THE EFFECTS OF MUSIC TEMPO ON MEMORY PERFORMANCE USING MAINTENANCE REHEARSAL AND IMAGERY

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ABSTRACT

The aim of the study was to examine the effect of music tempo on memory performance when different learning strategies, namely, maintenance rehearsal and imagery are used. A mixed model design experiment was conducted on a total of 120 (37 male and 83 female) participants. Participants were presented two word lists under three music tempo conditions (slow – 60 bpm, optimum – 120 bpm, fast – 165 bpm) and a control condition, using either maintenance rehearsal or imagery in sequential order. A counting task was then introduced to induce delayed recall before being tested using free recall. This study found that participants were not affected by the order in which rehearsal or imagery was used; participants scored significantly higher using imagery in comparison to maintenance rehearsal in all four music conditions; and participants achieved the highest memory performance in the 120 bpm in comparison to the control condition, 60 bpm and the 165 bpm conditions. A research question regarding the interaction between music tempos and learning strategies was also investigated. Under within-subject conditions, no significant effect was found between music tempos and learning strategies, which means that the effect of a particular music tempo on a single participant was constant and the same level of arousal would be effected during Trial 1r (Rehearsal) and Trial 2i (Imagery).

Keywords: Music tempo, memory performance, maintenance rehearsal, imagery

INTRODUCTION

Background music is becoming an increasingly common feature in daily life as it is readily available through radio, recordings, television and videos. Many people go through daily activities such as working, studying, driving, shopping and relaxing to the accompaniment of music. Music, in general, plays a powerful social role in assisting communication (O'Donnell et al., 1999), influencing cognitive functioning (Rauscher, Shaw & Ky, 1993), stimulating deep emotions (Juslin & Sloboda), and influencing the establishment and maintenance of social groups (Hargreaves & North, 1997).

Hallam (2001) conducted research on the physiological and psychological effects of music and concluded that music lies on a continuum from highly stimulating and invigorating to soothing or calming. Additionally, Knight and Rickard (2001) found that

when participants were faced with a cognitive stressor, listening to classical music significantly reduced subjective anxiety, systolic and diastolic blood pressure, heart rate, as well as salivary immunoglobulin A (sIgA) levels, which is a component of the immune systems "first-line of defence" against pathogenic viruses and bacteria.

In a learning context, Giles (1991) stated that appropriate background music is one which enables students to generally function better, makes them less stressed, more relaxed, happier and more productive. Effective music was one that improved children's performance in tasks, on condition that it did not overly excite them. The idea of combining music and learning has been explored for quite some time. In fact, early researchers such as Hall (1952, as cited in Hallam & Price, 1997) found that performance of 58 % of the 245 eighth and ninth graders on the Nelson Silent Reading Tests was significantly improved when background music was played. This study also found that there were 'settling down periods' at the beginning of the morning and afternoon sessions and a mid-afternoon fatigue period when music was of greatest assistance. Hall (1952, as cited in Hallam & Price, 1997) also suggested that background music aided the students by increasing accuracy and those students who were 'below average in intelligence and achievement' benefited more from the presence of background music than those who were 'above average'. It could be suggested that this is the case because music plays the role as an aid to concentration among children who need it.

Later Etaugh and Ptasnik (1982) investigated the effect of music on different types of tasks and found that music had positive effects on literacy tasks such as comprehension. Participants who seldom studied with background music, showed better comprehension in a laboratory study when they learned in silence, while those who frequently studied with music performed better when in the presence of music (Etaugh & Ptasnik, 1982). Researchers also attempted to describe the effect of Mozart's classical music on cognitive functioning through spatial reasoning tasks. Rauscher, Shaw, and Ky (1993) called this influence "the Mozart effect", and defined it as the improved performance on spatial reasoning tasks while listening to Mozart's classical music. College students were found to perform significantly better in the paper folding and cutting task of the Stanford-Binet Scale of Intelligence while listening to Mozart as compared to listening to a relaxation tape or silence (Rauscher, Shaw & Ky, 1993).

Kiger (1989) studied the effect of music on literacy tasks by instructing 54 high-school students to read a passage of literature in silence, or with low or high `information-load' music based on the criteria of loudness, variety, complexity and tonal range. It was found that reading comprehension scores were significantly higher in the low information-load condition than in either silence or the high information-load condition (Kiger, 1989). From this study, it can be concluded that slow, soft and repetitive low-information music provides optimally arousing conditions for learning literacy tasks.

Based on the research quoted above, it can be concluded that music with specific qualities does have an effect on task performance. In this study, the variable music tempo was introduced in addition to learning strategies (maintenance rehearsal and imagery) as factors that could influence memory performance. Coleman (2001) defined maintenance rehearsal as the simple repetition (without elaboration) of items or information that need to be remembered in order to prevent them fading from short-term memory. On the other hand, Goldstein (2008) defined imagery as the recreation of a mental image in the absence of the physical stimuli. In addition, a new element was introduced in the study which was to

examine the combined effects of music tempo and learning strategies on memory performance. Lavy (2001) defined music tempo as the speed at which music is played, usually measured in beats per minute (bpm). The idea to introduce music tempo into this memory study was derived from the theoretical basis stated below.

