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Effect of Music and Perceptual Load on Decision Making

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Abstract

There are various kinds of information present in the environment, due to which it affects an individual's ability to accurately detect and distinguish information. Therefore, the current study aims at understanding the effect of perceptual load (high load and low load) and music (tempo) on decision making (i.e., during a conjunction search task). 62 participants were recruited for the experiment and the responses were collected through Open Sesame. The participants were asked to report whether a red circle is present or absent, while listening to music. Two-way Anova, one-way Anova and student's t-test were employed. The results indicate that perceptual load does not have a significant effect on the accuracy of responses. However, tempo of the music has a significant effect on the accuracy of responses (pes=0.08), in a conjunction search task. There is a significant difference between the proportion of hits and correct rejections, across different perceptual and tempo conditions. Students and workers listen to various kinds of music during their task involving varying levels of difficulty and perceptual systems. The perception during this process can either be facilitated or hindered with. Various studies have investigated upon the influence of music (i.e., classical, jazz, pop) but only few have focused upon Bollywood music with varying tempo.

Keywords: Music, perceptual load, accuracy, experiment, task relevant, task irrelevant

Introduction

A long withstanding debate in cognitive psychology yet persists whether there is a relationship between awareness and attention and whether the contents of the awareness can exert its influence on the attended objects and can therefore affect the efficiency with which they are processed in the visual field. Furthermore, not only the contents of the awareness influence the efficiency of responding to the targeted information, but selective attentional capacities are also widely affected by the auditory stimuli which are present in the environment. Within the real life, humans are faced with copious information which cumulatively affect the way an individual processes the information, they may or may not be aware of the influence of these external stimuli. For example, individuals willingly choose to play music with varying tempos, volumes, and types, when they are

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driving their cars. While performing the activity of driving, they may come across several stimuli on the road (such as other vehicles, individuals, diverging roads, animals). Considering this very instance, the various kinds of sounds can mediate and affect their efficiency to drive leading to misperceiving the presence of certain stimuli and failing to perceive certain stimuli which are present in their visual field but not detected. Current researches have immensely tried to understand the role of both, perceptual load, and music on cognitive tasks but fewer researches have considered the individual and combined effect of music and perceptual load on the efficiency of an individual to respond during a conjunction search task. Furthermore, fewer researches have been conducted where this phenomenon is studied within the Indian context. Therefore, the current study will take into account the effect of perceptual load (high load and low load) and music (tempo) on decision making (i.e., during a conjunction search task).

1.1 Theoretical Framework

Perceptual load theory

The perceptual load theory which was introduced and developed by Lavie, has been highly influential over the past decades and it proposes that the ability to selectively attend to a stimulus is highly dependent upon the contents and demands of the current task they are processing and performing. Based on this, their efficiency to reject the distractor or task-irrelevant stimuli will be dependent upon the level of perceptual load in their visual array (Murphy et al., 2016).

It applies a capacity approach and states that perceptual processing capacity is very limited in nature but it processes the stimuli automatically and involuntarily, therefore, when excessive information is present in the environment (high perceptual load), the unattended information is not processed because the capacity is fully exhausted by processing of the attended information. On the contrary, when there is less information in the visual field (low perceptual load), the capacity is not fully exhausted and as perception occurs automatically, perception of the task-irrelevant also occurs as a failure to ignore the irrelevant information during the task-relevant task (Lavie et al., 2014).

Since the perceptual load model operates on a capacity approach, the perceptual capacity is not described rigidly, as such in an all-or-none bottleneck approach which allows for one object to be recognized at a time. In fact, the former approach allows for more objects to get recognized before it is exhausted. Therefore, depending on the high versus low perceptual load task, the information will either be processed early or late. During low perceptual load, due to more spare capacity, the selection occurs late. Whereas, when the perceptual load is high and the capacity is exhausted, the task-irrelevant stimulus will not be processed and therefore the selection will occur early (Lavie et al., 2009).

