Tobii AB

Accuracy and precision Test report

Tobii Pro X3-120 fw 1.7.1

Date: 2015-09-14
Methodology/Software version: 2.1.7*

1. Introduction

This document provides an overview of tests in terms of accuracy and precision regarding the Tobii Pro X3-120 Eye Tracker. The tests were conducted by the Department of Quality Assurance of Tobii AB, and took place in August 2015.

1.1 Product

Product category: Screen based eye tracker
Manufacturer: Tobii AB
Trademark: Tobii Pro
Type designation: X3-120
Firmware version: 1.7.1
Serial Number: X3120-030105011651

1.2 Method

The data acquired for this report was collected using the Tobii Accuracy and Precision Test Method version 3, however all the result presented in this report are presented in a way comparable with method version 2.1.7 with a few modifications that are outlined below. This is to enable more direct comparisons with other similar reports from Tobii Pro.
20 test participants were recruited from Tobii AB's local office in Stockholm. The subjects were not selected according to the "ideal population" criteria, instead they were selected arbitrarily from a population without sight correction who passed the criteria for the ideal condition. All subjects were between 21-50 years old (nine people between 21-30, six between 31-40, five people over 40). All subjects were Caucasian. All tests were performed in the Department of Quality Assurance test lab, at Tobii AB Headquarters. The lab set-up provides adequate conditions to perform accuracy and precision tests in a controlled environment. All tests were conducted by an experienced hardware technician.

The center of the track box was set to 65 cm from the eye tracker. The following five conditions were tested in successive tests: ideal conditions, large gaze angles, varying head positions, varying illumination and white background (Table 2 displays a summary of the different conditions tested). There was a short break between each test trial for the test leader to change conditions and for the participant to rest her/his eyes.

Accuracy and precision values measured were based on stimulus points on a TFT screen (1920 x 1200 pixels). The test subjects were asked to focus their gaze on each of the points in a test trial. Each point was presented for 2 seconds and the points were presented in random order. The target points were used in order to calculate accuracy, with the center point as a reference point in relation to the measured gaze point. Precision was measured from the same data for each point individually. All tests were performed without a chinrest.

Since the data presented in this report were collected using the Tobii Accuracy and Precision Test method version 3, which is a method where several variables are less controlled, the results presented in this report are not entirely comparable to data collected using method 2.1.7. Because of the differences the eye tracking data collected with method version 3 is expected to have a slightly lower accuracy and precision compared to data collected with method 2.1.7. See table below for the main differences between Tobii Accuracy and Precision Test method version 3 and version 2.1.7

**Table 1, The main differences between Tobii Accuracy and Precision Test method version 3 and version 2.1.7. The results presented in this report have been collected using method 3 but are presented in a format comparable with version 2.1.7*

Version 2.1.7	Version 3
Only people from "ideal population" included	Anyone without sight correction who passed the criteria for the ideal condition
All data collected with a chinrest	No chinrest was used
Stimulus point presentation repeated up to 3 times in case not enough data was collected	Stimulus points only shown once
Participant is excluded from a test in case one or more point has less than 80% samples	Participant is excluded from a test in case the average samples collected for all points in a test is less than 80%
Room mainly illuminated from the sides	Room mainly illuminated from above
Stimulus points located within 20°, 25°, 30° on the screen	Stimulus point located on the entire screen, only points located within 20°, 25°, 30° included in this report.

Table 2, Manipulated variables in each of the accuracy/precision tests. The table describes the different test categories and which variables are manipulated for each of them.

		Ideal conditions	Large gaze angles	Varying illumination	White background	Varying head positions
20 Participants (Same for all tests)	**Eye color**	Mixed	Mixed	Mixed	Mixed	Mixed
	Sight correction	None	None	None	None	None
	Age (years)	20 - 50	20 - 50	20 - 50	20 - 50	20 - 50
Calibration		9-point default	9-point default	9-point default	9-point default	9-point default
Gaze angle		≤20°	**25°, 30°**	≤20°	≤20°	≤20°
Illumination		300 lux	300 lux	**Manipulated**	300 lux	300 lux
Stimulus (Foreground/ background color)		White/Black	White/Black	White/Black	**Black/White**	White/Black
Eye placement in box		Center of box	Center of box	Center of box	Center of box	**Manipulated**

The accuracy and precision calculations are specified in the Accuracy and Precision Test Specification document. The variable "Precision" is calculated via the RMS of successive samples, whereas SD Precision is the standard deviation measure of the data set. All accuracy and precision results are based on raw data, collected directly from the SDK after personal calibration.

