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EXAMINATION OF MUSICAL EFFECTS ON GAZE PATTERNS IN PORTRAIT DRAWING

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Abstract. *We aimed to clarify how music influences portrait drawing. We had an artist listen to an identical melody at slow (75 bpm), medium (100 bpm) or fast (150 bpm) tempos as she drew a portrait for 7 min while we used an eye tracking system to acquire her gaze point coordinates. The melody consists of the same simple tone except velocity. Listening to faster tempos caused her to transfer her gaze between the drawing area and the portrait model significantly more frequently. The artist exhibited greater GTFs (Glance translation frequency, which is how frequently the participant's gaze transferred between the drawing area and the portrait model) when listening to faster music, with significant differences when comparing the fast and slow tempos. This suggests that faster music tempos may improve observational abilities and concentration levels.*
Keywords: Music, Tempo, Portrait, Observation ability, Concentration, Eye tracking, Eye movement

1. **Introduction.** In today's information-rich society, it is difficult to develop the ability to concentrate on tasks. Improving concentration and observational ability enhances working efficiency and decreases errors [1]. D. Levitin [2] reported that listening to music changes human neurotransmitter levels. Music can increase concentration levels, so some athletes listen to music immediately before important matches. This is important in contests like the Olympic Games where a player's concentration can decide the outcome.

Indeed, there is some evidence suggesting that music, particularly music with faster tempos, may enhance cognitive and physical performance [3,4]. We previously used gaze point measurements to analyze differences between good and bad artists as they drew a portrait. By analyzing how frequently participants transferred their gazes between the drawing area and the portrait model, we found that better artists exhibited better concentration [5]. In other reports, we showed that musical tones or push-button sounds affected impression [6-8]. These previous papers did not describe how these musical elements influence listeners' work.

There are some researches that improve human-machine interfaces, predict car drivers' behaviors and recognize Chinese characters by using an eye tracking system [9-13]. However, no studies have yet used glance tracking to measure observational abilities and

concentration levels in subjects who are drawing portraits. We therefore conducted this study examining how musical tempo influences concentration by having an artist listen to an identical melody at different tempos as she drew a portrait for 7 min. We used a convenient, non-restraint and non-contact eye tracking system to acquire her gaze point coordinates as she drew, because gaze point measurements are good indices of artistic proficiency and task concentration. We hypothesized that faster tempos would enhance her drawing performing.

The remainder of this paper is organized as follows. Section 2 describes the experimental method of acquiring the participant's glance coordinates and heart rate while she drew the portraits. Section 3 discusses the data analysis. Section 4 describes our results. Finally, Section 5 states our conclusions.

2. **Experimental Method.** The participant (1 healthy, left-handed, artistically skilled woman) listened to a melody at 1 of 3 tempos while she drew a portrait, and we measured her heart rate and gaze movements using non-restraint and non-contact methods. The study was performed in accordance with the regulations of the Hiroshima International University's ethics committee. The participant gave written informed consent to participate. Figure 1 outlines the experiment. The room was illuminated with 3-wavelength fluorescent lamps as in a normal office. The artist worked on a liquid crystal display with a built-in optical touch sensor panel (LCD AD221FB-T, 1920 × 1080, 21.5-inch; I-O DATA, Kanazawa, Japan).

