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The Effects of Background Music on The Screen-Based Reading Material Among University Students: An Eye Tracking Study

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ABSTRACT

Reading performance is a crucial skill that can predict success in education. Many factors can influence reading performances, such as background music and perceiving the sentences while reading. This study explores the effects of music on screen-based reading materials among health sciences university students. One hundred twelve participants from The National University of Malaysia, Kuala Lumpur Campus, participated in this study. Participants were asked to read and understand the general theme text given on the computer screen. The participants were segregated into two groups according to their preferred way of reading, either music or non-music. Then, participants in the music group randomly listened to rap or classic music (rap = 86 BPM or classic = 161 BPM) using a Sony headphone (MDR-XB450AP) while reading. The reading duration was recorded, and reading comprehension was determined by the correct answers to four questions based on the text. A webcam-based GazeRecorder software was used to measure the eye-tracking metrics (dwell time, first view time, and number of AOI views) on the area of interest (AOI). Reading speed is significantly associated with reading comprehension ($r_s = -0.1933$, $p = 0.0412$). Reading duration, reading speed, and reading comprehension were not considerably different while listening to and not listening to music. The results show a similar pattern in all eye-tracking metrics. However, the reading duration while listening to rap music (2.68 ± 1.94 minutes) was significantly shorter ($U = 299.5$, $p = 0.02642$) compared to classical music (3.42 ± 1.91 minutes). Moreover, reading speed is significantly higher ($U = 299.5$, $p = 0.02642$) while listening to rap music (139.38 ± 102.96 wpm) as compared to classical music (109.47 ± 51.51 wpm). Music seems not to affect reading performance and eye-tracking metrics. Despite this, rap music can improve reading performance by reducing the reading duration and increasing reading speed.

Keywords: reading performances, music, eye-tracking

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1 INTRODUCTION

Reading is collecting information from books or any reading material. In this era, online learning has become a new trend as a way of studying for university students. During the COVID-19 pandemic, most universities used online learning as an alternative to replace physical classes. This is to reduce the risk of the spread of COVID-19. Students nowadays prefer to use e-books or e-journals as their reference compared to thick books that students used in the past. Gen Z rents e-books most or all the time and gets free e-book sites most or all the time at 30% and 26%, respectively (Nicholas, 2020).

Moreover, due to the COVID-19 pandemic, the learn-from-home method causes students to use more screen-based reading material such as e-books, e-journals, and e-articles as their reference since they cannot borrow books at the library. Reading is an everyday routine in our daily lives, but we rarely realise eye movement and gaze when we read. With the development of eye-tracking systems in the last two decades, we can collect high-quality recordings for research among children and adults (Schroeder et al., 2015). Eye movement can be divided into two components, which are fixations and saccades (Pivec et al., 2006). Fixations are defined as a time in which nearly stable eye movements where information is processed. At the same time, saccades are rapid movements between the fixations in which the eyes move from one area of interest to another point. However, we can gain more significant results by analysing both components with other parameters.

Listening to music while studying or reading has become a new practice in the student population. Some groups of students claim that this practice could enhance their academic efficacy, while some research denies the statement. However, a researcher stated that listening to music while studying helps students concentrate on their studies and might improve their academic performance (Kumar et al., 2016). More research has been done to see whether the influence of background music or any other distraction can affect reading and academic performance. There is research to support the theory that multitasking during educational activities negatively affects learning and academic performance (Chen et al., 2016).

A few populations of students preferred reading in silence without interruption of any background music. The reading-comprehension scores revealed that the participants scored significantly lower after listening to the non-preferred music while reading than in silence (Johansson et al., 2011). Furthermore, most of the time, if a student studies while listening to music, they will read silently. Reading in silence is better, which leads to higher comprehension in the retelling measure (Schimmel et al., 2017). However, the result of either listening to music or not is more consistent, and previous studies claimed that background music could harm second or foreign-language students' learning process (Sahebdel et al., 2014).

