' Midsleep point (in minutes past midnight), shown in Figure 3. The correlation was significant (r = .47, n = 35, p = .005), indicating that active and performing musicians with later midsleep points tended to practice or perform music later in the day, while those with earlier midsleep points practiced or performed music earlier in the day. In a follow-up analysis, we assessed the relationship of nightly sleep timing to the daily timing of musical activity across the week, based on self-reports from the daily activity diary. Nightly sleep onset time was not a significant predictor of the daily timing of music practice/performance (r^2 = .033, fixed-effect slope = .378, p = .103).

[Figure 3 here]

Performing musicians were also asked about their preferred time of day to perform music and we assessed whether this was related to chronotype (n = 21; 5 participants did not report a preferred time of day to perform music). Strikingly, none of the 21 participants indicated a preference to perform music in the morning. A 2x3 chi-squared test on Time of Day (Afternoon, Evening) by Chronotype Category (Early, Neutral, Late) was conducted. There was a main effect of Time of Day (χ^2 = 4.76, p = .03) and no other significant main effects or interactions, indicating that overall, participants preferred to perform music in the evening versus the afternoon (evening: 76.2%; afternoon: 23.8%) regardless of their chronotype (see Figure 4a).

We also tested whether chronotype was related to preferred time of day to practice music. The same chi-squared analysis was conducted with participants from both the AM and PM groups (n = 34; 8 participants did not report a preferred time of day to perform music). There were no significant main effects or interaction effects. As seen in Figure 4b, there was a pattern for the late chronotypes to prefer practicing music in the evening compared to the morning (42.9% vs 14.3%) and for the early chronotypes to prefer practicing music in the morning compared to the evening (50% vs 25%). A one-way ANOVA on Actual Playing Time by Preferred Performance Time (Morning, Afternoon, Evening) was not significant; a one-way ANOVA on Actual Playing Time by Preferred Practice Time (Morning, Afternoon, Evening) was also not significant, suggesting that musicians' preferred and actual music-making times were not related (F (3,30) = .92, p = .44).

[Figure 4 here]

Finally, we assessed whether chronotype was related to the daily timing of exercise. The simple correlation between Midsleep Point (minutes past midnight) and Exercise Onset Time (minutes past midnight) did not reach significance (r = .20, n = 84, p = .068). Notably, the correlation is in the same direction (positive) as the correlation between Midsleep Point and Music Onset Time.

COVID19-Related Changes in Daily Activities: Music, Exercise, and Social Interaction

We considered how music-making, exercise, social interaction, and sleep times changed between the pre-COVID-19 and the COVID-19 period. Specifically, we asked participants whether there had been a change in the amount (Less, Same Amount, More) and daily timing (Earlier, No Change, Later) of their daily music-making, exercise, and social interaction from the pre-COVID-19 to the COVID-19 period. We also compared sleep onset and offset times between pre-COVID-19 and COVID-19 periods (Earlier, No Change, Later).

Changes in Amount of Daily Activity

First, we conducted a 3 x 1 chi-squared test on music performance amount (Less, Same, More). This analysis was restricted to performing musicians (PM group) as by definition they were the only group to perform music. As seen in Table 2, this analysis showed a significant effect (χ^2 = 23.25, p < .001) with the majority of performing musicians (79.2%) reporting a decrease in music performance during the COVID-19 period. A 3 x 1 analysis was conducted for the change in music practice amount (this analysis was restricted to active musicians, AM, and performing musicians, PM), which was also significant (χ^2 = 6.00, p = .0497). Musicians (51.3%) tended to reduce how much they practiced music during the COVID-19 period (see Table 2).

[Table 2 here]

Next, we compared changes in amount of exercise and social interaction for all participant groups. A 3 x 4 chi-squared test on all participants' change in Exercise Amount (Less, Same Amount, More) by Musicianship group (NM, IM, AM, PM) showed a main effect of Exercise ($\chi^2 = 10.78$, $p < .005$) and no other main effects or interactions. As shown in Table 3, most participants exercised either less (45%) or more (36%) during the COVID-19 period. A 3 x 4 chi-squared test on Social Interaction Amount (Less, Same Amount, More) by Musicianship group yielded a significant main effect of Social Interaction Amount ($\chi^2 = 77.28$, $p < .001$), and no other main effects or interactions. Unsurprisingly, as seen in Table 3 this analysis indicated that the majority of participants (75%) reported having less social interaction during the COVID-19 period.

