A New Vection Stimulus:
Immerse yourself in vection

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Abstract—We created a new vection stimulus, which we presented to participants with Google Cardboard and via a portable terminal based on the Android operating system. This method is quite new, very affordable, and highly portable. It thus has high potential for bringing in a new age of vection research. The new stimulus can be modified as observers move their heads and bodies; we conducted an experiment comparing it to the standard stimulus that cannot be changed in this manner. Results showed that vection can be stronger with the new stimulus, but facilitation effects were obtained both in our new stimulus and the old stimulus when there were their head and body movements. We discuss the possible reasons for this result.

Keywords: vection, immersion, cardboard, portable

1 Introduction

The history of experimental examination of vection can be said to be a history of examining stimulus attributes for effective or inefficient vection induction. It began with an early experiment conducted by Brandt and colleagues (Brandt, Dichgans, & Koenig, 1973 [1]). Subsequently, much research has focused on which stimulus attributes lead to effective vection induction (for reviews, see Dichgans & Brandt, 1978 [2]; Howard, 1982 [3]; Riecke, 2011 [4]; Palmisano et al., 2015 [5]). Vection researchers have examined almost every possible stimulus parameter in the last 40 years.

In our latest study, we have created a totally new vection stimulus in which you can immerse yourself in a 360°-view of vection space. The vection space can be modified in response to head and body movements. Additionally, we succeeded in creating this new stimulus at a very low cost and even making it portable.

Some studies have reported that vection can be affected by the posture of the observers (e.g. Nakamura & Shimojo, 1998 [6]; Seno, 2014 [7]). Kano (1991) [8] also reported that vection is not determined solely from viewer-centered retinal coordinates, but can also be affected by external world-centered coordinates.

Vection can also be modified by our active body movements. Seno, Funatsu, and Palmisano (2013) [9] reported that vection was enhanced by hand and head movements. A series of Ash’s studies (2011a, 2011b, 2013) [10, 11, 12] also reported that head movements could facilitate vection. Other studies have reported that locomotion could modify vection strength (e.g. Onimaru et al., 2010 [13]; Seno et al., 2011 [14]).

From these facts, we hypothesized that our body movements and body posture have a strong effect on vection strength. In this study, we presented totally new body movements and body posture during the observation of vection stimuli.

In addition to the stimuli themselves, the history of vection research also includes changes in the apparatus for stimulus presentation. Many studies have used a CRT projector and a wide screen (e.g. Gurnsey et al., 1998 [15]; Palmisano et al., 2011 [16], or some large self-emission display like a Plasma Display (e.g. Seno et al., 2014 [7]). Some have used Head Mounted Display, while others have used CABIN or CAVE systems (e.g. Riecke et al., 2011 [4]). Indeed, many different apparatuses have been used over the last 40 years. In this study, we propose a completely new system using Google Cardboard and a portable terminal based on the Android operating system that is easy to obtain in Japan and is quite inexpensive.

2 Methods

2.1 Ethics Statement

The present study was approved by the Ethics Committee for Psychological Research at Kyushu University and was conducted following the guidelines

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of the Helsinki Declaration. Written informed consent was obtained from all participants.

2.2 Apparatus
We used Zenfone2 (ASUS, ZE551ML) and Google Cardboard (HAKOSUKO) with the “Unity” Platform with “C#” and Cardboard SDK (Google). See Figure 1.

Figure 1. The system used in this article.

2.3 Participants
Participants were 18 students (7 men and 11 women) with an average age of 27.50 years (range: 21 to 40 years). Participants did not know the purpose of the experiment. They reported no visual or vestibular abnormalities.

2.4 Stimuli
We included two movie conditions (Control and Experimental). The Experimental stimulus comprised expanding dots that could be moved in response to head and body movements. The stimulus was corresponding both to the vertical and horizontal translational head and body movements and the three-axis rotational head and body movements. These two translational and rotational movements could be correctly obtained by using gravity change three-axis gyroscope of the Zenfone2.

The Control stimulus comprised expanding dots that did not move in response to head and body movements.