THEORETICAL BASIS

The theoretical basis of the effect of music on arousal and how it subsequently influences memory performance was explained by Kalat (1986) using the Yerkes-Dodson law, which holds that high arousal produces the best performance when one is attempting a simple task, while medium arousal produces the best performance when one is attempting a difficult task. Leung and Fung (2005) stated that there are many stimuli that could increase arousal such as light, temperature, noise, decoration, space management and background music. Hallam, Price and Katsarou (2002), found that background music was able to increase the arousal level of a person because it influences mood. However, increased arousal levels will increase performance up to an optimal level but underarousal and overarousal may cause deterioration of performance (Hallam, Price & Katsarou, 2002). The Yerkes-Dodson Law is essential to this study as different music tempos used could create different levels of arousal. Based on this theoretical basis, the optimum music tempo for learning is investigated and the validity of the Yerkes-Dodson Law is analysed.

LITERATURE REVIEW

This section reviews research involving comparisons between different learning strategies and the combined effects of background music and learning strategies. The current study investigates comparisons of memory performance when maintenance rehearsal and imagery were employed. Among the past research into memory performance between maintenance rehearsal and imagery techniques was the study by Bower and Winzenz (1970), where participants were presented a list of 15 pairs of nouns such as boat and tree. One group was told to silently repeat the pairs as they were presented, while another group formed mental pictures of the two items interacting. Participants were tested using cued recall and it was found that participants who created images remembered more than twice as many pairs as those who only repeated (Bower & Winzenz, 1970). From this study, it can be concluded that an imagery learning strategy led to better memory performance in comparison to a maintenance rehearsal strategy. Craik and Tulving (1975) explained in a further research that participants had superior memory when using imagery because meaningful connections were made between items.

Past research has also looked into the combined effects of music and imagery on memory performance although the literature is limited. Stein, Hardy and Totten (1982) performed a test on postgraduate students to see if music (Handel's Water Music) and imagery could help in memorising a list of vocabulary words. Participants were divided into three groups: first group (music and imagery), second group (music and read only) and third group (read only). Each group was given a pretest, posttest, and a test one week later in the presence of music and results showed that groups using music and imagery; and music and

read only scored better than the read only group. Results a week later showed that the music and imagery group performed better than groups using music and read only as well as groups using a read only approach (Stein, Hardy & Totten, 1982). Thus, the combination of music and imagery while learning was able to improve recall and retention of words as the meaning of the word was emphasised. This suggests that background music functioned as a retrieval cue as it enters into memory along with the information learned.

The current study also attempted to research the combined effects of music and maintenance rehearsal on memory performance as there is little research in this area. Therefore, a comparison of the combined effects of music and maintenance rehearsal against music and imagery was not feasible.

As mentioned above, the combined effects of music tempo and learning strategies on memory performance was also examined. Rigg (1964 as cited in Katagiri, 2007) suggested that music tempo is the most important feature in determining emotional responses to music. Thus, listeners find some tempos more enjoyable than others, notice discreet differences in tempo, and remember rhythmic speed over a long period of time (Brodsky, 2005). Nevertheless, slow tempo has always been associated with serenity, sentimentality, solemnity and sadness while fast tempo was associated with exhilaration and joy (Hevner, 1935 as cited in Griffin, 2006). Rigg (1964 as cited in Katagiri, 2007) also found that music described as 'happy' had fast tempo, major mode, a simple harmony, staccato notes and regular rhythms; while music which wase 'sad' had slow tempo, minor mode, irregular rhythms and slow register.

Many studies including Furnham and Allass (1999) have determined that fast music induces greater arousal levels than slow music, as the listener has to process more musical information in a given time frame. Hence, faster music is perceived to be more complex and takes up more attention that should be focused on the relevant task. This reasoning was supported itself by Furnham and Allass (1999).

Generally, most suitable background music falls in the range of 60 and 120 beats per minute (bpm), with a favoured range of between 70-110 bpm (Kellaris & Kent, 1993). Webster and Weir (2005) also stated that music faster than 144 bpm begins to lose effectiveness in accordance to the Yerkes-Dodson law of arousal and performance. Nonetheless, the effect of musical tempo on memory was found to yield contradictory research results. Balch, Bowman and Mohler (1992) found that changing music genres had no effect on recall but changing tempo (slow to fast) decreased recall. On the other hand, LeBlanc and McCrary (1983) examined the tempo preferences among fifth and sixth graders in relative to a cognitive task. Jazz music was used as a control instead of classical music and the tempos were varied from slow, to moderate, and to fast (LeBlanc & McCrary, 1983). Results showed that tempo preferences with jazz music were the same as when classical pieces were played (LeBlanc & McCrary, 1983). However, instrumental music with faster tempos had the most effect on fifth and sixth graders in this study (LeBlanc & McCrary, 1983).