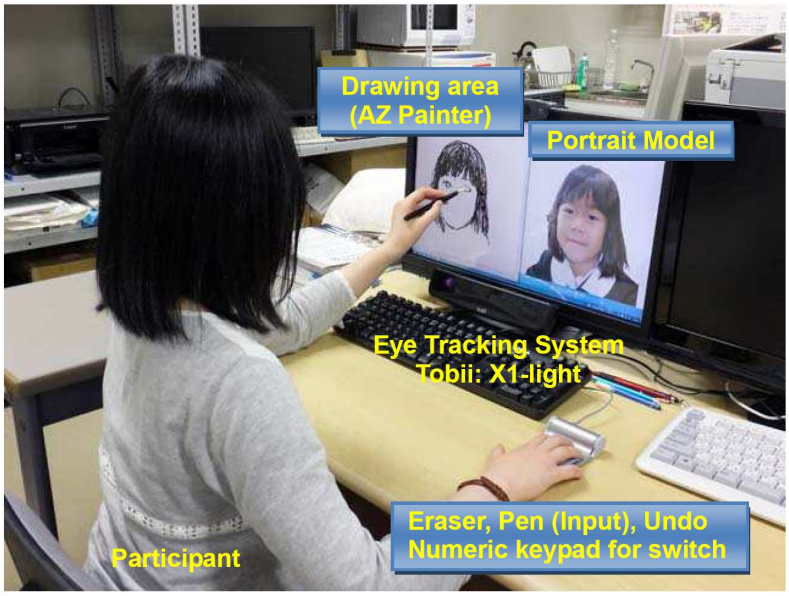


FIGURE 1. Outline of the experiment

The portrait model was a 6-year-old girl's face that was displayed on the screen's right half. The participant drew a portrait on the screen's left half in Az Painter (free software; http://azsky2.html.xdomain.jp/) using a piezo-electric pen. Drawing the portrait took approximately 7 min ± 30 s. Prior to the experiments, the artist grew accustomed to using the piezo-electric pen by drawing simple shapes and lines in the drawing area. She then listened to music at slow (75 bpm), medium (100 bpm), or fast (150 bpm) tempos while drawing a portrait. She drew 1 portrait at each tempo daily. The tempo presentation order was randomized. The resulting presentation sequence is shown in Table 1.

The music was produced with repetition Windows Media Player (Microsoft, Redmond, Washington). To prevent existing musical knowledge and preferences from influencing the results and to preserve the beat, we composed a monophonic melody for piano in C major. The participant's eyes were tracked with an infrared eye tracking system (Tobii X1-Light;

Table 1. Experimental sequence

	Tempo order		
	1	2	3
Trial 1	Medium	Fast	Slow
Trial 2	Slow	Medium	Fast
Trial 3	Fast	Slow	Medium
Trial 4	Medium	Slow	Fast
Trial 5	Slow	Fast	Medium
Trial 6	Fast	Medium	Slow

The interval between experiments was at least 7 days.
She drew 1 portrait at each tempo daily.

Tobii, Danderyd, Sweden). The sampling frequency was 30 Hz. The participant could control all drawing functions through a keypad on which she rested her right hand, so she did not need to glance at anything except the portrait model or the drawing area. The participant's heart rate was measured with a wristwatch-type device (Runsense SF-810; Seiko Epson, Suwa, Japan) during 1 min of rest before and after drawing.

3. **Data Analysis.** To determine whether musical tempo influenced drawing behaviors, we analyzed heart rate, the glance translation frequency (GTF), which is how frequently the participant's gaze transferred between the drawing area and the portrait model, and the drawing glance rate (DGR), which is the ratio of useful glance movements to total glance movements. The recorded gaze point coordinates were visualized as gaze plots and heat maps. The gaze plots sequentially plotted points where the gaze lingered for 60 ms or more and connected them with straight lines. The heat maps used a grey scale to indicate how often the gaze lingered at a point for 60 ms or more.

From the gaze plots, we calculated the sum (A) of all straight lines that were at least 25 mm long. We further calculated the sum (M) of all straight lines that were at least 75 mm long and had slopes between -0.3 and 0.3 inclusive. We defined these longer lines as gaze transfers between the portrait model and the drawing area, and we considered these the useful glance movements. We calculated the DGR as M divided by A. One-way analyses of variance (ANOVAs) with 3 levels of musical tempo were performed on the GTF and DGR data. We defined statistical significance as $p < .05$. We evaluated the participant's tension during the portrait drawing by comparing her heart rate at different musical tempos.

4. **Results.** Figure 2 shows typical portraits drawn at each tempo. These were drawn in the second trial. To maximize portrait fidelity, the participant paid particularly close attention to the facial balance and positions of facial features. The portraits are of similar quality, which suggests that tempo hardly influenced their completion. Figure 3 shows typical heat maps. The heat maps indicate that the artist allocated her gaze similarly at all tempos. Figure 4 shows typical gaze plots. The plots indicate that the participant's gaze movements were almost identical at all tempos. Table 2 shows the mean GTF and DGR values at each tempo.

