Study on improvement of visual abilities by watching stereoscopic image

Yuji Sano

Faculty of Science and Engineering, Toyo University,
2100 Kujirai, Kawagoe-shi 350–8585, Japan

Abstract: We measured improvement of five visual abilities by watching stereoscopic image. Kinetic visual acuity and depth perception were improved by 3.06% and 1.95% respectively compared with un-observing. In eye movement and near point distance, there is not nearly change. However, peripheral vision declined by 3.49%.

Keywords: 3D display, depth perception, peripheral vision, eye movement, near point distance, dynamic visual acuity

Classification: Electronic displays

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1 Introduction

Stereoscopic picture and stereoscopic display have become popular. Popular stereoscopic image is using parallax of visual pictures in right and left eyes. However, stereoscopic image causes eye tiredness more than two dimensional
In watching stereoscopic image, eyes are busy with adjusting direction and focusing on image more than two dimensional image. Therefore it is suspected that stereoscopic image damages visual abilities. In watching stereoscopic image, stimulating muscles of eyeball may improve some visual abilities and make other visual abilities worse [4, 5, 6, 7, 8, 9].

The purpose of this study is examining improvement of visual abilities by watching stereoscopic image. If we can find visual abilities improved by watching stereoscopic image, it can be used for training of visual abilities.

2 Methods of experiment

Three stereoscopic images were used in our experiment. We had 20 subjects. The subjects were divided into two groups that consisted of 10 subjects observing the stereoscopic images and the other subjects un-observing, to clarify change of visual abilities by watching the images. We analyzed change of visual abilities as described later. The visual abilities were measured once a week for 8 weeks. Observing subjects watched the stereoscopic images twice a week.

2.1 Measured visual abilities

(a) Kinetic visual acuity (KVA)
   Ability for definitely grasp shape of object approaching from far.
(b) Depth perception
   Ability for definitely grasp a perspective and a third dimension.
(c) Peripheral vision
   Ability for grasp periphery at one point.
(d) Eye movement
   Ability for quickly moving eyes to object recognized.
(e) Near point distance
   The shortest visual distance being able to be focused.

2.2 Example of measuring method

2.2.1 Kinetic visual acuity

We made stereoscopic moving images to measure the kinetic visual acuity with software which makes stereoscopic images [10]. In the images, landolt ring was moved to front direction for in the stereoscopic display image. As the landolt ring was moved to front of the display, it was gradually grown as visual acuity from 1.5 to 0.1. When subjects were able to see a direction of the landolt ring, they told experimenter the direction. Kinetic visual acuity was decided at visual acuity of the landolt ring at that time. Subjects were measured 5 times, and average value of visual acuity became measured result.

2.2.2 Depth perception

We explain measuring method for depth perception. It is currently measured by the parallel method, and we made “moving bar target depth perception measuring system”. The parallel method measures accuracy in distance of bar, when observer sees three bars on same distance. Fig. 1 and Fig. 2 show inside and front view of the depth perception measuring system.
Experimenter moves only one of center bar to back and forward. Observer signs to experimenter when center bar lined on same position with two bars of both sides. Then experimenter measures longitudinal error which is difference of distance of bar from center to both sides. Distance from observer to bars is 2.5 meters.

### 2.2.3 Eye movement

Fig. 3 shows stereoscopic image for measurement of eye movement. In this image, numbers from 1 to 30 were written on rectangular parallelepipeds at random, and those were moved to front and depths direction of display screen.

Subjects counted those numbers from 1 to 30 in turn. Then, subjects pointed to the number with finger, in order that they didn’t point wrong turn. Eye movement was evaluated by counting time till subjects had finished counting the numbers. Subjects were measured 3 times, and average value of the time became measured result.

### 2.3 The stereoscopic moving images for observation

Fig. 4 shows stereoscopic image for training of visual abilities with idiom made by 4 letters. In this image, the letters appeared on surface of each box at random.
Observers were able to understand the letters and meaning of the idiom by reading the letters one by one. And a central box was moved to front and depth direction, thus they practiced focusing by reading. They watched this image for 15 minutes. And they did training 3 times using stereoscopic image shown in Fig. 3.

3 Results

The following figures show change in each visual ability. The figures (a) show measurement results of observer, and the figures (b) show that results of un-observer. Solid lines on the figures show regression lines. Error ranges show 95 percentile.

For the first time, Fig. 5 shows measured results of kinetic visual acuity. It is understood that ability of observer was improved, but un-observer did not nearly change.

Next, Fig. 6 shows measured results of depth perception. Longitudinal errors for evaluating depth perception of observer were decreased more than that of un-observer. Therefore depth perception of observer is thought to be improved compared with that of un-observer.

Fig. 7 shows measured results of peripheral vision. Its perfect point is 100 points. Ability of observer was declined, but that of un-observer was improved. Therefore peripheral vision is thought to be declined in observer compared with un-observer. However, we don’t understand reason of declining in peripheral vision by watching stereoscopic image.

Fig. 8 shows measured results of eye movement. It did not nearly change in both groups of observer and un-observer.

Fig. 9 shows measured results of near point distance. Observer did not nearly change. However un-observer was decreased. It is thought near point distance of several un-observers became long from first to third measurement, because the un-observer were not used to measurement.

Table I shows effect on each visual ability by watching stereoscopic image. In order to examine the effect, differences in rates of changes in the visual abilities was calculated. The rates of changes per one measurement were calculated by dividing their regression coefficients by average value in first measurement. To eliminate influence from getting used to be measured, difference in the rates of changes was evaluated by being subtracted value of observer from one of un-observer.

![Fig. 4. Stereoscopic image for training](image)
Fig. 5. Measured results of kinetic visual acuity

(a) Observer

\[ y = 0.026x + 0.62 \]

(b) Un-observer

Fig. 6. Measured results of depth perception

(a) Observer

\[ y = -0.0966x + 1.2316 \]

(b) Un-observer

\[ y = -0.0793x + 1.3456 \]
Fig. 7. Measured results of peripheral vision

Fig. 8. Measured results of eye movement
4 Conclusion

As shown in Table I, kinetic visual acuity and depth perception with observing stereoscopic images were improved by 3.06% and 1.95% respectively compared with un-observing. However, measured peripheral vision was declined. The peripheral vision of un-observer was more improved by 3.49%. And eye movement and near point distance did not nearly change. We are going to analyze cause of declining in peripheral vision by watching stereoscopic image.

We have been worried about having wrong influence on visual ability by watching stereoscopic image, so far. However, we have found possibility to improve kinetic visual acuity and depth perception by watching stereoscopic image [11, 12].

| Visual ability       | Difference in rates of changes [%] | Effect on observation         |
|----------------------|------------------------------------|-------------------------------|
| Kinetic visual acuity| 3.06                               | Improved                      |
| Depth perception     | 1.95                               | Improved                      |
| Peripheral vision    | −3.49                              | Declined                      |
| Eye movement         | 0.93                               | It did not nearly change       |
| Near point distance  | 3.67                               | It did not nearly change       |

Fig. 9. Measured results of near point distance