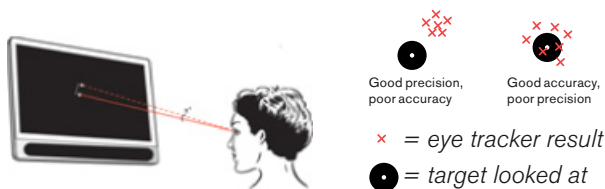


# Specification of Gaze Accuracy and Gaze Precision, Tobii X2-60 Eye Tracker

Tobii Technology has adopted a comprehensive method for gaze accuracy and precision measurements to facilitate performance comparisons of different remote eye tracking systems. Below you can see the preliminary test results for Tobii X2-60 Eye Tracker Compact Edition and Tobii X2-60 Eye Tracker Wide Edition according to this method. A detailed description of the test method can be downloaded at [tobii.com](http://tobii.com).

Gaze accuracy describes the angular average distance from the actual gaze point to the one measured by the eye tracker. Gaze precision describes the spatial variation between individual gaze samples. Gaze accuracy and gaze precision are measured in degrees of visual angle. One degree accuracy corresponds to an average error of 11 mm (0.45") on a screen at a distance of 65 cm (26").



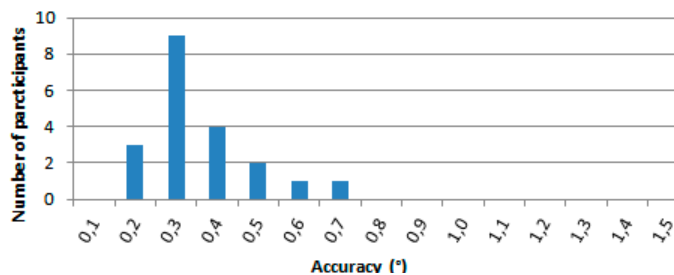
In the figure above, the dashed red line represents the subject's actual gaze direction, whereas the solid line represents the gaze point measured by the eye tracker. Gaze accuracy is expressed as the deviation in degrees between the two lines, with the point of origin determined by the position of the eye.

## Gaze accuracy

Accuracy is measured under ideal conditions, as well as under various conditions that influence a non-restrictive eye tracking test, e.g. change of gaze angles, light conditions or head position. All measurements are performed in a carefully controlled lab environment. <sup>1)</sup>

	Tobii X2-60 Eye Tracker Compact Edition		Tobii X2-60 Eye Tracker Wide Edition	
	Binocular <sup>2)</sup>	Monocular <sup>2)</sup>	Binocular	Monocular
Accuracy under ideal conditions <sup>1)</sup>	0.4°	0.5°	0.4°	0.5°

The graph below illustrates distribution of accuracy under ideal conditions for each subject for the Tobii X2-60 Eye Tracker Compact Edition. Data shown is binocular.

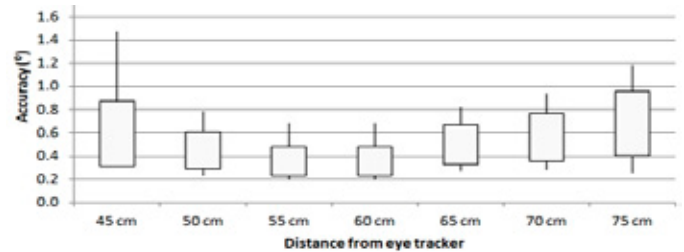


## Accuracy with large gaze angles <sup>3)</sup>

	Tobii X2-60 Eye Tracker Compact Edition		Tobii X2-60 Eye Tracker Wide Edition	
	Binocular	Monocular	Binocular	Monocular
25° gaze angle	0.5°	0.6°	0.5°	0.6°
30° gaze angle	0.5°	0.6°	0.5°	0.6°
35° gaze angle	N/A	N/A	pending	pending

## Accuracy at varying distances <sup>4)</sup>

The diagram shows average accuracy for all test subjects at varying distances from eye tracker to subject for the Tobii X2-60 Eye Tracker Compact Edition. The total average accuracy for each distance is illustrated with a line. Max/min and standard deviation from mean is presented with boxes and vertical lines. Data shown is binocular.



## Gaze precision

Precision measurements are done using dark pupil <sup>5)</sup> artificial eyes to eliminate artifacts from human eye movements. Tobii specifies precision both with and without noise reduction filters. All precision measurements are done at a variable sampling rate and a distance of 65 cm (26"). Precision is calculated as root-mean-square (RMS) of successive samples.

		Tobii X2-60 Eye Tracker Compact Edition		Tobii X2-60 Eye Tracker Wide Edition	
		Binocular	Monocular	Binocular	Monocular
Precision with raw data <sup>6)</sup> Artificial Eye	With Stampe filter <sup>7)</sup>	Pending	Pending	Pending	Pending
	Without filter	Pending	Pending	Pending	Pending
Precision with raw data <sup>6)</sup> Human eye	With Stampe filter <sup>7)</sup>	Pending	Pending	pending	pending
	Without filter	0.32°	0.43°	0.32°	0.43°

Precision is related to frequency. If filters are applied all precision values can be lowered significantly.