[Table 3 here]

Changes in Timing of Daily Activities

A 3 x 1 chi-squared analysis on change in the timing of Music Performance (Earlier, No Change, Later) was conducted for performing musicians (PM group). This analysis yielded a significant effect ($\chi^2 = 27.25$, $p < .001$) indicating that the majority of participants did not change the daily timing of their music performance (83%). Similarly, a 3 x 1 chi-squared analysis on Music Practice Timing (Earlier, No Change, Later) conducted on the AM and PM groups yielded a significant effect ($\chi^2 = 27.95$, $p < .001$) with the majority of participants reporting no change in the daily timing of their music practice (72.5%). Together, these analyses suggest that musicians did not alter the daily timing of music playing.

To test for changes in sleep timing, a 3 x 4 chi-squared analysis on Sleep Onset Time (Earlier, No Change, Later) by Musicianship group (NM, IM, AM, PM) showed a significant main effect of Sleep Onset Time ($\chi^2 = 9.87$, $p = .007$), and no other significant main effects or interactions. Overall, more participants reported going to sleep later (48.9%) than earlier (24.4%) or the same time (26.7%) during the COVID-19 period than the pre-COVID-19 period. Similarly, a 3 x 4 chi-squared test on Sleep Offset Time (Earlier, No Change, Later) by Musicianship group showed no significant main effect or interaction effect, indicating that participants did not show systematic changes in their wake-up times during the COVID-19 period compared to the pre-COVID-19 period (see Table 4). Together, these findings suggest that participants tended to go to bed later during the COVID-19 period, but they did not tend to wake up later. Importantly, no single group of participants reported altering their sleep timing from the pre-COVID-19 to the COVID-19 period relative to another group. This is evidence that the between-group chronotype findings reported above in the Midsleep Point by Musicianship analysis are not simply an artefact of COVID-19-related disruptions to daily sleep timing.

[Table 4 here]

To test for changes in timing of Exercise, a 3 x 4 chi-squared test on Exercise Timing (Earlier, No Change, Later) by Musicianship group (NM, IM, AM, PM) was conducted. There was a significant main effect of Exercise Timing ($\chi^2 = 8.68$, $p = .01$), and no other significant main effects or interactions. Overall, more participants indicated there was no change (47.4%) in the daily timing of their exercise than a shift to exercising earlier (26.8%) or later (25.8%). The same 3 x 4 chi-squared test was performed on change in Social Interaction Timing (Earlier, No Change, Later) by Musicianship group. This analysis showed a significant main effect of Social Interaction Timing ($\chi^2 = 28.78$, $p < .001$) and no other significant main effects of interactions. This analysis suggests that the majority of participants did not alter their social interaction timing (58.8%), similar to the exercise timing findings.

Discussion

This study compared chronotype and daily activity patterns from adult individuals with various levels of musical training. Groups of non-musicians, inactive musicians, active (practicing) musicians, and performing musicians recruited during the summer months from similar longitudinal axes (representing comparable total hours of daylight) completed a 7-day online survey about their chronotype and musical training as well as daily amount and timing of music activities, exercise, social interaction, and sleep. The 97 participants also indicated how the amount and timing of their daily activities changed as a result of the COVID-19 period.

First, the sample contained more late chronotypes (MSF_{sc} > 05:01h) than early or neutral chronotypes. The presence of more late chronotypes in this young adult sample (mean age = 21.66 years) is consistent with findings that young adults tend to show a later chronotype than older adults (Duffy & Czeisler, 2002; Roenneberg et al., 2003). Early chronotypes were more prevalent among performing musicians than among the other groups (as seen in Figure 1), although this pattern was not significant and there were no between-group differences in average midsleep point. These findings diverge from the expectation that performing musicians have later chronotypes, and from Gjermunds et al.'s (2019) finding that musicians, in particular composers, were later chronotypes than non-musicians. Similar to Gjermunds et al. (2019), the current findings suggest a lack of support for a single chronotype pattern in musicians. However, important methodological differences may have contributed to the different pattern of chronotype findings between the two studies. Gjermunds et al. (2019) did not distinguish between performers and non-performers, and they used the MEQ to measure chronotype rather than the MCTQ used in the current study.