Most research find that fast music improved memory performance such as the study by Nittono, Tsuda, and Nakajima (2000), which reported that cognitive performance was significantly better when participants were exposed to fast classical music (158 bpm) in comparison to slow (60 bpm) classical music. A major study which supported this notion was conducted by Husain, Thompson and Schellenberg (2002), where it was found that performance on a sequential test of spatial abilities was better among those who heard

Mozart's sonata K.448 in D Major performed quickly rather than slowly. Participants were presented with Mozart's sonata K.448 with the tempo modified such that it ranges from 60 bpm (slowest) to 165 bpm (fastest) as these were the fastest and slowest tempo that still sounded natural to the experimenters (Husain, Thompson & Schellenberg, 2002).

Despite the fact that most studies (LeBlanc & McCrary, 1983; Nittono, Tsuda, & Nakajima, 2000; Husain, Thompson & Schellenberg, 2002) found that music with faster tempo was able to enhance performance in comprehensive, spatial and cognitive tasks, Gunter (1995) stated that music at 60 bpm has been shown to produce a state of relaxation in both children and adults as it is speculated that 60 beats is approximately the ideal resting heart rate for the human body. Therefore, the 60 bpm music functions as a type of relaxation training that allows listeners to slow down their heart rate to match the musical beat. This slowed heart rate enhances relaxation and may actually promote focus and concentration as a by-product.

The current study used the same musical piece as Husain, Thompson and Schellenberg (2002), which was Mozart's Piano Duet: Sonata K.448 in D Major. As the musical structure and emotions evoked is essential to the current research as all these factors may act as confounding factors to the performance of participants' in this study, much care was taken in selecting a classical musical piece in major mode with regular rhythms and a moderate tempo by Mozart which would purportedly induce positive emotions in the participants. The Mozart's Piano Duet: Sonata K.448 in D Major was selected because research by Isen and Labroo (2003), found that a positive mood enhances learning and cognitive processing such as decision making, problem-solving and flexibility in thinking.

This research also attempts to investigate whether the memory performance pattern obtained would be similar to the results by Husain, Thompson and Schellenberg (2002) (i.e., faster music improved memory performance) or the inverted-U graph backed by the Yerkes-Dodson Law. As 60 bpm is also included in the range of tempo investigated, the statement by Gunter (1995) that the tempo of 60 bpm would result in optimum performance is examined as well. These two key research (i.e., Husain, Thompson & Schellenberg, 2002; Gunter, 1995) would eventually form the problem statement of this current study.

Based on the evidences stated above, it is clear that the effect of music tempo on memory performance using cognitive strategies such as maintenance rehearsal and imagery is an area which requires more in-depth research. The main objectives of this study are to examine comparisons of memory performance when different learning strategies such as maintenance rehearsal and imagery were employed and investigate the optimum music tempo for learning. There are three hypotheses and they are stated as follows:

Hypothesis 1: When the order in which rehearsal or imagery learning strategy is alternated, there would be no significant difference in participants' performance for both maintenance rehearsal and imagery (i.e. no order effect).

Hypothesis 2: The memory scores of participants in the imagery condition would be consistently higher than participants in the maintenance rehearsal condition.

Hypothesis 3: The performance of participants in both maintenance rehearsal and imagery will be optimum for the tempo of 120 bpm in comparison to the no music condition, 60 bpm and 165 bpm as reflected in the Yerkes-Dodson Law.

Additionally, there is also a research question that is studied upon Hypothesis 1 being satisfied:

Research Question: Is there an interaction between music tempo and learning strategies (trial 1: Rehearsal and Trial 2: Imagery)?

METHODOLOGY

There were a total of 120 participants consisting 37 (30.8%) male and 83 (69.2%) female participants as shown in Table 1. The age of the participants ranges from 15 to 27 years with a mean age of 19.62 years (SD = 2.018). All participants were students from various Sunway programmes and affiliate members of the Psychology Club from Sunway University College. Participants were randomly approached to take part in the experiment. There were no specifications for gender, race or nationality of the participants. The participants were divided equally into four group conditions: no music (control), 60 beats per minute (bpm), 120 beats per minute (bpm) and 165 beats per minute (bpm), as shown in Table 1.

Table 1. Descriptive Statistics of Participants' Characteristics (n=120)

Variables	Participants (%)
Age (years)	15 – 27
Mean age	19.62
SD	2.018
Gender	
Male	37 (30.8%)
Female	83 (69.2%)
Music tempo	
No music (control)	30 (25.0%)
60 beats per minute (bpm)	30 (25.0%)
120 beats per minute (bpm)	30 (25.0%)
165 beats per minute (bpm)	30 (25.0%)

Research design

This study was a mixed model design experiment. Generally, music tempo and learning strategy (rehearsal or imagery) was the independent variable while the mean scores of words listed correctly was the dependent variable. Under each condition, the learning strategy used was alternated to determine order effect (i.e., rehearsal first, imagery second or imagery first, rehearsal second). The total number of words listed correctly was scored and mean scores obtained.