The ANOVA showed that the participant exhibited significantly higher GTFs when she was listening to fast music than when she was listening to slow music ($F(2, 10) = 6.75$, $p < .05$). Her GTFs when listening to medium tempo music were not significantly different from her GTFs when listening to fast or slow music. This suggests that she observed her work more closely and with better concentration when listening to faster music. However, we found no significant differences in the DGR data at different tempos.

(a) Portrait model

(b) Slow tempo

(c) Medium tempo

(d) Fast tempo

FIGURE 2. Model and portraits drawn by the participant while listening to music of different tempos

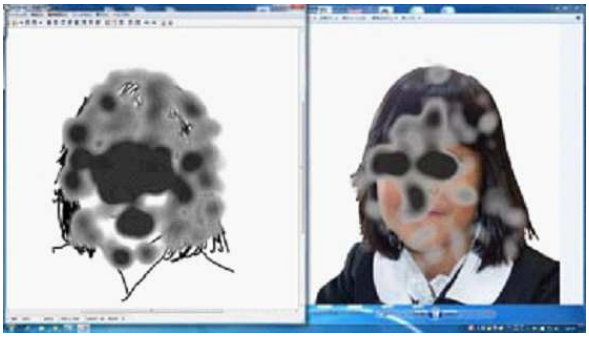
TABLE 2. Glance translation frequencies and drawing glance ratios

	Glance translation frequency $[\text{min}^{-1}]$			Drawing glance ratio		
	Slow	Medium	Fast	Slow	Medium	Fast
Trial 1	43.7	43.9	47.3	0.586	0.597	0.662
Trial 2	40.0	41.0	46.0	0.608	0.573	0.642
Trial 3	39.3	47.8	48.1	0.576	0.614	0.608
Trial 4	43.5	44.7	45.0	0.635	0.605	0.625
Trial 5	45.9	44.7	53.9	0.643	0.586	0.663
Trial 6	47.8	49.4	49.8	0.679	0.658	0.674
Mean	43.4 (3.01)	45.3 (2.70)	48.4 (2.90)	0.621 (0.04)	0.606 (0.03)	0.646 (0.02)

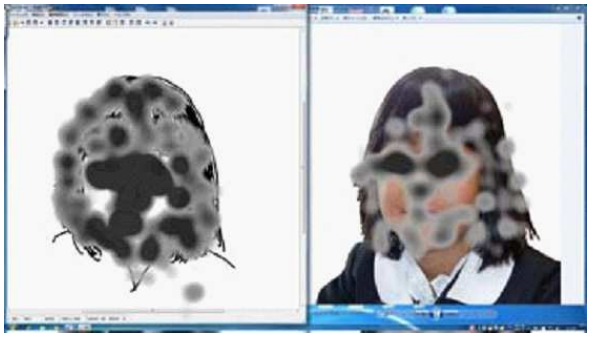
Standards deviations are noted in parentheses.

Figure 5 shows the participant's heart rate variability at each tempo when drawing in the second trial. At all tempos, her average heart rate while drawing exhibited approximately equal increases of 5-15% over her resting heart rate. This indicates that the tempo barely affected her heart rate.

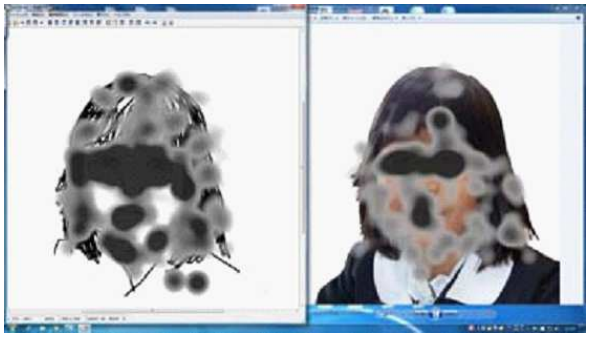
5. **Conclusions.** In this study, we examined how listening to music at 3 different tempos while drawing a portrait influenced an artist's observational abilities and concentration