Second, musicians' chronotype and sleep timing were related to the daily timing of their music-making activities. Musicians with early chronotypes tended to practice or perform music earlier in the day while musicians with late chronotypes tended to practice or perform music later in the day. These findings are in line with research showing that athletes with earlier chronotypes tend to train earlier in the morning than athletes with later chronotypes (Henst et al., 2017), and they extend previous work to show that musicians' chronotype is predictive of daily music-making behavior. Skilled motor performance has been shown to vary across the day (Reilly et al., 2007), and Van Vugt et al. (2013) have suggested potential optimal times of day for music performance based on chronotype.

Our findings complement this research as they show that in everyday life, chronotype, but not nightly sleep timing, is related to the daily timing of music practice and performance. This may indicate that musicians make music at times of day that are optimal for their chronotype. In the current study, musicians indicated a preference to make music at times of day that aligned with their chronotype, although this finding was not statistically significant. However, it is important to note that the circadian clock can be phase shifted by daily activity timing (Miyazaki et al., 2001), with early-morning exercise leading to phase advances and evening exercise leading to phase delays (Youngstedt et al., 2019). Although the association between chronotype and daily timing of exercise did not reach significance, the pattern suggests that later chronotypes tended to exercise later in the day than early chronotypes, consistent with earlier findings (Vitale et al., 2015). As the current findings are correlational in nature, it is possible that the daily timing of music performance influences the phase of the circadian clock and nightly sleep timing. Goel (2006) found greater phase-advancing effects when individuals listened to early-morning bird song with a classical music background compared to a control condition, suggesting music may serve as a nonphotic (not light-based) resetting cue for the circadian system. Further investigation into which aspects of music might serve to shift the phase of the circadian clock is needed.

Participants also reported changes in their daily behaviors that occurred during the COVID-19 period. Musicians reported performing and practicing music less during the COVID-19 period compared to the pre-COVID-19 period. This decrease in music-making transcended individual differences in chronotype and is consistent with previous research from Spiro et al. (2021) as well as with decreased opportunities to perform music in public due to the closures of public music venues during the COVID-19 period. Whereas other studies have assessed COVID-19-related changes in the amount of music practice or performance (Cabedo-Mos et al., 2021; Carlson et al., 2021; Ferreri et al., 2021), information on the daily timing of these activities was not investigated. Although musicians in the current study reported a decrease in music performance and practice, they did not report changes in the daily timing of music performance or practice. This finding strengthens the interpretation that chronotype may be an important factor in the daily timing of music-making activities, as musicians retained the same daily timing of music-making despite the COVID-19 period and associated changes to other daily activities.

All participants reported going to sleep later during the COVID-19 period but reported wake-up times similar to the pre-COVID-19 period. This finding is in line with Smit et al. (2021) who report shorter nightly sleeps in a university-aged sample during the COVID-19 period compared to a different university-aged sample during the pre-COVID-19 period. However, other recent research has shown that individuals tended to go to sleep later and sleep for a longer duration during the initial few months of the COVID-19 period (Leone et al., 2020; Wright et al., 2020). One important methodological difference is that Leone et al. (2020) and Wright et al. (2020) measured sleep duration in the same individuals before and during the COVID-19 period, whereas the current study reports participants' retrospective measures of sleep onset and wake up times.

Most participants reported increases or decreases in the amount of daily exercise as well as decreased social interaction amounts during the COVID-19 period, but no change in the timing of these activities. Together with the findings that daily music performance and practice timing did not change during the COVID-19 period, this may indicate that the temporal organisation of individuals' daily schedules was not highly disrupted during the COVID-19 period, despite altered amounts of daily activities.

