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Optimizing Music Learning: The Effects of Contextual Interference on Memorization

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Abstract

The purpose of this study was to assess if blocked or interleaved practice learning was more effective for memorizing music, and to assess if metacognitive judgements aligned with performance. The study included 21 proficient pianists who regularly engage in piano practice. Participants learnt two excerpts and two technical studies, and played them from memory on both day 1 and day 2 of testing. Performances were recorded and rated by an expert in the field on a percentage scale. A two-way repeated measures ANOVA analysis revealed no significant main effect of day on practice schedule, ($F(1,20) = .15$, $p = 0.70$, $\eta_p^2 = .01$), or schedule on day, ($F(1,20) = 1.03$, $p = .32$, $\eta_p^2 = .05$), with no significant interaction between the two variables ($F(1,20) = 3.20$, $p = .77$). Results revealed that metacognitive judgements did not align with performance. Although results were not significant, overall performance under the interleaved condition was slightly better than the blocked condition, indicating that there may be some benefits to interleaved practice. This warrants further research on how the contextual interference effect impacts memorization amongst pianists.

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Statement of Contribution

This study is part of a larger joint study conducted at the University of Western Ontario by Dr. Jessica Grahn, Dr. Jonathan De Souza, and Dr. Elizabeth Kinghorn, and at Memorial University of Newfoundland. I developed the research questions jointly with Dr. Elizabeth Kinghorn. Musical stimuli were from two composers developed in the 18th and 19th century by Jan Ladislav Dussek and Carl Czerny, respectively. Practice schedules were created by Dr. Jessica Grahn. I conducted part of the data collection, which was a joint effort that had been ongoing since January 2021 till January 2022. Recordings were subsequently cut by research assistants at the Western and Memorial universities and were rated by Dr. Elizabeth Kinghorn. The data analysis conducted in SPSS was conducted by me with the guidance of Dr. Elizabeth Kinghorn.

Optimizing Music Learning: The Effects of Contextual Interference on Memorization

Being able to memorize things in the most efficient way possible is something that is expected of musicians, especially when they are tasked with learning new musical pieces in a short period of time. However, much remains unknown about the efficacy of different strategies and tactics for musical memorization. Musicians tend to favour repetitive learning schedules, as do many of their teachers (Barry, 2007; Rohwer & Polk, 2006). It has become somewhat habitual and the standard mode of practice, but there may be a better way to tackle musical memorization. The purpose of the present study is to explore whether a particular type of practice schedule is more beneficial for memorizing repertoire and if an individual's metacognitive judgement is accurately reflected in their performance. In other words, the goal of the study is to ultimately to help musicians memorize music more efficiently. This is done through the use and comparison of blocked versus interleaved practice schedules, which have shown promise in the area of motor skill acquisition (Carter & Grahn, 2016) and category learning (Wong et al., 2020), but it is unknown if the effect of these practice schedules might extend to the context of memorizing music. This study explores the phenomenon of metacognitive judgement, blocked and interleaved learning, as well as contextual interference, and how they are associated with memorization amongst musicians.

Blocked and Interleaved Schedules

The primary interest of this study is memorization, however little research exists on whether certain practice schedules are more beneficial for memorization. Past research had been intrigued with the effectiveness of different practice schedules and have investigated this in a lab setting, some of which investigated the difference between blocked versus interleaved practice schedules in a motor skill and categorical learning context (Carter & Grahn, 2016; Shea &

Morgan, 1979; Simon, 2007; Stambaugh, 2011; Wong et al., 2020; Young, Cohen, and Husak, 1993). A blocked practice schedule consists of practicing one motor task repeatedly in one single session, until the desired number of trials has occurred, before switching to the next motor task (Simon, 2007). This is a repetition focused type of practice, one that many musicians endorse (Barry, 2007). An interleaved practice schedule, however, is one in which multiple motor tasks are learnt concurrently by alternating between them (Carter & Grahn, 2016). This means that a task is practiced for a certain period of time, before switching to the next task for the same amount of time, and then switching back to the first. These practice schedules employ a type of learning called contextual interference. The findings from these studies might be applicable to musical memorization, however no prior research has been conducted to examine this association.

Contextual Interference Effect in Motor Tasks

Contextual interference effect is the amount of interference, such as switching of tasks, to cognition during the practice of multiple tasks (Stambaugh, 2011). This effect posits that although interleaved schedules seem to disrupt practice, as opposed to blocked schedules, it increases long-term learning. In other words, the contextual interference hypothesis states that blocked practice, which is low contextual interference, will lead to better performance immediately after practice, whereas interleaved practice, which is high contextual interference, can lead to better performance only when there is a delay in retention testing (Stambaugh, 2011).

There are multiple theories that explain this paradox. One such theory is known as action-plan reconstruction, which proposes that the constant switching from task to task in interleaved practice requires cognitive plans for each movement to be reconstructed during each trial, which thereby strengthens the representation of each task in the mind (Young et al., 1993). The increase

in information processing activities during each trial due to the intervening practice causes the learner to forget the information that was previously encoded. Thus, much effort is required during processing for performance acquisition which therefore leads to retention. In contrast, blocked practice does not require the same action plan reconstruction as information from the previous trial would still remain available in the working memory while performing, thus eliminating the need for reconstruction (Young et al., 1993). The alternative explanation for the contextual interference effect is the theory known as elaboration. This was proposed by Shea and colleagues, and it posits that the simultaneous presence of multiple tasks held in working memory allows for an increase in multiple and variable processes, such as comparisons and elaborations, to be made within and amongst the various tasks (Shea & Morgan 1979; Shea and Zimny 1983, 1988). This in turn leads to the development of more distinctive and elaborate representations of the movements that were practiced, which is ultimately beneficial for retention. Therefore, within-task processing associated with blocked practice is more effective for acquisition performance, but not for long-term retention performance (Young et al., 1993). Multiple studies have been found to support the elaboration hypothesis (Lin, 2007; Shea and Zimny, 1988; Zimny, 1981).

The contextual interference effect has been observed across a wide variety of motor learning fields. In 1979, Shea and Morgan examined the effects of blocked and interleaved practice schedules on the acquisition and retention of three similar motor skill tasks. They also looked at the effects of contextual interference during acquisition or during a later transfer to a task with either the same or greater complexity than the original task. This study was based on the concept that increased contextual interference during skill acquisition can potentially lead to improved retention or transfer, especially during changed contextual conditions. Participants

were assigned to either the blocked or interleaved practice schedule and learned three motor tasks. Retention was measured either after a 10-minute or 10-day delay. Results revealed that retention was greater in the interleaved condition than blocked condition. A possible explanation for these results was that performance under the interleaved condition was more difficult than in the blocked condition. Thus, subjects in the interleaved group had to use multiple processing strategies to optimize their performance during acquisition. In contrast, the blocked group did not require the same processing. Hence, better retention performance and improved transfer for the interleaved condition was achieved, particularly when the context of the performance was changed (Shea and Morgan, 1979). The results provide evidence for the theory of elaboration, that is, there is an increase in multiple and variable processes made within and amongst various tasks when these multiple tasks are simultaneously held in working memory (Young et al., 1993).

Similarly, a study conducted by Simon (2007) investigated whether the standard contextual interference effect would take place when participants practiced two different multi-segment movement tasks in blocked or interleaved schedules. This was done to see if the standard contextual interference effect would be applicable to a two-patterned task, as opposed to the normal three-patterned movement task employed in other studies. Participants were randomly assigned to either the blocked or interleaved practice condition. The movement task consisted of pressing two different key sequences on a computer keyboard and had specific target execution times between the first and last key press. In the blocked schedule, participants performed one task for a total of 30 trials before switching to the next task. In the interleaved condition, participants performed a total of 30 trials per pattern, but these patterns were arranged in a semirandom order, with no more than two trials of the same pattern repeating consecutively.

Participants returned the next day for retention testing and were assessed on their metacognitive judgements by predicting how closely they would be able to perform each pattern to the corresponding target times on the retention test. Results showed that blocked learners' performance was better during acquisition, which is consistent with the contextual interference effect, while interleaved learners had better performance, with few errors, 24-hours after retention. Additionally, it was found that interleaved learners were able to recall the details of the patterns they practiced better than blocked learners. The overall results support the notion that having an interleaved practice schedule is more advantageous than a blocked practice schedule.

Contextual Interference Effect in Musical Tasks

Similar to Simon's (2007) study, Stambaugh (2011) conducted the first music learning experiment based on the contextual interference hypothesis to investigate the effects of blocked and interleaved practice schedules and assessed the performance accuracy, speed, temporal evenness, and attitude of beginning clarinet students in elementary schools. Participants were randomly assigned to either the blocked practice schedule or the interleaved practice schedule. Over the course of a week, participants completed three practices of three seven-pitch exercises and one retention test. In the blocked condition, participants performed 18 trials of one exercise one each day. In the interleaved condition, participants performed six trials of each of the three exercises each day, which were organized in a random order. In both conditions, the last three practices for each exercise were used as the acquisition score, and the following three trials performed 24-hours after acquisition were the retention trials. Then they had to perform three transfer trials of each transfer task. No significant differences were found between the blocked and interleaved condition for accuracy, speed, or temporal evenness. During the retention test, participants in the interleaved group performed significantly faster than the blocked group,

without compromising their accuracy. The blocked group performed significantly slower at the end of the practice trials compared to the interleaved group. Interestingly, there were no significant differences found between the groups for transfer tasks. The results suggest only partial support for the contextual interference hypothesis as the interleaved group had faster performance at retention. However, the interleaved schedule did not affect the performance at acquisition as there were no differences found between the two conditions, which contradicts the contextual interference hypothesis. This discrepancy in data emphasizes the need for further research in a musical context.

Likewise, Carter and Grahn (2016) conducted a study to compare the effects of blocked and interleaved practices on advanced clarinet players. It was based on the limited but existing contextual interference research in music (Stambaugh, 2011; Wong et al., 2020) but expanded on multiple parameters such as length and type of music practices, length and structure of practice sessions, approach for retention assessment, and type of analytical designed used. Clarinetists (N = 10), who were at least 18 years of age, and had to have been playing the clarinet for a minimum of 4 years, with a minimum of 2 years of private study, and be actively practicing the instrument for 8 hours per week were recruited for the study. This was a within-subjects design, so participants experienced both the blocked and interleaved conditions. In the blocked schedule, participants practiced the two musical pieces, one concerto exposition and one technical excerpt, each for 12 minutes straight. In the interleaved condition, participants were given two new pieces, again a concerto exposition and technical excerpt, and practiced each piece for 3 minutes in alteration until a total of 12 minutes of practice was completed for each piece. Participants sight-read each piece prior to practice and performed them after a 24-hour delay. They also filled out a questionnaire at the end of the testing session, which gathered demographic data and

musical experience data. Performances were recorded and subsequently rated by three professional clarinet players on a percentage scale. Results revealed that pieces performed under the interleaved condition were rated better than pieces in the blocked condition, with results varying across raters. The questionnaires also demonstrated that there were positive effects from the interleaved condition on certain factors like goal setting, mistake identification, and focus. Overall, these results suggest that an interleaved practice schedule is more effective than a blocked practice schedule in a music-learning context. Interestingly, although most of the subjects found that the interleaved schedule to be more useful, many still preferred the blocked schedule. This preference for blocked learning can be attributed to increased feelings of fluency after repetition, which in interleaved learning decreases. Thus, learners are often misled to believe that blocked learning is more beneficial as they underestimate how much they would be able to retain in the other condition.