Additionally, a repeated measures ANOVA was conducted to examine interaction between music tempo and learning strategies as well as the effects of repeated trials on participants' performance. In this case, within-subjects factors were scores obtained in Trial 1r (rehearsal) and Trial 2i (imagery). Between-subjects factor was music tempo (i.e., control, 60 bpm, 120 bpm and 165 bpm). This analysis was conducted upon evidence that there would be no order effect within participants' performance when maintenance rehearsal and imagery was alternated. A line graph would be plotted to show the changes in word mean scores across Trial 1r and Trial 2i and demonstrate the general memory pattern obtained by participants.

Materials

Participants were required to study two different word lists, each consisting of thirty words which were adapted from a study by Lujan and Dicarlo (2006), an experiment conducted by Craik and Tulving in 1975 and the Verbal Associates subtest in the Weschler Memory Scale – Revised (WMS - R) by David Weschler (1987). The WMS-R validity index was not found but it has an internal consistency index of 0.77 and test-retest reliability index of 0.80.

Overall Procedure

The classical piece used in this experiment was Mozart's Piano Duet: Sonata K.448 in D Major at 120 bpm in mp3 format and was modified using the Nero Soundtrax programme to obtain 60 bpm and 165 bpm for the low and high arousal conditions respectively. The loudness of the music was standardised during the tempo modification process by setting it at a standard frequency. Overall, there were four group conditions: 60 bpm, 120 bpm, 165 bpm and a control condition (no music). Standard instructions were given to the participants before conducting the experiment and a debriefing session was conducted at the end of the experiment.

In general, participants were briefly welcomed at the start of the experiment and were given basic explanations about what they were expected to do during the experiment. They were then given a consent letter and an answer sheet.

When rehearsal learning strategy should be used, participants were told to repeat the words silently to themselves while for imagery learning strategy, participants were told to picture the words shown and they were allowed to make associations between the words to form a pictorial story. Participants were informed that the whole word list would be put up at the end of each session for them to study again.

In the debriefing session, further explanations about the motive of the study were explained and participants were reminded not to discuss this experiment to maintain confidentiality of the experiment.

Standard procedure for each group condition

The background music used was Mozart's Piano Duet: Sonata K. 448 in D Major at 60 bpm, 120 bpm and 165 bpm. The experiment was carried out individually so that participants would not be influenced by peer pressure. Participants were randomly assigned into two groups under each condition. Participants who fell under the first group were required to

learn the first list using rehearsal and the second list using imagery. The second group were required to learn the first list using imagery and the second list using rehearsal. The manipulation of learning strategies (rehearsal and imagery) was done to examine and counterbalance order effect.

First group [(rehearsal – imagery), n = 15]
The participants were shown the first list of thirty words using Power Point. Each word was initially displayed one by one with a stimulus interval of five seconds. The participants were asked to remember the words from the list by continuously repeating it silently to themselves. At the end, the whole list was put up and the participant was then given two minutes to study the list.

The list was then closed and the participants were asked to count backward by 3's from 100 to 76. The participants were then requested to list down the words learnt on the answer sheet provided. The words could be stated in any order.

A short interval of two minutes was given for the participants to relax before the second list was shown. Like the first list, each word was initially displayed one by one with a stimulus interval of five seconds. The participants were asked to imagine/form mental pictures of the words and make a connection between the mental images to form a story. At the end, the whole list was put up and the participants were given two minutes to study the list.

The list was then closed and the participant was asked to count backward by 3's from 100 to 76. The participant was again requested to list down the words learnt on the answer sheet provided. The words could be stated in any order. The scores obtained by the participant was the number of correct words listed.

Second group [(imagery – rehearsal), n = 15]
The same procedure was repeated for the second group, except that the participants were given instructions to learn the first list using imagery first and the second list using rehearsal. The above procedure was replicated for each of the music tempo conditions, which was 60 bpm, 120 bpm, 165 bpm and the no music (control) condition.

Pilot Study

A pilot study was initially carried out on 40 participants to test the study hypotheses and standardise experimental parameters. The pilot study found that the first hypothesis (i.e. null hypothesis) was supported, where participants' performances were not affected by the order in which learning strategies were used first. A paired sample t-test was done to examine mean score differences within learning strategies (i.e., maintenance rehearsal and imagery) when the learning strategy was alternated and no significant differences was found. It was decided at this point that this analysis would also be conducted in the real study and that the first hypothesis be examined again as it is not clear that the same results would be obtained when a bigger sample size was used.

The second hypothesis was also supported as participants were found to score highest in the 120 bpm condition using both maintenance rehearsal and imagery. The mean score differences obtained in the four music tempo conditions for both maintenance rehearsal and imagery were examined. Although there were no significant differences, the

result demonstrates that the pattern in memory scores conform to the pattern proposed by the Yerkes-Dodson Law.