Factors such as sex can influence the relationship between chronotype and musical activities. There is some evidence that adult females tend to have earlier chronotypes than males (Duffy et al., 2011). The current study sample was predominantly female (n=77); there was a similar distribution of males and females within musicianship groups, and so it is unlikely that the chronotype scores of any one musicianship group were influenced by the ratio of females to males. Additionally, the participants in this study were not required to be professional musicians. As such, their chronotype and daily music practice and performance activities may not be representative of those of professional musicians, but they nonetheless represent an important group of active performers and music students. Finally, the correlational nature of this study precludes conclusions as to the causal roles of chronotype and sleep timing in daily music practice and performance. The current study was designed to offer a more thorough investigation of natural daily rhythms in musical behaviors than existing literature offered. Future research may directly manipulate chronotype and sleep timing variables to investigate whether they influence not only the timing of daily music performance but also the quality of music performance at different times of day.

In sum, a survey of individuals’ daily sleep and musical activities during the summer months showed significant individual differences in chronotype that were related to daily musical behaviors. No group differences in chronotype were found between non-musicians, inactive musicians, active musicians, and performing musicians, somewhat contrary to previous reports (Gjermunds et al, 2019). Results showed that chronotype was related to the timing of daily music practice and performance: musicians with later chronotypes reported making music later in the day. We observed changes in the amount of music performance, daily exercise, and social interaction during the COVID-19 period compared to the pre-COVID-19 period, but no change in the timing of these daily activities. Overall, these findings suggest that individual differences in chronotype are predictive of the daily timing of music practice and performance.

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Disclosure of Interest

The authors report no conflict of interest.

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Table 1: *Age (mean, minimum, and maximum) across musicianship groups.*

Group	*N*	*M Age* (*SD*)	*Min-Max*
Non-Musicians (NM)	28	22.46 (3.87)	19-34
Inactive Musicians (IM)	27	21.41 (2.39)	18-30
Active Musicians (AM)	16	20.81 (2.40)	18-28
Performing Musicians (PM)	26	21.56 (3.48)	18-31

Table 2: *Change in Musicians' Amount of Musical Activity from the Pre-COVID-19 to the COVID-19 Period*

					Chi-Square	
Musical Activity	Less	Same	More	Total	X^2	*p*
Performance	**19**	4	1	24	23.25	< **.01**
Practice	**20**	11	8	39	6.00	< **.05**

Note. Table shows AM and PM groups' responses to amount of change in musical activity from pre-COVID-19 to COVID-19 period. Overlapping subsets of participants provided responses for music performance (PM) and music practice (AM + PM).

Table 3: *Change in Daily Amount of Exercise and Social Interaction for all Groups from the Pre-COVID-19 to the COVID-19 Period*

					Chi-Square	
Activity	Less	Same	More	n	X^2	p
Exercise	**44**	18	**35**	97	10.78	**.005**
Social Interaction	**73**	15	9	97	77.28	< **.001**

Note. Table shows the frequency and statistical output of a 4 x 3 Musicianship X Change in Exercise Amount Chi-Square test (top line) and a 4 x 3 Musicianship X Change in Social Interaction Amount Chi-Square test (bottom line).

Table 4: *Change in Timing of Sleep Onset and Offset from the Pre-COVID-19 to the COVID-19 Period for all groups*

					Chi-Square	
Activity	Earlier	No Change	Later	n	X^2	*P*
Sleep Onset	22	24	**44**	90	9.87	**.007**
Sleep Offset	27	29	34	90	0.867	.65

Note. Table shows the frequency and statistical output from a 4 x 3 Musicianship X Change in Timing chi-square analysis for each measure (sleep onset and sleep offset). No other main effects or interactions were statistically significant.