The contextual interference effect has also been demonstrated in non-motor domains of musical learning, emphasizing that the contextual interference effect is applicable beyond the motor skills area. Wong and colleagues (2020) investigated the effects of interleaved presentation of musical pieces by multiple different classical music composers on learning to identify the different composer's styles. Participants (N = 71) who had 4 or fewer years of general music experience were recruited. Participants were presented with music pieces from six different composers in an interleaved fashion, and another six music pieces each from different composers in a blocked manner. Subsequent tests were conducted in which participants had to classify novel pieces by the same 12 composers. Results revealed that interleaved presentation was more beneficial than blocked presentation, with majority of the participants having judged the blocked condition to be more effective than the interleaved condition. This demonstrates

evidence that interleaved learning, even in a non-motor skill acquisition context, is more advantageous. It extends the current existing literature on the interleaving effect in category induction to the auditory domain, suggesting that the contextual interference effect might generalize to non-motor skill domains.

Only these few studies have been done on this phenomenon in a music-learning context, despite the broad potential to be employed in music practice. Previous studies such as Stambaugh (2011) and Carter and Grahn (2016) only looked at beginner and advanced clarinet players, respectively, while Wong and colleagues (2020) looked at the effect of contextual interference in the area of audition. Yet, none have explored this effect amongst different musicians, and no known study has investigated this effect with regards to memorization.

Metacognitive Judgement

Metacognitive judgement is essentially the assessment of one's own thinking and current state of knowledge. It is the knowledge of one's own knowledge (Metcalfe, 2009). It is the knowledge regarding the performance of an ongoing task, perceptual awareness, and self-awareness (Siedlecka & Wierzchoń, 2016). Individuals make judgements on their learning during or after acquisition, and these judgements are based on how well they have acquired the information (Peynircioğlu et al., 2014). Previous metacognitive judgement studies have only explored this phenomenon in a verbal material context in association with learning and memorization. Therefore, by assessing the metacognitive judgements in musicians, this paper aims to extend the prior knowledge with regards to metacognitive judgements from a musical perspective, such that these judgements will be based on the actual performance of the musical pieces.

Simon's (2007) study also assessed for predicted versus actual retention performance of two-patterned motor movement tasks. The participants' predicted retention performance errors did not match to the actual performance during retention testing, indicating poor judgement of the benefits of their practice schedules. However, since predictions were made before performance, it is unknown whether the blocked group performed better on retention than had they not made these predictions, as it could have influenced their performance outcome. It was also possible that participants recalled their previous predictions before retention, when assessing their own performance after retention. This means that rather than making explicit judgements on their actual performance, they were recalling their previously predicted performance assessment. Despite these interesting findings, further investigation is still required for metacognitive judgements, particularly in the context of music learning and performance.

Present Study

This study aims to extend the current literature on the phenomenon of contextual interference and its effects on memorization in the music-learning context. Therefore, the questions remain as to whether blocked or interleaved practice schedules are more beneficial for memorizing musical excerpts. Furthermore, it is also unclear whether there is a difference between practice schedules when participants are tested immediately after practice and again after a 24-hour delay. Moreover, no known study has assessed whether an advanced musician's metacognitive judgment, that is their assessment of their own performance, accurately reflects their actual performance. Thus, this study explores how memorization is affected based on practice schedules and a delay in retention, and to see if a musician's metacognitive judgement aligns with their performance. Investigating the contextual interference effect is essential for

fostering more efficient and productive learning and memorization techniques, both for musicians and potentially for the general student population.

The Carter and Grahn (2016) research study is a pilot study for this current study. Thus, advanced piano players were recruited to participate in a within-subjects design study, in which they will experience both the blocked and interleaved learning conditions and will be assessed on their performance immediately after learning the music excerpts and one day after learning. Additionally, their metacognitive judgement will be assessed through the completion of a questionnaire. It is hypothesized that participants will perform better with the blocked practice schedule immediately after acquisition, but they will perform better with the interleaved practice schedule after a 24-hour delay in retention, which is consistent with the contextual interference hypothesis. It is also hypothesized that participant's metacognitive judgement of their own performance will not align with their performance, that is they will rate that their performance for the blocked practice schedule to be better as it is the mode of learning that tends to be favoured (Bjork, 1999; Carter and Grahn, 2016).

Methods

Data collection follows methods from a larger pilot study done by Carter and Grahn (2016), which examined the effects of blocked and interleaved practice schedules in advanced clarinet players.

Participants

Participants were recruited from Western University's SONA system, Memorial University of Newfoundland, and other post-secondary institutions via posters, email, and social media advertisements. Individuals recruited were at least 18 years of age, with the exception of

registered Western University and Memorial University students who would be eligible if they were at least 17 years old. There were a total of 21 participants, with 6 males and 15 females, whose ages ranged from 18 to 48 (M = 26.52, SD = 10.88). Participants were proficient pianists who had anywhere from 8-43 years total experience playing the piano. At the time of participation, they were practicing anywhere from 1-34 hours a week (no means and standard deviations were calculated for these values as in some cases, participants indicated a range of years of experience or hours of weekly practice; one participant declined to provide information about average weekly practices). Participants were compensated with a standard honorarium of cash payment or SONA credits based on completion. Participants were compensated with up to a total of $15 (CAD), $10 (CAD) for the first day and $5 (CAD) for the next, or up to 1.5 SONA credits. The study was approved by the Western University Research Ethics Board (see Appendix A).

Stimuli

Four different musical stimuli were chosen, two excerpts from pieces by Jan Ladislay Dussek, and two excerpts from technical studies by Carl Czerny. The chosen excerpts provided authentic musical scores that contained a variety of technical and musical elements. In terms of difficulty level, they were chosen to be challenging but not overwhelming for participants. The excerpts were drawn from the standard repertoire, which means that they came from particular styles or composers that are generally representative of classical piano music. However, these excerpts were deliberately chosen to be less popular in order to minimize the likelihood that the participants would already be familiar with them. The two pieces were 16-measure long excerpts from piano sonatinas. Both were composed by Jan Ladislav Dussek in the late 18th century (see

Appendix B). The two technical studies were around 24 measures long and were from the early 19th century by Carl Czerny. All excerpts were in the key of C major (see Appendix C).

Procedure

Data for the current study had been collected continuously since January of 2021 and took place both in person and online via Zoom.

In-person testing

Upon arrival, participants were given a letter of information about the study and then signed a consent form (see Appendix D). Prior to starting the study, participants were given a few minutes to warm up if they wished to do so. During the first testing session, each participant completed two practice schedules consecutively, the blocked schedule and the interleaved schedule. The blocked schedule represented low contextual interference whilst the interleaved schedules represented high contextual interference. Each practice condition would require the participants to learn and practice one excerpt and one technical study piece in the same way that they would normally practice. In the blocked condition, participants were told to sight-read one of the excerpts and to do so to the best of their ability without stopping. They were then instructed to practice the piece for a total of 12 minutes. They were then told to sight-read one of the study pieces and practice it for 12 minutes in the same way that they had done for the excerpt. A short break of approximately one to two minutes took place before testing continued. In the interleaved condition, participants sight-read both the excerpt and the study piece at the beginning of the practice session to the best of their ability without stopping. They then alternated practicing between the excerpt and study piece, switching every three minutes until a total of 12 minutes per piece was completed. A breakdown of each practice schedule can be seen

in Table 1 below. A short one-to-two-minute break was held after practice before immediately proceeding to the testing session, which is the acquisition trial. During the acquisition trial, participants had to play each piece, in the same order that they had learnt them in, from memory. They were allowed to silently read, but not play, each piece before turning the sheet music face down and playing it as accurately and musically as possible from memory. This trial provided the measure of immediate practice retention.

Table 1

Breakdown Of Practice Schedule Day 1 Example

Blocked Schedule	Interleaved Schedule	Test Schedule
Warmup (5 mins)	Sight-read P2	P1*
Sight-read P1	Sight-read T2	T1*
Practice P1 (12 min)	Practice P2 (3 mins)	P2*
Sight-read T1	Practice T2 (3 mins)	T2*
Practice T1 (12 mins)	Practice P2 (3 mins)	
Break (1-2 mins)	Practice T2 (3 mins)	
	Practice P2 (3 mins)	
	Practice T2 (3 mins)	
	Practice P2 (3 mins)	
	Practice T2 (3 mins)	
	Break (1-2 mins)	

Note: P1 = piano excerpt 1, P2 = piano excerpt 2, T1 = piano study 1, T2 = piano study 2, * indicates “from memory”.

On the second day of testing, 24 hours after the first testing session, participants returned for the retention trial. Participants were given five minutes to warm up and were then asked to play the pieces, in the same order that they had previously learnt, as accurately and musically as possible from memory. They were allowed to silently read, but not play, each piece prior to playing them. This trial provided the measure of retention after a delay. All sight-reading and testing sessions from both day 1 and 2 were recorded using a Zoom recording device.

After the testing session, participants were required to complete a musical background questionnaire to establish demographic information and level of musical expertise (see Appendix E). In addition, they were asked questions regarding the practice schedules they experienced, such as which practice schedule they preferred, which schedule they found to be most useful, which practice schedule was most similar to their own personal daily practice routine, and if they had previously heard or played any of the musical pieces from the study. At the end of the study, participants were given a debriefing form to explain the current study in further detail, which also consisted of a list of references to previous studies in the case of interest (see Appendix F).

Online participation

Data collection for online participation was conducted in the same way with a few of the following exceptions. Links to secured Zoom calls were sent to participants via the email address they provided. Participants were also sent PDF copies of the musical stimuli that they would practice prior to the first session. They were instructed to print the music sheets, or prepare it in any other way to be accessed during the session like uploading it to a tablet, but to not look or practice the pieces before attending the first session. On Day 1, participants attended the Zoom call and consent was obtained via Qualtrics. Participant testing was then carried out in the same manner as in-person testing, in that they followed the practice schedule they were assigned,

practiced musical pieces in the specific given order, and experienced both blocked and interleaved schedules. They were tested at the end of the session for immediate practice retention. Participants were told to not look at the music pieces between the end of the Day 1 session to the beginning of the Day 2 session. The following day, participants attended another Zoom session to perform the music pieces again for the retention after a delay measure. They then completed the questionnaire via Qualtrics and were sent a debriefing form to their email address. The sight-reading trials, along with the Day 1 and Day 2 acquisition trials, were recorded by the participant and sent to the researchers, which were then uploaded on to a secure OneDrive folder that only researchers had access to.

