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Analysis of Gaze while Viewing Videos at Various Playback Speeds

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ABSTRACT

We analyze gaze while viewing videos at various playback speeds. The aims of this paper are to evaluate the comprehension and viewability of videos. In our experiment, we used 0.75x to 3.0x speed, and measured gaze. We report differences in gaze behavior among different playback speeds in viewing same video.

1 Introduction

With the emergence of streaming platforms such as Netflix and Hulu, we are entering the heyday we can watch various videos on our computers, smartphones, and so on. Viewers can access to many old to new videos in various genres thanks to these services.

To watch more of the videos, some people fast-forward the video (speed-watch) [1]. Particularly, streaming platforms such as Netflix and Hulu offer the ability to change the playback speed (Fig. 1), and they take advantage of these features to watch video content. More and more viewers are viewing at faster playback speeds.

In addition, the COVID-19 pandemic has increased the use of online lectures, and some researchers had examined the level of comprehension when students view videos at different playback speeds [3]. Their results reveal that increasing the speed of video up to 2x may be an efficient strategy since the level of comprehension does not decline up to the speed.

In some genres, such as sports and movies, it is important to consider realism and viewability in addition to comprehension. In this study, we focus on gaze, one of the human biological reactions during video viewing. We can know people's unconscious reactions to fast-forward video from gaze measurement. By analyzing the gaze, it can be possible to understand the essential characteristics of viewers' cognition for fast-forward video. There have been several studies analyzing the gaze during video viewing [4-9], but none have focused on playback speed. Therefore, our study aims to understand viewers' unconscious reactions to evaluate the comprehension and viewability of videos by analyzing their gaze. The findings obtained in this study are expected to analyze and recommend acceptable playback speeds.

We hypothesize that changes in playback speed will change the viewer's gaze. At high playback speeds, the viewer's gaze will gather at the center of the screen to evaluate to comprehend the video in a short period, while they will be able to view various objects over time at slow playback speeds. In this paper, we verify this hypothesis using gaze measurement experiments to clarify the difference in gaze during viewing a fast-forward video. We will help to analyze viewers' understanding of video content in the future.

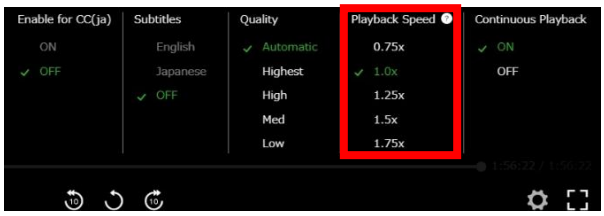


Fig. 1 Changing playback speed (Hulu) [2].

Table 1. Experimental video parameters.

	Parameters
Genre	Tennis, Action, Musical, Nature
Speed	0.75x, 1.0x, 1.25x,1.5x, 1.75x, 2.0x, 3.0x
Length	1 min. (1.0x)
Resolution	1,920×1,080
Sound	None

Table 2. Experimental video scenes.

Genre	Scene
Tennis	Shot of a tennis court in vertical.
	About 10 rallies in the vertical direction.
Action	Camera follows Car Chase.
	High speed car driving.
Musical	Circus troupe show.
	Singing and dancing.
Nature	Shot of a cascading waterfall.
	Overlooking a waterfall in forest.

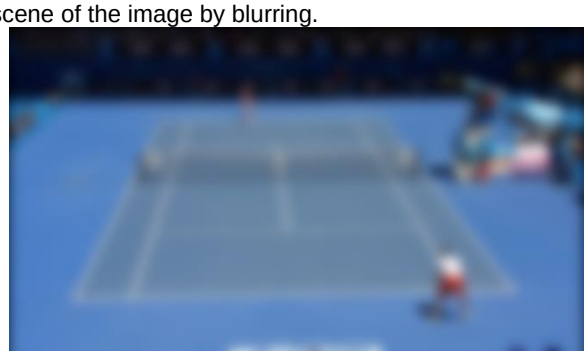
2 Experiment

We conducted an experiment in which participants watched videos of 0.75x to 3.0x playback speed of four genres and measured their gaze while viewing them.

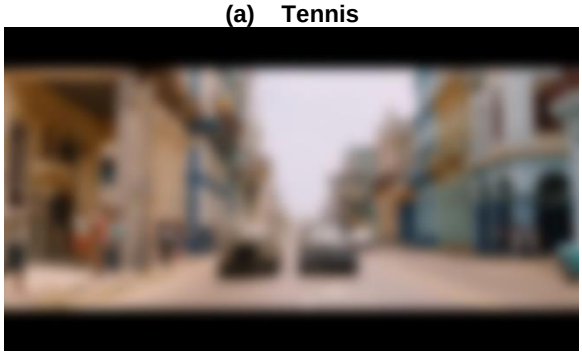
2.1 Video Setting

The experimental videos were commercially available Blu-ray discs: "Air-K" (Tennis), "The Fate of the Furious"