In recent years, the scientist has begun to make a noteworthy commitment to eye-tracking studies. The researcher has done many studies regarding eye tracking in reading. Reading is a process of collecting information, and we rarely realise eye movement when we read. Various factors may affect reading comprehension, speed, and efficiency. Music is one of them. Music is a combination of sounds and vocals which create a harmonious melody and expression of emotion. The music

consisted of various genres such as rock, hip hop, ballad, and classic. There will be significant differences when reading while listening to a different type of genre music. Reading while listening to calm and relaxed music gives better concentration and performance than reading with the interruption of hardcore and aggressive music (Bugter et al., 2012). The different tempos of the music have different impacts on individual actions and behaviour. Readers need more time to read when the music or background speech is interrupted, but it does not deleterious affect comprehension performance (Cauchard et al., 2012).

This study is conducted to explore the effects of background music on screen-based reading materials during online learning among university students. Besides that, this study will question how the background music's influence affects students' attention when reading. Precisely, this study will unravel how background music affects reading speed, comprehension, and eye movement parameters (heat map, dwell time, and first view time). We hypothesised that using the eye tracker, the variety of students' behaviour while reading and listening to different kinds of music can be observed based on eye movement patterns. Eye-tracking is a study process to examine eye movement and point of gaze. The aim is to get information on how individuals assemble the data and what factor affects their decisions and behaviour.

2 METHODOLOGY

2.1 Research design

This research was approved by the institutional ethics committee of UKM with ethical code UKM1.21.3/244/NN-2019-058. This study is a cross-sectional and experimental study among the students from The National University of Malaysia Kuala Lumpur Campus (UKM KL). The data collection began on 17 November 2020 until 19 December 2020.

2.2 Participants

One hundred twelve participants (20 male, 92 female, age = 21.91 ± 1.062) from The National University of Malaysia, Kuala Lumpur Campus, participated in this study (Table 1). The participants were randomly selected from any courses in the faculty. The inclusion criteria are that subjects must be Malaysian citizens and undergraduate students from The National University of Malaysia Kuala Lumpur Campus. They can understand the English language with MUET Band 3 and above. The exclusion criteria are individuals with eye problems affecting the eye tracking process, such as squint, and those with hearing problems.

The participants include 85 Malay, 19 Chinese, 4 Indian, and six other races. Based on the MUET result, most of the subjects achieved Band 4 (n = 70), followed by Band 3 (n = 29), Band 5 (n = 12), and Band 6 (n = 1). Fifty-two subjects preferred to study in silence, while 60 preferred to study while listening to music. Furthermore, 41 preferred to listen to the classic genre, while another 19 subjects preferred to listen to rap.

2.3 Instrument

The materials and apparatus required for the experiment are as follows: 1) PC laptop (1366 x 768-pixel resolution) with a dedicated built-in 3.2-megapixel webcam, 2) GazeRecorder software (https://app.gazerecorder.com/?gr), 3) Comprehension text extracted from the AceReader, Inc. website http://www.freereadingtest.com/ (General/ Level 13/ Story 01), 4) The level of difficulty of the comprehension text was checked by using the open access readability test tool (https://www.webfx.com/tools/read-able/). 5) A Sony headphone (MDR-XB450AP), 6) demographic questionnaires.

2.4 Music stimulus

Firstly, a questionnaire was distributed to all the targets. The participants voluntarily filled in the form in section A (demographic questions) and section B (reading behaviour) with their consent. After that, the participants were separated into two groups, which were music and non-music groups. They were segregated according to their preference, either to read with or without interruption of background music. For a music group, they listened to music using a Sony headphone (MDR-XB450AP) with their preferred volume. The genre of music (rap = 86 BPM or classic = 161 BPM) was randomly selected for all the participants in the music group. The rap music stimulus file (.MP3) used was Coke Moet Gepushed Worden by Kempi (2007). In contrast, the classical music stimulus file (.MP3) used was Symphony No. 5 Piano Concerto in E-flat Major by Beethoven (London Festival Orchestra, 1991).

