Tobii Pro VR Analytics
User's Manual

tobii pro

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1. Introduction

Tobii Pro VR Analytics is an analysis software tool that integrates into new or existing Unity environments. This software enables the collection and playback of eye tracking data using new or existing Unity environments. It provides analysis on a range of human behaviors, including automated visualizations and analytics for interaction, navigation, and eye tracking data. Playback and analytics are available for both individual and combined, multi-participant sessions. The automated statistics ensure the rapid availability of results after recordings are complete.

Tobii Pro VR Analytics supports most Unity3D environments. Its gaze-based functionalities require the **Tobii Pro VR Integration – based on HTC Vive**, an HTC Vive headset with integrated eye-tracking.

Use Tobii Pro VR Analytics for:

- market research
- human behavior research
- wayfinding
- training and performance optimization
- education
- medical research and testing
- automotive development
- design and architecture
- UX and interface design

1.1. How Tobii Pro VR Analytics is structured

Tobii Pro VR Analytics is delivered as a downloadable package containing the Pro VR Analytics Unity package and documentation. The Unity package needs to be integrated into a Unity project via the Unity editor. To perform the integration there is a separate Pro VR Analytics - Integration Manual that can be found in the downloaded package. When integrated into a Unity environment the recording, replay and analysis is performed within the resulting executable file.

1.2. The Record module

The Record module is where recordings with Pro VR Analytics are made. The module enables you to calibrate the eye tracker, setup participant info and control the recording process.

1.3. The Replay module

The Replay module provides analysis tools that enable you to replay, visualize, interpret and export the data you have collected.

1.4. How to read this manual

The manual assumes that you have a Tobii Pro VR Analytics enabled Unity environment and a Tobii Eye Tracking enabled VR headset that is compatible.

The actions are grouped by the software module in which they are performed. This also means that, if you have questions about how to use the different modules, check the appropriate manual sections for the answers, i.e. Make recordings for the recording, and Analyze data for replay.

Some of the features in the Tobii Pro VR Analytics enabled Unity environment can only be configured when integrating the Pro VR Analytics Unity package in the environment via the Unity editor. These are marked with the symbol below and provides information on what can be changed. It can also be use to show other important notes.

This symbol and following text will show important notes, for example features that can only be configured when integrating the Pro VR Analytics Unity Package in the environment.

If you want to reconfigure such feature, please read the Pro VR Analytics - Integration Manual. The nature of these features highlights the importance of understanding how the research will be carried out before integrating the Unity package.

In the manual there are also some best practice information that can help you to perform your research successfully. These are noted by the following symbol.

This symbol and following text provide best practice information to help you in your research.

2. Install and Update Pro VR Analytics

The objective of this chapter is to describe how to enable Pro VR Analytics in a Unity environment and upgrade to latest version.

2.1. Enabling Pro VR Analytics

Pro VR Analytics is a plug-in solution and not a standalone software. It is delivered as a downloadable folder that contains documentation and the Pro VR Analytics Unity package. To enable Pro VR Analytics in a Unity environment the Unity package needs to be imported and integrated into the Unity project, using the Unity editor. The Pro VR Analytics – Integration Manual and other supporting documents can be found in the downloaded folder or online at www.tobiipro.com.

When the Pro VR Analytics Unity package has been integrated into a Unity project and compiled there will be an executable file. This executable file is a Pro VR Analytics enabled version of the Unity environment and can be used to record, replay and analyze eye tracking data and behavior. For optimal performance make sure that the computer fulfills the requirements to run the virtual world and system.

2.2. Licenses

Each Pro VR Analytics license gives the right to record data with one specific VR headset. This headset is defined prior delivery of the software and the license key is included as part of the Pro VR Analytics Unity package. New recordings can be performed on any compatible computer. If there is a need to change recording headset, please contact Tobii Pro Support.