Design

The current study was a within-subjects design, thus participants experienced both practice conditions, the blocked and interleaved practice schedules. To control for individual differences amongst participants, the order of practice schedules was counterbalanced. This means that half of the participants experienced the blocked condition first, while the other participants began their Day 1 session with the interleaved condition. Moreover, the same counterbalancing was applied to all the musical stimuli in each condition. In other words, some participants experienced practicing the first excerpt in the blocked condition and the second excerpt in the interleaved condition, while others experienced the first excerpt in the interleaved condition and the second excerpt in the blocked condition. Some participants would have also practiced the first study piece in the blocked condition and the second study piece in the interleaved condition, while others experienced the first study piece in the interleaved condition and the second study piece in the blocked condition. Hence, there were a total of 8 variations of

the practice schedule. This was done so to ensure that results were due to the practice conditions, and not the musical pieces themselves.

The participants' performances on acquisition and retention trials, Day 1 and Day 2 respectively, were rated for accuracy and musicality by a musical expert. Participant's scores were based on how much of the excerpt they were able to play through, as well as the accuracy and musicality of the section they did manage to play.

Analysis

Incomplete data were excluded from data analysis. Normality was assessed through visual inspection of a histogram, as well as numerically and mathematically via skewness, kurtosis, Kolmogorov-Smirnov test, and the Shapiro-Wilk test. This was done to see if values were in an acceptable range, and if they were heavy-tailed or light-tailed with respect to the normal distribution. A 2x2 repeated measures ANOVA was then conducted through SPSS using ratings for each condition, the blocked and the interleaved condition. The two within-subject factors were the practice schedules, blocked versus interleaved, and the testing day, Day 1 versus Day 2. Metacognitive data was then assessed using contingency tables and descriptive analysis was conducted by plotting participant averages of their scores to assess for trends in the data.

Results

Performance scores for two excerpts practiced in the interleaved condition were averaged to create composite interleaved scores for Day 1 and Day 2, and the same was done with blocked scores for Day 1 and Day 2. For Day 1, the average interleaved score for all 21 participants was 27.17 (*SD* = 18.48), and the average blocked score was 24.88 (*SD* = 19.63). On Day 2, the average interleaved score for all 21 participants was 26.83 (*SD* = 17.94), and the averaged

blocked score was 23.77 (*SD* = 17.32) (See Table 2 below). Normality tests such as the Kolmogorov-Smirnov test revealed that the blocked schedule on day 1 was not normally distributed ($D(21) = .23$, $p = .004$), and the blocked schedule on day 2 was also not normally distributed ($D(21) = .25$, $p = .001$). Moreover, the Shapiro-Wilk test revealed that scores from both schedules on both days were significant, indicating that the normality assumption was violated. The interleaved schedule on day 1 showed a significant departure from normality ($W(21) = .90$, $p = .03$), as did the interleaved schedule on day 2 ($W(21) = .87$, $p = .009$). The blocked schedule on day 1 was not normally distributed ($W(21) = .85$, $p = .005$), and the blocked schedule on day 2 was also not normally distributed ($W(21) = .84$, $p = .003$). However, since the ANOVA is a very robust test towards significance, analysis was still conducted but with caution.

Table 2

Descriptive Statistics of Each Practice Schedule for Both Test Days

Schedule	**Day 1**			**Day 2**		
	N	**M**	**SD**	**N**	**M**	**SD**
Interleaved	21	27.17	18.48	21	26.83	17.94
Blocked	21	24.88	19.63	21	24.77	17.32

Note: Average scores were based on a percentage scale.

A 2x2 (practice schedule [blocked, interleaved] x day (Day 1, Day 2]) repeated measures ANOVA was conducted to compare performances from both practice conditions and both days. Performance scores were highest for the interleaved practice schedule on day 1 (*M* = 27.17, *SD* =

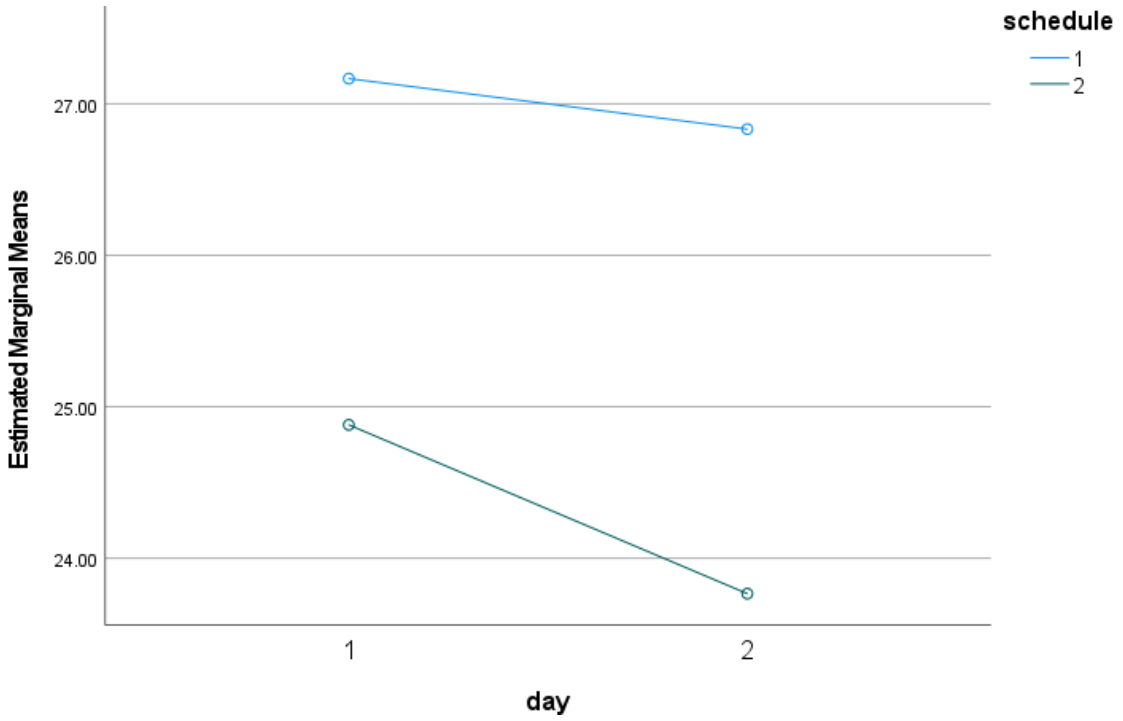
18.48), followed by the interleaved practice schedule on day 2 (M = 26.83, SD = 17.94), then the blocked practice schedule on day 1 (M = 24.88, SD = 19.63), and lastly the blocked schedule on day 2 had the lowest performance scores (M = 24.77, SD = 17.32).

Although descriptive statistics demonstrated that scores from the interleaved schedule were better than scores from the blocked schedule, the ANOVA test revealed that this was not a significant difference (See Figure 1 below). The analysis revealed that there was no significant main effect of day on practice schedule ($F(1,20) = .15$, $p = 0.70$, $\eta_p^2 = .01$). Moreover, results revealed that there was no significant main effect of practice schedule on day ($F(1,20) = 1.03$, $p = .32$, $\eta_p^2 = .05$). There was also no significant interaction between the two variables, practice schedule and day ($F(1,20) = 3.20$, $p = .77$, $\eta_p^2 = .00$).

Metacognitive judgement data revealed that most participants were not able to accurately judge which practice schedule truly benefitted them. On day 1, 13 participants were inaccurate in their metacognitive judgements while 8 participants were accurate. On day 2, 14 participants were inaccurate while 7 participants were accurate in their judgements of their performance (See Figure 2 below).

Figure 1

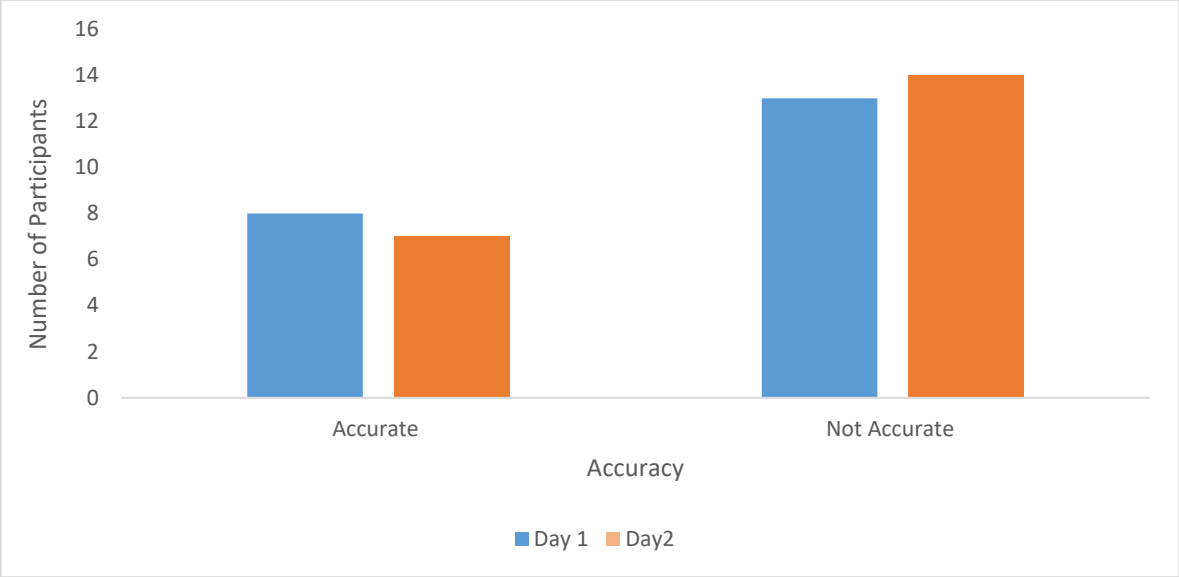
Estimated Marginal Means for Retention Trial Scores in Blocked and Interleaved Practice Schedules



Note: Schedule 1 represents the interleaved schedule while schedule 2 represents the blocked schedule. Scores are based on a percentage scale and represent the overall average of all participants under that condition and of that test day.

Figure 2

Metacognitive Judgement Accuracy



Note: Metacognitive judgement accuracy was inaccurate for both test days.