(a) Slow tempo

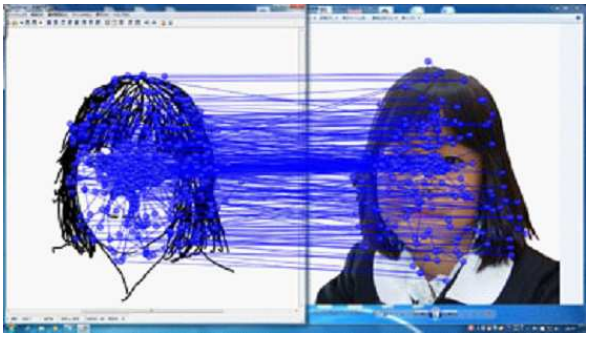


(b) Medium tempo

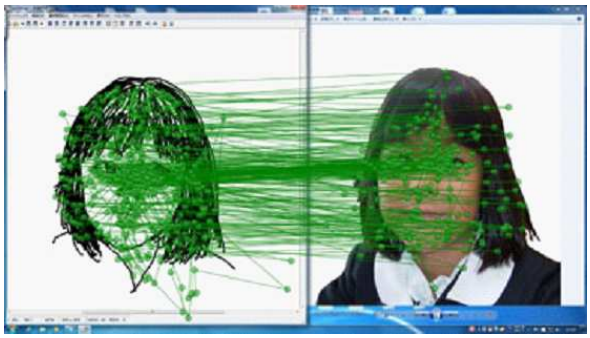


(c) Fast tempo

FIGURE 3. Typical heat maps from the second trial of drawing portraits while listening to music of different tempos. (The map uses dark, medium, and light grey zones to indicate areas at which the artist gazed for at least 0.50%, 0.25%, and 0.12%, respectively, of available drawing time.)



(a) Slow tempo



(b) Medium tempo

(c) Fast tempo

FIGURE 4. Typical gaze plots from the second trial of drawing portraits while listening to music of different tempos

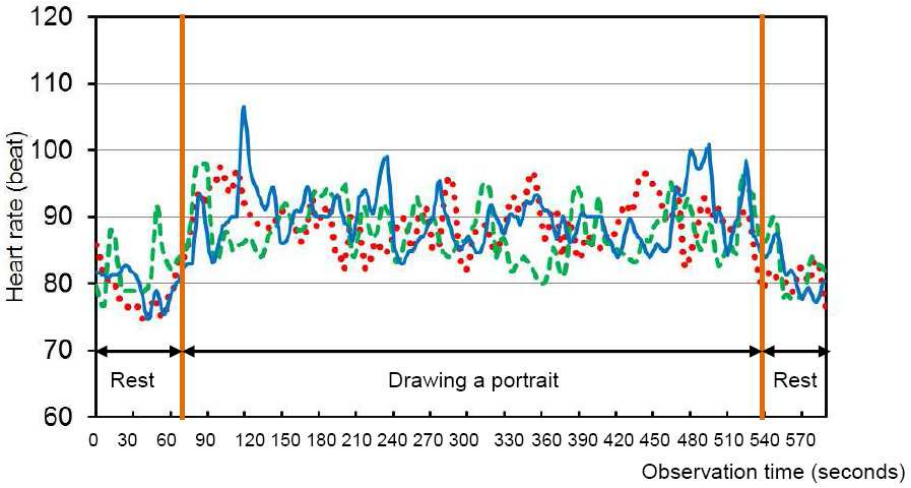


FIGURE 5. Heart rate variability during portrait drawing. The dotted, dashed, and continuous lines represent heart rates while listening to fast, medium, and slow tempos, respectively.

levels by recording heart rates, preparing heat maps and gaze plots, and calculating GTFs and DGRs. We found that her heart rate increased by 5-15% while drawing a portrait, which suggests tension levels typical for portrait drawing. She exhibited greater GTFs when listening to faster music, with significant differences when comparing the fast and slow tempos. This suggests that she concentrated more when listening to faster music. This effect could be mediated by changes in arousal and mood, factors that may generally account for music's multifaceted effects [14].

The major limitation of this study is that we only had 1 participant, which is insufficient for performing ANOVAs on the GTFs and DGRs, even though we acquired both indices at each tempo. In future studies, we plan to recruit more participants and analyze their task performance in detail.

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