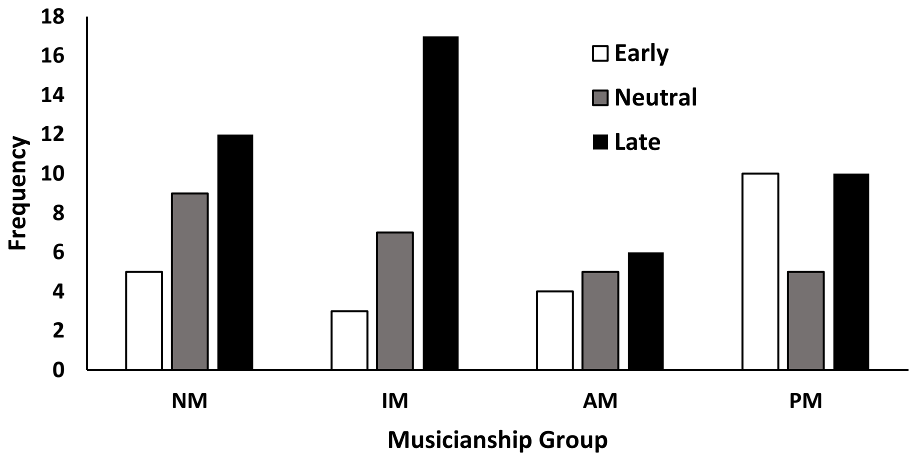

18
16
14
12
10
8
6
4
2
0
Frequency
Early
Neutral
Late
NM
IM
AM
PM
Musicianship Group

Figure 1.

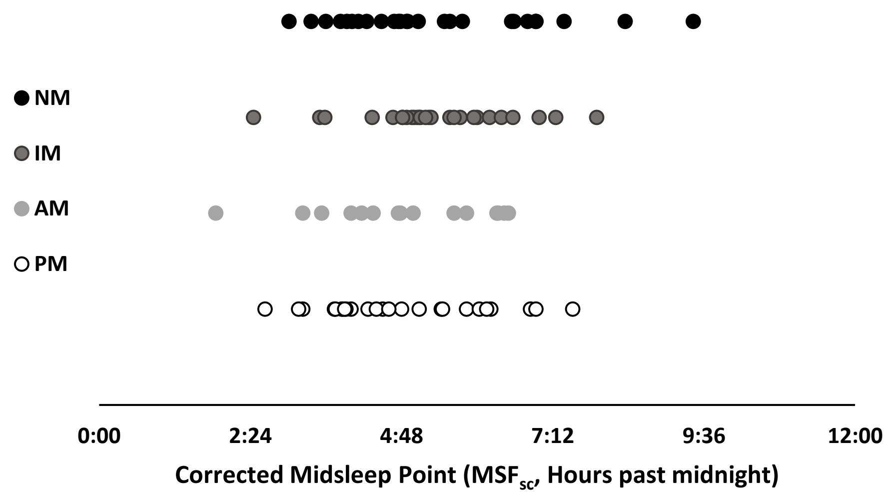

NM
IM
AM
PM
0:00
2:24
4:48
7:12
9:36
12:00
Corrected Midsleep Point (MSF$_{sc}$, Hours past midnight)

Figure 2.

