# Study of Eye Gaze and Presence Effect in Virtual Reality

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**Abstract.** This study explores the characteristics of eye gaze in an immersive virtual environment. The study investigated the eye gaze data of users by using VR stimuli and analyzing users' concentration. The goal of the study was to investigate how eye movements are affected by the story of an animation. In the study, users' level of concentration as well as presence effect were measured with 53 participants by analyzing their eye gaze movements and gaze fixations.

**Keywords:** VR, Eye Tracking, Gaze, Presence.

## 1. INTRODUCTION

Virtual Reality (VR) allows users to experience the contents of a software program as if it was a real physical space through human senses such as sight and hearing [1]. The psychological responses and state that occur in the virtual space are called Presence. Marvin Minsky [2] uses the term "telepresence" to define the user experience as a phenomenon wherein he feels physically present in an imaginary space through feedback he receives from the machine using teleoperation technology. Steuer argues that Presence leads to a natural perception of the environment [3]. Slater and Usoh define Presence as a degree of confidence that one is in a place other than where one is, i.e. that the user has left the real world and is in a virtual environment [4]. Witmer & Singer define it as a subjective experience in which the user feels he or she is physically in another place or environment [5]. Lombard defined Presence as psychological state and the subjective perception state [6]. Kim & Yoon identified the subjective structure of an audience using 3D media through Q methodology [7]. In the Q methodology, subjectivity is determined by an individual's 'internal frame of reference' in a way that allows people to relate to the social phenomena through behavioral studies.

This study investigates the eye gaze in a VR story and measures their concentration when animation changes.

## 3. METHODOLOGY

The FOVE HMD was used to receive users' orientation and position information. The gaze data includes information from both the left and right eyes. Tare Orientation and

Tare Position match the position of different users' focus and Calibrate allows users with physically different characteristics to optimize their eyeball. The user is more likely to use the same content after optimization with the device. Interaction with FOVE was implemented as 'Unity'. Unity is an integrated creative tool for creating interactive content such as 3D video games, architectural visualizations, and real-time 3D animation, which an editor can run on Windows and Mac OS. The editor also contains an asset store for downloading needed assets directly. 'R' is a statistical analysis program specializing in data analysis, visualization, machine learning, etc. We let the user experience the virtual environment created with Unity through the FOVE HMD and analyze the user's gaze tracking data using 'R'. The mean and standard deviation of this data are determined, and the objects being viewed by the user are analyzed and visualized. For the analysis, users' x, y, z-axis time data are collected, and the average is calculated for each frame. By calculating the standard deviation using these averages it is possible to grasp how many users' eyes are scattered in each frame shown in Table 1. When visualizing the frames, researchers can specify which frames have the most eye movements and identify the objects of focus on the screen. The animation was created as typical story develop line. It is a FPS (First person shooting) game style, so the user will find he or she has a gun in front. The camera-view shows where the user sees, and the gun aims along the gaze. The BGM (Back ground music) is very heavy and dark so the user can become tense. The animation was made with the assets provided by Unity Asset store.

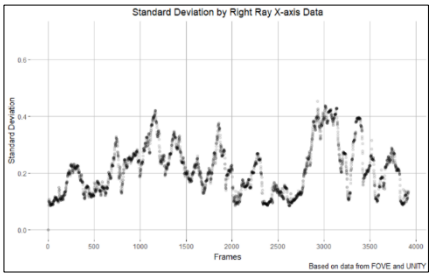
**Table 1. User screen by frame**

| | |
|---|---|
| Intro | Frame 0: Experiment text appears on the front and no objects are visible. |
| | Frame 300: The phrase disappears and the screen appears. |
| | Frame 300: A soldier corresponding to the back label runs from behind in the same frame. |
| | Frames 300~1150: The soldier who ran from behind and a meteor that falls from the sky simultaneously appear on the front screen. |
| Rising Action | Frame 1150: The soldier stops at the front of the screen. |
| | Frame 2000: Two soldiers run from behind the building on the left. |
| Climax | Frame 2300: Aliens appear behind the building on the left. A soldier shoots an alien. |
| | Frame 3000: Aliens turn from the front of the screen and begin to walk in the user's direction, while soldiers flee from every direction. |
| Ending | Frame 3400: The alien stops at the front of the screen. |
| | Frame 3700: The ending phrase appears and the content ends. |

## 4. RESULTS AND DISCUSSIONS

53 people (male 27, female 26) participating first listened to an explanation of the experiment. A pre-survey was conducted to analyze the types of users before they experience the VR content. After sitting in a designated chair and putting on the FOVE HMD, the position and angle of the user could be adjusted with the Tare Orient and Tare Position functions. After adjustment, the device calibrates and optimizes the subject's gaze and eye tracking. After optimization, all participants could enjoy the

experimental content. Following this, users removed the FOVE HMD and answered a simple post-survey.



