International Journal of Internet, Broadcasting and Communication Vol.7 No.1 57-61 (2015)
http://dx.doi.org/10.7236/IJIBC.2015.7.1.57

IJIBC 15-1-11

Change of Total Convergence on Visual Function Case after 3D Images

Jung Ho Kim[1], Deok-Young Yun[1], Kwang Chul Son[2], Seung Hyun Lee[2], and Soon Chul Kwon[2]*

[1]*Department of Plasmabiodisplay, Kwangwoon University, Korea*
jungho2cho@ naver.com

[2]**Graduate School of Information Contents, Kwangwoon University, Korea*
tkdrambo@hanmail.net ,{*ksc0226, kcson, shlee}@ kw.ac.kr

Abstract

The level of change in distant PTC, near PTC, distant NTC, and near NTC was measured divided by before and after viewing 3D images. The 50 examinees were categorized into Low/ Middle/ High groups according to the level of change by test subject. Among all the entries, the exophoria group showed the highest change distribution, and in the distant and near NTC entries showed statistically significant differences in variation.

Keywords: *PTC, NTC, 3D images, 3D watching, FPR*

1. Introduction

Multidimensional images (3D), unlike 2D images, is an image shown through a sensory fusion in the brain about the differences in 2 different images and the cognitive processes that occur in the eye aredifferent [1]. While viewing 3D images generally adjustment responds correspondingly to the distance between the eyes and the display and eye movement (convergence, divergence) occurs according to the fused image displayed on screen. The unbalance of adjustment and convergence that occurs at this time is the cause of the fatigue [2-3]. In this way 3D image viewing causes eye movement response through different feedback than that for 2D images and according to the viewers' total convervence ability the environment and quality of image viewing can change. The study tried to find out about the effects of 3D image viewing by types of visual function on total convergence by analyzing the change in total convergence in the viewers after viewing 3D images.

2. Experimental subjects

The examinees were people in their 20~40's that were able to view 3D images (average age 23.9±3.93) without particular ocular disease or systemic disease. They were university students (30 male, 20 female) that had CVA (corrected visual acuity) of more than 0.8.

3. Test method

Manuscript Received: Jan. 15, 2015 / Revised: Jan. 22, 2015 / Accepted: Feb. 10, 2015
Corresponding Author: ksc0226@ kw.ac.kr
Tel: +82-2-940-8637, Fax: +82-2-940-5443
Graduate School of Information Contents, Kwangwoon University, Korea

The testing was done before viewing and 30 minutes after viewing. Prism bar was used and the testing order was distant NTC (Negative Total Convergence), distant PTC (Positive Total Convergence), near NTC, and then near PTC [4]. After distant full correction, 0.7 vertical display was placed at 5.0 m for distant and 0.4 m for near then the examinee was directed to focus on the display. For NTC the B.I (Base In) prism within the edges was slowly increased to measure the break point and recovery point. For PTC the B.O (Base out) prism within the edges was slowly increased to measure the break point and recovery point. Following the characteristics of total convergence data, the focus was on changing flow. The display used in the experiment was FPR (film patterned retarder) TV. The data in this study is in 6 steps 2, 4, 5, 9, 10, 11 △ showing differences after viewing and these were categorized into 3 groups Low group (2 △), Middle group (4, 5 △), and High group (9, 10, 11 △). The standard for low group was insufficient change, for middle and high groups it was clear changes occurring. For categorization of visual function, following the standard of Morgan [5], the orthophoria was set as distant horizontal Exophoria 1±1 △(Eso 1 △ ~ Exo 2 △), near horizontal Exophoria 3±3 △(0 ~ Exo 6△). The categorization was done as follows: The group with normal range horizontal phoria for both near and distant as Basic esophoria, the group with normal range horizontal phoria for distant but with near below normal range as excessive convergence, the group with normal range horizontal phoria for near but with distant below normal range as insufficient divergence, the group with above normal range horizontal phoria for both near and distant as Basic exophoria, the group with normal range horizontal phoria for distant but with near above normal range as insufficient convergence, the group with normal range horizontal phoria for near but with distant above normal range as excessive divergence (Table 1). For data analysis SPSS (Ver. 18.0) paired t-test was used and with 95% of confidence interval it was evaluated as statistically significant when $p<0.05$.

4. Results and discussion

4.1 Change in distant PTC

Among the 18 examinees showing change in distant PTC, there was 8 low group, 9 middle group and 1 high group. Low group had an average point of 2.00±0.00, middle and high groups had average of 5.10±1.45. For types of visual function in the group with inadequate change there were 2 insufficient convergence, 3 Basic Exophoria, 3 Orthophoria. In the group with sufficient change there were 1 excessive divergence, 3 insufficient convergence, 4 Basic Exophoria, 2 Orthophoria (Exophoria group 72.22%, orthophoria group 27.78%). There was a trend of minute change from before viewing (16.94±7.44 △) to after viewing (16.89±8.00 △) and there was no statistical significance.

Table 1. Change in distant PTC immediately after image viewing 3D image

unit:△

Mean±SD		MD	t	p-value
Before (16.94±7.44)	3D (16.89±8.00)	0.06	0.055	0.957

SD : standard deviation
MD : mean difference

4.2 Change in near PTC

Among the 18 examinees showing change in near PTC, there was 7 low group, 9 middle group and 2 high group. Low group had an average point of 2.00±0.00, middle and high groups had average of 5.82±2.09.