The third hypothesis was also supported as it was found that participants consistently obtained higher performance scores using imagery as compared to maintenance rehearsal in all four music tempo conditions. Differences in memory scores between imagery and rehearsal were examined. Although there were no significant differences, the result also demonstrates that participants performed better using imagery, which requires emphasis on the meaning and associations of pieces of information as compared to maintenance rehearsal, which emphasises repetition of information.

RESULTS

Paired Sample T-Test

A paired sample t-test was conducted to determine if there is a difference in memory performance when the order of learning strategy was alternated (i.e., rehearsal – imagery and imagery – rehearsal). The analysis showed that there was no significant differences in word mean scores when rehearsal or imagery was used first or second for all four conditions [i.e., control (no music), 60 bpm, 120 bpm and 165 bpm]. In conclusion, there was no order effect in the learning strategies used (i.e., the memory performance of participants was not affected by the order in which rehearsal or imagery was used).

Repeated Measures ANOVA

A one-way repeated measures ANOVA was conducted to examine if there were significant differences between mean scores obtained using rehearsal and imagery across all four music tempos. The analysis shows that there was a significant effect of learning strategies on memory scores across all four music conditions in general [$F(1,119) = 102.12$, $p<.01$]. Participants also scored higher consistently using imagery learning strategy with an overall mean score of 18.61 (SD = 5.18) as compared to maintenance rehearsal with an overall mean score of 14.39 (SD = 4.88).

Table 2. Repeated measures ANOVA of Learning Strategy across Four Music Conditions

Variable	Trial 1r (Rehearsal)		Trial 2i (Imagery)		df	F
	Mean	SD	Mean	SD		
Music tempo	14.39	4.88	18.61	5.18	1	102.12**

Note: ** p < .01

Repeated Measures ANOVA

The repeated measures ANOVA also examined the interaction of learning strategies and music tempo. The within-subjects effects analysis shows that there was no significant effect of music tempo on participants' performance when different trials (i.e., learning strategies) were used [F (3, 116) = 0.33, p>.05] as seen in Table 3. This means that the effect of a particular music tempo on a single participant was constant and the same level of arousal would be effected during Trial 1r (Rehearsal) and Trial 2i (Imagery).

Table 3. Within-Subjects Effects of Music Tempo on Learning Strategies

Effect	Mean Squares (MS)	df	F	p	Greenhouse-Geisser	Huynh-Feldt
Learnstr	1066.82	1	100.40	<.01	<.01	<.01
Learnstr x Music Tempo	3.52	3	0.33	>.05	>.05	>.05
Error	10.63	116				

Tukey Post-Hoc Comparison

Post-hoc comparisons of the four music conditions for both rehearsal and imagery learning strategies show that the word mean scores obtained in the 120 bpm condition are significant as compared to all other three conditions: control, 60 bpm and 165 bpm as shown in Table 4. In addition, it is also shown that there are no significant differences between word mean scores for control and 165 bpm conditions. This shows that among the music tempos, 120 bpm provides the best learning with the highest word mean scores obtained for both learning strategies (i.e. rehearsal and imagery). Participants in the control and 165 bpm condition also obtained similar memory scores.

The general memory pattern obtained is categorised as the following: The highest scores were obtained in the optimum music condition of 120 beats per minute (bpm). The lowest mean scores were obtained in the 60 bpm condition while moderately high mean scores were obtained in the no music (control) and 165 bpm conditions as shown in Table 5 and demonstrated by Figure 1.

Table 4. Tukey Post-Hoc for Four Music Conditions

Music Tempo (I)	Music Tempo (J)	Mean Difference (I-J)	p
No music (Control)	60 bpm	2.68*	<.05
	120 bpm	-3.72*	<.05
	165 bpm	0.03	>.05
60 bpm	No music	-2.68*	<.05
	120 bpm	-6.40*	<.05