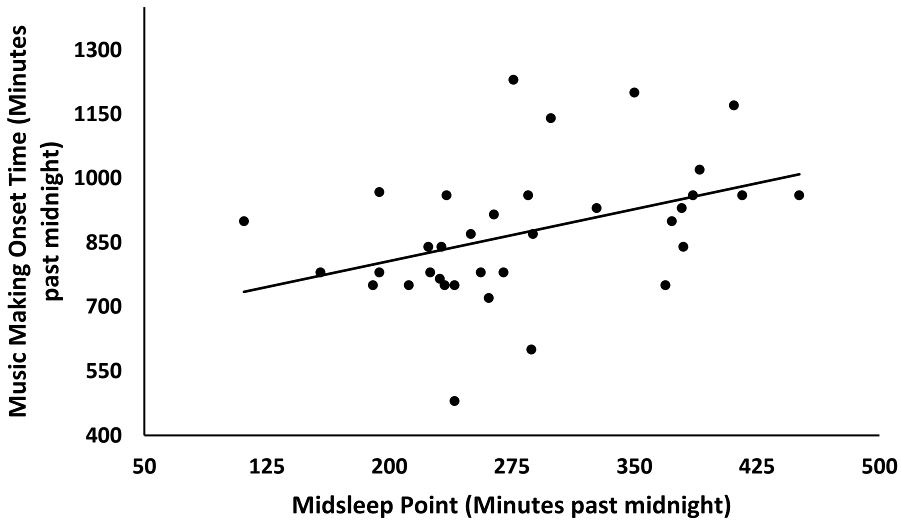
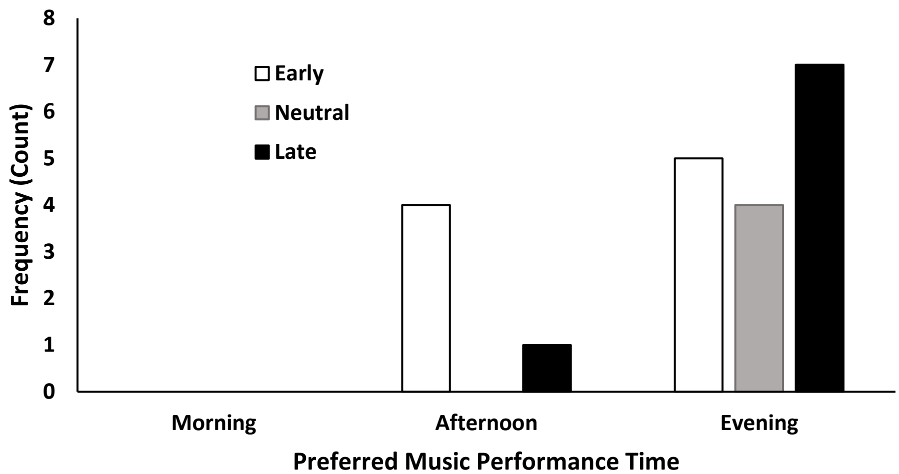

Music Making Onset Time (Minutes past midnight)
1300
1150
1000
850
700
550
400
50
125
200
275
350
425
500
Midsleep Point (Minutes past midnight)

Figure 3.

A)


8
7
6
5
4
3
2
1
0
Frequency (Count)
Early
Neutral
Late
Morning
Afternoon
Evening
Preferred Music Performance Time

B)

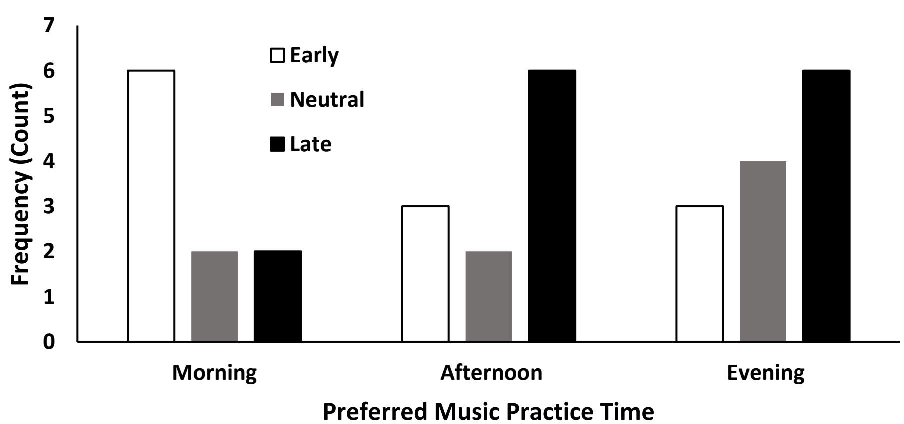

7
6
5
4
3
2
1
0
Frequency (Count)
Early
Neutral
Late
Morning
Afternoon
Evening
Preferred Music Practice Time

Figure 4.

Figure Captions

Figure 1. Distribution of chronotypes by Musicianship Group.

Figure 2. Distribution of midsleep points (MSF_{sc}) by Musicianship Group.

Figure 3. Onset time of music-making for AM and PM groups as a function of Midsleep Point. Each dot = one participant. Trend line indicates significant correlation (N = 35, r = .47, p = .005).

Figure 4. A) Self-reported preferred music performance times by chronotype (Early = $MSF_{sc} \leq$ 04h, Neutral = MSF_{sc} between 04:01h and 05h, Late = $MSF_{sc} \geq$ 05:01h) and B) Self-reported preferred music practice times by chronotype.