Tobii T60XL Eye Tracker

Widescreen eye tracking for psychology and neuroscience research

- **Present large and high resolution stimuli: separate objects in spatially-contingent paradigms, display HD video and more**
- **Tracks a wide range of subjects, regardless of ethnic background or age**
- **Accommodates large head movements**
- **Highly accurate and precise data**
- **Compatible with a broad selection of software applications**

Tobii T60XL Eye Tracker

Tobii T60XL Eye Tracker enables you to accurately and unobtrusively measure gaze over widescreen angles and large stimuli. Its high screen resolution also allows for studies of detailed stimuli. The system is suitable for a broad range of psychology and neuroscience research.

Widescreen for large stimulus display
Tobii T60XL Eye Tracker is integrated into a high resolution 24-inch 1920 x 1080 pixels widescreen monitor, and is designed for eye tracking research that requires a large stimuli display. It offers high quality tracking over widescreen gaze angles, and large stimulus such as multiple image objects, movies, and virtual environments. Its high screen resolution allows studies of detailed stimuli, such as facial features or text fonts.

Characterized by its unobtrusiveness, robust tracking capability, high accuracy and widescreen features, Tobii T60XL is suitable for a broad range of psychology and neuroscience research, including studies requiring large stimuli displays or involving peripheral vision. Psychology studies span the fields of cognitive, behavioral, social, emotional and experimental psychology.

Tobii T60XL is suitable for:

- Developmental research
- Psycholinguistics research, for instance language acquisition
- Social perception and interaction studies
- Scene perception and cognitive workload
- Neuroscience research, for instance anti-saccade tests
- Media perception research
- HCI research, including websites, video games, interactive television, and control panels
- Research of virtual environments
- Non-human primate research
- Eye-based computer interaction

The large head movement box, which allows test subjects to move naturally, makes the Tobii T60XL Eye Tracker particularly suited for research involving infants and children.

Freedom of movement makes the Tobii T60XL particularly suited for research that involves infants or children and the widescreen facilitates preferential looking paradigms.

Its widescreen enables automated preferential paradigms, and closely fills the test subject's field of view in a natural way.

A broad selection of research software applications are compatible with the Tobii T60XL, including Tobii Studio, Tobii Toolbox for Matlab, Presentation, and E-Prime Extensions for Tobii. These, and many more applications built with the Tobii Software Development Kit (Tobii SDK), can be found at the Application Market for Tobii Eye Trackers: appmarket.tobii. com.

Freedom of movement, unobtrusive

- Large head movement tolerance allows test subjects to move freely and naturally in front of the stimulus. If the subject moves out of the head movement box and then back into it, tracking is resumed almost instantly.
- All hardware, including the eye tracking technology, user camera and speakers, is integrated into an ordinary looking monitor so as not to distract the subject.
- Stable and reliable calibrations eliminate the need for recalibration during long sessions and can be reused for repeat sessions with the same subject.

The freedom of movement and unobtrusiveness allow subjects in behavioral studies to act naturally, thus ensuring research validity. It facilities research involving infants or children, and lengthy and accurate studies can be performed without subjects experiencing fatigue.

Accurate, precise and reliable

- Highly accurate and precise gaze-position data in real-life conditions and over widescreen angles.
- Head movement compensation algorithms ensure high accuracy and precision when subjects move 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 a subject's ethnic background or age. The system also tracks subjects, who use glasses, contact lenses or mascara, or have so-called "droopy" eyelids.
- Automatic selection of bright or dark pupil tracking.
- Robust tracking capability also in ambient light conditions and during large and fast head movements.
- Effective binocular tracking allows studies of individual eyes' movements.

Accurate and precise data creates a solid foundation for reliable research results. Robust tracking ensures very little loss of test subject data and allows you to work with a wide range of the population.

The high resolution widescreen is useful in HCI research involving large and detailed stimuli.

Accommodates short attention spans and does not require subjects to be restrained, which enables stress-free primate research studies.