2.3. Upgrade Pro VR Analytics

From time to time, Tobii Pro will release upgrades for Pro VR Analytics that will improve its performance and/or introduce new functionality. When a new version is available there will be communication sent to the user. Please notice that to receive the latest version in the Unity environment the latest Unity package needs to be integrated and the environment recompiled. Instructions for how to upgrade can be found in the Pro VR Analytics - Integration Manual.

With the release notes of the upgrade it will be stated if it is possible to move recordings made with the earlier version of Pro VR Analytics to the new.

3. Manage projects

With Pro VR Analytics each Unity project, environment, will be available as separate Unity executable file. This section explains how to open and close an environment and how to handle files.

3.1. Folder structure

An environment that has been integrated with Pro VR Analytics has the folder structure depicted here. The name of the executable file is the environment name. In this example, the environment is called "Apartment". The folders can be placed anywhere in your PC.

📁 Apartment_Data
📁 MonoBleedingEdge
◁ Apartment.exe
◁ UnityCrashHandler64.exe
▣ UnityPlayer.dll
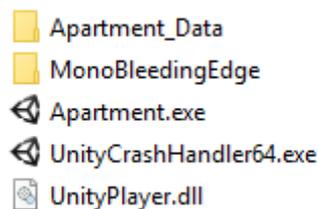
Figure 1. Folder structure of the projects

3.2. Opening an environment

1. Launch the environment by clicking on the .exe file in the folder structure. In the example above, click Apartment.exe.
2. The environment starts in one of two ways:
   a. The environment loads in full-screen or windowed mode depending on its configuration.
   b. Or, a configuration dialog screen appears. Launch the environment by clicking "Play!"

All the recordings and data are automatically saved in the folder structure and will be available when you open the executable after making recordings.

3.3. Exporting and importing recordings

Recordings can be moved between different computers if it is between the same version of the environment. For example, if you have made recordings on several computers, you can merge them to one computer for analysis. Note that changes in the environment made between recordings may prevent merging.

Export recordings to the same environment on another PC with the following procedure:

1. Open the environment folder.
2. Open the Data folder (commonly having the environment's name appended by _Data). In the example in 3.1, the data folder is called Apartment_Data.
3. Open the Recordings folder.
4. Recording files are stored in a JSON format. Select the desired recording files.
5. Copy the selected files to the same folder on the destination PC. The transferred recordings will then show up when opening the executable.

3.4. Deleting recordings

To delete recordings, go to the environment folder (described in chapter 3.1), find recording data and delete them.

Delete recordings with the following procedure:

1. Open the environment folder.
2. Open the Data folder (commonly having the environment's name appended by _Data). In the example in 3.1, the data folder is called Apartment_Data.
3. Open the Recordings folder.
4. Recording files are stored in a JSON format. Select the recording files to delete and delete.

When you delete a recording file in the Recordings folder, it is permanently erased. Therefore, always make a backup of the folder before deleting a file if there is a chance it is needed again.

3.5. Backing up environments

It is recommended that you keep a backup of your project.

1. Keep a backup of the Unity project before integrating the Pro VR Analytics Unity package
2. Keep a backup of the environment that has been integrated with Pro VR Analytics
3. Keep a backup of the recorded data files

4. Make recordings

This section describes how you record a participant's activities in an environment. Here are a few pertinent points:

• Tobii Pro VR Analytics has two modes: Replay and Record. An environment always opens in Record mode.

• When Recording mode is active, the environment appears in real-time in the headset. The participant may move in the environment already at this stage, before the start of the actual recording.

4.1. Preparing for a recording

Make sure that the VR headset that is going to be used is up and running. If not already set up, please read Appendix A for a detailed setup guide of the Tobii Pro VR Integration – based on HTC Vive.

Before starting a recording, go through this checklist.