2.5 Data collection procedure

The participants sat approximately 40 cm away from the laptop, and the experiment started with the participants following the instructions from the GazeRecorder before starting the eye calibration tracking. The continuous authentication process will be made along with real-time gaze tracking. The tracker's track box authenticated the subjects' faces before the subjects started the eye calibration tracking. If the tracker's track box does not detect the subject's face, the sensor turns red as a warning. To ensure the subject's face was visible on screen, the experiment must be done in a room with good lighting (the room should be bright with no backlight behind the subjects) and no light reflection on glasses for those wearing glasses. After the authentication, the subjects proceeded to the calibration and validation process.

After that, a comprehension text popped up on the screen. Participants were asked to read and understand the general theme text (number of words = 374, Flesch Kincaid grade level = 12.6, and Coleman Liau Index = 12.1) given on the computer screen within 10 minutes. However, they were allowed to skip if they had fully understood the text. Then, the participants must answer the comprehension questions and be unable to refer to the text while answering the questions. There were four objective questions, and they must answer all the questions provided in 10 minutes. The reading duration was recorded, and reading comprehension was determined by the correct answers

to four questions based on the text. A webcam-based GazeRecorder software was used to measure the eye-tracking metrics (dwell time, first view time, and number of views) on the area of interest (AOI).

2.6 Statistical analysis

Descriptive statistics and normality tests were performed to decide which hypothesis test would be used. The Statistical Packages for the Social Sciences (SPSS) software version 26 (SPSS Inc., USA) was used to analyse the data. Non-parametric analysis is used due to the data is not normally distributed. A Mann-Whitney U test was used to compare the reading duration, reading speed, reading comprehension, dwell time, first view time, and number of AOI views between non-music and music groups. Spearman's rho correlations test was used to correlate the reading speed and every eye-tracking metric with reading comprehension. Outlier data due to the misregistration of eye-tracker data will be removed. The p-value < 0.05 will be considered statistically significant for all the analysis data.

Table 1. Socio-demographic characteristics of the sample (n = 112, mean age = 21.91 ± 1.062).

Variables	Frequency (n)	Percentage (%)
Gender		
Male	20	17.9
Female	82	73.2
Age		
< 20	0	0
20 – 21	35	31.2
22 – 23	73	65.2
24 – 25	3	2.7
> 26	1	0.9
Race		
Malay	85	83.3
Chinese	19	18.6
Indian	4	3.9
Others	6	5.9
Course		
Speech Science	4	3.6
Physiotherapy	3	2.7
Pharmacy	1	0.9
Optometry	5	4.5
Nutrition Science	36	32.1
Environmental Health	2	1.8
Dietetic	8	7.1
Diagnostic Imaging	25	22.3
Dentistry	6	5.4
Biomedical science	22	17.9

Preferred way of study and music		
Silence	52	46.4
With music	60	53.6
English proficiency test result (MUET)		
Band 1	0	0
Band 2	0	0
Band 3	29	26
Band 4	70	62
Band 5	12	11
Band 6	1	1

3 RESULTS

3.1 Reading performance

The participants were separated into two groups, which were music and non-music. The participants in the music group randomly listened to either rap or classical music during the reading. Table 2 shows the reading performance allocated into three groups: reading duration, reading speed, and reading comprehension. For reading duration (minutes) analysis, the music group showed higher median scores (3.15 ± 2.396), and the non-music group showed lower median scores (3.14 ± 2.167). It is contradicted by the reading speed (wpm) analysis in which the participants revealed higher median scores in the music group (119.05 ± 74.82) and lower median scores in the non-music group (118.73 ± 93.28). Analysis in reading comprehension displayed identical median scores in both groups (3.00 ± 2.000). The analysis did not show any significant difference between the reading performance and the influence of music, with $p > 0.05$.

Table 2. Reading performance while listening to music and not listening to music.