Discussion

Practice schedules

The purpose of this study was to assess how the contextual interference effect expands to memorization amongst pianists. This was done by observing which practice schedule was more beneficial for memorizing music. In other words, was blocked practice or interleaved practice better, and was there a difference between practice schedules when participants were tested immediately after practice and again after a 24-hour delay? Overall, analyses revealed that there was no significant difference between performances from both practice schedules. Although, results did reveal that there was a slight difference in that performances were marginally better under the interleaved condition than the blocked condition, partially supporting the hypothesis.

However, it was previously hypothesized that performance would be better under the interleaved condition on day 2, but that was not the case. Performance scores seemed to rank higher on day 1 under the interleaved condition rather than on day 2. This indicates that participants performed better with immediate retention rather than retention after a delay under the interleaved practice condition. In general, the interleaved practice schedule produced better performance scores than the blocked schedule when scores from all participants were averaged, but this difference was not enough to reach statistical significance. These findings are important to extend the current literature on how the contextual interference effect, represented by the interleaved practice schedule, effects memorization in the music context. Limited research had explored this phenomenon in music-learning, but no known study had investigated this effect with regards to memorization and pianists. Investigating this affect is essential for creating more efficient and productive learning and memorization techniques, both for musicians and potentially for a more general population.

The current findings were consistent with Stambaugh's (2011) study on the contextual interference effect on performance accuracy of beginning clarinet students. Stambaugh (2011) found no significant differences between the blocked and interleaved condition for accuracy and acquisition. Similar results were found for the present study as no significant differences were found in terms of memorization between the two practice schedules. Moreover, current findings were only partially consistent with Carter and Grahn's (2016) study which compared the effects of blocked and interleaved practices on advanced clarinet players. They found that performances were rated better under the interleaved condition than the blocked condition. The same observation was made for the current study. However, one main difference in results was that the

difference between performance under the two practice conditions in the present study was not statistically significant, which contradicted Carter and Grahn's (2016) study.

Additionally, the findings from the present study contradicted the contextual interference hypothesis. It posits that low contextual interference, represented by blocked practice, would lead to better performance immediately after practice. Whereas high contextual interference, represented by interleaved practice, would lead to better performance only when there was a delay in retention testing (Stambaugh, 2011). This study found that regardless of a delay in retention testing, performance was better under the interleaved condition. Studying the contextual interference phenomenon in applied, varied settings, pose as a challenge, potentially giving rise to these inconsistent results. Studies conducted under laboratory settings that provide high interference conditions reduces acquisition and promotes learning through retention and transfer tests (Barreiros, 2007). However, studies conducted under applied settings may not observe positive effects after manipulating the contextual interference. This may be due to the characteristics of the tasks used in experimentation with serial tasks yielding the best results, the uncommon occurrence of short intertrial intervals in applied settings, and the different interference produced by the use of varying motor skills (Barreiros, 2007). Therefore, the inconsistent results with the previous existing literature may be due to the different motor tasks used and the settings in which testing was conducted.

Metacognitive Judgement

Additionally, this study assessed whether a participant's metacognitive judgment accurately reflects their actual performance. Results revealed that metacognitive judgements did not align with performance, indicating that most of the participants were unable to tell which practice schedule truly benefitted them. Most participants thought that they performed better

with blocked practice learning when in reality they performed better with interleaved practice. This finding was important as previous metacognitive judgement studies have only explored this phenomenon using verbal stimuli to assess learning and memorization. Therefore, the assessment of metacognitive judgements amongst pianists in the context of memorization extends the prior knowledge with regards to metacognitive judgements from a musical perspective.

Results were consistent with multiple other studies such as Carter and Grahn's (2016) study and Wong and colleagues (2020) study. In 2016, Carter and Grahn found that the interleaved schedule was more useful for music acquisition and accuracy amongst beginner clarinetist, but they still preferred the blocked schedule. The same was found for the present study as most of the participants preferred the blocked practice schedule and thought that performances from that condition was better. Likewise, results were consistent with the findings from Wong and colleagues (2020) as majority of the participants from that study judged the blocked condition to be more effective than the interleaved condition in terms of identifying composers.

The preference for blocked learning may be attributed to the increased feelings of fluency gained after repetitive learning. Feelings of fluency tend to decrease under interleaved learning (Carter & Grahn, 2016). Feelings of fluency can ultimately impact performance judgments, regardless of how much learning and practice has occurred. Moreover, musicians are taught that repetition is key to learning, and they have incorporated it into their practice routines. Thus, participants might have been misled to believe that blocked learning is more beneficial as they are unaware of how much they would be able to retain in the interleaved condition.

Implications

The findings from this study have provided important insight to the contextual interference theory. It extends the existing knowledge of how this phenomenon applies in the musical-learning context and memorization; an area that has not been thoroughly studied. Examining these learning strategies can help us understand which type of learning technique should be incorporated into a pianist's practice routine in order to achieve the best performance results. Findings may even have broader population implications such as in non-musical domains like sports and students studying for exams, as that incorporates repetition as the main skill for memorization. Additionally, metacognitive judgement results sheds light on self-regulation habits. It provides a better understanding of how repetition can influence inaccurate judgements on performance, demonstrating why musicians may favour the blocked practice schedule.

Despite there only being a small difference in performance based on practice schedules, the results of the study suggest that an interleaved schedule may be a better way to practice musical pieces. One main advantage of this form of practice is its similarities to a real-world context. It is a more realistic simulation of an audition or concert setting, as repetition during these demanding conditions is not possible. The constant switch between tasks in the interleaved condition gives rise to processing that is more likely to transfer, thus facilitating various opportunities to start practicing the material from scratch in a new way (Carter & Grahn, 2016).

Another benefit to interleaved practice for musicians is its implications on the overall health for musicians. Interleaved practice does not cause as much of a physical strain on the body as blocked practice, which employs repetition as the learning strategy. The demanding repertoire leads to over-use injuries and soft-tissue symptoms with risk to these injuries increasing as the number of hours of playing increases (Kenny & Ackermann, 2009). Approximately 75-85% of

all injuries amongst musicians consist of upper limb over-use injuries. Other symptoms that stem from strenuous repetition include inflammatory disorders like tenosynovitis, arthritic issues, and hypermobility (Kenny & Ackermann, 2009). Switching to an interleaved practice schedule may help reduce the risk of developing such disorders as interleaved learning builds on physical variety rather than repetition.

Limitations

There are several limitations for this study, which may be attributed to the inconsistent findings. Firstly, the sample size for this study was very small, which may be associated to the marginal differences seen between practice schedules. It was evident that performance under the interleaved condition was better, but not by a vast amount. Second, due to the nature of the study, data collection was conducted via Zoom for some participants. This means that these participants could have practiced the musical pieces before testing on day 1 and before testing on day 2. Although participants were instructed to not look at the stimuli prior to the Zoom sessions, they would still have been able to as they were emailed the pieces the day before the first Zoom session. Hence, this was not properly controlled for, and it is unknown if this occurred due to self-report bias. This would have changed the performance scores for these individuals, inflating their overall scores and skewing the data.

Another limitation is that although the musical stimuli selected had comparable difficulty and were less popular in order to minimize the likelihood that the participants were familiar with them, some participants did know the pieces. Their familiarity with the pieces could have helped their memorization and performance, further inflating scores. Furthermore, normality tests revealed that there were a few outliers, but they were not present under all conditions. Data showed no indication of performance issues, such as a false start, therefore these outliers could

be attributed to individual differences. It is unknown how these individual differences may have influenced performance and memorization outcomes.

Lastly, performances were rated by an expert in the field on a percentage scale. Unlike Carter and Grahn's (2016) study, ratings were conducted by only one expert rather than three. This means that performance scores could have been influenced by subjective interpretation. Although there is a strict criterion for how performances should be scored, it does not completely eliminate subjective scoring, it only minimizes it. Thus, subjective scoring may have influenced the performance scores for each participant, and in turn the overall average performances under each practice conditions on both test days.

Future Directions

The current study aimed to extend knowledge in contextual interference research in music by employing a different class of musicians. However, inconsistent study results emphasize the important of determining if it was due to the study design of the present study. Thus, future studies should include a bigger sample size to allow for potential effect sizes and interactions between variables to be observed. Longer practice sessions should also be included in future studies. These practice sessions should extend over multiple days to truly test the effect of contextual interference on memorization and to simulate more realistic practices that musicians experience. This is important to implement in future studies as existing studies on contextual interference often employ a few acquisition trials, much like this study (Shea et al., 1990). The advantages of interleaved practice over blocked may not become apparent until later on in practice, thus having few acquisition trials may result in small or non-significant effect sizes.

In addition, future research should use more complex musical stimuli. The musical stimuli used in the current study were deliberately chosen to be of similar complexity to one another, but they did not necessarily have a high degree of difficulty. However, more observable effects of contextual interference in applied settings may be more evident when participants are required to learn a series of highly complex tasks (Barreiros, 2007). Thus, the potential musical pieces that would be employed in future studies should be of high difficulty, but still be of similar complexity between them.

Future studies should implement a more ecologically valid rating system. This system should have multiple expert raters that give an overall performance percentage for each piece, and these scores would subsequently be averaged to one overall performance score per piece. This is important as this is what would mimic music juries. Although variability across raters may pose as an issue, having a large number of evaluators may reveal specific patterns of performance improvement when they are consistently observed amongst different raters.

Finally, there is potential to extend the current study to different applied musical domains, such as ear training, singers, and other instrumental groups, with different levels of ability like beginners and professionals. Moreover, this study can extend to non-musical domains where memorization is required, such as math, spelling, and sports. This would allow for a better understanding of the effects of contextual interference on memorization, especially in applied settings.

Conclusion

Repetition, which was represented by the blocked practice schedule, is a highly favourable learning strategy. However, it is possible that there may be a more effective way for

musicians to memorize their musical pieces. This study assessed the generalizability of the contextual interference effect, represented by the interleaved practice schedule, on memorization to an ecologically valid setting particularly for advanced pianists. It seems as though there is potential for interleaved practice to be the main mode of learning as opposed to blocked learning. However, due to inconsistencies in the literature and the present study, more research is required to properly determine if contextual interference has positive impacts on memorization. Moreover, it is evident that musicians' metacognitive judgements of their own performances were not accurately reflected in their performance scores. This means that more understanding in how we perform self-assessments is required, with the potential to produce a new way of conducting these self-assessments so that musicians can benefit from being able to accurately judge themselves.

The research on contextual interference in the musical domain has many practical applications within and outside of the musical realm. People may greatly benefit from this deeper knowledge and understanding of this phenomenon as it can potentially yield new strategies that help with memorization and learning. In order to see the potential benefits of contextual interference in music practice, it must be successfully implemented into the practice routine. This shift from the traditional way of learning requires more musicians, both students and teachers alike, to endorse and take part in interleaved learning. Although it may seem like it is not as effective, there are more potential long-term benefits to this form of practice.