2. Results

2.1 Summary

Average binocular accuracy and precision values for all tests are presented in table 1. For Head positions the best and poorest attained value is specified for each dimension. In addition to accuracy and precision values, (N) is the number of participants that met the track requirements. The track box includes offsets of 10 cm in vertical axis, 15 cm in horizontal axis and distances from 45 to 90 cm.

Table 1, All results. The table presents the binocular accuracy and precision results for all test conditions. N is the number of participants who met the method requirement, i.e. used for analysis. For the head position tests, where several tests were performed in each direction the best and poorest value is specified. As specified in the test specification, all measurements are based on raw data.

		N	Accuracy (°)	Precision (°)
Ideal conditions	20°	20	0.4	0.24
Large Gaze angles	25°	19	0.6	0.25
	30°	20	0.6	0.31
Illumination variation	1 lux	19	1.0	0.26
	600 lux	19	0.5	0.28
	1000 lux	18	0.5	0.33
	White background (300 lux)	16	0.7	0.40
Head position variation	Z axis	7-20	0.4-0.6	0.23-0.52
	X axis	16-20	0.4-0.7	0.23-0.31
	Y axis	20	0.4-0.9	0.24-0.30

2.2 Accuracy and precision at ideal conditions

The binocular and monocular accuracy and precision values under ideal conditions are presented in table 2. Standard deviation precision (SD Precision) is presented as a complement to the regular precision value. All participants met the track requirements (N=20). The average value for each metric is specified along with the standard deviation (Std).

Table 2, Accuracy and precision under ideal conditions. The average and monocular accuracy and precision are presented along with the standard deviation (Std) for each metric. All participants met the tracking requirements (N=20).

			Accuracy		Precision		SD Precision
		N	Binocular	Monocular	Binocular	Monocular	Binocular
Ideal conditions	Average	20	0.4	0.5	0.24	0.34	0.47
	Std		0.2	0.3	0.06	0.10	0.37