Reading performance	Non-music	Music	Statistical test
Reading duration (minutes)	3.14 ± 2.167	3.15 ± 2.396	U = 1478.5, p = 0.638
Reading speed (wpm)	119.05 ± 74.82	118.73 ± 93.28	U = 1478.5, p = 0.638

Reading comprehension (Full mark = 4)	3.00 ± 2.000	3.00 ± 2.000	U = 1388, p = 0.317

3.2 Eye tracking metrics and influence of music

Figure 3 demonstrated the heatmap at the area of interest (AOI), which recorded the dwell time, first view time, and the number of AOI views. The red heatmap distributed on the central reading material indicates the higher participant focus. Table 3 shows the details of eye-tracking metrics while listening to and not listening to music. For the dwell time, the music group had a higher median score in AOI 1 (0.47 ± 1.210) and AOI 2 (4.40 ± 4.710) than the non-music group. Nevertheless, the non-music group had a higher median score in AOI 3 (1.94 ± 3.243) and AOI 4 (2.16 ± 3.743) than the music group. In terms of first view time, the music group gained a higher median score in AOI 1 (9.71 ± 32.818) and AOI 3 (55.26 ± 75.543), while the non-music group had a higher median score in AOI 2 (16.35 ± 17.715) and AOI 4 (32.99 ± 67.393) respectively. The median score for the number of AOI views was the same in both groups (4.00 ± 1.000). Overall, the result shows no significant difference between groups in dwell time, first view time, and number of AOI views.

3.3 Number of AOI views, reading speed, and reading comprehension correlation

Table 4 shows the correlation data between the number of AOI views, reading speed, and reading comprehension. The analysis of the correlation between the number of AOI views with reading comprehension is not significant. The correlation value (r_s = 0.04472, p = 0.63962) is positive and negligible. Furthermore, the analysis showed a statistically significant between reading speed and reading comprehension (r_s = -0.1933, p = 0.04115). However, the analysis displayed a weak negative correlation between the groups.

3.4 Rap music and classical music

Figures 1 and 2 display rap and classic music groups' median reading duration and reading speed scores, respectively. The results show a significant difference between rap and classic music groups (U = 299.5, p = 0.02642) in reading duration and reading speed parameters. The median score for reading duration in the classic group (3.42 ± 1.91) is higher compared to the rap group (2.68 ± 1.94). Moreover, the median score for reading speed in the rap group (139.38 ± 102.96) is higher than the classic group (109.47 ± 51.51).

4 DISCUSSION

All students have their preferred way of reading. In this research, the participants were classified into their favoured way of study, either non-music or music. The non-music group was expected to achieve a better reading comprehension score than others. Reading with the influence of music makes reading comprehension less proficient (Zhang et al., 2018). The reading duration and reading speed were also predicted to differ between those groups. The readers might spend more time rereading the sentence due to the music interruption. Reading in the presence of music did make the task more challenging, as revealed by increased rereading and overall duration (Zhang et al., 2018). However, the result of this study displayed that there was no significant difference between those groups. Various factors may affect reading, but music did not show any difference in reading comprehension in this research. This result is a consequence of the classification of groups according to their preferred study method.

Table 3. Eye-tracking metrics during reading while listening to music and not listening to music.

Eye-tracking metrics (s)	Non-music	Music	Statistical Test
Dwell time			
AOI 1	0.31 ± 1.150	0.47 ± 1.210	U = 1544, p = 0.9282
AOI 2	3.56 ± 4.043	4.40 ± 4.710	U = 1296, p = 0.1235
AOI 3	1.94 ± 3.243	1.69 ± 3.395	U = 1432, p = 0.4593
AOI 4	2.16 ± 3.743	2.09 ± 4.333	U = 1553, p = 0.9681
First view time			
AOI 1	7.88 ± 20.093	9.71 ± 32.818	U = 1404, p = 0.36282
AOI 2	16.35 ± 17.715	13.30 ± 22.050	U = 1450, p = 0.52218
AOI 3	52.97 ± 63.360	55.26 ± 75.543	U = 1514, p = 0.78716
AOI 4	32.99 ± 67.393	4.40 ± 72.748	U = 1459.5, p = 0.5619

Number of AOI views	4.00 ± 1.000	4.00 ± 1.000	U = 1514.5, p = 0.7948

Other than that, the reading speed results in this study were lower than the normal range. College-educated students usually read at a speed of about 200 to 400 wpm (Rayner et al., 2016). This result might be due to the participant being a non-native English speaker. Reading speed is an indicator of accessing the readability of non-native and native English speakers. Non-native English speakers had a lower reading speed than native English speakers (Boudjella et al., 2017). Besides, the readers read slowly because they read the text repeatedly. Since they were not allowed to refer to the text when answering the question, they must use their cognitive skills to answer the questions. To memorise and comprehend better takes a longer time and slower speed in this study.

