Tobii TX300 Eye Tracker

For research of oculomotor functions and natural human behavior

- 300 Hz
- Large track box

- 300 Hz sampling rate for studies of saccades, fixations and blinks
- Large head movement box enables unobtrusive capture of natural human behavior
- Highly accurate and precise data provides a solid foundation for eye movement research
- Flexible stimuli presentation – both on-screen and real-world stimuli set-up options

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Tobii TX300 Eye Tracker

The Tobii TX300 Eye Tracker sets a new standard for remote eye trackers. Its unique combination of 300 Hz sampling rate, very high precision and accuracy, robust tracking and compensation for large head movements extends the possibilities for unobtrusive research of oculomotor functions and human behavior.

Study eye movements such as saccades and short fixations. Capture natural human behavior without the need for a chin-rest. Tobii TX300 offers maximum flexibility with numerous stimuli set-up and software options.

Study oculomotor functions and capture natural human behavior

Tobii TX300 Eye Tracker collects gaze data at 300 Hz yet allows large head movements. The system is designed for studies that require a higher sampling rate; e.g. the need to study eye movements such as saccades, correction saccades, fixations, pupil size changes and blinks. In behavioral studies, subjects do not have to be positioned in an unnatural chinrest.

Tobii TX300 is suitable for:

- Neuroscience studies (e.g. studies combining eye tracking and EEG data)
- Ophthalmology studies
- Reading studies
- Psychology research (e.g. developmental psychology and psycholinguistics studies)
- Gaze-contingent paradigms due to the very low latency

The unique combination of a higher sampling rate and large head movement box benefits studies where freedom of movement is important, including behavioral research or eye movement research involving children.

Flexibility of stimuli set-ups and software

- The Tobii TX300 Eye Tracker comprises an eye tracker unit and a removable 23” wide screen TFT monitor. The eye tracker can be used with the supplied monitor, or as a standalone eye tracker. The modular design of the system enables both stimuli presentation on the supplied monitor, and studies of real-world flat surfaces or scenes (such as external video screens, projections and physical objects).

- A wide range of research software applications are compatible with the Tobii TX300, including Tobii Studio 2.2, Tobii Toolbox for MATLAB, and E-Prime Extensions for Tobii. These, and many more applications that build on the Tobii Software Development Kit (Tobii SDK), can be found at the Application Market for Tobii Eye Trackers: appmarket.tobii.com.

- The TX300 can be used together with most EEG systems, such as Brain Products, EGI and ANT.

- The sync out port enables real time synchronization with external equipment. The eye tracker delivers a precise trigger signal when each data sample is collected.

The Tobii TX300 is suitable for studies involving children.

The numerous stimuli set-up and software options provide a flexibility that makes the system ideal for a wide variety of studies as well as use across research departments.

Freedom of movement and unobtrusive design

▪ Tolerance for head movements allows subjects to move freely and naturally in front of the stimulus. If the subject moves out of the head box and then back into it, tracking is resumed almost instantly.

▪ All hardware, including the eye tracking technology, user camera and speaker, is fully integrated into the eye tracker unit and monitor so as not to distract the subject.

▪ Stable and reliable calibrations eliminate the need for recalibration during long sessions.

The freedom of movement and unobtrusiveness allow subjects in behavioral studies to act naturally, thus ensuring research validity. Lengthy and accurate studies can be performed without subjects experiencing fatigue.

Accurate, precise and reliable data

▪ The Tobii TX300 Eye Tracker provides highly accurate and precise gaze position data under real life conditions and over wide gaze angles.

▪ Head movement compensation algorithms ensure high accuracy and precision when subjects are moving relative to the eye tracker.

▪ Advanced drift compensation maintains high accuracy and precision under varying light conditions.

▪ Robust tracking capability ensures very low data loss, regardless of subject's ethnic origin, age, if the subject wears glasses, contact lenses, mascara or has so-called "droopy" eyelids.