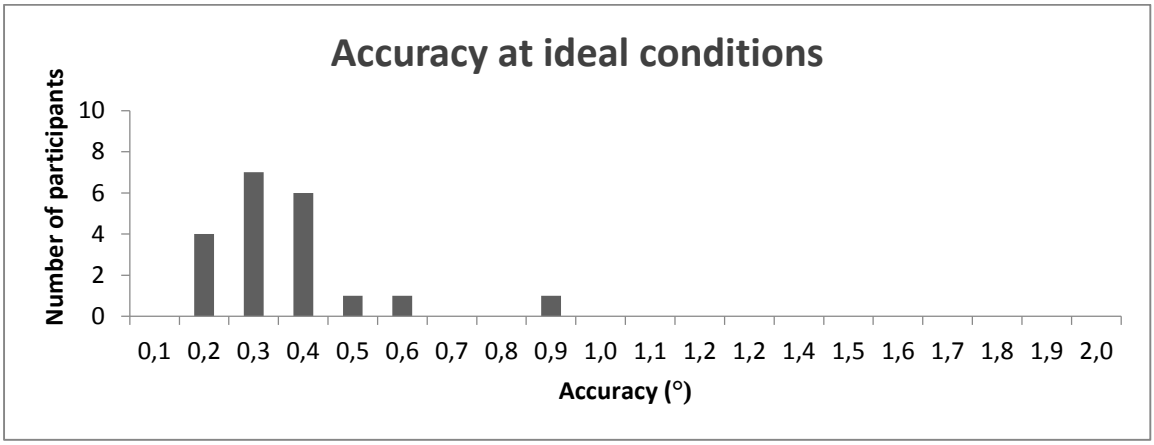

Diagram 1: Accuracy distribution among the participants

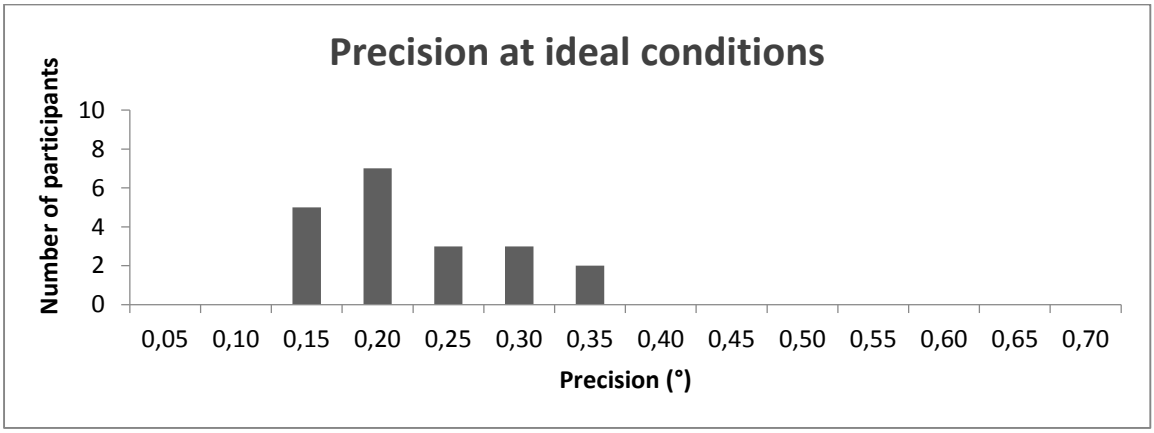

Diagram 2: Precision distribution among the participants

2.3 Accuracy and precision at large gaze angles

The binocular and monocular accuracy and precision results at large gaze angles are presented in table 3, as well as in diagram 3 and 4. The average value for each metric is specified along with the standard deviation (Std).

			Accuracy		Precision	
		N	Binocular	Monocular	Binocular	Monocular
25° Gaze angle	**Average**	**19**	0.6	0.7	0.25	0.34
	Std		0.3	0.3	0.06	0.08
30° Gaze angle	**Average**	**20**	0.6	0.8	0.31	0.41
	Std		0.4	0.5	0.13	0.15

Table 3, Accuracy and precision at 25 and 30 degrees gaze angle. Binocular and monocular accuracy and precision values are presented for both angles of measurements. The average values are presented along with the standard deviation (Std).

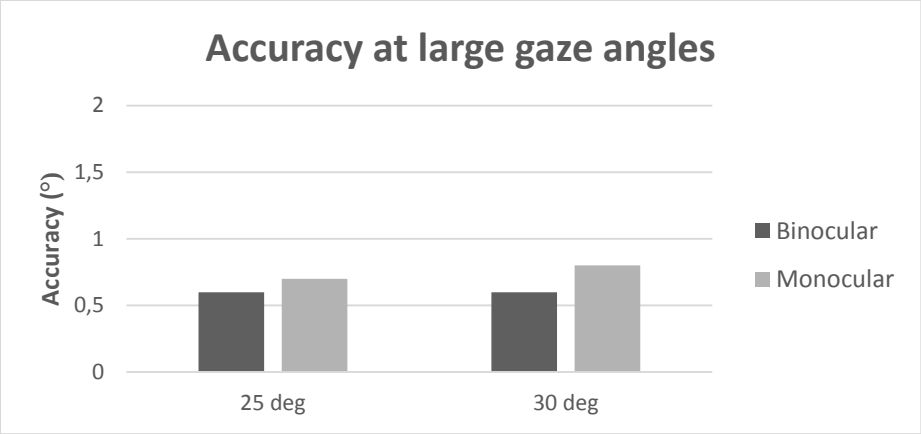

Diagram 3: Accuracy at large gaze angles. The average binocular and monocular accuracy is presented for both measured gaze angles.

