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3D cinema and human stereovision

Abstract

One of the modern entertainment industry spheres is three-dimensional (3D) cinema. In recent years it has experienced rapid development. However, the opinion about 3D cinema varies. Some people believe that 3D cinema has negative impact on their vision. It causes discomfort (headache, nausea) or even inability to see the 3D effect in movies and animations. The purpose of the research is to study the causes which lead to vision problems and complaints relating to 3D cinema. A significant part of the study was a questionnaire with an aim to find out the opinions about 3D cinema and the vision problems, which block the ability to see 3D. Three groups underwent a stereovision test-a group without complaints, a group with complaints and a group who do not see the 3D effect at all. The questionnaire also defined the reasons for the difficulties to see 3D effect. Findings of the questionnaire indicate that almost a half of all respondents-65%-prefer movies in 2D format due to the vision discomfort when watching 3D movies, namely, headache (7%), eye fatigue (41%) etc. However, 4% of all respondents confirmed that 2D movies cause some asthenopias as well. That leads to an assumption that complaints depend on the perception of 3D effect and vision problems (e.g., anisometropia, amblyopia etc.) by every individual. In comparison to research carried out in Great Britain by 'The Eyecare Trust", where the findings show that 10-12% of Great Britain's population does not see 3D, we discovered in our research that 17% of respondents in Latvia have difficulties to see 3D effect.

Keywords: stereovision, stereoblindness, stereoacuity, 3D cinema

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Introduction

Stereovision is one of the main preconditions for the ability to have spatial vision. It provides information about the depth of the sceen and the perception of three-dimensional sceen.[1] Every eye perceives its own sceen. Both images are sent to brain and then processed. When they simultaneously come to the back of the brain they are put togehter with the help of similarities and differences from both images. As a result, a three dimensional stereo image is gained.[2] Stereoacuity is the slightest difference in depth, which we can discriminate. It is the depth dicrimination threshold. To notice the most detailed differences, it can be gained with foveal fixation which is located in fixation plane (horopter). Stereothreshold is measured with spatial offsets.[3] Better stereoacuity does not mean a better stereovision.[4]

Not all find 3D cinema pleasant. Between 2 and 12% (the proportion varies among experts) of all viewers are unable to fully enjoy 3D video. Inability to fully enjoy 3D movies or television has two possible causes: i. Inability to see the 3D effect. ii. Ability to see the 3D effect but with unacceptable side-effects such as headache and nausea. The inability to see 3D effect is called stereo blindness, which having monocular vision, being a flat-viewer or lacking depth perception.[5] Dr. Habermehl, an optometrist, explains that some people may not be able to see 3D effect because of vision problems. It may be an unconnected refractive condition-one eye is more near-sighted or far-sighted than another. The reason could be astigmatism-inability to see clearly-and that could be a lazy eye.[6]

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The following situations approve the presence of vision problems:

i. If you do not see the 3D effect immediately, but in 30 seconds.

ii. If you can see the 3D effect immediately, but afterwards you suffer from headache or your eyes hurt.

Maybe your eyes are working harder than they are supposed to.

i. If you have trouble to see the 3D effect and need to take visual breaks during the movie.

ii. If you cannot see the 3D effect, the problem is not only in the special effects. It can be a sign that a vision problem may be interfering with your ability to concentrate, your reading comprehension, short attention span and even sports performance.[6]

Experimental

The research was divided into two parts-a questionnaire and stereovision test. The questionnaire covered 230 respondents-170 women and 60 men ranging from 10 to 66 years. Questions were made in a simple format so that people who do not understand particular things about vision could answer them properly. Results of questionnaire showed the opinion about the 3D effect, the complaints when watching 3D movies and the presence of problems to perceive the 3D effect properly.

The stereovision test involved three groups to compare results among them. Three stereotests were used:

i. Polarized test (qualitative test)

ii. TNO test (anaglyph quantitative test)

iii. Titmus test (quantitative test).