▪ Robust tracking capability also under ambient light conditions and during large and fast head movements.

▪ Very stable sampling rate allows for precise synchronization of gaze data with data from other sources, e.g. EEG systems.

▪ Effective binocular tracking allows for studies of individual eyes' movements.

▪ The raw data from the eye tracker contains information about pupil diameter size, which can be used to study pupil size changes over time.

The highly accurate and precise data enables detailed studies into minute eye movements and viewing behavior, and creates a solid foundation for reliable research results. The high tracking robustness allows you to work with a wide range of the population.

Ease of use

- Rapid, fully automatic calibration procedure, including flexible options for difficult subjects such as infants and low-attention subjects.
- Fully automatic tracking through simple commands.
- Simple set-up and installation on a large proportion of standard Windows computers.
- Software support for hardware configuration in studies using real-world stimuli.

Because it is easy to use, you can get results within a short time frame. A variety of researcher profiles, including students, can use the system without needing extensive training.

Tobii has developed a number of clearly distinguishable technological innovations that contribute to the very high quality data provided under varying conditions. Some of these innovations are presented below:

Physiological 3D Model

Tobii has developed a highly sophisticated 3D model describing the geometry and characteristics of the human eye. During the calibration phase of the eye tracking session, the Tobii TX300 customizes the 3D model by producing a set of parameters unique for each test subject. The model includes parameters such as size, shape, refraction and reflection properties of the cornea, lens and vitreous body, as well as both optical and visual axis of the eyes. It allows for accurately handling such situations as when the test subject moves away from the head position held during the calibration, or when the light in the room (and thus pupil size) has changed from the time of the calibration. This enables much more accurate compensation for head movements and pupil drift than when using less sophisticated gaze direction algorithms and methods.

Dual Sensor Technology

Tobii TX300 has dual image sensors that enable “3D vision” - truly accurate measurement of the distance from the eye tracking sensors to the subject’s eyes. Dual sensors enable accurate compensation for head movements and are also used for pupil size measurement compensations if the distance from subject to the sensors changes. The sensors provide two sets of data which can be used for gaze data calculations, leading to significantly improved precision and redundancy so that robust tracking can be maintained even if one sensor is occluded.

Precise Sensor Control

With Precise Sensor Control, the eye tracker processor interfaces very closely with the image sensor to carefully control and measure the exposure timing of the sensor, in order to obtain a perfectly consistent sampling rate and a perfectly accurate time-stamp of each eye data point. This enables accurate synchronization of eye tracking data to stimuli presentation and other data such as EEG.

High Quality Sensors

The Tobii TX300 utilizes customized versions of some of the highest quality image sensors available, with optimum light sensitivity and very high pixel resolution. This is critical to obtain very high precision in combination with tolerance for large head movements and high sampling rate.

Specification of Gaze Precision and Gaze Accuracy

Tobii has recently adopted a comprehensive method for gaze accuracy and precision measurements to facilitate performance comparisons of different remote eye tracking systems. This Tobii TX300 specification is a condensed version of the preliminary results from these measurements. In early 2011, final test results as well as a whitepaper containing a detailed description of the complete method, will be available.

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 typically 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").

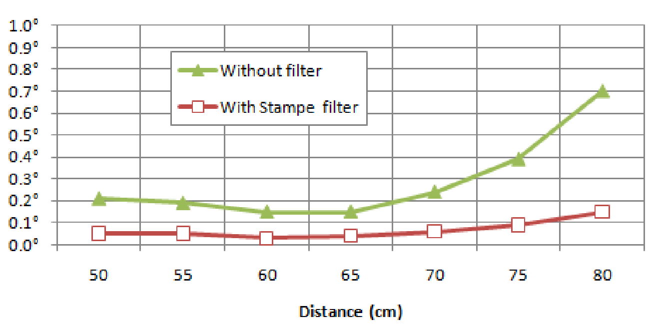
Gaze precision

Precision measurements are done using 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 300 Hz sampling rate and a distance of 65 cm (26"). Precision is calculated as root-mean-square (RMS) of successive samples.