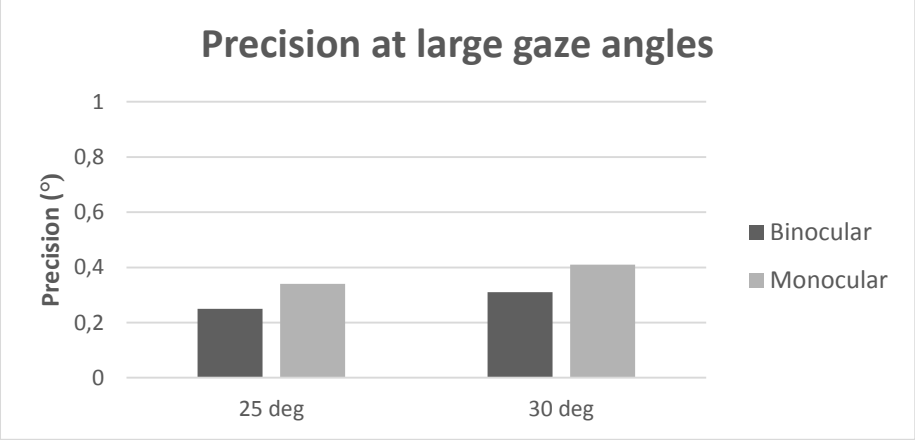

Diagram 4: Precision at large gaze angles. The average binocular and monocular accuracy is presented along with both measured gaze angles.

2.4 Accuracy and precision with varying illumination

Binocular and monocular accuracy and precision results for the illumination test are presented in table 4, as well as in diagram 3 and 4. The average value for each metric is specified along with the standard deviation (Std).

Table 4, Accuracy and precision under varying illumination and stimuli background. The number of participants who met the tracking requirements is presented along with the binocular and monocular accuracy and precision data for each test condition.

			Accuracy		Precision	
		N	Binocular	Monocular	Binocular	Monocular
1 lux (darkness)	Average	19	1.0	1.6	0.26	0.36
300 lux	Average	20	0.4	0.5	0.24	0.34
600 lux	Average	19	0.5	0.6	0.28	0.39
1000 lux	Average	18	0.5	0.7	0.33	0.45
White background	Average	16	0.7	0.9	0.40	0.59

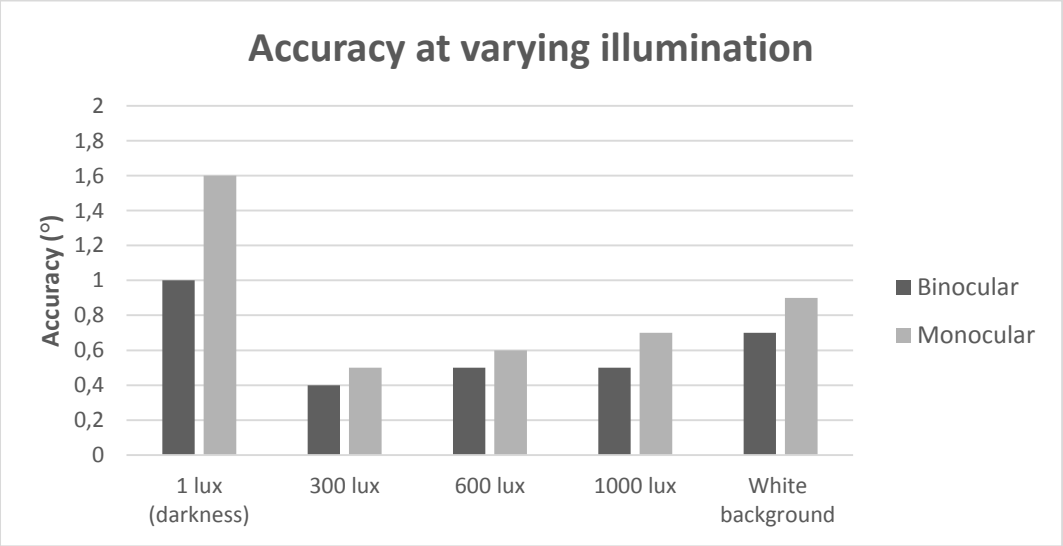

Diagram 5: Accuracy under varying illumination. Binocular and monocular accuracy data is presented for each illumination condition.