Polarized test is a qualitative test which can detect whether a participant has setereovision. If participant cannot see 3D effect, this test cannot evaluate stereovision. Polarized test detects coarse stereovision. TNO test is based on stereogram principle. There are red and green random dots on the plates. In order to see a 3D image, it is necessary to use anaglyph glasses. In a place where this 3D image appears, red and green dots are moved horizontally aside from each other. TNO test can detect stereovision from 480 arc seconds to 15 arc seconds. Titmus test has various vectograms-a fly which can establish coarse stereovision, approximately 3000 arc seconds, and other vectograms which can establish finer stereovision-circles 40 arc seconds and animal's 100 arc seconds. Measures were made three times. However, the results were equal and thus it was impossible to extract standard deviation and standard error. It was established that participant could not hold stereo test in a distance of 40 cm properly and the possible distance change could be in a border +/- 1 cm. The situation was constructed to establish what image offset it would be– whether pupillary distance of every participant would be 64 mm. It was assumed that given stereoacuity thresholds in tests will be for 64 mm papillary distance. Taking in account this offset, it was possible to calculate the error of every participant. If pupillary distance is different from 64 mm, there is stereoacuity offset unlike given stereoacuity thresholds in TNO and Titmus stereovision tests (Figure 1).

PD(mm)	15'	30'	40'	50"	60'	80'	100'	120"	140"	200"	240'	400'	480"	800"
55	0.38"	0.75"	1.00'	1.24'	1.50"	2.00"	2.5"	3'	3.5'	5"	6"	10'	12"	19.93'
60	0.38"	0.75"	1.01'	1.25'	1.50"	2.00"	2.5"	3'	3.5'	5"	6"	10'	12"	19.98'
65	0.38"	0.75"	1.00'	1.25'	1.50"	2.00"	2.5"	3'	3.5'	5"	6"	10'	12"	20.02'
70	0.38"	0.75"	1.00'	1.25'	1.50"	2.00"	2.5"	3'	3.5'	5"	6"	10'	12"	20.06'

Figure 1 Percentage amount of people who have or do not have problems to see 3D effect.

Results

As a result, the questionnaire it was showed that 17% of respondents have problems to see 3D effect (Figure 2).

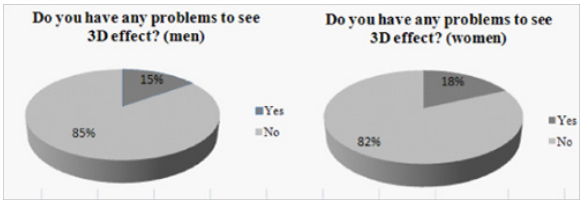

Figure 2 Percentage amount of people who have or do not have problems to see 3D effect.

The most common complaints when watching 3D cinema are eye fatigue (46%), sensation of eye pressure (21%), eye strains (10%) etc. (Figures 3 & 4). In a research which was carried out by American Optometrist Association it was established that 13% suffer from headache, 12%-from blurry vision and 11%-from dizziness.[8] Information about 3D movies/animations was gained from cinema "Citadele" IT manager Maris Misevics. Among movies the respondents had seen the only movie made on anaglyph method was "Spy Kids". 13% of respondents had complaints relating to it. Other movies included in the questionnaire were made based on polarization. Those movies were: "Avatars" complaints by 51% of respondents, "Step Up"- complaints by 30%, "Adventure at the center of the Earth"-complaints by 23% respondents. Comparing results of three groups, the best results gained the control group. It was a group which did not have any complaints when watching 3D movies. The average stereoacuity in a distance of 5.20 meters was 642 arc seconds. The average stereoacuity in TNO test was 89 arc seconds, in Titmus test (circles)-51 arcs second and in Titmus test (animals)-100 arc seconds. In the second group 21 participants, had complaints when watching 3D movies. The average stereoacuity in a far distance was 641 arcs second, in TNO test-108 arc seconds, Titmus test (circles)-69 arc seconds and Titmus test (animals)-105 seconds (Figure 5).