For types of visual function in the group with inadequate change there were 1 excessive divergence, 3 insufficient convergence, 1 Basic exophoria, 2 Orthophoria. In the group with sufficient change there were 4 insufficient convergence, 1 Basic exophoria, 1 excessive convergence, 2 Orthophoria (Exophoria group 55.56%, orthophoria group 38.89%, Esophoria group 5.55%). There was a trend of minute decrease from before viewing (25.83±10.86 △) to after viewing (24.50±12.11 △) and there was no statistical significance.

Table 2. Change in near PTC immediately after image viewing 3D image

unit:△

Mean±SD		MD	t	p-value
Before (25.83±10.86)	3D (24.50±12.11)	1.33	1.149	0.266

SD : standard deviation
MD : mean difference

4.3 Change in distant NTC

Among the 28 examinees showing change in distant NTC, there was 23 low group and 5 middle group. Low group had an average point of 2.00±0.00, middle group had average of 4.00±0.00. For types of visual function in the group with inadequate change there were 1 excessive divergence, 8 insufficient convergence, 8 Basic exophoria, 3 Orthophoria, and 1 Basic esophoria. In the group with sufficient change there were 2 Basic exophoria and 3 Orthophoria (Exophoria group 67.86%, Orthophoria group 21.43%, Esophoria group 10.71%). There was a trend of increase from before viewing (9.93±2.75 △) to after viewing (11.57±2.57 △) and there was statistical significance.

Table 3. Change in distant NTC immediately after image viewing 3D image

unit:△

Mean±SD		MD	t	p-value
Before (9.93±2.75)	3D (11.57±2.57)	-1.64	-4.60	0.000

SD : standard deviation
MD : mean difference

4.4 Change in near NTC

Among the 42 examinees showing change in near NTC, there was 36 low group and 5 middle group and 1 high group. Low group had an average point of 2.00±0.00, middle and high groups had average of 5.17±2.86. For types of visual function in the group with inadequate change there were 1 excessive divergence, 13 insufficient convergence, 11 Basic exophoria, 8 Orthophoria, 1 Basic esophoria and 2 excessive convergence. In the group with sufficient change there were 3 insufficient convergence, 2 Orthophoria, and 1 excessive divergence (Exophoria group 69.05%, Orthophoria group 23.81%, Esophoria group 7.14%). There was a trend of increase from before viewing (13.86±2.98 △)to after viewing

(15.64±3.49 △) and there was statistical significance.

Table 4. Change in near NTC immediately after image viewing 3D image

unit:△

Mean±SD		MD	t	p-value
Before (13.86±2.98)	3D (15.64±3.49)	-1.79	-5.101	0.000

SD : standard deviation
MD : mean difference

According to visual function the Exophoria group showed the highest distribution[6]. In the case of PTC, there was a trend of minute decrease (divergence direction) after viewing in both distant and near, but there was no statistical significance. Although most of the changes in NTC after viewing was in the low group, it showed a statistically significant level of increase. This is seen as in the same context of previous studies [7-8] where Exophoria increases immediately after 3D image viewing.

5. Conclusion

Multidimensional images (3D), unlike 2D images, is an image shown through a sensory fusion in the brain about the differences in 2 different images and the vision function processes that occur are different. The unbalance of adjustment and convergence that occurs during 3D image viewing is the cause of the fatigue. According to the characteristics of the image, there occurs a more excessive convergence relative to adjustment response due to near-depth, and sometimes insufficient convergence occurs due to far-depth. Considering these visual physiological characteristics it can be predicted that according to personal visual function by total convergence ability viewing fatigue and quality will change. In the results of this study, among each entry the Exophoria groups of examinees showed the highest distribution. It seems that change in total convergence is caused by unstable response of convergence ability due to convergence stimulus and it is estimated that the examinees of the Exophoria group will show higher fatigue with continued viewing compared to the other groups. Because increased aspects of convergence potential lead to the effect of vision therapy it is deemed that there needs to be duality research in the future about 3D image viewing.

Acknowledgement

This work was supported by the ICT R&D program of MSIP/IITP. [2014(10041812), Full color 360 degree 3D holographic video making technology

References

[1] T. Takeda, K. Hashimoto, N. Hiruma, and Y. Fukui, "Characteristics of accommodation toward apparent depth", *Vision Research*, Vol. 39, No. 12, pp. 2087-2097, 1999.
[2] D.M. Hoffman, A.R. Girshick, K. Akeley, and M.S. Banks, "Vergence-accommodation conflicts hinder visual performance and cause visual fatigue", *Journal of Vision*, Vol. 8(3), No. 33, pp. 1-30, 2008.
[3] Sumio Y, "Visual perception from stereoscopic images for system design", *Global 3D technology forum, Korea chamber of commerce & industry*, pp. 11-36, 2011.
[4] P.J. Sung, *OPTOMETRY*, Daihaks, pp. 253-260, 2008.
[5] Mitchell S., and Bruce W., *CLINICAL MANAGEMENT OF BINOCULAR VISION Heterophoric, Accommodative, and Eye Movement Disorders*, Lippincott Williams & Wilkins, pp. 9-12, 2008.
[6] R. Asadi, K. Ghasemi-Falavarjani, and N. Sadighi, "Orthooptics treatment in the management of intermittent exophoria", *Iranian Journal of Ophthalmology*, Vol. 21, No. 1, pp. 35-40, 2009.

[7] J.H. Kim, *The influence of visual function on near watching 3D image*, M.S Thesis. University of Kyungwoon, Gumi, Korea., 2011.
[8] D.S. Kim, W.J. Lee, J.D. Kim, D.S. Yoo, E.T. Jeong, J.S. Son, "Change of phoria and subjective symptoms after watching 2D and 3D image", *Journal of Korean Ophthalmic Optics Society*, Vol. 17, No. 2, pp. 185-194, 2012.