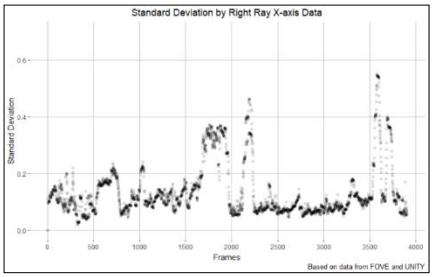
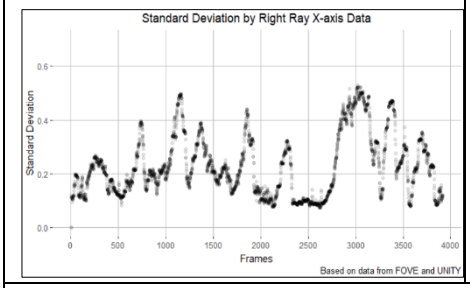




**Figure 1. Standard deviations of PAEPP & PASE**

Figure 1 is the SD-graphs of Presence as an extended personal enjoyment of the various experiences provided by the VR (PAEPP) (left) and Presence as sensory organ enlargement (PASE) (right). The result shows that the concentration of PAEPP is relatively low as expected from the previous study. The SD value even when the eyes are all focused is high, and the time to hold each object is also short. They react to certain events that attract attention in all sections, but they soon turn off interest and the gaze spread to various parts. The users in PASE, they not afraid of immersion. This group's data is stable with less rapid eye movement and is characterized by an ability to react to all factors vying to have their attention yet keeping a good level of concentration. See the section of 1150-2300 frame (Rising Action) in both graphs. The concentration level between PAEPP and PASE are clearly different. In the section of 2300-3400 frame (Climax), the tension of story capture PAEPP's eyes for short time, but their attention doesn't remain long as much as PASE's.



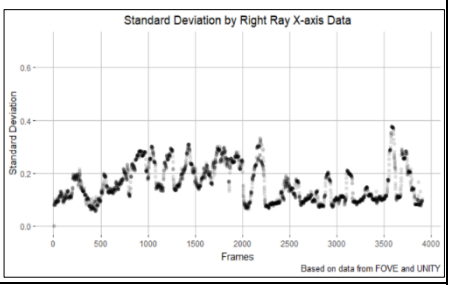




**Figure 2. Standard deviations of PAEPP & PASE in two genders.**

Figure 2 shows the concentration of gaze difference between men and women can be seen at a glance.

The focus intense of the experiment is initially similar for all users, but there is a clear distinction beginning near the middle frame. In the male experimental group, the concentration of section of 2300-3400 frame, which is the climax of the story, is

significantly lower than the intensity of section 1150-2300 frame. Even within 'Rising Action' part, the concentration on the gaze of men is relatively low and distracted, while the gaze of women is stable and concentrated. The female users' concentration on the section of 'Climax' is high and the gaze was collected on 'Tripod', which is the alien coming out from the front according to the data that detect from the collided objects in Unity editor.

In the story, section 'Rising Action' which is the development of the story, the number of collision event detected from the eye gaze hitting the objects were 27 times per object with the PAEPP 31 times per object with the PASE. In the section of 'Climax', the numbers were 45 times per object with PAEPP, 61 times per object with PASE. As a result, more than twice as much as the appearance of an object. The result show that the frequency of eye movements increases in the climax of the story in both groups.

## 5. CONCLUSIONS

This study examined the presence effect through eye gaze movements in a VR storytelling. Users' presence level in a VR storytelling is not much different from a conventional storytelling. The concentration between the two groups is related to the time length that the gaze of each type of group remains on objects in the animation. Particularly, 24% (12 out of 51) has the same gaze pattern in the climax of the VR story.

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