Groove and Grip: The Effects of Music Tempo on Manual Dexterity Among Senior High Students

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ABSTRACT

Manual dexterity is the ability to perform coordinated, precise hand movements that is essential in both academic and professional contexts. This study examined the effects of different music tempos on manual dexterity among Senior High students. Using a quantitative quasi-experimental within-subjects design, 50 participants completed the Nine-Hole Pegboard Test under four conditions: silence, slow tempo (60 BPM), medium tempo (124 BPM), and fast tempo (175 BPM). Results from repeated measures ANOVA revealed a significant effect of music tempo on manual dexterity, $F(3, 147) = 4.21$, $p = .007$, partial $\eta^2 = .079$. Post hoc tests indicated that both medium and fast tempos produced significantly faster placement times than silence. Effect sizes across comparisons suggested small to medium practical significance. Future research should explore various music genres, non-dominant hand performance, and long-term impact.

Keywords: Music Tempo, Manual Dexterity

INTRODUCTION

Introduce the problem

Manual dexterity refers to the ability to perform coordinated hand and finger movements that require precision and control [1] . It is important in performing various daily tasks, including writing, typing, and manipulating small objects, which are fundamental to academic and occupational performance [2]. Several factors can influence manual dexterity, such as sensory input, coordination, and environmental stimuli, especially music.

Music has long been recognized for its psychological and physiological effects, influencing mood, arousal, and cognitive performance. Recent studies have examined its impact on motor performance, showing mixed results depending on the type and tempo of the music [3]. For instance, Adamo et al. [4] explored how different acoustic stimuli such as classical, rock, and environmental noise affect manual dexterity performance in adults using the Nine- Hole Peg Test. Their results showed no significant differences in performance in each conditions, suggesting that not all auditory environments influences fine motor control. In contrast, long-term musical engagement or training has been shown to improve fine motor coordination. Rosendahl and Burlingame [5] reported that adolescents with music training exhibited enhanced fine motor skills compared to non-musicians, particularly in complex coordination tasks, indicating that auditory-motor integration develops through repeated exposure to rhythmic stimuli. This indicates that consistent auditory interaction may strengthen hand-eye coordination and movement precision.

Furthermore, tempo is one of the defining feature of music that is based on rhythm and pacing. It appears to play a crucial role in shaping movement patterns. Zhang et al. [6] found that different musical tempos significantly influenced “movement flow” and coordination quality, with moderate tempos promoting smoother and more controlled motion than either slow or fast tempos. These findings suggest that tempo may directly affect task precision and motor efficiency.

In the Philippine context, listening to music while studying, performing academic tasks, or engaging in manual activities is a common practice among students. Filipino high school students, in particular, often use music as a coping mechanism to enhance focus, reduce stress, and improve motivation while doing tasks. However, there is a limited amount of local research exploring how music tempo affects manual dexterity among Filipino learners.

Thus, this study aims to examine the effect of music tempos on manual dexterity among Senior high school students. Findings from this research are expected to contribute to the growing body of literature on music and motor performance, while providing localized evidence on how auditory stimuli, specifically music tempo, may affect fine motor task execution among Filipino students.

Research Questions

1. What is the average Pegboard task completion time across different types of music tempo?

a) No music

b) Slow

c) Normal

d) Fast

Is there any significant effect of Music tempo to Manual dexterity?

Research Hypothesis

H_0: There is no significant effects of Music tempo to Manual dexterity

LITERATURE REVIEW

Music Tempo

Liu et al. [7] found that tempo and musical training significantly influence emotional processing. Their results showed that musicians perceived higher valence in fast music, while medium tempo obtained the highest arousal. Neural activation patterns also differed between musicians and non-musicians, demonstrating that tempo interacts with training to shape emotional experience.

Similarly, Vigl et al. [8] investigated tempo reproduction among 403 participants and reported generally high accuracy, particularly around 120 BPM. Their study found that musical expertise enhanced precision and that factor such as age, gender, familiarity, and accompaniment also affected performance.