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Appendix A

Ethics Amendment Approval

Western Research

Date: 25 October 2021

To: Dr. Jessica Grahn

Project ID: 109152

Study Title: Optimizing Music Learning: The Effects of Contextual Interference

Application Type: NMREB Amendment Form

Review Type: Delegated

Full Board Reporting Date: November 5 2021

Date Approval Issued: 25/Oct/2021 21:38

REB Approval Expiry Date: 29/May/2022

Dear Dr. Jessica Grahn,

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the amendment, as of the date noted above.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
REBID-109152 - LOI & Consent (Exp. 1.1 Online) - V4 - 23-09-2021	Written Consent/Assent	23/Sep/2021	V4
REBID-109152 - LOI & Consent (Exp. 1.2 Online) - V4 - 23-09-2021	Written Consent/Assent	23/Sep/2021	V4
REBID-109152 - LOI & Consent (Exp. 1.3 Online - pianists) - V4 - 23-09-2021	Written Consent/Assent	23/Sep/2021	V4
REBID-109152 - LOI & Consent (Exp. 1.3 Online - singers) - V4 - 23-09-2021	Written Consent/Assent	23/Sep/2021	V4
REBID109152 - Protocol - V3-23-09-2021	Protocol	23/Sep/2021	V3
Recruitment Email Script (1.1, 1.3 - pianists) - V4 - 12-10-2021 - REBID-109152	Recruitment Materials	12/Oct/2021	V4
Recruitment Email Script (1.2, 1.3 - singers) - V4 - 12-10-2021 - REBID-109152	Recruitment Materials	12/Oct/2021	V4
Recruitment Poster (1.1, 1.3 - pianists) - V4 - 12-10-2021 - REBID-109152	Recruitment Materials	12/Oct/2021	V4
Recruitment Poster (1.2, 1.3 - singers) - V4 - 12-10-2021 - REBID-109152	Recruitment Materials	12/Oct/2021	V4
Social Media Recruitment Ad (1.1, 1.3 - pianists) - V3 - 12-10-2021 - REBID-109152	Recruitment Materials	12/Oct/2021	V3
Social Media Recruitment Ad (1.2, 1.3 - singers) - V3 - 12-10-2021 - REBID-109152	Recruitment Materials	12/Oct/2021	V3
SONA Recruitment Ad (1.1, 1.3 - pianists) - V3 - 12-10-2021 - REBID-109152	Recruitment Materials	12/Oct/2021	V3
SONA Recruitment Ad (1.2, 1.3 - singers) - V3 - 12-10-2021 - REBID-109152	Recruitment Materials	12/Oct/2021	V3

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as

Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

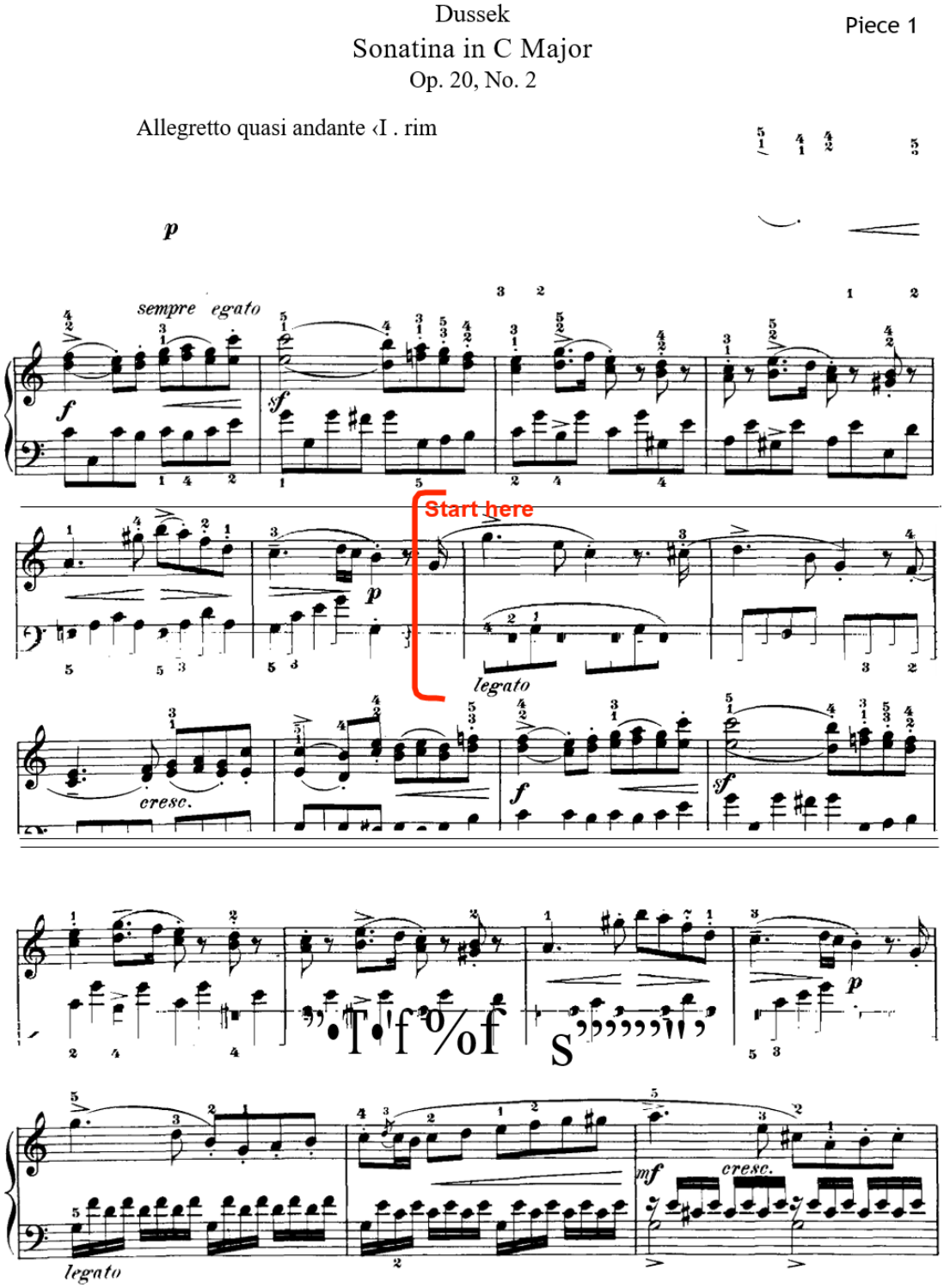
Sincerely,

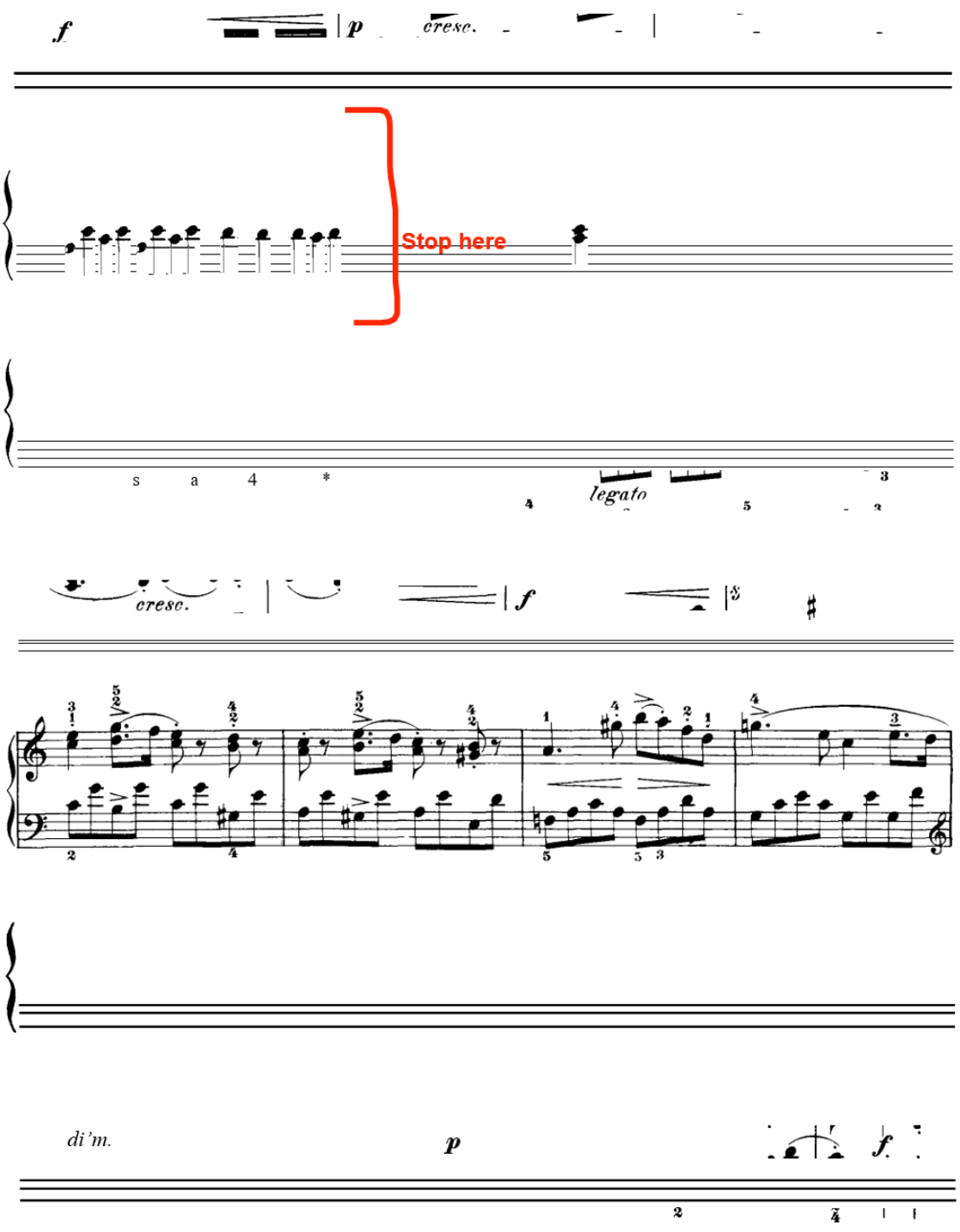
Kelly Patterson , Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Appendix B