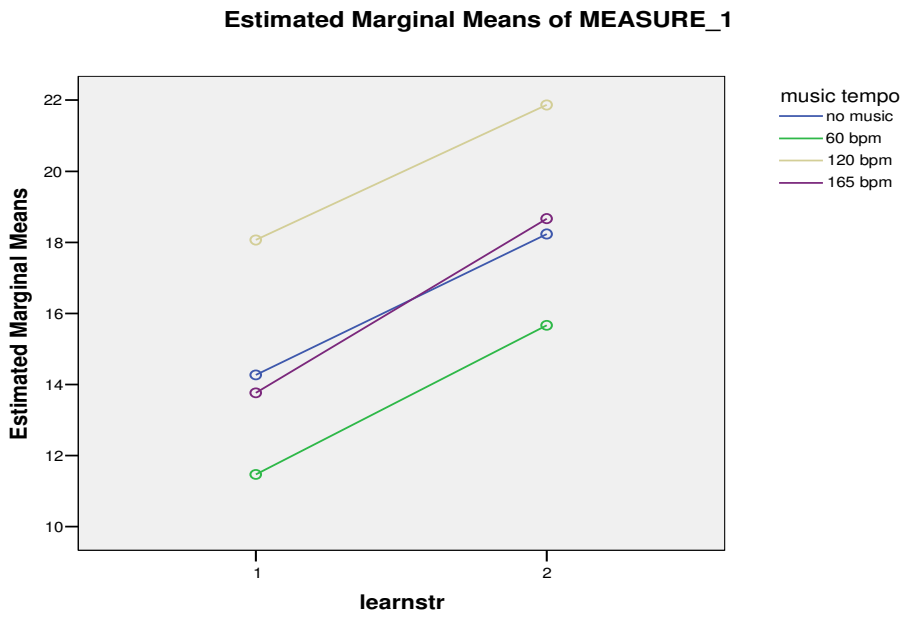
	165 bpm	-2.65*	<.05
120 bpm	No music	3.72*	<.05
	60 bpm	6.40*	<.05
	165 bpm	3.75*	<.05
165 bpm	No music	-0.03	>.05
	60 bpm	2.65*	<.05
	120 bpm	-3.75*	<.05

Table 5. Breakdown of Word Mean Scores across Four Conditions and Learning Strategies

Variable	Control	60 bpm	120 bpm	165 bpm
Rehearsal	14.27	11.47	18.07	13.77
Imagery	18.23	15.67	21.87	18.61

The overall results can also be viewed in the following line graph:

Figure 1. Changes in word mean scores across Trial 1r (Rehearsal) and Trial 2i (Imagery)



DISCUSSION

Findings of the Study

The first aim of this study was to examine the validity of the null hypothesis, which is the performance of participants in both maintenance rehearsal and imagery strategies would not be affected by the order in which rehearsal or imagery is used first or second. This study found that participants' memory performance was not affected by the order in which rehearsal or imagery strategy was used. Thus, there was no order effect in the learning strategies used and the null hypothesis (i.e., Hypothesis 1) was accepted.

The second aim was to determine whether participants using imagery learning strategy performed better than participants using rehearsal learning strategy in all four music tempo conditions. This study found that participants using imagery consistently scored significantly higher than participants using rehearsal in all four music tempo conditions with the highest scores being in the 120 bpm condition at the significance level of .01. This result showed that although imagery strategy is able to aid students' memory performance, external influences such as the presence of background music and music tempo will affect the learning experience. This finding was supported by Craik and Tulving's (1975) study, which found that superior memory performance are obtained when there are meaningful connections between test items in comparison to maintenance rehearsal, which just involves repeating words until it enters the short-term memory. The study by Stein, Hardy and Totten (1982) had also proven that the combination of music and imagery was able to improve memory performance directly after learning and improve retention of information after one week. Therefore, Hypothesis 2 was supported.

The third aim of this study was to determine if memory performance pattern obtained would be similar to the inverted-U graph backed by the Yerkes-Dodson Law with 120 bpm being the optimum music tempo for learning. At the same time, the results by Husain, Thompson and Schellenberg (2002) (i.e., faster music improved memory performance) and the statement by Gunter (1995) that the tempo of 60 bpm would result in optimum performance as it promotes relaxation, focus and concentration was also investigated since the 60 bpm was among the range of tempos examined. This study found that despite including learning strategies as a variable, there was a common trend in the participants' memory performance. The highest mean scores were obtained in the optimum music condition of 120 bpm. On the other hand, the lowest mean scores were obtained in the 60 bpm condition while moderately high mean scores were obtained in the control (no music) and 165 bpm condition. Hence, Hypothesis 3 was partially supported as the optimum tempo of 120 bpm was supported. However, similar performance scores for control and 165 bpm was not expected and runs against the Yerkes-Dodson Law.

Therefore, the optimal music tempo for memory performance was 120 bpm and the results of this study were supported by the Yerkes-Dodson Law which states that increased levels of arousal would lead to optimum performance but underarousal and overarousal would lead to deterioration of performance (Hallam, Price & Katsarou, 2002). The drop in performance in the 165 bpm condition also demonstrated that there is a cut-off point between effective and ineffective music tempos. This concurs with the study by Webster and Weir (2005) which was able to determine that music faster than 144 bpm loses its

effectiveness, which explains the lower mean scores obtained in the 165 bpm in comparison to 120 bpm.

When comparing the current findings with past research, several key results were noted. The low mean scores obtained by participants in the 60 bpm group do not support the statement by Gunter (1995) that 60 bpm improves focus and concentration. However, an intriguing discovery was that moderately high scores were obtained in both control and fast (165 bpm) conditions which supports Mayfield and Moss's (1989) study where it was found that the performance of participants in the presence of fast music and silence was similar. Therefore, the memory pattern obtained in this study supported the inverted-U graph in the Yerkes-Dodson Law for the following tempos examined: 60 bpm, 120 bpm and 165 bpm. However, performance of participants in the control condition and 165 bpm were almost similar and mean scores obtained for these two conditions were higher than mean scores obtained in the 60 bpm condition. This runs against the Yerkes-Dodson Law as participants appear to perform better in no arousal conditions (control) as compared to mild arousal conditions (60 bpm).