	Monocular[1)]	Binocular[1)]
Precision with Stampe filter [2)]	0.06°	0.04°
Precision without filter [3)]	0.22°	0.15°

Precision at varying distances

Precision is dependent on distance from the eye tracker. The graph below illustrates precision results for different distances. Data shown is binocular.



1) *Monocular data shown is based on data from each eye individually. Binocular data is the average of the two eyes.*

2) *Stampe (Behavior Research Methods, Instruments & Computers 1993, 25 (2), 137-142) describes a noise reduction filter commonly used for eye tracking data. In these measurements, the Stampe stage 2 algorithm has been applied.*

3) *Raw data, without any noise reduction filters.*

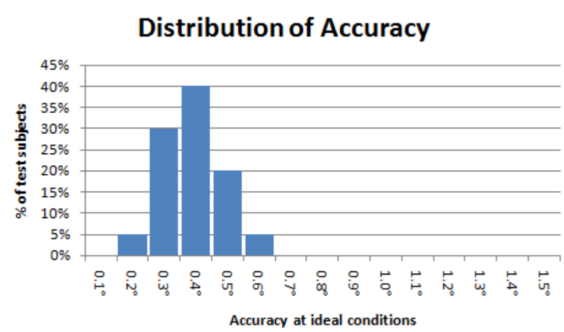
4) *Accuracy under ideal conditions is measured in the center of the head movement box with the subject fixed in a chinrest. Data is collected immediately after calibration, in a controlled laboratory environment with constant illumination, with 9 stimuli points at gaze angles <=18°. Measurements are done on 20 test subjects without lenses, glasses or droopy eyelids. Accuracy for one subject is calculated as the mean of several data samples for of all of the 9 stimuli points across a screen. The accuracy figure presented is the mean accuracy from all subjects.*

Gaze accuracy

Accuracy is straight-forward to measure under ideal conditions; with the test subject fixed in a chinrest in a carefully controlled lab environment. However, an important rationale for choosing a remote eye tracking system is to avoid chinrests and allow for more natural test scenarios.

The specifications below provide information on accuracy under various conditions that influence a non-restrictive eye tracking test, e.g. change of head position or light conditions after calibration.

	Monocular	Binocular
Accuracy under ideal conditions [4)]	0.5°	0.4°

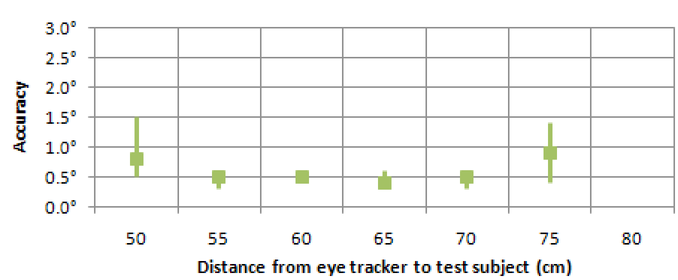


Accuracy at large gaze angles [5)]		
25° gaze angle	0.5°	0.4°
30° gaze angle	0.6°	0.5°

Accuracy at varying illumination [6)]		
1 lux	1.1°	0.9°
300 lux	0.5°	0.4°
600 lux	0.6°	0.4°
1000 lux	0.6°	0.5°
White stimuli background (300 lux)	0.8°	0.6°

Accuracy at varying distances [7)]

The bars show min, max and average accuracy for all test subjects at different distances from eye tracker to test subject.