1.2 Operational Definitions

Perceptual load

Perceptual load is often operationally defined in either of the two ways, one is defined in terms of the set size (i.e., the number of items or objects in a task), where the higher number of items present in the search task the higher perceptual load. Second is defined in terms of the complexity of the perceptual operation (i.e., what type of a perceptual task is it, is it a feature selection task or a conjunction search task).

High/low tempo music

Tempo of the music is regarded as the speed in which the musical sequence progresses. The pulsations which occur in a minute decide whether the tempo will be slow or fast. The more pulsations that occur in a minute the faster the tempo will be. On the contrary, the less pulsations would equate to a slower tempo. The measure of tempo is the beats per minute (Arboleda et al., 2021).

1.3 Review of Literature

Perceptual load

In a study conducted by Johnson & McGrath et al. (2002), titled as 'Cueing Interacts with Perceptual Load in Visual Search', tested the perceptual load hypothesis which conceptualizes and posits that the only determining factor for selective attention is the perceptual load. Their results were consistent with the perceptual load hypothesis when they showed evidence that the distractor was processed more when the perceptual load was low as compared to when it was high, when there was no cueing involved. However, the results were inconsistent when there was cueing involved and participants were not processing the distractors in the low load condition. Therefore, their research suggested that perceptual load is an important factor for selectivity of attention, but is not the only one or not sufficient to indicate selectivity of attention and its effectiveness.

Music

In a study, the mediating effect of arousal and the tempo was tested and experimented upon. Participants in the experiment were divided into three groups of two different tempos and one control group. These groups included high tempo music, low tempo music and no music group. Their cognitive processing speed was measured such as motor speed, visuospatial processing speed and linguistic processing speed. Results indicated that the slow tempo group performed slower and worse performance in all the three tasks as compared to the no music group. Furthermore, as compared to the no music group, the fast tempo group had no significant difference in performance in all the three tasks. However, in the linguistic task, participants within the slow-tempo group had a higher accuracy as compared to the other groups. The findings show that arousal was not mediating the relationship between music tempo and the cognitive processing speed (Lin et al., 2023). However, this research does not consider its effect on a visual search task.

Another research focused on investigating the influence of background music on visual search performance. The tempo included the fast and slow conditions and the loudness also contained two conditions, high and low. The correct/accuracy rate and the search time was measured to indicate related performance. Results indicated that background music loudness significantly impacted the performance in the visual search task. On the contrary, the tempo of the music did not have a significant impact on the performance during the visual search task. Music which is low in loudness facilitates the visual search process and performance (Yang & Yu, 2017).

Research performed undertaking music as a variable, produced very inconclusive and contradictory results from previous literature. Some results were substantiated by previous literature and others were found inconclusive. For example, the arousal hypothesis states that when individuals listen to music, it actually facilitates and enhances their performance by influencing their mood positively (Schellenberg, 2005). Similarly, when individual's listen to music while performing a task, it can reduce their inattentional blindness as listening to music puts them in a positive concentration mode (Beanland et al., 2011).

Another study aimed to examine the role of music and distraction on the performance of science undergraduate students on the visual search task. Participants were supposed to identify as many numbers as they could on an 8 x 8 grid, where they were randomly assigned to one of the four conditions such as silence (controlled), distraction (talking), instrumental music, and lyrical music. Based on the Newman-Keuls post hoc analysis, it was shown that significantly higher scored were attained when the participants were assigned to the lyrical music group than the instrumental music group, talking group and controlled group. Furthermore, the instrumental group performed better as compared to the distraction group or the controlled group. Based on this, lyrical music was facilitating a simple visual search in this study (Crust et al., 2004).

However, another research suggests that listening to a faster tempo music increases the accuracy of harder decision making as compared to slower tempo music. In a study, the effect of music tempo and task difficulty was examined on the performance. The results concluded that the search pattern of the participants had become more intra-dimensional when the faster tempo music was played along with an enhanced accuracy as compared to the slower tempo (Day et al., 2009).