Musical Stimuli for Excerpt Pieces P1 and P2

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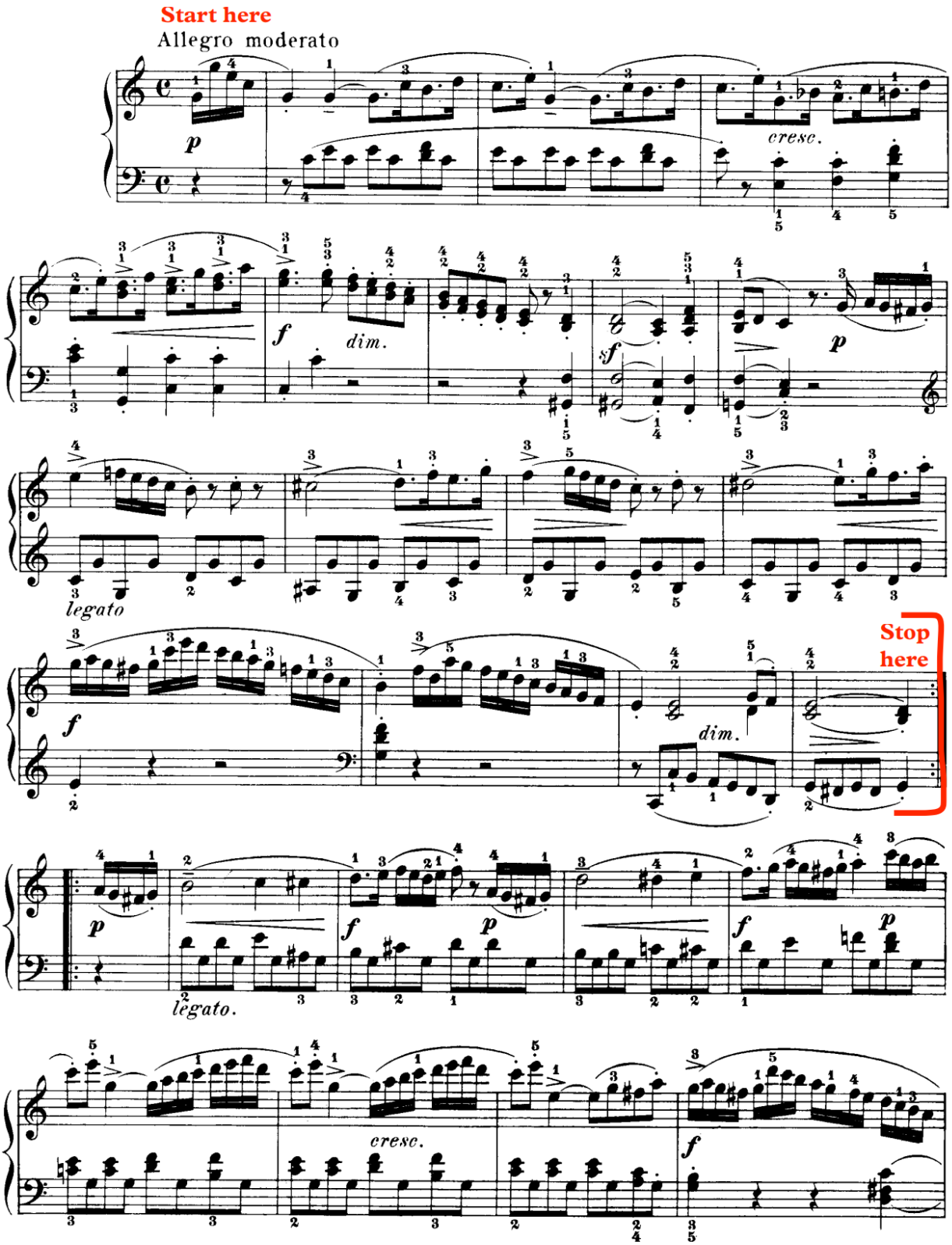
cresc.
Stop here
s a 4 *
legato
cresc.
f
di'm.
p
f

Piece 2


Start here
Allegro moderato
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cresc.
f
dim.
sf
p
legato
f
dim.
Stop here
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p
f
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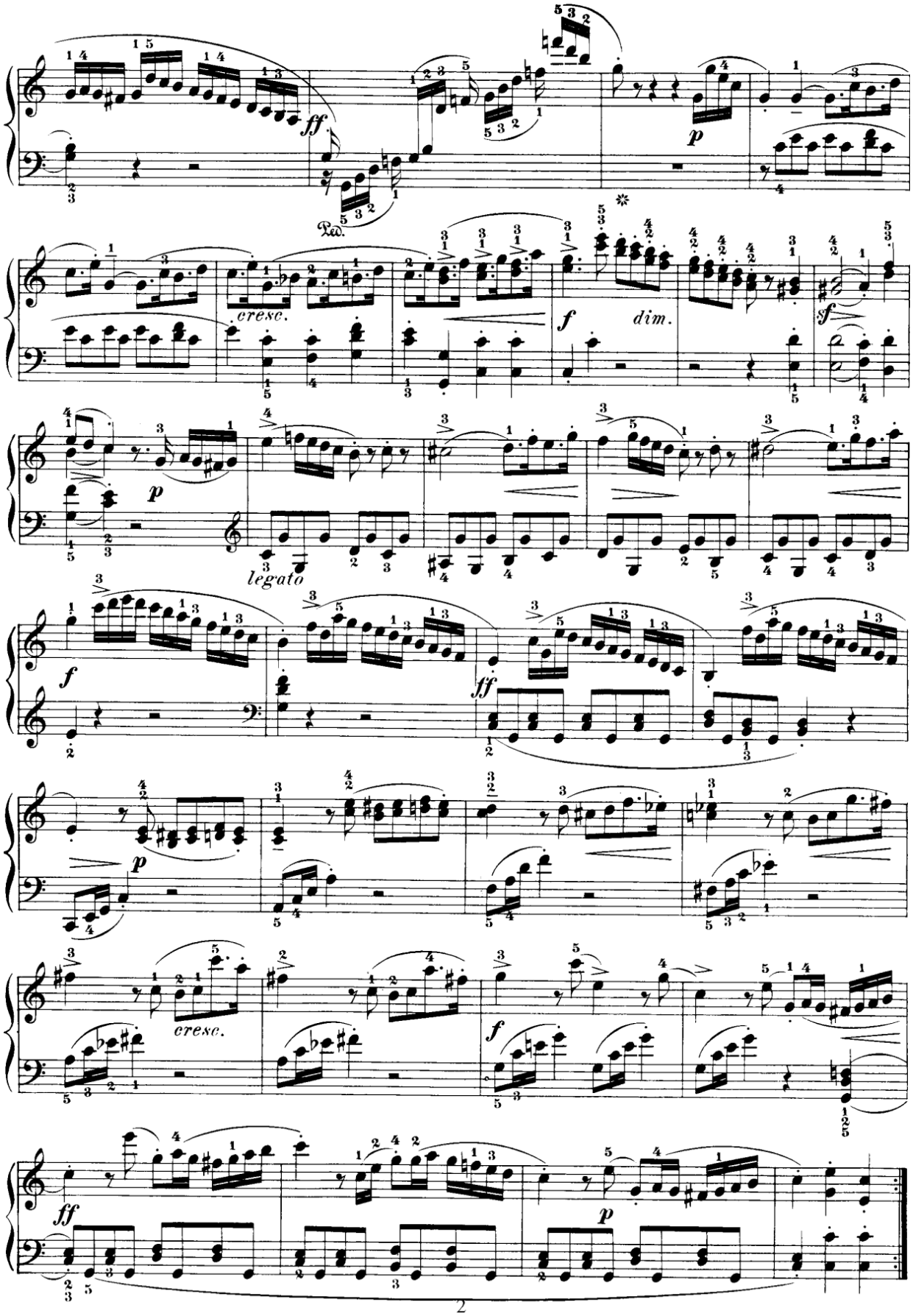
legato.
cresc.
f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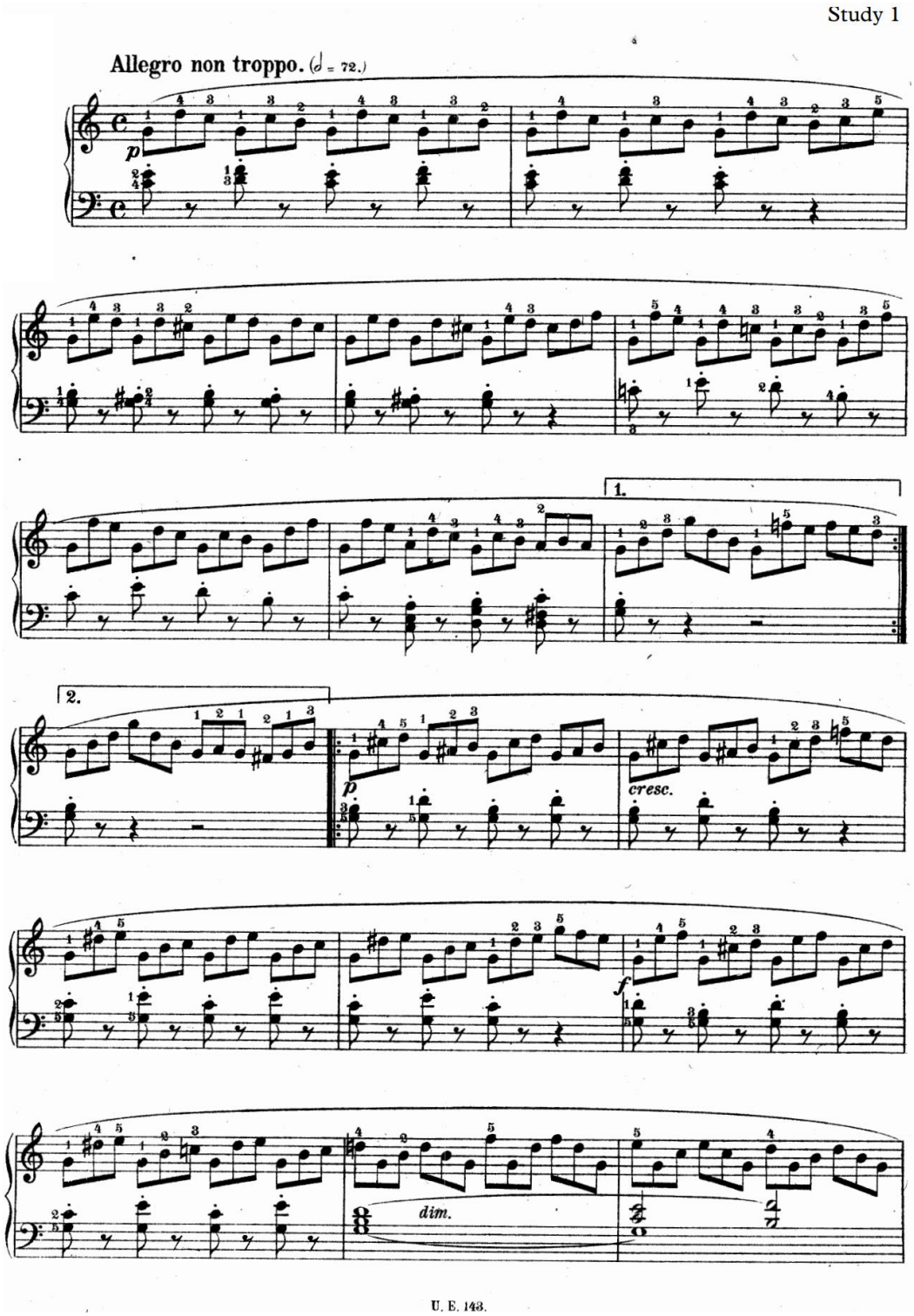
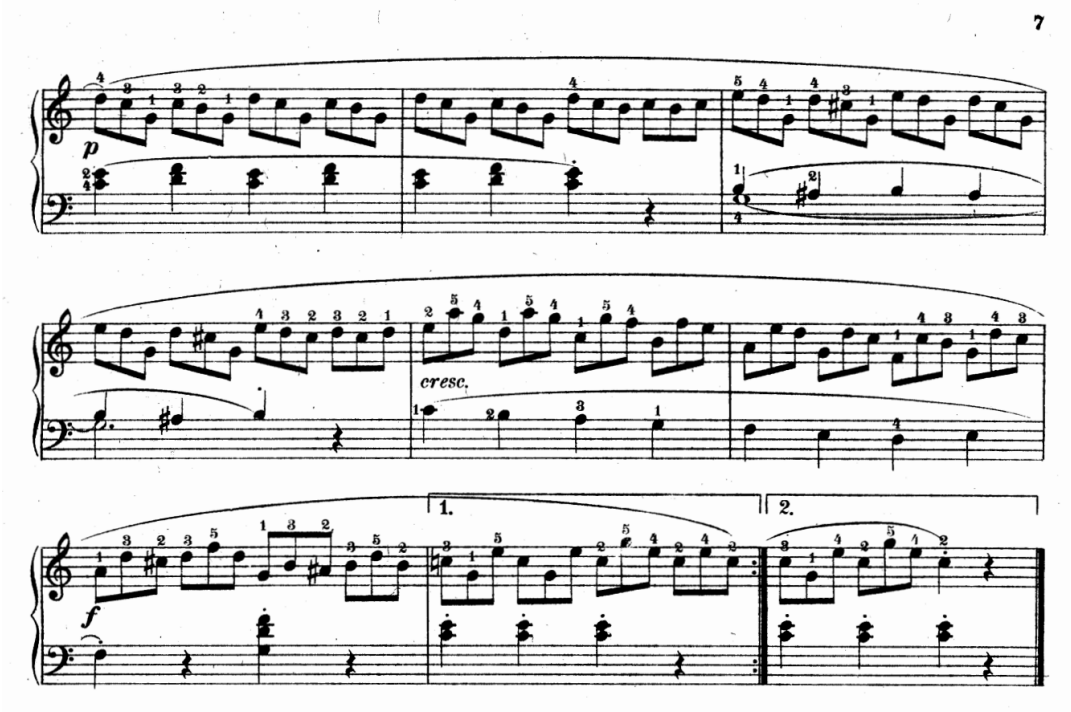
Appendix C