In reflection, a possible reason for this result is that there is influence of internal factors such as the personality traits of the participants. In particular, Eysenck (1967) proposed a personality theory with two personality dimensions, namely, introverts (quiet, reserved and thoughtful) and extroverts (active, sociable and outgoing). Eysenck's theory of personality argues that introverts have lower optimum cortical threshold and do not need much external stimulation from the environment to reach their optimum level of functioning. Therefore, they are more likely to prefer quiet areas of study such as the library which is far away from noise and distraction. On the other hand, if introverts are subjected to too much stimulation such as fast music they become averse to the over stimulating environment and their task performance deteriorates. Extroverts have higher optimum arousal thresholds and are constantly seeking more external stimulation to reach their optimal level of functioning (Eysenck, 1967). Thus, the presence of background music while studying may help extroverts to perform better.

To prove the reliability of Eysenck's personality theory, Morgenstern, Hodgson and Law (1974) conducted a study using the Eysenck Personality Inventory which found that extroverts performed better in a task which requires them to remember words from a long list in conditions where there were distractions such as conversations in comparison to a silent condition. The performance among introverts, however, showed a decline when introverts were placed in conditions full of distractions (Morgenstern, Hodgson & Law, 1974). Later on, Daoussis and McKelvie (1986) examined the effects of background music on task performance of introvert and extrovert participants and found that extrovert participants reported working with music twice more than introverts (i.e., 50% versus 25% of the time). Both groups were given a recall test with fast background music played very softly and the results showed that there was no difference in the scores of extroverts with or without the presence of music but the introverts' performances were significantly poorer in the presence of music (Daoussis & McKelvie, 1986). In conclusion, the arousal and performance hypothesis by Eysenck (1967) was supported (Morgenstern, Hodgson, & Law, 1974; Daoussis & McKelvie, 1986).

Therefore, a possible explanation in relation to the current study for the similarity in memory scores in silence and fast music conditions was that the presence of introverts and extroverts among the participants may have counterbalanced the performance scores

obtained in the silence and fast music (165 bpm) condition although this effect is not as noticeable in the 60 bpm and 120 bpm conditions. Although, participants in this study did not undergo a personality test before the experiment, it is possible such a situation may have occurred and it is therefore suggested that this factor be examined in future studies.

Additionally, the research question of whether there is an interaction between music tempo and learning strategies (trial 1: Rehearsal and Trial 2: Imagery) was examined as Hypothesis 1 was fulfilled. No significant results were found on the effects of music tempo on participants' performance when different trials (i.e., learning strategies) were used. Retrospectively, this finding makes sense in that as it was examined in a within-subject design and the level of arousal stimulated by a particular music tempo should be constant during both trials. The element in effect could be the different learning strategies used. Nevertheless, upon examination of scores obtained across the four music conditions using rehearsal and imagery, there is an optimum music tempo and learning strategy (i.e., imagery learning strategy and music tempo of 120 bpm) that stands out as proving Hypothesis 3.

Strengths and Limitations

This research is one of the first attempts to compare the combined effects of learning strategies (imagery and maintenance rehearsal) and music tempo (60 bpm, 120 bpm, 165 bpm and no music) on memory performance. This study has added to the growing literature on improving learning through the aid of learning strategies and music. Much music research have been done in the area of whether learning music helps to promote intellectual development among children (Schellenberg, 2004). Indeed, it was found that musical talent was associated with literacy (Anvari, Trainor, Woodside, & Levy, 2002) and general intelligence (Lynn, Wilson, & Gault, 1989). Research was also done among musicians and music theorists on how musical measurements such as timing, mode, tempo and musical structure would influence memory of musical scores affect musical performance (Gabrielsson, 2003). However, it should be noted that not every child from every aspect of the society has the opportunity or resources to learn a musical instrument. Instead, background music is available as long as there are basic household appliances such as the radio. Therefore, the influence of background music as an external stimulus that could affect memory and learning is considered worth investigating further.

Besides that, the methodological strengths of this study were that there was a large sample size of 120 participants, which has increased the accuracy of the results. This study also focused on the student population as they are the population most influenced by this research. Most of the participants in this study have not been exposed to a memory experiment such as this and hence, would not be influenced by any beliefs and pre-conceptions about the outcome of this study.

In addition, the conditions in which the participants were tested in the Containment Laboratory were controlled so that external confounding factors (noise, conversations and peer pressure) would not affect their performance. A pilot study was also conducted earlier so that the procedural instructions given during the experiment would be standardised. Thus, this reduces the risk of giving additional verbal cues to the participants and ensures that the instructions given were easily understood.