Methodology

Objectives:

1. To determine the effect of music on the accuracy of responses during a conjunction search task.
2. To determine the effect of perceptual load on the accuracy of responses during a conjunction search task.

Variables:

Independent variable:

1. Tempo of the music (faster tempo music, no music and slower tempo).
2. Perceptual load (high load and low load).

Dependent variable:

1. Accuracy

Quantitative 3x2 Factorial Design			
	Perceptual Load		
Music		High Load	Low Load
	Fast tempo music	62	62
	No music (control)	62	62
	Slow tempo music	62	62

Research Design

A quantitative within-subjects research design was undertaken. It had a 3x2 factorial design. Within the 3x2 factorial design, there are two independent variables, tempo of the music and the perceptual load, respectively. The tempo of the music contains three levels, fast tempo, no music, and slow tempo. Perceptual load contains two levels, high load, and low load. Within the high load level/condition, the set size was seven. Whereas, the low-load condition/level has a set size of 3. Since this design is a within-subjects design, a total of 62 participants underwent all the conditions, therefore the sample was 62 participants. The responses were collected through an experiment by using Open Sesame as a tool.

Hypotheses (alternate)

H1: Accuracy of responses will be higher during the slow tempo music as compared to the high tempo music.
H2: Accuracy of the responses will be higher in the high perceptual load condition as compared to the low load condition.
H3: Tempo and Perceptual load will have an interaction effect on the accuracy of responses.

Apparatus

The experiment was conducted on a Windows Desktop laptop, with Ryzen 3 processor. The participants were asked to be seated in a room devoid of any noise, where the temperature remained adequate and they were asked to sit approximately 100 to 150 cm from the laptop screen. The experiment was coded on OpenSesame but was displayed via Psychopy screen within the OpenSesame in-line. The data was imported into Microsoft Excel, and the analysis was conducted using Microsoft Excel and R.

Stimulus

During the search display, the location/position of the target and distractors were randomised. The target was a red circle which was presented at different locations on a screen of 800x600 px against a black background. The size of the target and the distractors remained equal, the distractors included a circle, rectangle, triangle, and square. The colours were also randomised and included red, purple, green, yellow, white, and blue.

Procedure

The experiment is divided into three equal blocks, each containing 50 trials each. Within the first block, a high arousal/tempo music was played. During the second block, no music was played. In the third block, a low arousal/tempo music was played. After each block, a break of one minute was given to the participants, to avoid any carryover effects. Each trial consisted of a fixation cross at the centre of the screen (0,0) which lasted for 250 milliseconds. After the fixation cross, the stimuli were presented on the screen for 250 milliseconds. The participants were expected to respond while viewing the stimulus. The trials could either have a high load (i.e., containing seven stimulus) or a low load (i.e., containing three stimulus). Within these load conditions, the target could either be present or absent. The number of high load trials and low load trials were randomised. So the target could be either present or absent within those conditions. The participants were supposed to indicate whether the target stimulus was present, whilst ignoring the task irrelevant shapes. The target was a red circle which appeared at random locations along with either six distractors (equalling the set size to seven in total) or 2 distractors (totalling to 3 set size). If the target is not present, the set size would include either seven or three stimuli, all of them would be distractors. The distractor shapes included circles, squares, triangles, and rectangles presented at random location.

Within the first block, the high arousal music will be played which the participant has to listen for the first 32 seconds and then begin performing the task. The music will be played simultaneously with the visual search task. When the participants encounter a screen with the text "take a beak" they will take a break and that will be the end of that block and the participants will have to take a break for one minute. When the new block begins (block 2) participants must perform the conjunction search task without any music (control condition). When the block ends, the participants are again supposed to take a break for a minute and then perform the conjunction search task by simultaneously listening to the low arousal/tempo music. The participants have to listen to the low arousal music for the prior 20 seconds and then start performing the task.