In a related perspective, Wöllner and London [9] argued that tempo perception extends beyond BPM alone. They emphasized that embodied cues, movement, memory, and contextual information shape how listeners perceive musical speed, suggesting that tempo is understood through both auditory and non-auditory influences.

Manual Dexterity

Sobinov et al. [10] highlighted the anatomical and neural complexity of the human hand. They explained how fine motor control depends on coordinated sensory input and specialized neural circuits, enabling both precise and adaptable movements.

Building on assessments of dexterity, Konieczny et al. [11] observed that children's performance on the Box and Block Test has declined over the past 40 years. This trend suggests potential generational changes in manual dexterity and emphasizes the importance of ongoing assessment.

Similarly, Stuhr et al. [12] examined a 4-week dexterity training program for preschoolers and found improvements in manual dexterity, verbal working memory, and selective attention within the intervention group. However, they reported no significant effects on inhibition, cognitive flexibility, processing speed, or numeracy skills.

In addition, Seol et al. [13] explored the effects of home-based dexterity training on older adults using a digital trail-making peg test. Their findings showed improvements in both manual dexterity and cognitive functioning, demonstrating the cognitive load involved in dexterity tasks.

Likewise, Giustino et al. [14] used the Grooved Pegboard Test to assess children's performance and found that practice improved dexterity across repeated trials. They also noted that dual-task conditions did not impair performance, suggesting that individuals can maintain fine motor accuracy under increased cognitive demands.

Finally, Patti et al. [15] demonstrated that children who engaged in Capoeira or other structured physical activities performed better on the Grooved Pegboard Test than sedentary peers. Their results highlight the positive influence of physical activity on fine motor coordination.

Music Tempo significant effect on Manual Dexterity

Woo and Song [16] investigated how temperature and music tempo affect hand coordination. Their results showed that fast-tempo music produced the greatest improvements in pegboard performance, and that moderate temperature (30 °C) enhanced dexterity compared to colder conditions.

Similarly, Martins et al. [17] examined the effects of 24 weeks of Orff-based music training on children and found significant improvements in manual dexterity and bimanual coordination. These improvements remained evident after a 4-month follow-up, suggesting long-term benefits of music-based training.

In addition, Taheri et al. [18] explored how background music influences task performance and found that certain types of music improved task speed and efficiency, indicating that auditory stimulation can enhance cognitive and motor performance when appropriately matched to the activity.

Lin et al. [19] investigated musical tempo and task performance and found that slow music reduced performance in motor, visual, and language tasks, while fast music showed no significant difference compared to silence. Their findings suggest that tempo does not consistently affect motor performance.

Similarly, Magdy et al. [20] assessed college students' quiz performance under different music tempos and found no significant differences between fast, slow, and no-music groups. This indicates that tempo may not influence certain academic or cognitive tasks.

In addition, Adamo et al. [4] examined various background sound conditions and concluded that although some sounds improved accuracy, overall background noise did not significantly affect manual dexterity. They also found that younger adults outperformed older participants.

THEORETICAL FRAMEWORK

This study is anchored on two theories in the Sensorimotor Entrainment Theory and the Yerkes-Dodson Arousal-Performance Law.

The Sensorimotor Entrainment Theory explains that rhythmic auditory cues can synchronize motor timing with external beats, resulting in improved movement coordination and speed. The theory highlights how auditory rhythms influence the timing and precision of motor actions by aligning the body's internal rhythms with external stimuli. In this study, it supports the idea that different music tempos may produce varying effects on manual dexterity, as rhythmic cues can enhance or alter coordination and timing in performing fine motor tasks.

The Yerkes-Dodson Arousal-Performance Law posits that performance improves with increasing arousal levels up to an optimal point, after which excessive arousal may reduce efficiency and accuracy. This theory suggests

that moderate arousal, such as that induced by rhythmic or fast-tempo music, can enhance focus, alertness, and motor performance. It supports the idea that music tempo can produce varying effects on manual dexterity, as different levels of arousal may either facilitate or interfere with coordinated movement.