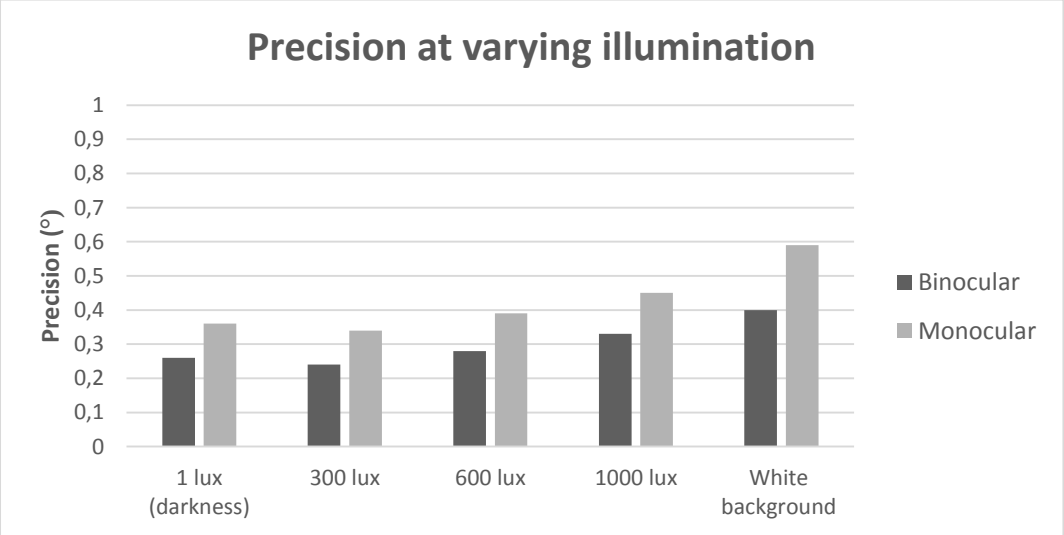

Diagram 6: Precision under varying illumination. Binocular and monocular precision data is presented for each illumination condition.

2.4.1 Distance from eye tracker, Z axis

The accuracy and precision measured at varying distances from the eye tracker (X=0, Y=0) are presented in table 5 and diagram 5 and 6. In these diagrams the average value is presented with a line and the distribution (max, min and SD from mean) is illustrated with boxes and vertical lines.
The average value for each metric is specified along with the standard deviation (Std).

Table 5, Accuracy and precision at varying distances from the eye tracker. The binocular and monocular accuracy and precision are presented in average values along with the standard deviation (Std) and the number of participants who met the tracking requirements (N) for each distance.

3.	4.	5.	Accuracy (°)		Precision (°)	
Distance		N	Binocular	Monocular	Binocular	Monocular
45 cm	Average	7	0.6	0.7	0.24	0.33
	Std		0.4	0.4	0.06	0.12
50 cm	Average	18	0.5	0.7	0.24	0.32
	Std		0.3	0.3	0.09	0.12
55 cm	Average	20	0.4	0.6	0.23	0.31
	Std		0.2	0.3	0.06	0.09
60 cm	Average	20	0.5	0.6	0.25	0.34
	Std		0.3	0.4	0.09	0.11
65 cm	Average	20	0.4	0.5	0.24	0.34
	Std		0.2	0.3	0.06	0.10
70 cm	Average	20	0.4	0.5	0.27	0.38
	Std		0.2	0.3	0.07	0.10
75 cm	Average	20	0.4	0.6	0.32	0.45
	Std		0.2	0.3	0.06	0.12
80 cm	Average	19	0.5	0.6	0.37	0.53
	Std		0.2	0.3	0.08	0.14
85 cm	Average	19	0.5	0.7	0.45	0.65
	Std		0.3	0.3	0.13	0.19
90 cm	Average	15	0.5	0.7	0.52	0.74
	Std		0.2	0.3	0.13	0.20