The experiment also utilised a mixed model design where repeated measures were obtained using different learning strategies on the same participants in a particular music

condition. Alternating the order of learning strategies used also helped to counterbalance order effects and eliminate variance between treatments due to individual differences.

The limitations of this study were mostly methodological as a more reliable and validated free recall task and scoring standard could be used. The word list used in this current study was adapted and combined from several sources because the initial word list in the WMS – R was too short. Although the WMS – R has an internal consistency index of 0.77 and test-retest reliability index of 0.80, it is now difficult to determine the validity and reliability of the adapted lists. Thus, should this study be replicated in the near future, the researchers could attempt to validate the current word list and determine its test-retest reliability or utilise a cognitive task from a validated testing instrument.

There may also be problems in generalising these results as the participants were only from Sunway University College although they came from various educational levels and schools of study.

Directions for Future Research

In future, it is recommended that other factors such as gender, personality traits (i.e., Five Factor Personality: Agreeableness, Conscientiousness, Openness to New Experiences, Extraversion and Neuroticism) and socioeconomic background be examined to determine if there is a relationship between these factors and preference for specific music tempos while studying. This study could also be conducted on a larger scale, and other musical genres could be included as a comparison. The participants' age range could also be widened by including primary and secondary school students. Students from other universities and various schools could also be included in the study. Methodologically, this study could be used as a baseline for the mean scores obtained by the participants. Future studies could set cut-off scores for classification of memory performance (i.e., low, moderate, high) and develop a standardised scoring criterion.

Implications of Study

It is well known that students who achieve excellent academic results practice good study skills and techniques. Learning strategies such as elaboration, organising information into a flow chart, imagery, studying with short period breaks and matching learning and testing conditions are some of the methods recommended (Goldstein, 2008). However, the influence of music may also be beneficial as music helps to maintain alertness in study sessions that requires lots of continuous attention, without impairing performance in the study task (Bonnefond, Tassi, Roge, & Muzet, 2004).

Research shows that music is able to create a calming effect on special students' behaviour as demonstrated in the study by Scott (1970), which found that aggressive and disruptive behaviour are reduced and attention in the classroom is sustained. From this study, it can be surmised that if special students are able to benefit from background music, students from normal populations should be able to benefit more Therefore, it is hoped that the results of the current study will further increase awareness on how external stimuli such as the presence of background music, music tempo and the application of study techniques can aid memory retention.

Teachers could attempt to include music while doing classroom activities and academic tasks especially after a long session of teaching to sustain students' attention and increase alertness in class. Moreover, Knight and Rickard (2001) stated that listening to classical music would help to reduce anxiety, blood pressure and heart rate among people who are faced with difficult tasks. Alternatively, teachers could also introduce short intervals between tasks with background music being played to break the monotony of classroom routines. This would be applicable for students whom the effect of background music on classroom tasks works less satisfactorily. Thus, teachers should take special care to identify learning environments that are suitable for their respective students. In application to the education setting, background music could be used as part of a therapy to calm down students who are easily anxious when faced with a difficult academic task or classroom activity.

It useful to note that music is not only able to aid memory retention but can also be utilised as a tool to reduce anxiety, destructive and aggressive behaviours so that students are able to focus their attention on solving difficult cognitive tasks. Consequently, the current study on music tempo and learning strategies has helped to determine the optimum music tempo and learning strategy that would result in optimum task performance so that in future, these aspects could be applied in classroom management.

Conclusion

There are two important findings in this study: (i) the optimum music tempo for performance in a free recall task is 120 bpm and (ii) memory scores are consistently higher when imagery is used in comparison to rehearsal. The results of this study suggest that external stimuli such as background music can act as memory cues to improve task performance. Music at 120 bpm also creates a medium level of arousal, which exerts the appropriate level of good stress to increase performance, as proposed by the Yerkes-Dodson Law. The imagery learning strategy, which emphasises meaning and associations between chunks of information, is also better than using rehearsal or rote memorisation.

These are two important points that the Ministry of Education and academicians could take note of, so that teachers who are coaching students for important examinations may use the findings to enhance factual learning and the application of knowledge in various situations. Perhaps the use of music would encourage students to think and analyse what is learnt, instead of just reciting the whole textbook. Music, at an appropriate tempo, could help overworked students to calm down and increase alertness, which leads to more efficient study. Alternatively, it may also be a distraction for some students. Hence, teachers need to identify students who are able to work effectively with and without music, as well as match the use of music with appropriate tasks. On the whole, this study has managed to bring forward evidence that there are many methods that Malaysian teachers can apply to help students study more effectively in a relaxed and fun environment, besides constantly drilling them with more homework and exercise practices. Although it is a well-known fact that the world is more competitive, with teachers and parents pushing the students to obtain more A's, the students' well-being while studying to achieve goals should not be neglected. It is hoped that the findings in this study will be of guidance to educators in facing new challenges as informational and technological progress in the education area continue to evolve.

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