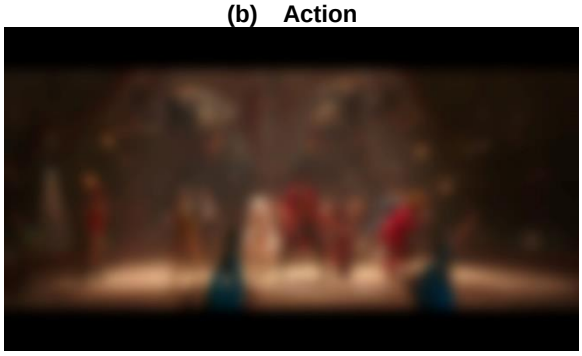
(Action), “The Greatest Showman” (Musical), and “Forest Bath Surround Blu-ray Edition” (Nature). We extracted scenes, including dynamic objects, from these videos and combined them into a 1 min. video at 1.0x playback speed as experimental videos. The video parameters are summarized in Table 1. The each video scene details are summarized in Table 2. The cuts of each video scene example are shown in Fig. 2. For copyright reasons, the images are used only to show the general content of the scene of the image by blurring.



(a) Tennis



(b) Action



(c) Musical

(d) Nature

Fig. 2 Video scene example.

Fig. 3 Experimental scene.

2.2 Viewing condition

Plasma TV: TH-P46VT2 (Panasonic Corp.) was used for video viewing. The viewing distance of the participants was 174 cm from the screen with reference to 3 H (H: Display height) of high-definition video. During the experiment, indoor lighting was turned off, and the screen brightness was a minimum of 0.01 cd/m^2 and a maximum of 200 cd/m^2. Figure 3 shows the experimental scene.

2.3 Procedure

Tobii Pro Glasses 3 (Tobii Technology K.K.) was used for gaze measurements.

The participants watched the same video at different playback speeds and rated the playback speed on a 5-point scale of how fast the playback speed felt after viewing each video. The experiment was conducted in 4 sessions, with a 5-minute break interval. The playback order of the experimental videos was randomized. The participants watched each video with a 15-second interval in each session.

We had 24 participants in their 20s to 60s (12 males and 12 females). They had normal visual acuity (including corrected vision). This experiment was conducted in accordance with the ethics panel regulations of Nagoya University, Japan.

3 Results

Examples of a participant's gaze while viewing the Action video in playback speed 1.0x and 3.0x is shown in Fig. 4. The gaze was visualized in Tobii Pro Lab.

Gaze Filter of Tobii I-VT (Attention) from Tobii Pro Lab was used to generate gaze points from the measured gaze data. The generated gaze point data were analyzed for each genre and at each playback speed.

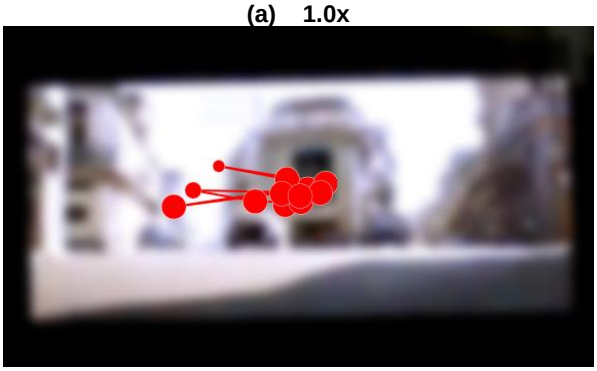
We calculated the number of gaze points per second to verify whether the number of gaze points decreased, the standard deviation of the mean gaze points to verify whether the gaze points distribution became narrower, and the total distance between gaze points to verify whether the distance between gaze points became shorter, due to differences in playback speed. Here, we present the results of one participant's data.

Figure 5 shows the number of gaze points per second among different playback speeds. As the playback speed increased, the number of gaze points tended to decrease for Action and Musical videos, and to increase for Tennis and Nature videos.

Figures 6 and 7 show the standard deviation of the mean gaze points among different playback speeds. As the playback speed increased, the standard deviations tended to decrease for all genres in the horizontal direction and for Action and Musical videos in the vertical direction. There were slightly larger at 2.0x than 1.75x and 3.0x playback speeds in Action and Musical videos.

Figure 8 shows the total distance between the gaze points among different playback speeds. As the playback speed increased, the distance between the gaze points tended to decrease.

(a) 1.0x



(b) 3.0x

Fig. 4 Examples of gaze while viewing the Action video.