The eye tracking method was used in this study to see any effect on the eye tracking metrics (dwell time, first view time, number of AOI views) when the subjects read with the influence of music. Previous research also observed longer fixations when listening to music than in silence (Schäfer et al., 2015). The result of dwell time and number of AOI views was expected to be longer in the music group compared to the non-music group. As shown in Table 3, the result shows that no group, either non-music or music, is dominant in the outcome. This result might be associated with the current study trend where students enjoy listening to music while studying. Some students have created cognitive strategies that enable them to concentrate on study tasks despite competing background stimuli (Anderson et al., 2010). The students in this research might have adapted to their preferred way of study.

Table 4. Correlation of eye-tracking metrics and reading speed with reading comprehension.

Variables	Reading Comprehension	
	r_s	p-value
Number of AOI views	0.04472	0.63962
Reading speed	-0.19330*	0.04115*

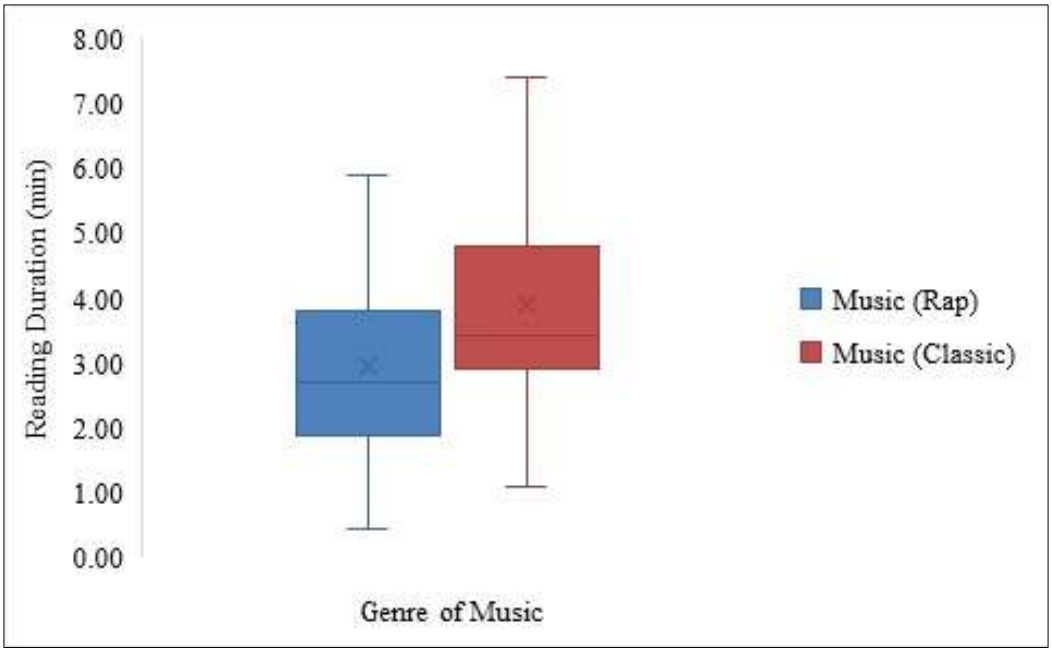
*Significant at $p < 0.05$

Based on Table 4, the number of AOI views shows a weak correlation with reading comprehension but is insignificant. Each student's eyes, gaze, and movement can randomly rely on cognitive skills and learning strategies (Clifton et al., 2016). In reading, it is sometimes word-dependent, which depends on the difficulty of recognising the words in particular sentences. The word recognition process amounts to the information at the fixation point area of interest (Josephson, 2008). Fortunately, reading speed and comprehension displayed a statistically significant difference, but the correlation is weak and negative. (Seabra et al. 2017) revealed that reading speed uniquely contributes to reading comprehension after controlling for word recognition and listening. The slower the reading speed, the better the comprehension score. A reader with slow reading speed

leads to a genuine comprehension of what is being read (Bell, 2001). Other than that, language proficiency may be a factor that affects reading speed and comprehension. Most participants were Band 4 students (62%) who are advanced in English. Undergraduate students with higher English language capability score better in their universities (Rahmat et al., 2015). Therefore, they can gain high scores in fast reading speed.