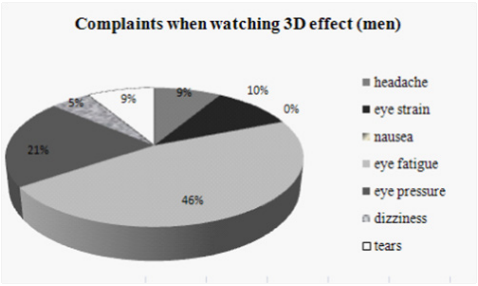

Figure 3 Percentage amount of complaints watching 3D cinema.

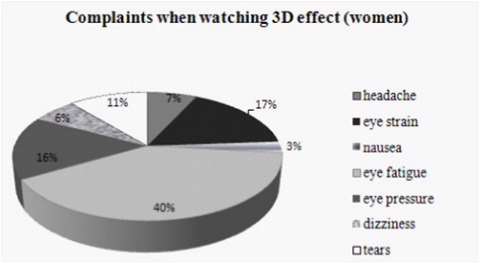

Figure 4 Percentage amount of complaints among women watching 3D effect.

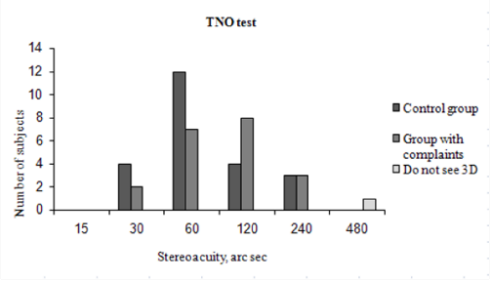

Figure 5 Stereoacuity of participants in TNO test.

In the third group 7 participants did not see the 3D effect. In a polarized test, some of them affirmed that they saw a point and two stripes, but they did not have a spatial sense-nothing was coming out of the plane. In every case the point was aberrant to one side-left or right side. Thus it was necessary to check if a participant uses binocular vision during the test. It was not possible to define the average value of TNO test results, because only one person could see spatial (in this case 480 arc sec, which is the lowest result of the test). In a Titmus test (circles) the average stereoacuity was 400 arc seconds, but in a Titmus test (animals)-it was 340 arc seconds (Figures 6 & 7). Comparing the average stereoacuity values and standard errors among three participant groups (Figure 8). The highest numerical results have the group who does not see 3D effect; the control group results are numerically lower. Standard errors are higher for the group who does not see 3D; however, in a TNO test only one participant gave an answer, therefore it is not possible to obtain standard deviation and standard error. The difference between standard errors could be explained by the difference of number of measures. Control group involved 23 measures, but the group who did not see the 3D effect involved only 7 measures. If there would be more measures, the standard error would be lower.

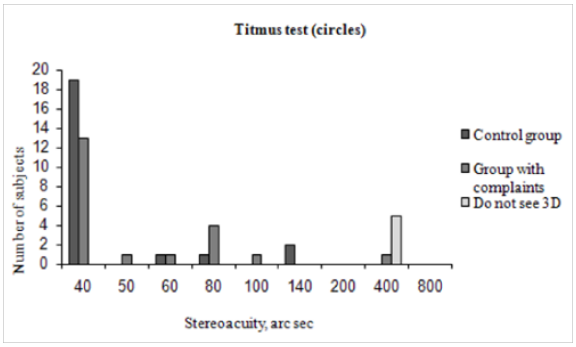

Figure 6 Stereoacuity of participants in Titmus test (circles).

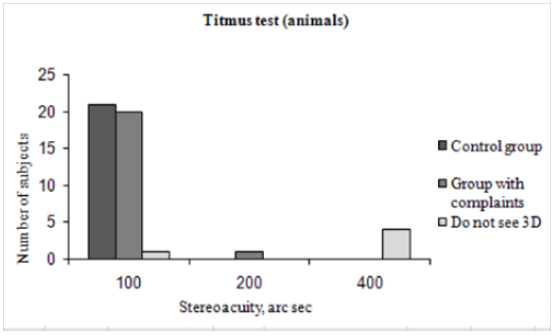

Figure 7 Stereoacuity of participants in Titmus test (animals).