## Eye tracking specifications

	<b>Tobii X2-60 Eye Tracker Compact Edition</b>	<b>Tobii X2-60 Eye Tracker Wide Edition</b>
Sampling rate	60 Hz (stdev. approx 0.1 Hz)	60 Hz (stdev. approx 0.1 Hz)
System latency <sup>8)</sup>	48 – 67 ms	48 – 67 ms
Time to tracking recovery	For blinks: immediate	For blinks: immediate
Freedom of head movement Width x height at 70 cm <sup>9)</sup>	50 x 36 cm (20 x 14 inch)	50 x 36 cm (20 x 14 inch)
Operating distance (eye tracker to subject)	45 – 90 cm	50 – 100 cm
Accuracy	See previous page.	See previous page.
Precision	See previous page.	See previous page.
Data sample output (for each eye)	Timestamp Eye position Gaze point <sup>10)</sup> Pupil diameter <sup>11)</sup> Validity code <sup>12)</sup>	Timestamp Eye position Gaze point <sup>10)</sup> Pupil diameter <sup>11)</sup> Validity code <sup>12)</sup>

## Eye tracking unit

	<b>Tobii X2-60 Eye Tracker Compact Edition</b>	<b>Tobii X2-60 Eye Tracker Wide Edition</b>
Eye tracker processing unit	Tobii X2-60 Eye Tracker external processing unit	Tobii X2-60 Eye Tracker external processing unit
Connectors	USB 2.0	USB 2.0
Weight	200 g (7.1 oz)	250 g (8.8 oz)
Size	184 x 28 x 23 mm (7.3 x 1.1 x 0.9")	400 x 28 x 23 mm (15.7 x 1.1 x 0.9")
Mounting alternatives	Adhesive mounting brackets for monitors, laptops and tablets. Desk stand for tripod and desks.	Adhesive mounting brackets for monitors, laptops and tablets. Desk stand for tripod and desks.

## Software options

Tobii Studio ≥ 3.2

i2 Visualizer Implicit System, Eyesquare

Attention Tool, iMotions

E-Prime, Psychology Software Tools (PST)

Other applications, built on the Tobii Analytics SDK ≥ 3.0<sup>13)</sup>

## Hardware package

Tobii X2-60 Eye Tracker Compact Edition or Tobii X2-60 Eye Tracker Wide Edition

External Processing Unit

Adhesive Mounting Brackets and Mounting Tape Kit

Wide Edition Mounting Aid (only Wide Edition)

USB stick containing Tobii Eye Tracker Installer

USB extension cable (only Compact Edition)

Installation Guide

Printed Tobii X2-60 Eye Tracker User Manual

Zipper bag for eye tracker

## Accessories

Tobii X2 Eye Tracker Laptop Case

Tobii X2 Eye Tracker Desk Stand Package (Tobii X2 Eye Tracker Desk Stand, Digital angle gauge, Measuring tape)

- 1) Accuracy under ideal conditions is measured in the center of the head movement box with normal office background illumination (300 lux). The nine stimuli points are placed within a 20° visual angle. See detailed information in the "Accuracy and Precision Test Method for Remote Eye Trackers" specification at Tobii.com.
- 2) Monocular data shown is based on data from the dominant eye of each subject. Binocular data is the average of the two eyes.
- 3) Good accuracy is difficult to achieve at large gaze angles, but is important when testing large stimuli. For instance, the upper corners of a 23" screen with a test subject at a distance of 65 cm (26") corresponds to a 32° visual angle relative to the center of the eye tracker unit (when the eye tracker is placed right below the screen).
- 4) Calibration is performed at the center of the head movement box. Measurements are performed with the test subject at precise and specific distances relative to the eye tracker, measured along the axis of the eye tracking sensors.
- 5) Because the Tobii X2 Eye Tracker tracks with both dark and bright pupil technique, precision is to be measured using eyes of each property. However, there is no bright pupil data at this time as such artificial eyes have yet to be developed. Typically, tracking with bright pupil has significantly better precision than dark pupil.
- 6) Raw data from the Software Development Kit (SDK) after individual calibration, without any noise reduction filters.
- 7) Stampe (Behavior Research Methods, Instruments & Computers, 1993, 25 (2), pp.137-142) describes a noise reduction filter commonly used for eye tracking data. In these measurements, the tampe stage 2 algorithm has been applied.
- 8) System latency describes the time required by the eye tracker to capture (measured from center of image exposure), transfer and process data, and make this available to an application during normal tracking.
- 9) Freedom of head movement describes the volume in front of the tracker in which the user must have at least one eye. The numbers are specified parallel/orthogonal to screen surface, assuming eye tracker is at a 20° angle to screen.
- 10) Both as absolute coordinates in mm relative to stimuli plane, and as normalized coordinates in the stimuli plane. From the eye position and the gaze point, the precise gaze angle can be calculated in degrees.
- 11) Pupil diameter, with accurate algorithms to compensate for the spherical corneal magnification effect as well as the distance to the eye. Robust compensation for gaze angle changes. Pupil diameter can be based on a dark or bright pupil. The diameter of a dark pupil can differ from a bright pupil depending on the test subject.
- 12) The validity code indicates the system's confidence in whether it has correctly identified which is the left and which is the right eye for the specific sample.
- 13) The Application Market for Tobii Eye Trackers (shown on [www.tobii.com](http://www.tobii.com)) has many applications that build on Tobii SDK 2.4.X and SDK ≥ 3.0 that you can search for and download.

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