5) *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 31° visual angle relative to the center of the eye tracker unit.*

6) *Illumination is measured in front of the respondents head in various directions. Then luminance of the stimuli or illumination in the lab changes, the size and shape of the pupil is affected. Unless compensated for, this may cause a significantly reduced accuracy.*

7) *Calibration is done with the subject in 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. Data shown in the graph is binocular.*

Specification of Tobii TX300 eye tracker unit

Sampling rate (binocular)	300 Hz
Sampling rate variability [1]	<0.3%
Processing latency [2]	1.0-3.3 ms
Total system latency[3]	<10 ms
Timestamp precision	
Via sync-out port [4]	<0.1 ms
As specified in each data sample [5]	Std dev 40 µs
Time to tracking recovery for blinks [6]	Immediate
Time to tracking recovery after lost tracking [6]	10-165 ms
Freedom of head movement at 65cm [7]	37 x 17 cm (15 x 7")
Operating distance eye tracker to subject	50-80 cm (20-31")
Max head movement speed [8]	50 cm/s (20"/s)
Max gaze angles	35 degrees
Tracking technique	Dark pupil
Data sample output *(for each eye)*	Timestamp Eye position Gaze point [9] Pupil diameter [10] Validity code [11]
Connectors	LAN *(TCP/IP - data samples)* 12 pin connector *(LVDS -sync-out port)* 3.5 mm audio plug *(audio in)*
Eye tracker processing unit	Embedded
Built-in speaker	3 W
Weight	6 kg
Size *(excl stand)*	55 x 24 x 6 cm (22 x 9 x 2")

Specification of Tobii TX300 screen unit

Screen size	23"
Aspect ratio	16:9
Screen resolution *(max)*	1920 X1080 pixels
Screen response time	typical 5 ms
Built-in web camera	640 x 480 @ 30 fps
Weight	4 Kg
Connectors	USB *(web camera)* DVI/VGA

Software options

The following software applications are compatible with the Tobii TX300:

- Tobii Studio 2.2
- Tobii Toolbox for MATLAB
- E-Prime Extensions for Tobii
- All other applications, built on the Tobii SDK[12]

Hardware package

The Tobii TX300 hardware package includes the following:

- Eye tracker unit
- Screen unit
- Digital angle gauge

1) *The deviation in sampling rate (defined by time of eye image exposure), also under non-optimal tracking conditions.*

2) *Processing latency describes the time required by the eye tracker processor to perform image processing and eye gaze computations.*

3) *The average duration from mid-point of the eye image exposure, to when a sample is available via the API on the client computer (assuming a dedicated Gigabit Ethernet connection). This includes half of image exposure time, plus image read-out and transfer time, processing time and time to transfer the data sample to the client computer.*

4) *The maximum temporal deviation of the signal on the sync-out port relative to the beginning of the actual exposure of the eye image.*

5) *The standard deviation of temporal deviation of timestamp precision in the data sample received by the client application. This includes any offset in the clock sync between the eye tracker processing unit and a typical client computer.*

6) *Describes the time it takes for the system to regain tracking after it has not detected the subject's eyes. For a short period of a few hundred ms, the system will regain tracking immediately, but only in the same approximate head position. This enables the system to re-acquire tracking instantly after blinks. Under normal tracking conditions, no samples are lost before, during or after blinks, other than samples that may be lost during the eyelid movement itself due to partial occlusion of the pupil. After a time period of a few hundred ms without detecting eyes, the system will instead start searching for the eyes in the head movement box, and will take the specified time to recover tracking. After about one minute, the system will enter a "slow search" mode which leads to larger recovery times.*

7) *Describes an area where at least one of the eyes is within the field of view of the eye tracker. Specified as width x height.*

8) *Describes the maximum head movement speed allowed while maintaining robust tracking. The specified number is for sideways head movements.*

9) *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.*

10) *Pupil diameter, with accurate algorithms to compensate for the spherical corneal magnification effect as well as the distance to the eye.*

11) *The validity code indicates the system's confidence in whether it has correctly identified which eye is left and right eye for the specific sample*

12) *At the Application Market for Tobii Eye Trackers (appmarket.tobii.com) a large number of applications, built and the Tobii SDK, can be searched for and downloaded.*

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