The results of the research were compared with the research carried out by Fawcett and Birch about Titmus and Random-dot test validity examining children with binocular disorders. 170 children with a good stereo threshold and with undeterminable stereo threshold took part in the research. Titmus test (circles) and Random-dot test showed similar results-160 arc seconds and even better. It was established that the results must be interpreted carefully, because a person who sees monocularly may gain a very good results.[9] The results were also compared with the research carried out by Garnham and Sloper about changes in steroacuity with age. There were different stereotests used, including Titmus and TNO. 60 subjects took part in this research ranging from 17 to 83 years. It was established that remarkable decrease of stereoacuity (in TNO test) was for 5 subjects which average age was above 55 years. But in Titmus test the stereoacuity of those subjects was much better.[10]

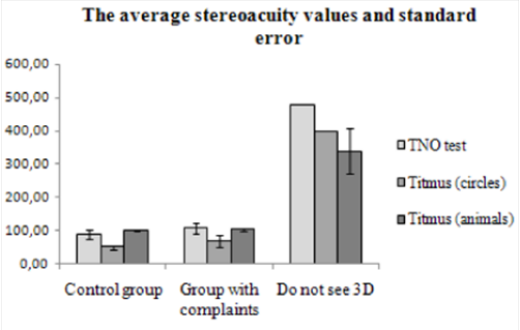

Figure 8 The average stereoacuity and standard error of participants.

Discussion

The questionnaire found out that people who have not seen 3D movies/animations complain when watching 2D movies. This group of people contains 4% of all respondents. It leads to an assumption that 3D cinema is not the only reason that cause complaints and discomfort when watching 3D movies. It depends on every subject vision and health condition. Some people notice winking of polarizing glasses, it can cause headache and dizziness. It is also important to learn how to watch 3D movies. For many people it is not clear where to focus during 3D movies. It causes problems to see 3D effect at all. During the movie the focus must be simultaneously on the background and on the objects which fly out of the screen. One of the problems is also the length of the movie. For instance, if we compare "Spy Kids" and "Avatar" the 3D effect lasts for some minutes in "Spy Kids", but for 2 hours in "Avatar". It forces people to watch movie in artificial circumstances. In Great Britain "The Eye Care Trust" made a research among inhabitants and found out that 6 million people do not see 3D effect due to binocular vision disorders.[11] American Optometrist Association claims that approximately 3-9 million people have problems to see 3D effect properly (American Optometrist Association, 2011). In our research we found out that 18% women and 15% men have difficulties to see 3D effect. It shows that they have possible binocular vision problems. Some respondents claimed that it is difficult to put 3D glasses on their own vision correction glasses. The inability to see 3D effect could be related with lazy eye, astigmatism, different refraction in both eyes, anisometropia, squeezing.

Conclusion

The findings of the research show that most of the people think that 3D movies/animations are the main reason for all vision problems. However, such statement is not true. There is a wide range of other reasons that may cause inability to perceive 3D effect properly. 17% cinema viewers in Latvia cannot perceive 3D effect in movies or animations properly. The most frequent complaints are headache 46%, sensation of eye pressure 21%, and eye fatigue 9% etc. Movies that cause eye discomfort are based on polarization method. Control group gained the best stereoacuity, where in TNO test it was 89 arc seconds, Titmus (circles)-51 arc second, but Titmus (animals)-100 arc seconds. For participants who do not see 3D effect the stereoacuity was 480 arc seconds in TNO test, Titmus (circles)-400 arc seconds

and Titmus (animals)-340 arc seconds. Researches like this should be carried out more frequently to develop ideas how to improve the way how 3D movies are demonstrated. 3D technologies are developing very rapidly. We should warn viewers about the possible vision problems and discomfort when watching 3D movies.

Acknowledgments

None.

Conflicts of interest

Author declares that there is no conflict of interest.

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