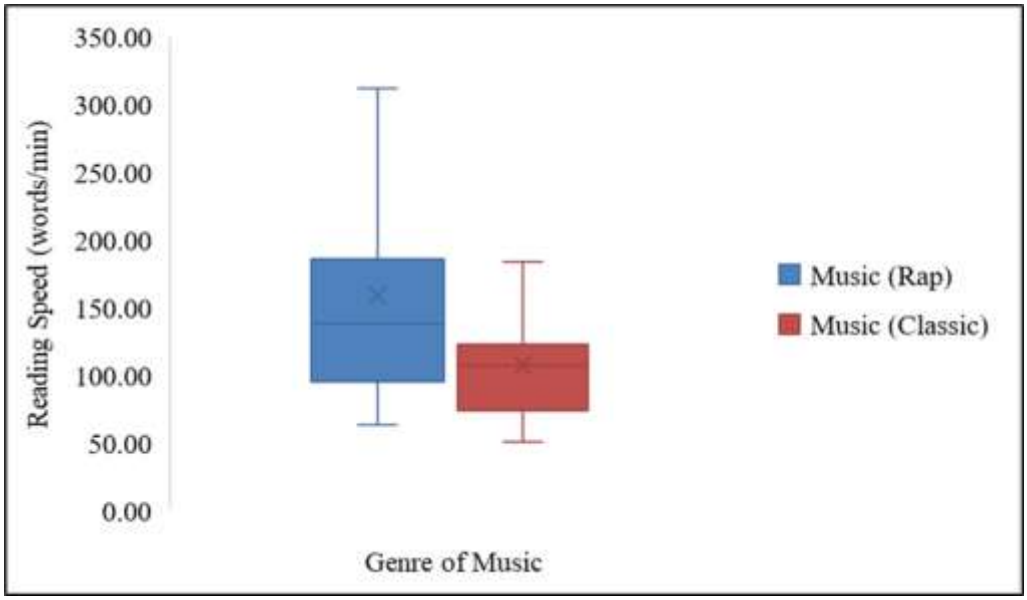
The participants in the music group randomly listened to either rap or classic genre music. These two types of music genres were used to separate either slow or fast-paced music preferences. This is due to a limitation of the imbalance of music genre preference in this research with rap music (n=19) and classic music (n=41). Most of them choose non-lyrical classical music, which acts as soothing music. We chose two types of music genres because we believe that the tempo will affect the reading performance. Other than that, rap music was expected to act as a distraction to the reader, which caused the reading duration to increase and reading speed to decrease. In this research, the result shows there is a significant difference between rap and classic groups.

However, it does not accept the hypothesis that rap music groups require longer duration and low reading speed. The median score in Figure 1 and Figure 2 displayed that the rap music group required a shorter duration with a faster rate. This result may be due to the type of music played affecting the listener's behaviour. The different tempos of the music have other impacts on individual actions and behaviour. For example, a faster music tempo causes someone to eat faster and increase food intake, while a slow music tempo shows the opposite result (Karapetsa et al., 2015). Rap music stimulates the reader to read more quickly, reducing the reading duration.



*Significant at $p < 0.05$

Figure 1. Reading duration while listening to rap and classic types of music.



*Significant at $p < 0.05$

Figure 2. Reading speed while listening to rap and classic types of music.