Instructions

The screen begins with a fixation cross, when the screen changes, the stimuli are shown. The participants should press on "Y" if they encounter a red circle, and they should respond with an "N" if they do not encounter a red circle. Participants should respond as soon as they see the shapes. The participants should rest for a minute when they encounter the screen "take a break". After one minute, they should begin performing the task again while listening to music.

Participants

Participants were recruited based on the convenience sampling technique. 62 students participated in the study from Ahmedabad University and St. Xavier's college (autonomous). The inclusion criteria for this study includes males and females with an age from 18 to 24. Individuals who were above or below that age range were in the exclusion criteria, visually impaired individuals, and individuals with a hearing aid.

Results

In order to calculate the significant effect of tempo and perceptual load on the accuracy of responses, t test (paired) and Anova were conducted by using R and Microsoft Excel. Along with the calculation of accuracy, the proportion of hits and correction rejections were also calculated since the experimental condition had the target present in 50 percent of the trials and absent in the rest 50 percent of the trials.

Table 3.1: Student's t test: Accuracy in High and Low perceptual load

N	M	Variance	t stat	Critical value	Level of Significance
61	35.07	25.83			
61	34.87	31.28	0.22	1.67	NS

*One tailed critical value.

Table 3.1 indicates that there was an insignificant difference between the accuracy in the high and low load conditions (mean=35.07 and 34.87, respectively), since the t value is lesser than the critical value (one-tailed). Therefore, the accuracy was not higher in the low perceptual load condition.

Table 3.2: Student's t test: Accuracy in High and Low Tempo

N	M	Variance	t stat	Critical value	Level of Significance
62	22.09	18.15			
62	24.48	14.09	3.04	1.67	0.05

* One tailed critical value.

Table 3.2 indicates that based on the t test, there was a significant difference in the accuracy in the high tempo condition and low tempo condition, showing that low tempo had significantly higher accuracy (n=62, mean=24.48, alpha=0.05).

Table 3.3: Student's t test: Proportion of hits and correct rejection in High Perceptual load Condition

N	M	Variance	t stat	Critical value	Level of Significance
61	22.59	22.91			
61	12.48	15.38	11.09	2.00	0.05

Table 3.3 indicates that based on the t test, there was a significant difference in the proportion of hits and correct rejections in the high perceptual load condition, showing that the number of hits were higher (n=61, mean=22.59, alpha=0.05) as compared to correct rejection.

Table 3.4: Student's t test: Proportion of hits and correct rejection in Low Perceptual load Condition

N	M	Variance	t stat	Critical value	Level of Significance
61	20.13	22.55			
61	14.74	13.5	6.59	2.00	0.05

Table 3.4 indicates that based on the t test, there was a significant difference in the proportion of hits and correct rejections in the low perceptual load condition, showing that the number of hits were higher (n=61, mean=20.13, alpha=0.05) as compared to correct rejection.

Table 3.5: Student's t test: Proportion of hits in Low and High Perceptual load Conditions

N	M	Variance	t stat	Critical value	Level of Significance
61	22.59	22.91			
61	20.13	22.55	3.54	2.00	0.05

Table 3.5 indicates that based on the t test, there was a significant difference in the proportion of hits in low and high perceptual load conditions, showing that the number of hits were higher in the high perceptual load condition (n=61, mean=22.59, alpha=0.05) as compared to the low load condition.

Table 3.6: Student's t test: Proportion of correct rejections in Low and High Perceptual load Conditions

N	M	Variance	t stat	Critical value	Level of Significance
61	12.48	15.39			
61	14.74	13.5	3.69	2.00	0.05

Table 3.6 indicates that based on the t test, there was a significant difference in the proportions of correct rejections in low and high perceptual load conditions, showing that the number of correct rejections were higher in the low perceptual load condition (n=61, mean=14.74, alpha=0.05) as compared to the high load condition.

Table 3.7: Student's t test: Proportion of hits and correct rejections in High Tempo Condition

N	M	Variance	t stat	Critical value	Level of Significance
61	13.48	12.52			
61	8.16	8.63	7.81	1.99	0.05

Table 3.7 indicates that based on the t test, there was a significant difference in the proportion of hits and correct rejections in high tempo condition, showing that the number of hits were higher (n=61, mean=13.48, alpha=0.05) than correct rejections.