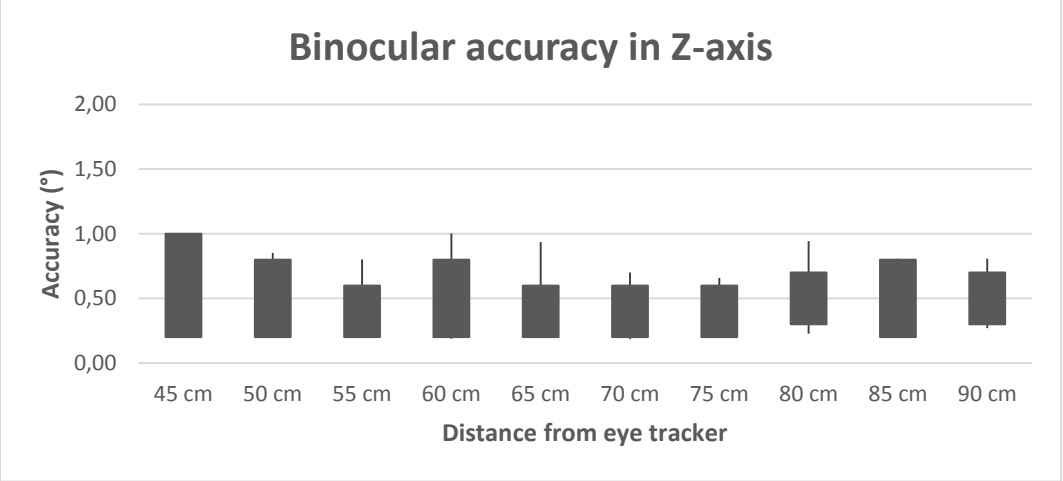

Diagram 7: Binocular accuracy at varying positions in Z axis. The average accuracy is illustrated with a line, and the max/min and standard deviation from mean is presented with boxes and vertical lines.

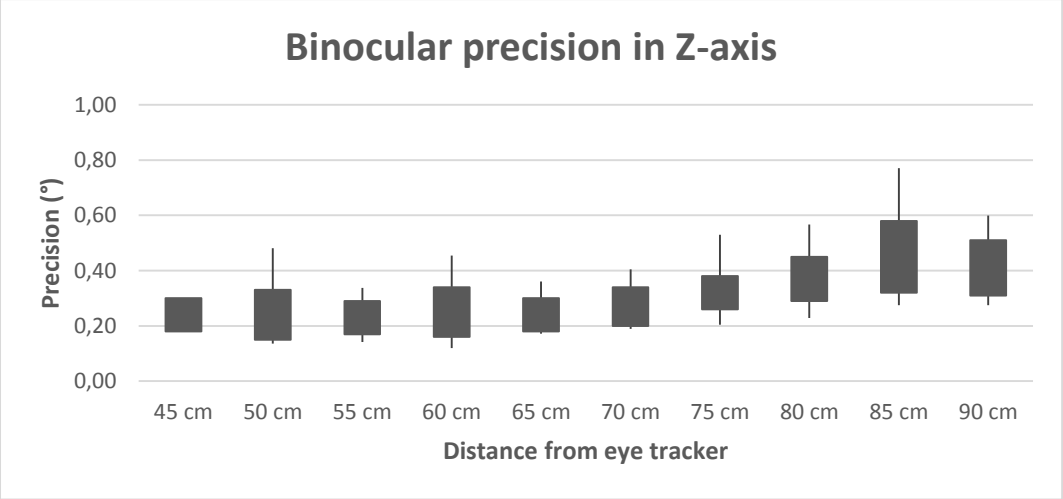

Diagram 8: Binocular precision at varying positions in Z axis. The average precision is illustrated with a line, and the max/min and standard deviation from mean is presented with boxes and vertical lines

5.1.1 Horizontal, X axis

Binocular accuracy and precision

The binocular and monocular accuracy and precision measured at varying distances from center of track box (Z=65 cm, Y=0) are presented in table 6 and diagram 7 and 8. In these diagrams the average value is presented with a line and the distribution (max, min and SD from mean) is illustrated with boxes and vertical lines.

Table 6, Accuracy and precision at varying positions in X axis. The average value for each metric is specified along with the standard deviation (Std). The number of participants who met the tracking requirements (N) is presented for each test.

