THE DEVELOPMENT OF A FREE STEREOPSIS TEST FOR ACTIVE SHUTTER DISPLAYS

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ABSTRACT

While many people enjoy S-3D, it is a well-known fact that a minority of the population is not able to perceive S-3D. These people have problems with stereopsis, or the ability of our brain to unconsciously fuse two 2D images into a single 3D percept. In clinical practice, several stereopsis tests are used to measure this deficiency. Most of these tests are expensive paper-and-pencil tests requiring trained observers. In this paper, we discuss a recently developed method to test stereopsis on active shutter glasses displays. This allows researchers in the lab or S-3D users at home to test stereopsis in a free and easy way. Furthermore, we were interested in the distribution of test scores. More specifically, we wanted to know if our test resulted in a continuous (graded stereopsis) or bipolar (stereopsis present or not) distribution. Results of a preliminary study (N = 128) showed evidence for the second.

***Index Terms*—** random dot, stereogram, stereoscopic 3D, stereopsis

1. INTRODUCTION

Since decades, opticians and vision researchers have developed stereo tests to provide a measure of stereopsis. Well-known tests are paper-and-pencil tests like the TNO test and the Titmus test (for a description and comparison, see [1], [2] or [3]). These tests make use of anaglyph or polarized glasses to send different images to both eyes. While these tests were thoroughly compared on validity and reliability in several studies [4] [3] and it is shown they are of great value in clinical practice, they are expensive and require trained people.

Therefore, our objectives were three-fold. First, because S-3D display technology has evolved from colored and polarizing filters towards active shutter glasses and autostereoscopic displays, our goal was to make it possible to test stereopsis with these latter technologies too. Therefore, we made an automatized test for active shutter glasses displays. The main feature of this technology is the fact the display alternately sends a full-HD (1920 x 1080 pixels) image to the relevant eye by shutting down the irrelevant eye with synchronized glasses.

Second, we aimed to make a stereopsis test which would be easy to administer. Because established stereopsis tests can only be administered by trained people, it was our goal to develop a test which could calculate a score of stereoscopic 3D vision automatically and present it afterwards. Moreover, the test should be able to log socio-demographic information, trial-specific accuracies, reaction times, and total test scores in an automatized way. This would make the test suitable for large-scale research in which hundreds of people have to be tested in a short time-span. Furthermore, by adding a challenging task component, it was our goal to make a test people would enjoy.

A third objective was to investigate whether it is possible to develop a test with a continuous outcome variable. Until now, most stereopsis tests result in categorical data with 6 (TNO) or 9 (Titmus) possible outcomes [3]. By incorporating a task component in the test, which adds additional variance in test scores, an outcome variable ranging from 0 to 20 was obtained. Next, we were interested in the distribution of test scores in a large sample. We expected the distribution would be either normal (stereopsis scores range from 0 to 20) or bipolar (stereopsis is disturbed or intact).

2. TEST CONSTRUCTION

The proposed test is conceptually similar to VT-07 of ITU-R BT.1438 [5] and based on random-dot stereograms, which are pairs of images with random visual noise. At first, the left and right image have exactly the same pattern of dots. Next, one or more objects, letters or geometrical shapes are cut out in one of the images and moved for a certain distance horizontally. When the left side of the stereogram is now directed to the right eye and the right side to the left eye, the brain tries to fuse both images into a single percept and the effect of binocular disparity is established. If a person's stereopsis is well-developed, the cut-out objects now seem to pop out of the background of visual noise.

Applied to our test, two identical noisy images were pasted together. Next, one to ten little squares were cut out in one of both sides and moved a certain distance horizontally (see Figure 1).

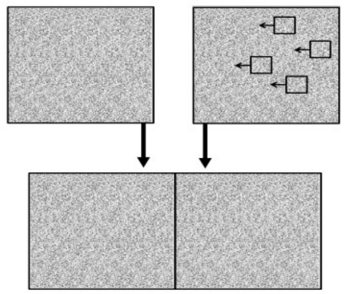

Fig. 1. Stereograms in active stereogram test. In this example, 4 squares are cut out and moved horizontally.

There were two replications for each number of squares, resulting in 20 different stereograms which were presented in random order for each participant. When displaying the stereogram full-screen (so both sides next to each other) and switching the television to 3D mode, the left and right side of the stereogram are directed to different eyes with a speed of 200 Hz which establishes binocular disparity. The novelty of our test is the challenging task component: the participant has to count the number of on-screen squares (one to ten). For each image, the participant has fifteen seconds to type in the correct answer on the numeric keypad. After 20 trials, a global score is calculated and presented.

At the beginning of the test, people are asked for age, gender and optical deviations. Per trial, responses, accuracies and reaction times are logged. The test (written in C) is open source and can be downloaded at https://sourceforge.net/projects/stereogramtest/. All technical details and information on reproducibility can also be found there.

3. PRELIMINARY RESULTS

At a technology fair, 128 people participated in the test. People were seated in a couch with a viewing distance of 2.5 meters. The television (Philips 46” 9000 LED series) was put on a cabinet, 0.5 meter above the ground. Participants (*N* = 128; 91 ♂, 37 ♀) were on average 31.34 years old (*SD* = 8.66).

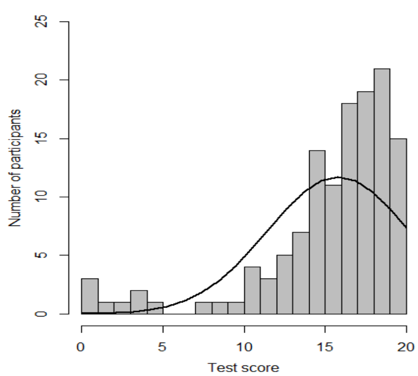

Fig. 2. Distribution of test scores in a validation study with N = 128 participants.

The histogram with test scores (see Figure 2) showed a left-skewed distribution, indicating the majority of participants scored rather high (*M* = 15.80, *SD* = 4.36). The large variance in scores can probably be attributed to the task: some people are better than others at counting objects in a visual search task. At the moment, we are inclined to say our test results in a bipolar (stereoblindness vs. stereopsis) distribution, but bimodal Gaussian distribution tests should confirm this in future research.

4. LIMITATIONS

In order to validate the test for medical diagnosis of stereoblindness, the test should be cross-validated with traditional tests like the TNO and the Titmus test ([1], [2] ,[3]). Since this validation has not yet been performed, we cannot make claims about which range of test scores indicates stereoblindness and which range of scores resembles intact stereopsis. Moreover, there are probably some unidentified factors playing a role in performance differences on the proposed test. Further research into these issues is definitely required.

5. CONCLUSIONS

At the moment, a free and easy test to estimate viewer’s performance on active shutter displays with respect to stereopsis is developed. This test may provide important insight into observer characteristics when performing subjective studies in the context of S-3D displays and/or content. Although preliminary results show promising features of stereopsis testing in combination with visual search, further research and cross-validation with well-established tests is necessary to make it usefull in clinical practice.

6. REFERENCES

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