Conceptual Framework

Figure 1: Music Tempo to Manual Dexterity

MATERIALS & METHODS

This study utilized a quantitative quasi-experimental research design with a within-subjects approach. The study involved a total of 50 Senior High School students who were selected using a simple random sampling technique. Prior to participation, a screening questionnaire was administered to identify students who regularly listen to music and find it helpful in doing tasks. The inclusion criteria required the participants (1) listens to music while performing activities, (2) perceive it as beneficial to their performance, and (3) experience no effects on concentration. Each participant was exposed to four experimental conditions: fast-tempo music (175 BPM), normal-tempo music (124 BPM), slow-tempo music (60 BPM), and a no-music (silence) condition.

The within-subjects design ensured that all participants experienced every condition, therefore minimizing variability due to individual differences and improving accuracy of comparisons across conditions.

The research instrument used to assess manual dexterity was the Nine-Hole Pegboard Test, a standardized tool widely recognized for its reliability and validity in measuring fine motor skills [21] The Nine-Hole Pegboard Test consists of a rectangular board with nine holes and nine pegs. Participants were instructed to place and remove all pegs as quickly as possible. A digital timer was used to record completion times in seconds. The test was conducted using each participant's dominant hand to obtain a consistent measure of their optimal fine motor performance. Using the dominant hand is a standard approach on dexterity assessment, as it minimizes performance variability and reflects the hand that is most frequently used in daily activities [22]

The musical stimulus was Mozart: Sonata in D for Two Pianos (K, 448), which was presented through a speaker system in a controlled classroom environment. To reduce fatigue effects, participants were given a one-minute break between each experimental condition.

Data Collection

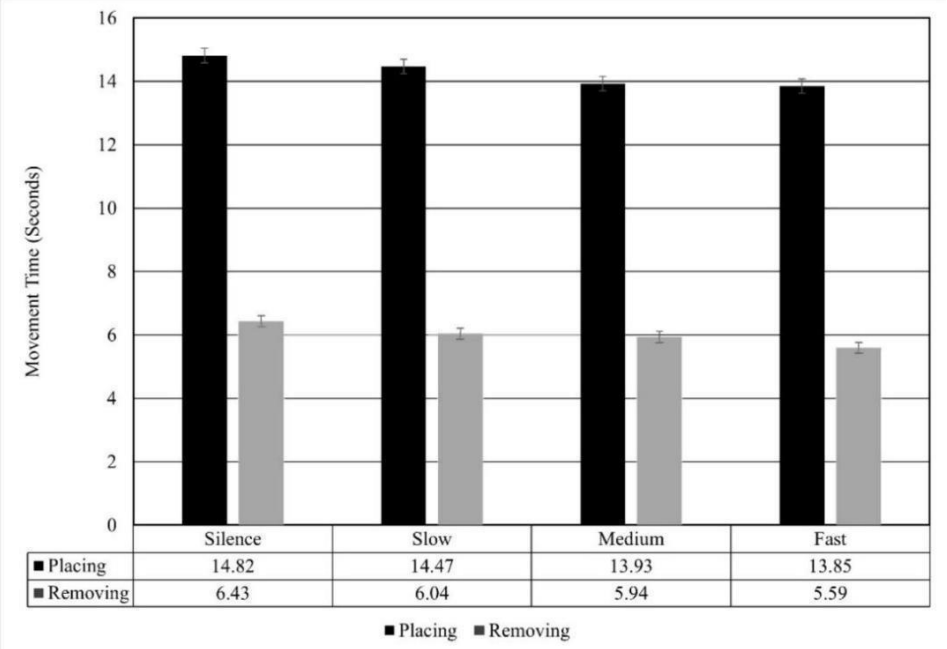
The data collection process began with participant briefing regarding the procedures and objectives of the study. Each participant performed the Nine-Hole Pegboard sTest under the four experimental conditions in a randomized order. During each trial, the completion time (in seconds) required participants to place and remove all nine pegs was recorded using a digital timer. The music stimuli was played through the same speaker system at the same volume level for all participants. After completing all four trials, participants' data were compiled and coded for statistical analysis.