Table 3.8: Student's t test: Proportion of hits and correct rejections in No music Condition

N	M	Variance	t stat	Critical value	Level of Significance
61	14.52	19.86			
61	9.03	10.82	7.05	1.99	0.05

Table 3.8 indicates that based on the t test, there was a significant difference in the proportion of hits and correct rejections in no music condition, showing that the number of hits were higher (n=61, mean=14.52, alpha=0.05) than correct rejections.

Table 3.9: Student's t test: Proportion of hits and correct rejections in Low Tempo Condition

N	M	Variance	t stat	Critical value	Level of Significance
61	14.82	11.13			
61	9.66	9.97	7.67	1.99	0.05

Table 3.9 indicates that based on the t test, there was a significant difference in the proportion of hits and correct rejections in low tempo condition, showing that the number of hits were higher (n=61, mean=14.82, alpha=0.05) than correct rejections.

Table 3.10: Anova: Tempo and hits

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	61	2	30.5	2.10303922	0.125025807	3.045312
Within Groups	2654.016	183	14.50282			
Total	2715.016	185				

Table 3.10 indicates that based on Anova, there was no significant difference in the number of hits obtained in the three conditions/groups of tempos (i.e., high tempo, no music and low tempo), since f value is lesser than the f critical value.

Table 3.11: Anova: Tempo and correct rejections

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	34.52688	2	17.26344	1.76046413	0.174864731	3.045312
Within Groups	1794.532	183	9.806187			
Total	1829.059	185				

Table 3.11 indicates that based on Anova, there was no significant difference in the number of correct rejections obtained in the three conditions/groups of tempos (i.e., high tempo, no music and low tempo), since f value is lesser than the f critical value.

Table 3.11: Anova: Tempo and correct rejections

Effect	DFn	DFd	F	p	p<0.05	pes
Tempo	2	122	5.38	0.006	**	0.08
PL	1	61	0.1	0.756		0
Tempo:PL	2	122	0.89	0.415		0.01

*PL indicates perceptual load

Table 3.11 indicates that based on Anova, tempo has a significant effect on the accuracy of responses, since the p value (0.006) is lesser than the significance value (0.05). Furthermore, it shows that it had a medium effect (pes=0.08) on the accuracy of responses. However, there was no significant effect of perceptual load on the accuracy of responses since the p value (0.075) exceeds the significance level (0.05). There was no interaction effect of tempo and perceptual load on the accuracy of responses since the p value (0.415) exceeds the significance level (0.05).

Discussion

As the study aimed at investigating and assessing the effect of music tempo and perceptual load on the accuracy of responses, by undertaking an experimental design, it also provides an insight into novel perceptual mechanisms which may have underlying and codependent auditory mechanisms which work together and influence decision making altogether. For instance, an individual's efficiency and ability to distinguish between two visual stimuli may be dependent upon the condition under which they are visually processing the stimuli. While perceiving the stimuli, an individual may not be able to actively filter out of auditory stimuli which coexists and is task irrelevant during the identification of the task relevant stimuli. This may hinder not only their efficiency to process the stimuli, but also the identification of a stimulus. Processing of a stimuli can only occur if it attended to and is identified based on certain task relevant features.