1. Set a starting point or orientation in the environment
2. Adjust live gaze point settings
3. Run a calibration
4. Verify accuracy
5. Instruct the participant what to do

> If the participant is new to virtual reality it can be good to give the participant a few minutes to get familiar with the headset and equipment by exploring another environment. That way they can be more focused on the research task when recording starts.

4.1.1. Set a starting point or orientation

Each environment has a pre-programmed default starting position that you cannot alter. However, a participant can move elsewhere in the environment before the start of the recording.

> Note that the default starting position is set in the Unity editor and can be changed before building the executable, in the integration phase.

4.1.2. Live gaze point settings

The live view with gaze point appears when Recording mode is active and the eye tracker is tracking. As default it only shows on the moderator screen. If you want the gaze point to also appear in the VR headset (for demo purposes for instance), you can toggle it on with the HMD Gaze button in the user interface or by pressing Z on the keyboard. When conducting your study, the gaze point in the VR headset should be turned off. If desired, scale the size of the gaze point with the Gaze Point Size slider.

4.1.3. Calibration

To ensure the best possible eye tracking data, a calibration should be performed for every new participant before data collection has begun.

Calibrate a participant by using the following procedure:

1. Make sure the headset is well positioned on the head. Ask the participant to position it where the graphics appear the sharpest, then it is placed correctly. It can be necessary to adjust the distance between the lenses to match the personal inter pupillary distance.
2. Start the calibration by pressing the "Calibrate" button in the lower control bar. A moving purple dot appears on the screen and in the headset. Instruct the participant to look at the dot during the calibration.
3. Tobii Pro VR Analytics signals a successful calibration by "Calibration succeeded".
4. If the calibration fails, rerun the procedure.
5. Verify the calibration's accuracy by asking the participant to focus on a few distinct points in the environment. If there is a clear offset, rerun the procedure.

4.1.4. Instructing the participant

Explain the tasks at hand to the participants. Ensure that the participant does not look at any areas of interest before the start of the recording. This is particularly important if you plan to measure their initial natural attention to such areas.

4.2. Starting recording

Start a recording by clicking the New Recording button in the Record control bar. A dialog titled New Recording appears. Enter the name of the recording and the gender of the participant and click Record.
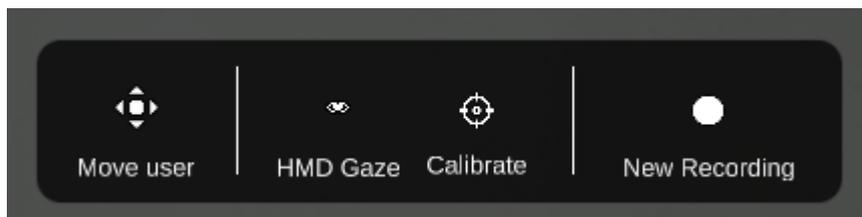

Figure 2. The recording control bar located at the bottom of the application window in Record mode.

4.2.1. Enter recording information

Enter a distinguishing name in the Recording Name field. Avoid long names, name duplicates and empty names. If the name field is left empty or contains a duplicate, you will get a validation message stating that the name cannot be empty or a duplicate.

Select the participant's gender. That determines the color of the avatar head in replay mode: green for females and purple for males.

4.3. Stop recording

Stop a recording by clicking the stop button in the Record control bar as illustrated in Figure 3 below. Recordings are automatically saved. A new recording can be started instantly.
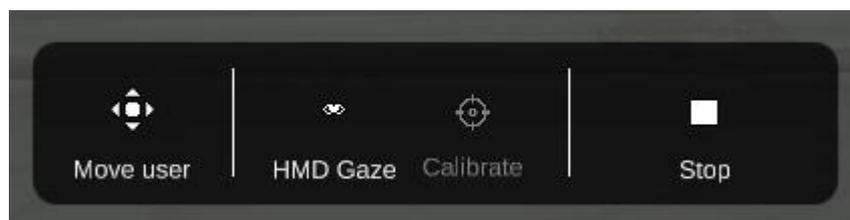
Figure 3. The recording control bar with stop button.