6.	7.	8.	Accuracy (°)		Precision (°)	
Distance		N	Binocular	Monocular	Binocular	Monocular
15 cm	**Average**	18	0.7	0.8	0.31	0.42
	Std		0.3	0.3	0.08	0.12
10 cm	**Average**	19	0.6	0.7	0.26	0.36
	Std		0.3	0.3	0.06	0.10
5 cm	**Average**	20	0.5	0.6	0.25	0.35
	Std		0.3	0.3	0.08	0.11
0 cm	**Average**	20	0.4	0.5	0.24	0.34
	Std		0.2	0.3	0.06	0.09
-5 cm	**Average**	20	0.4	0.5	0.24	0.34
	Std		0.2	0.2	0.05	0.09
-10 cm	**Average**	20	0.5	0.6	0.23	0.33
	Std		0.2	0.3	0.05	0.08
-15 cm	**Average**	16	0.7	0.8	0.27	0.37
	Std		0.2	0.3	0.07	0.11

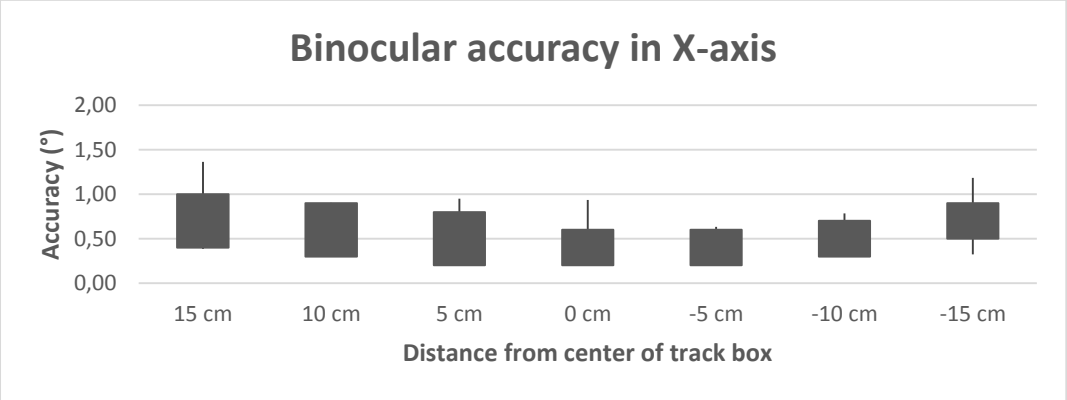

Diagram 9: Binocular accuracy at varying positions in X axis. The average accuracy is illustrated with a line, and the max/min and standard deviation from mean is presented with boxes and vertical lines.

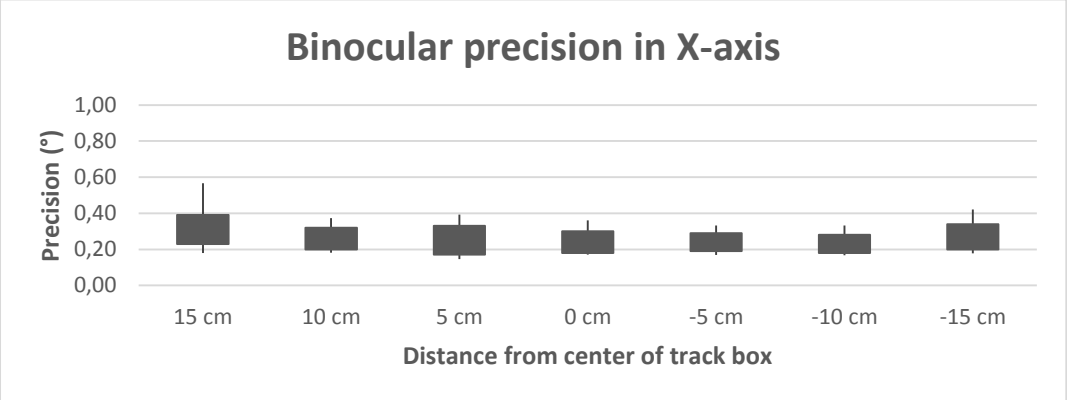

Diagram 10: Binocular precision at varying positions in X axis. The average precision is illustrated with a line, and the max/min and standard deviation from mean is presented with boxes and vertical lines.

Vertical, Y axis

The accuracy and precision measured at varying distances from center of track box (Z=65 cm. X=0) are presented in table 7 and diagram 11 and 12. In these diagrams the average value is presented with a line and the distribution (max. min and SD from mean) is illustrated with boxes and vertical lines.

Table 7, Accuracy and precision at varying positions in Y axis. The binocular and monocular accuracy and precision are presented as the average values along with the standard deviation (Std) and the number of participants who met the requirements (N) for each test trial.