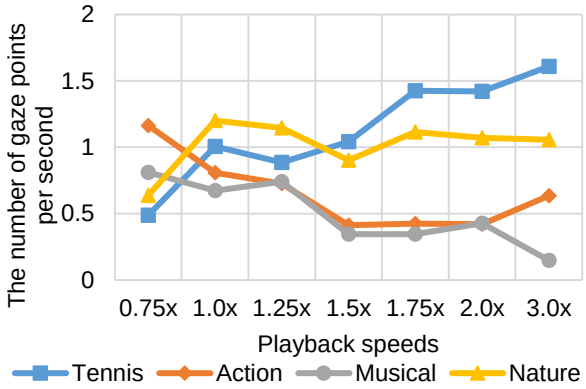


Fig. 5 The difference of the number of gaze points per second.

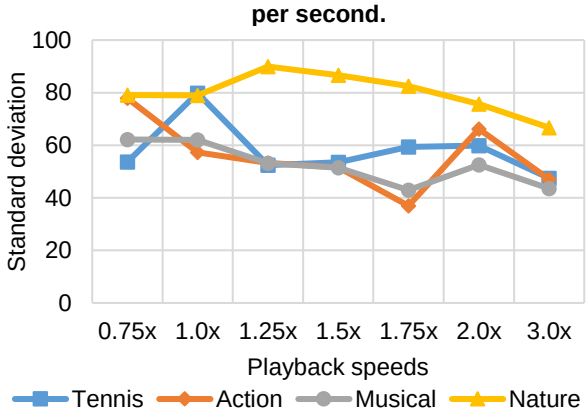


Fig. 6 The standard deviation of the mean gaze points (Horizontal).

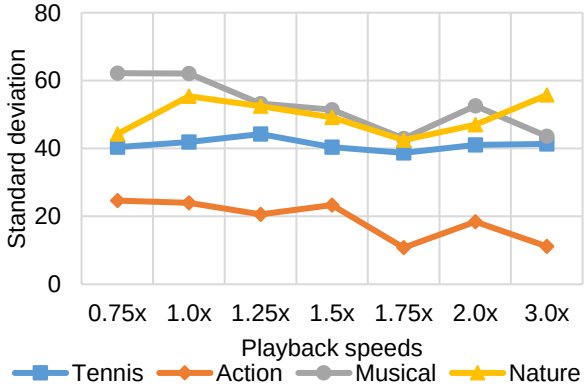


Fig. 7 The standard deviation of the mean gaze points (Vertical).

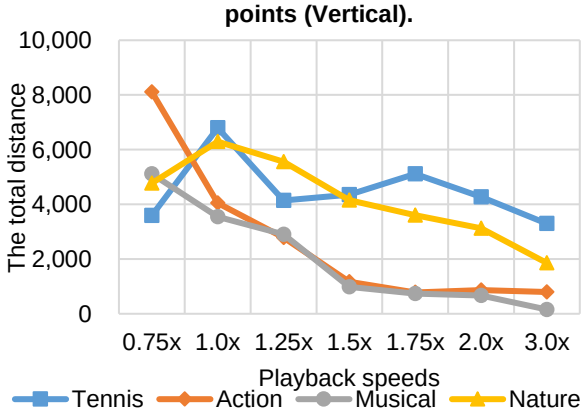


Fig. 8 The total distance between gaze points.

4 Discussion

The viewers locked their gaze mainly at rallies in Tennis videos, the movements of characters and objects in Action/Musical videos, and the space of landscapes in Nature videos. If the participants move their gaze in this way, it is consider that looking at various locations would increase the number of gaze points, widen the distribution of gaze points, and increase the total distance between gaze points.

In the experimental results, these gaze behavior were observed at slower playback speeds and not at faster playback speeds. One possible reason why this was not observed at faster playback speeds seems to be the length of the video itself. The playback time was considerably shorter for video, such as 3.0x playback speed. Therefore, the participants were required to make quick gaze movements if they viewed the video similarly at slower playback speeds. If the playback speed of a video was too fast, the participants might give up following the movement of the object and try to grasp the entire video by fixing their gaze on the center of the screen. This tendency was particularly strong in the Action and Musical videos that were smaller by a standard deviation. It is possible that the participant in this paper analysis was able to follow the movements of a rally in the Tennis video and the flow of a waterfall in the Nature video even at a somewhat high playback speed.

By unconsciously switching these gaze behavior, it is possible that efficient gaze for acquiring information adapted to each playback speed emerge. The analysis of the relationship between subjective evaluations remains as future works.

5 Conclusions

We analyze the gaze when viewing videos at various playback speeds. In this experiment, we used 0.75x to 3.0x playback speed videos of four genres and measured gaze.

We evaluated the number of gaze points per second, the standard deviation of the mean gaze points, and the total distance between gaze points.

We evaluated the number of gaze points per second, the standard deviation of the mean gaze points, and the total distance between gaze points. The results were shown as the playback speed increased, the number of gaze points tended to decrease for Action and Musical videos. The standard deviations tended to decrease for all genres in the horizontal direction and for Action and Musical videos in the vertical direction. The total distance between the gaze points tended to decrease.

We plan to analyze the relationship between subjective evaluations.

Acknowledgements

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