During analysis, the software aligns the starting points of the analyzed recordings. Therefore, make sure that all recordings use the same starting points.

4.4. How to move around in the VR world

Pro VR Analytics by default supports a set of navigation methods. Which is implemented in your environment depends on what was chosen in the integration phase. The options to move around in the VR world provided are:

- Walk inside the VR environment using the room tracking system.

- Teleport by pointing the Vive Controller in the desired direction and pressing the trackpad with your thumb. A green ray and dot appear. Put the dot in the desired location and release your thumb to teleport there.

- Glide by pressing the trackpad on the Vive Controller.

If you have other navigation needs, you can use your own navigation implementation. The analytic features in Pro VR Analytics supports all navigation methods that Unity supports.

⚠️ Note that the navigation methods available in an environment are set in the integration phase. If another method is desired, go back to Integration phase, change method and rebuild the environment.

4.5. Keyboard shortcuts in record mode

If desired there are some keyboard shortcuts that can be used to control the software:

Shortcuts in record mode

- C: calibrate
- S: start/stop recording
- U: toggle hide/display user interface elements
- Z: toggle Gaze point

5. Analyze data

To analyze the recordings with replay, visualizations and metrics, the Replay mode is used. Here it is explained how to use the mode.

5.1. Replay recordings

To open the Replay mode, you click the Replay tab in the top control bar.

5.1.1. Loading recordings to replay
1. When entering Replay mode, a window with all available recordings appear.
2. Select desired recordings by clicking their checkboxes.
3. Load the selected recordings by clicking the Load button.
4. If you later wish to load another selection of recordings, click the Load recordings button in the window's top control bar.

💡 The Fixation threshold is set to a default value defined by research. Please read Appendix B that explains how the Fixation filter works to understand if your use case is suitable for another value. If you wish to change the fixation threshold, do it before loading the recordings as the metrics are calculated based on the value when recording were loaded.

Figure 4. Select recordings to replay and click Load.

If you wish to see the participants' interactions with the environment, select and load a single recording. When you select multiple recordings, replaying will not display interactions, although visualizations and metrics still show what objects the participants interacted with.

Mode-switching resets the environment and unloads the recordings. When entering Replay mode after being in Record mode you need to reload the recordings you intend to use.

All recorded data is pre-loaded when entering the Replay mode which enables real time analysis. The loading time will increase with the size of the project and numbers of recordings.

5.1.2. Replay control

Once recordings are loaded, they can be controlled using the Replay controls in the Replay control bar.

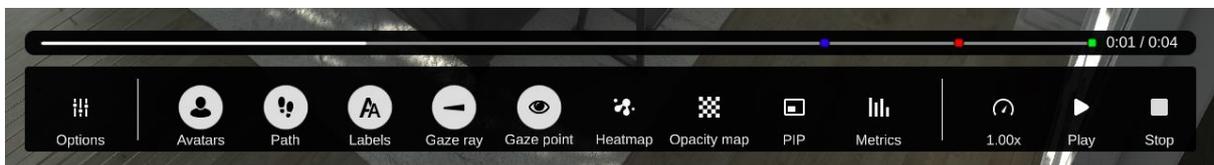*Figure 5. The replay control bar located at the bottom of the application window in Replay mode.*

- Start replaying selected recordings by clicking the Play button or pressing the space bar.
- Stop replaying by clicking the Pause button or pressing the space bar.
- Skip to a specific point in the recording by clicking in the timeline. Colored markers indicate the end of individual recordings.

- Change playback speed with the speed slider. Changing the replay speed only affects the speed of the avatars, paths, labels, gaze rays and gaze points. Thus, a replay speed change will not change the speed of animated objects in the scene that do not belong to Tobii Pro VR Analytics.