Data Analysis

The data collected will be analyzed using repeated measures ANOVA to determine whether music tempo significantly affects manual dexterity. Post hoc tests (e.g., Bonferroni correction) will be conducted to identify differences between each pair of conditions. Statistical significance will be set at $p < 0.05$. Descriptive statistics (mean, standard deviation) will be used to summarize participants' performance under each condition. Graphical representations, such as bar charts or line graphs, will illustrate differences in manual dexterity across the four tempo conditions.

RESULTS AND DISCUSSION

This chapter presents the results and discussions gathered from the experiment. The said data were presented in tabular form and graph form in accordance with the specific questions posited on the statement of the problem.



The average Pegboard task completion time across different types of music tempo, which is presented in Figures 1 & 2.

Figure 2. 9-hole pegboard test (Dexterity test)

Figure 2 presents the results of the Nine-Hole Pegboard Test for both placing and removing tasks across different music tempo conditions. The data indicate that placing pegs consistently took longer than removing pegs across all conditions. The longest placing time was recorded under the slow tempo condition with 14.47 seconds, while the shortest placing time occurred under the fast tempo condition attaining 13.85 seconds. For peg removal, the completion time gradually decreased as the music tempo increased, from 6.43 seconds in silence to 5.59 seconds under the fast tempo condition. These findings indicate that faster tempos enhance motor efficiency. This finding aligns with Zhang et al. [16], who found that participants exposed to fast-tempo auditory stimuli performed pegboard tasks more rapidly than those under slow or silent conditions, demonstrating that auditory tempo directly influences fine-motor coordination.

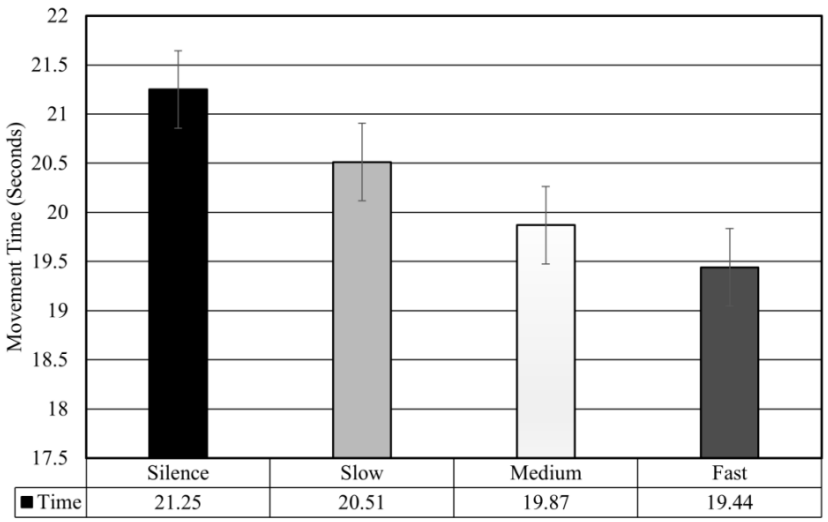


Figure 3. 9-hole pegboard test overall

Figure 3 summarizes the overall completion time for the 9-hole pegboard test. The longest completion time was observed under silence with 21.25 seconds, while the fastest performance was recorded under the fast tempo condition with 19.44 seconds. The results further show a progressive improvement in performance as tempo increases, with average times decreasing from silence to slow, medium, and fast conditions. This indicate that background music, especially with faster tempos, can positively affect dexterity performance by improving speed and efficiency compared to silence. These results are consistent with [19], who reported that slower music tempos impair processing speed, whereas faster tempos enhance information processing and task efficiency.

Overall the results demonstrate that increasing musical tempo facilitates faster and more efficient fine-motor performance. This can be explained by the Sensorimotor Entrainment Theory, which states that rhythmic auditory cues synchronize motor timing with external beats, leading to improved movement coordination and speed.

Effect of Music Tempo on Manual Dexterity

The significant effect of Music tempo to Manual dexterity, as presented in Tables 1, 2 & 3, with the effect analyzed using Repeated Measures ANOVA.