			Accuracy (°)		Precision (°)	
Distance		N	Binocular	Monocular	Binocular	Monocular
10 cm	**Average**	20	0.4	0.6	0.24	0.33
	Std		0.2	0.3	0.06	0.09
5 cm	**Average**	20	0.5	0.6	0.26	0.35
	Std		0.3	0.3	0.07	0.09
0 cm	**Average**	20	0.4	0.5	0.24	0.34
	Std		0.2	0.3	0.06	0.09
-5 cm	**Average**	20	0.7	0.8	0.27	0.38
	Std		0.5	0.6	0.09	0.12
-10 cm	**Average**	20	0.9	1.0	0.30	0.41
	Std		0.4	0.4	0.07	0.12

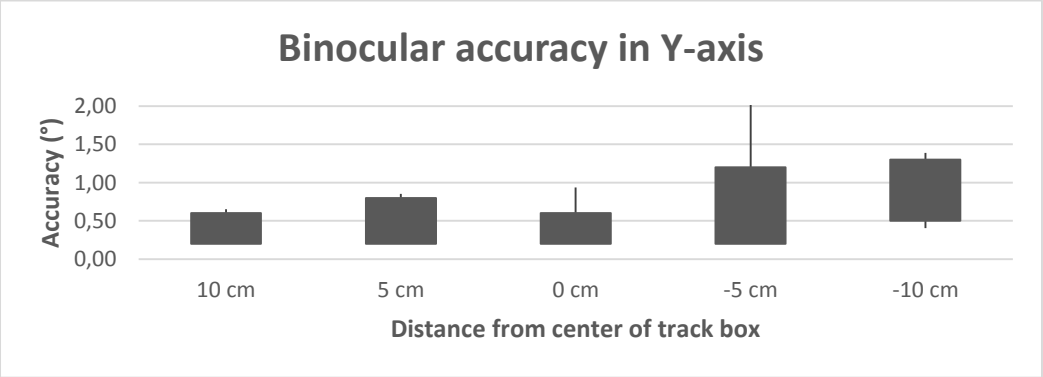

Diagram 11: Binocular accuracy at varying positions in Y axis. The average accuracy is illustrated with a line, and the max/min and standard deviation from mean is presented with boxes and vertical lines.

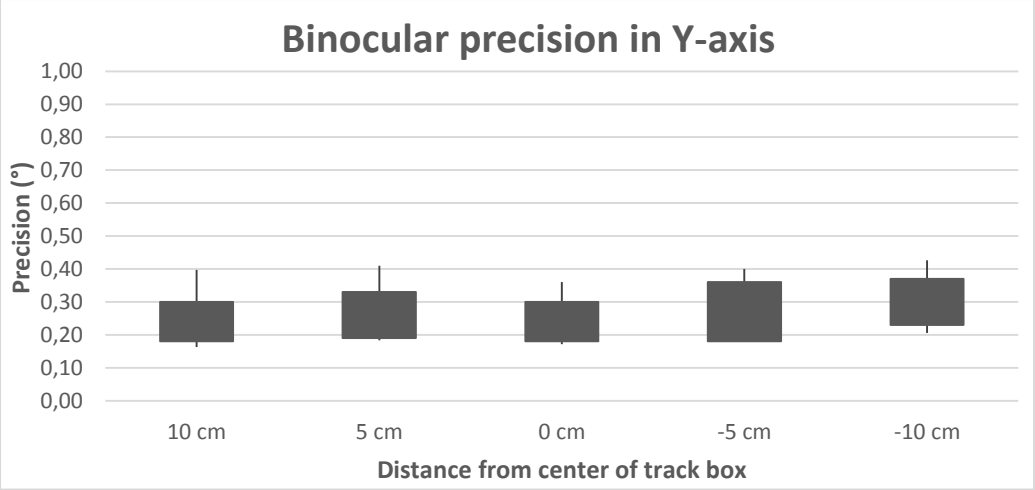

Diagram 12: Binocular precision at varying positions in Y axis. The average accuracy is illustrated with a line, and the max/min and standard deviation from mean is presented with boxes and vertical lines.