5.1.3. Replay camera options

Replay can be done from different camera positions or first-person camera. When you activate replay for a recording, it opens in first-person view (FPV) for an avatar. Use the drop-down menu in the view control shown in Figure 6 to switch between recordings. To change perspective and view the loaded recordings from a camera in the 3D world, select the camera (Cam) option in the view control. Then select camera in the dropdown. The available cameras are those that were added in the Integration phase of Pro VR Analytics.

Figure 6. View control with the camera called Living Room selected.

Note that the different camera options under "Cam" are added in the Integration phase. If it is needed to add or change camera positions, go back to Integration phase, add the cameras and rebuild the environment. If nothing else has changed in the environment, recordings can be moved to the new environment. Check section 2.7 for how to export and import data.

In the bottom replay control bar there is an option to activate a Picture-in-Picture (PIP) mode. This will make a screen visible in the bottom left corner.
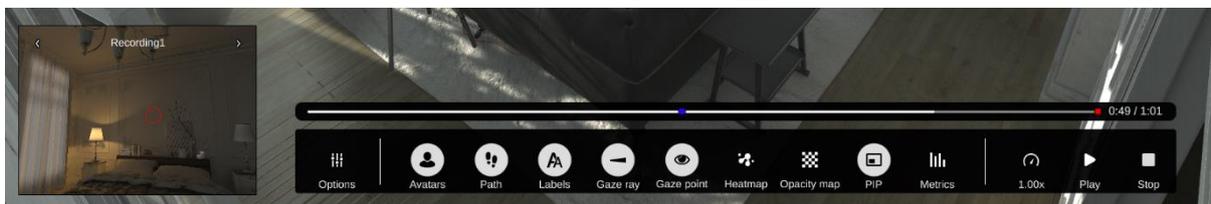

Figure 7. Picture-in-picture (PIP) window in bottom left corner of the screen.

The PIP window displays a first-person view and can be used, for example, to crosscheck the first-person view with an overview camera view on the main screen.

- Display or hide the PIP window by toggling the PIP button in the button replay control bar.
- Switch between recordings in the PIP window by clicking the left/right arrows at the top of the PIP window.

5.1.4. Replay visualizations

In replay mode there are several replay visualizations available on your screen. Depending on what is interesting to analyze different visualizations can be used. All visualizations will be shown or built up in real time. For example, the heatmap will build up in real time and to achieve the full session heatmap go to the end of the timeline.
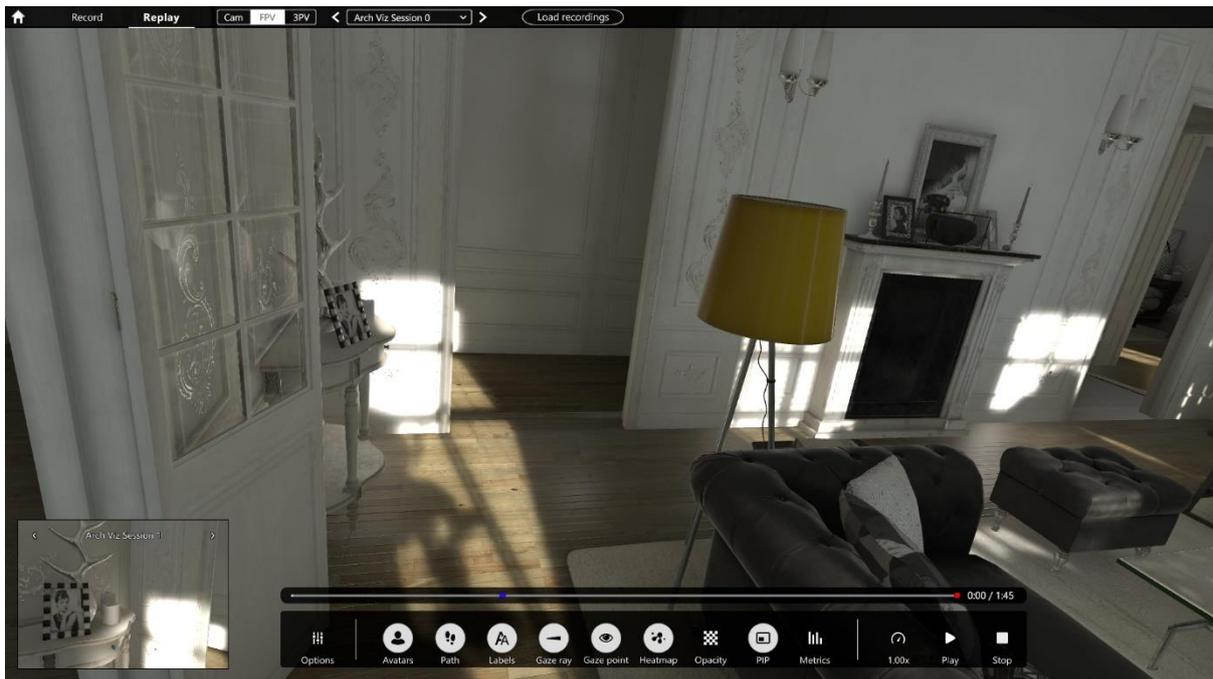
Figure 8. Replay control bar containing replay visualizations.