The simulation space was 300 m in front of the viewpoint and 100 m behind it, with a width of 70 m. The background of the simulated space was uniformly black, and 1600 white dots were randomly placed in the foreground. A 100-m/s forward movement was simulated. Binocular disparity was also added to the stimuli with a simulated 6-cm distance between the eyes.

The stimulus size was 12.5 cm (vertical) and 7.5 cm (horizontal). The viewing distance was 3.5 cm. The stimuli subtended about 130 degree (horizontal) x 78 degree (vertical) in visual angle.

Figure 2. Schematic illustration of the simulated space of our new stimuli. Left panel: The whole simulated space, and all dots in that space. The white arrow indicates the dots motion.

2.5 Procedure
There were three observation conditions: (1) the Control stimulus with head and body movements, (2) the Experimental stimulus with head and body movements, and (3) the Control stimulus without movements.
First we had participants experience Condition 3 and fully explained what vection is. We made the participants close their eyes and instructed them to hold the cardboard viewer. We confirmed that the focus of expansion could be seen centrally. When the experimenter said, "Start", participants opened their eyes and we started the stopwatch. Stimuli were presented for 60 seconds. After 60 seconds, we told the participants to stop responding. Finally, we asked participants to report the subjective strength of vection using Visual Analog Scales ranging from 0 (no vection at all) to 100 (very strong vection values).

Condition order was random, and each condition was repeated four times. Thus, each participant performed 24 trials (3 conditions × 4 repetitions).

For Conditions 1 and 2, we instructed participants as follows: "Please rotate your head during stimulus presentation. Up-down and left-right head movements are ok. Please look around the world. Additionally, feel free to stand up and sit down."

In no movement condition, we instructed the participant not to move at all. We never used chin-rest. The participants were asked to sit on a chair all over the stimulus presentations. Even though there were some small body movements, the expanding optic flow stimulus was not changed at all in this condition.

2.6 Hypothesis

Our new stimulus might induce stronger vection than the non-responsive stimuli used in previous vection research because it can give a stronger sense of immersion. Additionally, head and body movements themselves might alter vection strength.

3 Results and Discussion

![Graph showing vection magnitude with error bars indicating SDs.]

**p < 0.01

Figure 3. Vection magnitude. Error bars indicate SDs.

There was significant main effect of Conditions (F2, 14 = 7.214, p = 0.002). There were significant differences between Condition 3 (no head and body movements) and the other two conditions (Ryan's Method, Condition 1, p = 0.001; Condition 2, p = 0.005).

Our new stimulus induced stronger vection than a standard stimulus without body movements. At the same time, so did a standard stimulus when combined with head and body movements. Our new stimulus was not superior to the old stimulus if head and body movements were allowed. Thus, we confirmed that head and body movements themselves have some effect on vection strength.

Ash, Palmisano et al. (2011a & 2011b) reported that oscillatory head movements that were consistent or inconsistent with expanding oscillatory dot motion can enhance vection. They also reported that head movement has an effect even when head oscillations considerably lag behind the expanding dots. These facts are consistent with our current results. Thus, we can say that head and body movements facilitate vection.

Seno (2014) reported that vection strength can be weakened when the directions of body and self-motion are inconsistent (different). This could be why vection was not strongest in Condition 1 (Experimental stimulus with the head and body movements).

Limitations of this study and future tasks

Here, we only examined one set of stimulus parameters. Thus, we will now examine various dot speeds and
densities, and vary the width and length of VR space.
We will also examine the many different viewing postures allowed by our new vection setup. We can now present vection stimuli to participants who are lying on a couch or bed, or even an inverted posture.
Further, our new setup allows long walking paths. Viewing our new stimuli while walking freely in a much larger space will be an extremely interesting task in future research, and one that we can try once we can ensure that it will be safe for participants.
Importantly, the portability of our new system means that we can take it all over the world. We can conduct experiments in very bright rooms, on the top of high mountains, in hot or cold environments, or in very noisy locations.

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参考文献


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