"The Tobii T60XL Eye Tracker provided an ideal platform due to its large display area, and it coped admirably with the monkeys' occasionally erratic and unpredictable behaviour. The Tobii T60XL Eye Tracker proved to be easy to use, fast, and effective for data collection. For the first time, we were able to determine the exact focus of interest in these young macaques."

Dr Pier Ferrari, Assistant Professor, University of Parma.

Ease of use and automatic

- Fast and automatic calibration procedure, including flexible options for such difficult subjects as infants and low-attention subjects.
- Fully automatic tracking through simple commands.
- Simple setup and installation on a large proportion of standard Windows computers.

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 extensive training.

Tobii T60XL Eye Tracker is available for purchase or for rental.

"We have shown proof of principle with the T60XL Eye Tracker that studies involving young children are possible with only limited head restraint. Most other eye tracking systems are not child friendly, involving the user wearing a headset, etc, and it is unlikely that a child's eye movement behaviour would be 'normal' in such a situation."

Maggie Woodhouse, Senior Lecturer at the School of Optometry & Vision Sciences, Cardiff University

Tobii has developed a number of clearly distinguishable technological innovations that contribute to the superior performance of our eye trackers. Below are a few:

- TrueEye. Creates a unique physiological 3D model of each individual's eyes. Enables much more accurate compensation for head movements and pupil drift than any other product on the market.
- Dual Sensor Technology. "3D vision" using double image sensors enables an accurate measurement of the distance from the sensor to the user's eyes. Improves accuracy, precision, tracking robustness and contributes to the TrueEye model.
- High Quality Sensors. High resolution of each eye is critical to reduce noise and obtain good precision. High sensitivity is a prerequisite for a large track box.
- Precise Sensor Control. Contributes to high sampling rates, gives perfectly consistent sampling rates and an accurate timestamp of each data point.
- Embedded Processing. The eye tracker has its own dedicated processor and operating system integrated in the system. Because the system runs completely independent of computer and other software it is independent from, for instance, Windows upgrades.

Read more about Tobii's eye tracking technology at tobii.com.

Specification of Gaze Precision and Gaze Accuracy, Tobii T60XL

Tobii Technology has adopted a comprehensive method for gaze accuracy and precision measurements to facilitate performance comparisons of different remote eye tracking systems. This Tobii T60XL specification is a condensed version of the results from these measurements. The test specification and the complete test report for T60XL can be downloaded at 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. The 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.

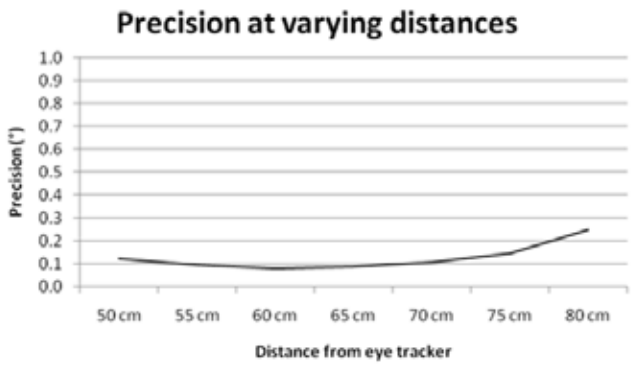
Gaze precision

Precision measurements are done using dark pupil[1)] 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 60 Hz sampling rate and a distance of 65 cm (26"). Precision is calculated as root-mean-square (RMS) of successive samples.

	Binocular [2)]	Monocular [2)]
Precision with raw data [3)]	0.09°	0.16°
Precision with Stampe filter 2 [4)]	0.03°	0.05°

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, based on two artificial eyes.