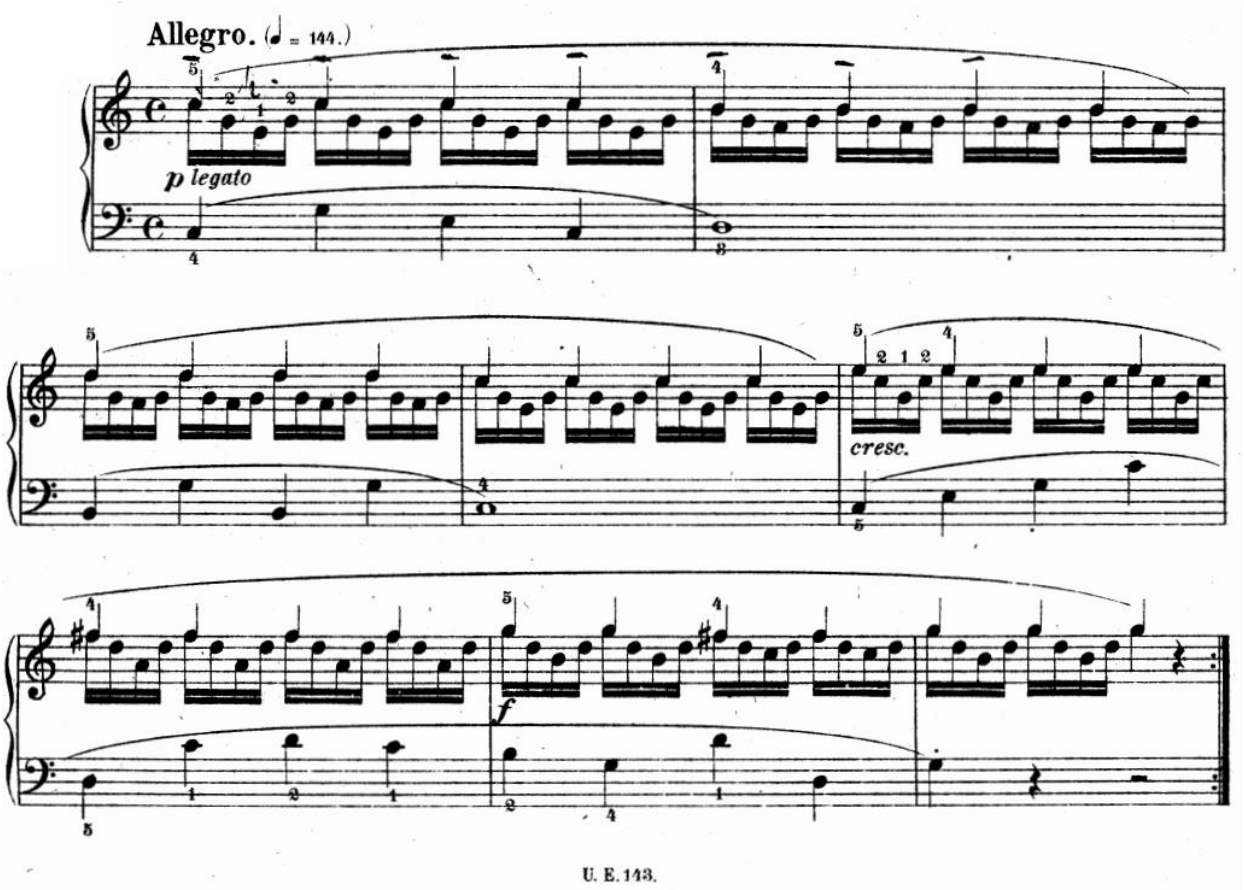
Musical Stimuli for Technical Studies T1 and T2

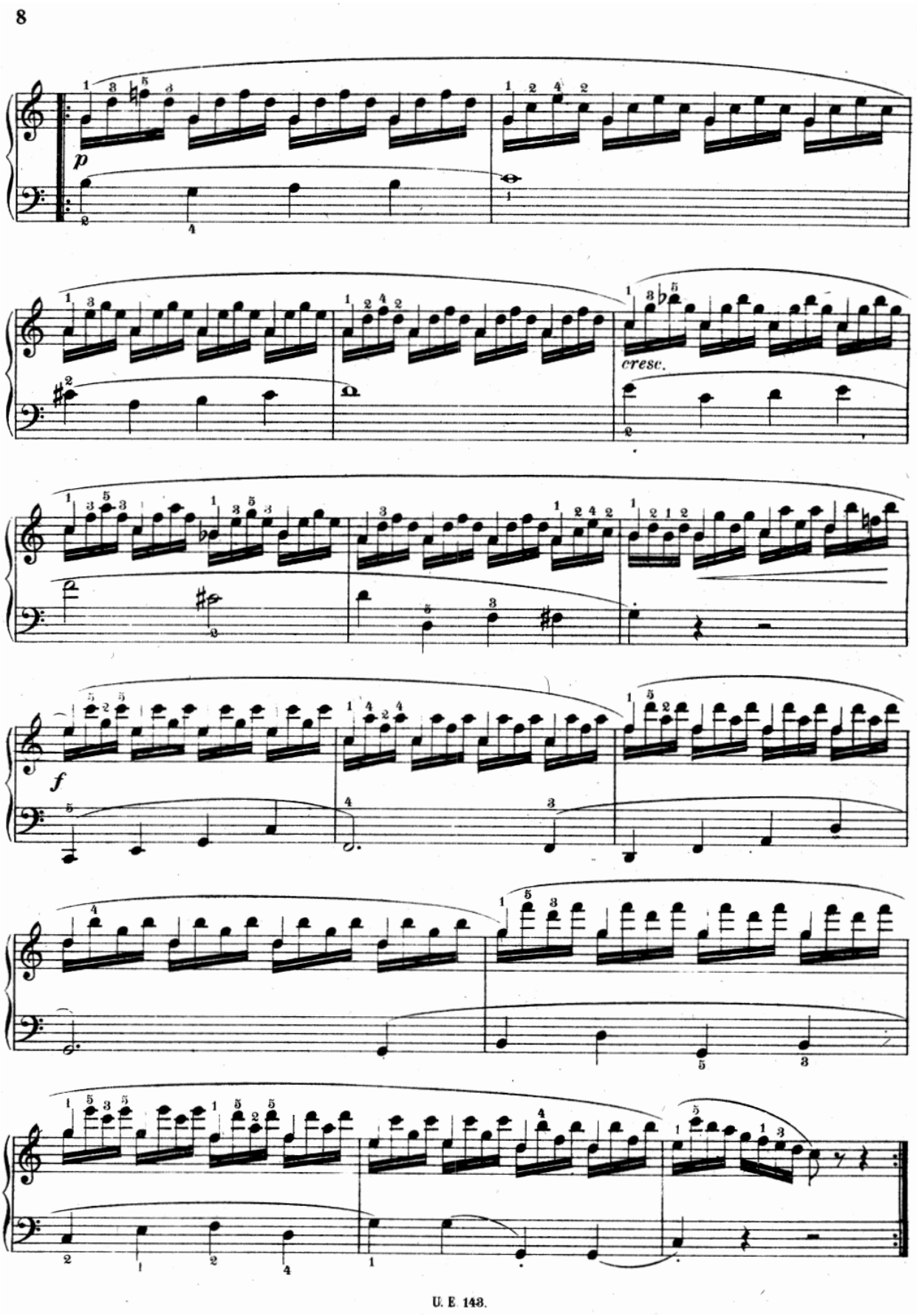




U. E. 143.

Study 2

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Appendix D

Letter of Intent and Consent Form

Western

Letter of Information and Consent

Project Title: Optimizing Music Learning: The Effects of Contextual Interference

Principal Investigators:

Dr. Jessica Grahn,

Brain & Mind Institute, Western University

jgrahn@uwo.ca, (519) 661-2111 **x84804**

Dr. Christine Carter

School of Music, Memorial University

c.carter@mun.ca, (709) 864-7401

You are invited to take part in a research project examining the effect of different learning strategies on musical performance.