As it is noted by the theory of perceptual load which operates on a capacity approach, that when the load is high there is less vacancy for the processing of the task irrelevant stimuli, due to exhaustion of attending to the amount of information present in the environment or the visual field. Based on this idea, the accuracy of the response should rather be high as compared to the lower loads, since in high load conditions the task irrelevant stimuli are not processed at all, therefore it will not hinder with the processing of the targeted stimuli in the visual search task (i.e., conjunction search task), thus increasing the accuracy of response. On the other hand, in the lower perceptual load, since the task is simple and less information is present in the visual field, the capacity is not fully exhausted due to which the individual may fail to ignore the task irrelevant stimuli, hindering their accuracy of responses. However, results of this study *were not in line with the perceptual load theory*, since there was *no significant difference in the accuracy of the responses of individuals during high perceptual load condition and low perceptual load condition*, indicating that they were able to respond similarly in both conditions. Furthermore, results also indicated that perceptual load did not have a significant impact on the accuracy of responses. However, the study notes that there was a significant difference in the accuracy of responses with respect to correct rejections and hits. Results strongly illustrated that *individuals were better able to detect a stimulus and report whether a target-feature exists as opposed to when the target feature is absent*. They were better able to report when the target itself was present as opposed to when it was absent. This may suggest that selection of the stimuli may occur early in the selection process. As it occurs early, individuals are more likely to make errors when they do not detect a task-relevant stimuli/stimulus.

Based on the arousal hypothesis, it enunciates that performance is mediated and facilitated by music as it puts an individual in a state of high and positive concentration (Beanland et al., 2011). This hypothesis highly supports the results of the current study, where the results showed that *tempo of the music had a significant impact on the efficiency and accuracy of detecting task-relevant stimuli*. Since listening to music puts an individual in a positive and high concentrative state, this may also reduce their inattentional blindness therefore increasing their accuracy of responses in a conjunction search task. The results of this study could not be corroborated by the findings by Yang & Yu (2017), who concluded that tempo has an insignificant effect on the performance on the visual task, however the loudness does impact the visual search (Yang & Yu, 2017). The current study suggested that tempo affected and influenced the visual search exercise, significantly. Another study by Day et al., (2009) support the findings of this research, where they indicated that faster tempo music facilitates harder decision making and interdimensional search patterns, therefore increasing the accuracy as compared to slower tempo music.

However, results also indicated that *perceptual load and tempo did not have any combination effect*, this could arise due to the fact that perceptual load itself did not have any significant effect on the accuracy of response or the visual search. Therefore, the alternate hypothesis 1 (i.e., accuracy of responses will be higher during the slow tempo music as compared to the high tempo music) *is not rejected* based on the result table (3.2). The alternate hypothesis 2 (i.e., accuracy of the responses will be higher in the high perceptual load condition as compared to the low load condition) is *rejected* based on the result table (3.1) since the findings are insignificant. The alternate hypothesis 3 (i.e., tempo and perceptual load will have an interaction effect on the accuracy of responses) is *rejected*.

Conclusion

Individuals are bombarded with several stimuli in the environment and excessive information, due to which it may become difficult for them to filter out irrelevant information. It may be easier for them to detect information rather than report when something is missing or is absent from the environment. Not only the amount of information in the environment, but other auditory stimuli may hinder or facilitate their attention to a specific object. This research suggests that the amount of information present in the visual field of an individual may not influence their ability to accurately report it. However, different types of sounds and music may facilitate or hinder their processing of that same visual stimulus. Temp of the music and the perceptual load do not have a combined effect upon the accuracy, since it may show that these two processes hold different processing paths as well.

Limitations

The study takes into account only college students; therefore, the results cannot be generalizable to older population. The sample size is fairly small. The participants were recruited based in a convenience sampling technique, due to which not every person had an equal chance if being selected. Any other stimulus or variable is not studied or taken into consideration (i.e., the effect size of the distractor). Furthermore, the highest/strongest effect of the tempo could not be studied.

Implications

For the recommendations for future research, the idea of saliency could be taken into account and then the effect of perceptual load could be investigated. Not only the increasing size of the set will affect the processing of the task-relevant stimuli, but ignoring the task-irrelevant stimuli which has a very salient disposition, might also influence the accuracy of responses regardless of the set size. This idea can relate to distractor suppression. Furthermore, the tempo of the music can be introduced as another variable, to see whether distractor suppression is efficient during high tempo or slow tempo music. Furthermore, it could also be investigated that which perceptual system is competing for the resources, which leads to inaccurate responses.

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