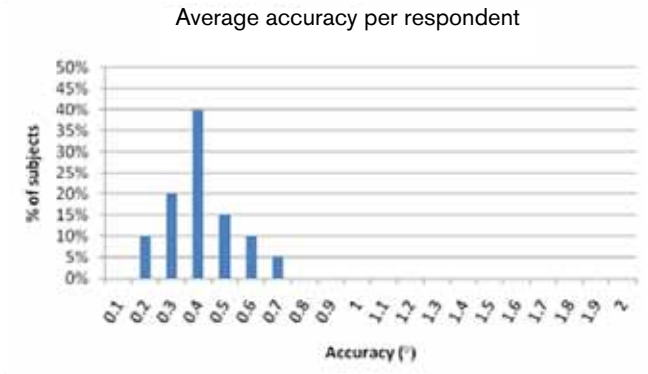


Gaze accuracy

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.

	Binocular	Monocular
Accuracy under ideal conditions [5)]	0.4°	0.6°

The graph below illustrates distribution of accuracy under ideal conditions for each subject. Data shown is binocular.

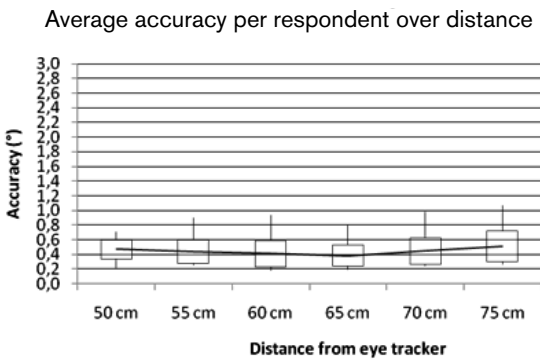


Accuracy with large gaze angles [6)]	Binocular	Monocular
25° gaze angle	0.5°	0.6°
30° gaze angle	0.4°	0.6°

Accuracy with varying illumination [7)]	Binocular	Monocular
1 lux	0.8°	0.9°
300 lux	0.4°	0.6°
600 lux	0.5°	0.6°
1000 lux	0.5°	0.7°
White stimuli background (300 lux)	0.5°	0.7°

Accuracy at varying distances [8)]

The diagram shows average accuracy for all test subjects at varying distances from eye tracker to subject. 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.



*) Please see the next page for footnotes and comments.

Specification of Tobii T60XL Eye Tracker

Sampling rate (binocular)	60 Hz
Processing latency [9]	< 17 ms
Freedom of head movement at 65 cm [10]	41 x 21 cm (16.1 x 8.3“)
Tracking technique	Bright/dark pupil tracking
Data sample output (for each eye)	Timestamp Eye position Gaze point [11] Pupil diameter [12] Validity code [13]
Connectors	LAN VGA DVI-D Power User camera Audio in
Eye tracker processing unit	Embedded
Speakers	Built in, 2 x 4W power
User camera [14]	Built in, frame rate 640 x 480@ 30 fps
Weight	13 kg (29 lbs)
Size (excl stand)	57.3 x 45 x 13cm (22.6 x 17.7 x 5.1“)
Size (incl stand, fully extended)	57.3 x 57.9 x 28.1cm (22.6 x 22.8 x 11.1“)
Screen size	24”
Aspect ratio	16:10
Screen resolution (max)	1920 x 1200 pixels
Response time	Typically 4 ms

Software options

The following software applications are compatible with the Tobii T60XL:

- Tobii Studio
- Tobii Toolbox for MATLAB
- E-Prime Extensions for Tobii
- All other applications, built on the Tobii SDK [15]

1) Because the Tobii T60 XL 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.

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) Raw data from the SDK after individual calibration, without any noise reduction filters.

4) 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.

5) 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.

6) 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.

7) The luminance of the stimuli and the illumination in the lab are manipulated in order to reveal accuracy effects of pupil dilation and varying surrounding light effects.

8) 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.

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

10) 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.

11) 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.

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

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

14) Note that this is a built in web camera to record video of the user, not the eye tracking camera.

15) The Application Market for Tobii Eye Trackers (appmarket.tobii.com) has many applications that build on Tobii SDK 2.4.X and 3.0 that you can search for and download.

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