The purpose of this letter is to provide you with information required for you to make an informed decision regarding participation in this research. It is important for you to understand why the study is being conducted and what it will involve. Please take the time to read this carefully, and feel free to ask questions at any point if anything is unclear.

Study Procedures

If you agree to participate, you will take part in two separate experimental sessions. These sessions may take place in person, on the Western University campus, or online via Zoom. On Day 1, you will sight-read and practice four musical excerpts in different orders and for different lengths of time. Immediately following practice, you will play through all of the excerpts you practiced from memory. On Day 2, you will play through all of these excerpts once more from memory and complete an online questionnaire via Qualtrics. **If your participation takes place online, you will be asked to record your playing (audio only) and upload your recording to a secure OneDrive after each session.**

Participation on Day 1 will take approximately 1 hour and 15 minutes. Participation on Day 2 will take approximately 15 minutes.

Potential Risk

There are no known or anticipated risks or discomforts associated with participating in this study.

Potential Benefits

Through participating in this study, you will learn about practice strategies that may prove useful in your personal music practice or other academic pursuits. In the long term, the data from this study is expected to inform the development of effective real-world practice strategies, of interest to professional musicians, educators, and students in Canada and beyond. At the end of the study, we will provide a more detailed explanation of the questions that motivate this line of research and the potential implications.

Voluntary Participation

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions, or withdraw from the study at any time with no effect on your future academic status. We will give you new information that is learned during the study that might affect your decision to stay in the study. You do not waive any legal right by consenting to this study. You may choose to withdraw at any time during the study. After completion of the study, collected data cannot be removed; however all data is completely anonymous.

Compensation

You will receive an honorarium of $10 for your participation on Day 1 and $5 for your participation on Day 2. This honorarium will be sent via e-transfer within 48 hours of your participation to the email address you provide.

Confidentiality and Anonymity

All data that you provide, including audio recordings, will remain confidential and will be accessible only to the researchers conducting this study. No personally identifiable information will be associated with your final data. In the event of publication, any data resulting from your participation will be identified only by case number without any reference to your name or personal information.

Data from this research may be published in relevant academic journals and at conferences. Data will be presented in aggregated and/or summarized form. If direct quotations are used from the post-experimental questionnaire, no personally identifying information will be included.

Representatives of the University of Western Ontario Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research.

Storing and Archiving of Data

All data that you provide will be stored indefinitely on password-protected computers, backup storage devices, and a secure Western OneDrive to which only authorized researchers will have access. Some data, as well as your confirmation of consent, will also be stored by the online survey software Qualtrics through Western University. Qualtrics uses encryption technology and restricted access authorizations to protect all data collected. In addition, Western's Qualtrics server is in Ireland, where privacy standards are maintained under the European Union safe harbour framework. The data will then be exported from Qualtrics and securely stored on Western University's server. Consent information will be stored separately from all data. Data will be kept for a minimum of seven years.

If you have questions about this study please feel free to contact Principal Investigator **Dr. Jessica Grahn** (Brain & Mind Institute, Western University; jgrahn@uwo.ca), or Co-Investigator **Dr. Christine Carter** (School of Music, Memorial University; c.carter@mun.ca).

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research (Memorial University) and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research, such as the way you have been treated or your rights as a participant, you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at (709) 864-2861.

If you have any questions about your rights as a research participant or the conduct of this study, you may also contact The Office of Human Research Ethics at Western University at (519) 661-2026 or ethics@uwo.ca.

A copy of this letter will be given/emailed to you for your records.

Western

Consent Form

I have read the Letter of Information, have had the nature of the study explained to me and I agree to participate. I understand the requirements of this study and all questions have been answered to my satisfaction. I have been given sufficient time to consider the information and to seek advice if I chose to do so. I understand that I can contact the researcher(s) at any time if I have further questions. I understand that I am allowed to withdraw from the experiment at any time without giving a reason.

Participant's Name (please print): _____

Participant's Signature: _____

Date: _____

Please leave this part blank for the experimenter to complete

Person Obtaining Informed Consent (please print): _____

Signature: _____

Date: _____

Appendix E

Music Background Questionnaire

Western

MUSIC BACKGROUND QUESTIONNAIRE

Participant #:

_____

Demographics:

Age:_____ Gender: _____

Dominant Hand (Right/Left): _____

Music Background:

How old were you when you started playing the piano?_____(age)

How many years have you taken private piano lessons?_____(# years)

If you stopped taking lessons, how many years ago did you stop?_____(years ago)

How many years have you played the piano (with or without lessons)?_____(years total)

How many hours/week do you spend playing the piano now (on average)?_____(# hours)

How many hours did you spend playing the piano during the last 7 days? _____(# hours)

If you do not currently play the piano regularly, how many years since you last played regularly? _____(# years)

How many years have you taught the piano (if applicable)?_____(# years)

Do you play instruments other than the piano? If so, please list each instrument, years, of experience, and years taking lessons for each instrument below:

Instrument	Years of Experience (#)	Years of Lessons (#)

What styles/periods of music do you most often play (e.g., classical, contemporary, jazz)?

_____

Do you perform regularly in any groups or ensembles? If so, please list them here:

_____

Do you perform in public on a regular basis? _____

Would you be willing to participate in future experiments for pay?_____(yes/no)

Do you have absolute (or "perfect") pitch? _____

Do you have any hearing problems? _____

On a scale of 1 – 10, how would you rate your proficiency on the piano? A response of "1" would represent a pianist who has just had their first lesson and a response of "10" would represent a top professional pianist. _____

Questions Related to Today's Study:

Have you previously played any of the musical excerpts presented today? If so, which one(s):

_____

During the study, you practiced in two different schedules. The blocked schedule required that you complete all of your practicing on one excerpt before moving onto the second excerpt. The interleaved schedule alternated between the two excerpts.

Which schedule type do you think helped you to improve your overall performance more? (about the same/blocked/interleaved)

Which schedule type do you think helped you to memorize the excerpts better? (about the same/blocked/interleaved)

If you were to judge your own performance, which of the excerpts you performed at the end of the study would you give the best rating (you may list multiple excerpts)?

_____

Which schedule type did you prefer? (no preference/blocked/interleaved)

Which schedule type is closest to the way you normally practice? _____

How do you normally structure your practice time? For example, if you had to learn two different pieces, or excerpts of pieces, how would you divide your practice time?

_____

_____

Appendix F

Debriefing Form

Debriefing Form

Project Title: Optimizing Music Learning: The Effects of Contextual Interference

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Musicians require thousands of hours of practice to learn the skills necessary for elite performance. Musicians must memorize extended compositions and master complex motor and aural skills involving pitch, rhythm, and musical style. While athletes benefit from sport psychology research to optimize their training, applied music psychology research is limited. For example, musicians most commonly practice in long blocks of continuous repetition (Rohwer & Polk, 2006; Barry, 2007). But research in other fields suggests that this type of repetition is not optimal for learning (Magill & Hall, 1990).

One promising strategy is *interleaved practice* (Magill & Hall, 1990). Although long blocks of repeated practice on individual tasks may increase performance during a training session, alternating among different tasks in an interleaved practice schedule leads to superior retention in the long term (Lee & Simon, 2004). For example, baseball batting practice consisting of 15 fastballs in a row, followed by 15 curve-balls, and then 15 change-up pitches facilitates performance and feelings of fluency *during* practice. However, interleaving the 45 different pitches so that pitch types are not repeated consecutively leads to superior performance *after* practice, the real test of learning (Hall, Domingues & Cavazos, 1994). This finding is called the *contextual interference effect* (Battig, 1979), and has received little attention in music. The purpose of this study is to build on research conducted by Carter and Grahn (2016) exploring the effects of blocked and interleaved practice schedules on musical skills. We are exploring whether the contextual interference effect generalizes across different instruments (including voice) and across the different skill sets required by musicians (including motor skills, expressivity, memorization, and aural skills).

By participating in this study, you have provided data that will help us determine whether interleaved practice generalizes across different areas of music learning. Your participation and responses are much appreciated.

If you have any further questions about this study please contact Dr. Elizabeth Kinghorn at ekinghor@uwo.ca or Dr. Jessica Grahn at jgrahn@uwo.ca. If you have questions about your rights as a research participant, you may contact Memorial University's research ethics board (icehr@mun.ca or 709-864-2861) or Western University's research ethics board (ethics@uwo.ca or 519-661-3036).

For further information on this topic, you may wish to consult the following articles:

Rohwer, Debbie and Jeremy Polk. “Practice Behaviors of Eighth-Grade Instrumental Musicians.” *Journal of Research in Music Education* 36 (Winter 2006): 350-362.

Barry, Nancy H. “A Qualitative Study of Applied Music Lessons and Subsequent Student Practice Sessions. *Contributions to Music Education* 34 (2007): 51-65.

Magill, Richard A. and Kellie G. Hall. “A Review of the Contextual Interference Effect in Motor Skill Acquisition.” *Human Movement Science* 9 (1990): 241-289.

Lee, Timothy D. and Dominic A. Simon. “Contextual Interference.” In *Skill Acquisition in Sport: Research, Theory, Practice,* edited by A. Mark Williams and Nicola J. Hodges, 29-44. London: Routledge, 2004.

Hall, Kellie G., Derek A. Domingues and Richard R. Cavazos. “Contextual Interference Effects with Skilled Baseball Players.” *Perceptual and Motor Skills* 78 (1994): 835-841.

Battig, William F. “The Flexibility of Human Memory.” In *Levels of Processing in Human Memory,* edited by Laird S. Cermak and Fergus I. M. Craik, 23-44. Hillsdale, NJ: Lawrence Erlbaum Associates, 1979.

Carter, Christine E. and Jessica A. Grahn. “Optimizing Music Learning: Exploring How Blocked and Interleaved Practice Schedules Affect Advanced Performance.” *Frontiers in Psychology* 7 (2016): 1251.

Stambaugh, Laura A. “When Repetition isn’t the Best Practice Strategy: Examining Differing Levels of Contextual Interference during Practice.” *International Symposium on Performance Science* (2009): 567-72.

Stambaugh, Laura A. “Repetition and Judgement of Learning in Wind Instrument Practice.” *International Symposium on Performance Science* (2011a): 431-36.

Kornell, Nate and Robert A. Bjork. “Learning Concepts and Categories: Is Spacing the ‘Enemy of Induction’?” *Psychological Science* 19, no. 6 (2008): 585-592.