Table 1: Completion time in Pegboard test across music tempo

Placing Removing

Tempo	**Mean + SD**	**Mean + SD**
Silence	14.82 + 2.23	6.43 ± 1.44
Slow	14.47 + 2.23	6.04 + 1.56
Medium	13.93 + 2.23	5.94 + 1.67
Fast	13.85 ± 2.23	5.59 ± 1.58

Deviation was consistent for placing pegs, it changed slightly for removing pegs. This finding suggests that a faster music tempo may enhance manual dexterity, probably by influencing focus, arousal, or motor coordination. This finding is consistent [6], who demonstrated that faster music tempo improves motor synchronization and smoothness of movement.

Table 2: Within Subjects Effects: Repeated Measures ANOVA

	Sum of Squares	df	Mean Square	F	p	η_P^2
Placement	31.6	3	10.52	4.21	0.007	0.079
Residual	367.7	147	2.5			

The repeated measures ANOVA showed a statistically significant effect of music tempo on students' dexterity performance as measured by the 9-Hole Peg Test, $F(3, 147) = 4.21$, $p = .007$, partial $\eta^2 = .079$. This indicates that music tempo accounted for approximately 7.9% of the variance in completion time, representing a medium effect size according to Cohen's (1988) benchmarks. These findings indicates that variations in music tempo significantly affect the students' dexterity performance. Since the ANOVA only establishes that at least one tempo condition differs from the others, it does not identify the specific pairwise differences. This finding is supported by Wang et al. [23], who found that rhythmic auditory stimulation significantly improves motor coordination and timing in tempo-based conditions.

Table 3: Post Hoc Comparisons – Placement

Comparison Mean

Placement	Placement	Difference	SE	df	t	pbonferroni
Silence	Slow	0.3497	0.301	49	1.163	1.00
	Medium	0.8868	0.287	49	3.092	0.02
	Fast	0.9685	0.309	49	3.139	0.017
Slow	Medium	0.5371	0.353	49	1.522	0.807
	Fast	0.6188	0.319	49	1.938	0.351
Medium	Fast	0.0817	0.326	49	0.251	1.00

Post hoc pairwise comparisons with Bonferroni adjustment revealed that task completion time in the placement phase was significantly faster under the medium tempo condition compared to silence, $t(49) = 3.09$, $p = .020$, and under the fast tempo condition compared to silence, $t(49) = 3.14$, $p = .017$. No other pairwise differences between tempo conditions reached significance (all $p > .05$). These findings suggest that both medium and fast music tempos facilitated greater manual dexterity relative to silence, whereas differences among the music tempo conditions themselves (slow, medium, fast) were not statistically significant. This is consistent with Adamo et al. [4], who found that participants exposed to background music both classical and rock performed the Nine-Hole Peg Test more quickly than those in silence.

Overall, the tabular results shows that music tempo significantly affects manual dexterity, with medium and fast tempos producing optimal results. This is supported by the Yerkes–Dodson Arousal– Performance Law, which posits that moderate arousal levels such as those induced by rhythmic or fast- tempo music can enhance motor performance efficiency.

CONCLUSION

The study revealed that music tempo has a significant effect on students' manual dexterity performance. Findings from the Nine-Hole Pegboard Test showed that participants completed tasks more quickly under medium and fast tempo conditions compared to silence. Statistical analysis confirmed a significant effect of music tempo on dexterity performance, $F(3,147) = 4.21$, $p = .007$, $\eta p^2 = .079$. Post hoc results further indicated that both medium and fast tempos significantly improved peg placement times compared to silence, however differences among musical tempos were not statistically significant.

These results indicate that faster musical tempos may enhance motor efficiency Moreover, the findings support the idea that auditory tempo can serve as an effective external stimulus for improving fine motor task performance. However, the study has several limitations. First, only classical music was tested, and other genres may produce different effects. Second, the experiment measured only dominant hand performance, leaving non-dominant hand dexterity unexplored. Lastly, the study focused on short-term exposure, so the long-term impact of repeated tempo exposure was not assessed. Future research is recommended to explore the effects of various music genres, tempo patterns, and non-dominant hand performance to achieve a broader understanding of how auditory stimuli affect manual dexterity.

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