Area of Interest (AOI) was associated with dwell time (Hessels et al., 2016), heatmap (Dickmann et al., 2015), and time to first fixation (TTFF). Dwell time is the total time a participant visits the AOI from start to end (Kok et al., 2017). Time to the first fixation: They recorded the time taken for participants' first fixation on the AOI (Mclaughlin et al., 2017). Heatmaps are time-aggregated density-based representations (Raschke et al., 2014). The heatmap is a visualisation in which the fixation counts are presented as colours on a scale from green to red. The red colour indicates a longer dwell time, while the blue colour indicates a shorter fixation time. Heatmap can illustrate a student gaze pattern variation (Mclaughlin et al., 2017).

Figure 3 shows the overall result of the heatmap. Heat maps do not provide an avenue for systematic comparisons but can still be used to exemplify and support quantitative eye-tracking parameters (Salehuddin et al., 2019). Most students focus on the centre of the text and concentrate less on the peripheral side of the text. The area of interest was mainly at the centre of the text. This led to a higher number of views in the area of interest, with a median score (of 4.00 ± 1.000). The type of text and questions significantly affect reading comprehension and reading speed, which may influence the student's performance in responding to the questions accurately (Batemanazan et al., 2014). Readers read faster if the sentence or information is similar. Most of the time, readers skip a similar part to reduce time-consuming. As in Figure 3, the students are most likely to skip the peripheral part to reduce the time-consuming.

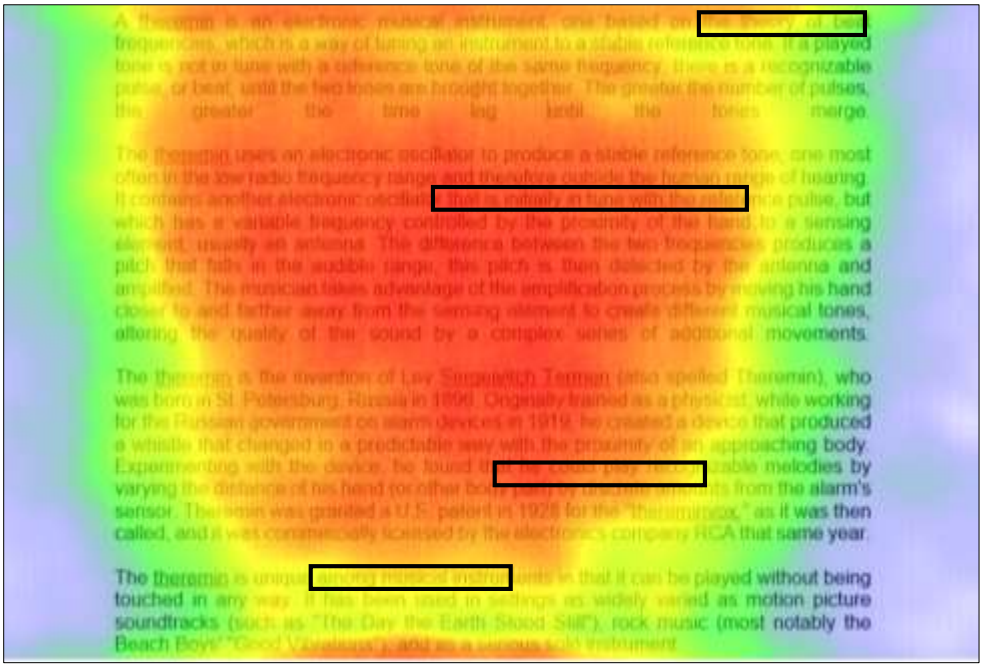


Figure 3. Overall participant's heatmap (n=112) and the area of interest in the comprehension text.

5 CONCLUSION

Music did not show any significant effect on someone's reading performance. The classification of the group, type of stimuli, and engagement of participants listening to background music should be considered important factors influencing the student's focus. However, music can help students increase their reading performance to the extent they listen to their preferred music. Even some previous researchers mentioned that music distracts the readers; music might also improve reading and academic performance. Besides that, language proficiency is a factor that should be addressed. Participants with better language proficiency may score better on reading comprehension tests. In future research, getting participants with equal language proficiency in each group is better to reduce biases. In addition, many other factors may also affect the reading performance score, such as speaker volume and students' mood. Lastly, the consequences of this study raised functional issues regarding students' study habits.

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