The different replay visualizations are togglable in the bottom replay control bar showed in Figure 8. The available visualizations are:

- Avatars – when activated, a participant is represented in the environment as a 3D floating head. Each recording is automatically assigned a unique color that cannot be changed, green for females and purple for males.
- Path – when activated, a participant's path through the environment is depicted as a series of arrows whose shapes and sizes indicate movement and duration, the larger the arrow the longer the participant stayed at that location.
- Labels – when activated, recording name is displayed above the avatar.
- Gaze ray – when activated, a line is displayed between an avatar's eyes and focus of attention.
- Gaze point – when activated, a circle is displayed at the point where the participant is looking.
- Heatmap – when activated, a heatmap showing the attention distribution in the environment is shown. The heatmap is shown for all participants.
- Opacity – when activated, an opacity map is shown in the environment. The opacity map show areas not seen (low opacity) and seen (fully visible).

5.2. Keyboard shortcuts in replay

If desired there are some keyboard shortcuts that can be used to control the software:

Shortcuts in replay mode

- A: toggle Avatars on/off
- P: toggle Path
- L: toggle Labels

- R: toggle Gaze Ray
- Z: toggle Gaze point
- H: toggle Heat map
- O: toggle Opacity map
- U: toggle hide/display user interface elements
- Space: play/pause
- Left/right arrow keys: forward/rewind

5.3. Metrics

Metrics is used to analyze behavior at an aggregate level and to get insights into how much attention is paid to specific VR assets (objects or surfaces) in the tested environment.

5.3.1. How metrics are calculated

Pro VR Analytics leverages the asset data that is in the Unity environment to automatically calculate metrics. Metrics are calculated for all VR assets in the environment automatically and uses their native name when displaying them. The metrics are calculated for the entire VR assets and it is not possible to add new objects of interest or change the names in the executable file.

To understand how the Fixation filter works, see Appendix B.

⚠️ Note that names of the VR assets can only be changed in the Integration phase. To change a name, go back to the Integration phase and change it. If nothing else has changed in the environment, recordings can be moved to the new environment. Check section 2.7 for how to export and import data.

5.3.2. Select metrics to display

1. As you enter Replay mode, a dialog appears where you select recordings to load.
2. Select the desired recordings by clicking their checkboxes.
3. Load the selected recordings by clicking the Load button.
4. Load a different selection of recordings by clicking the Load recordings button at the top menu bar.
5. Open the Metrics window by clicking the Metrics button in the bottom Replay control bar. A window with a list of objects of interest appears.
6. Load the desired metrics for the selected recordings by clicking the name of the object of interest.
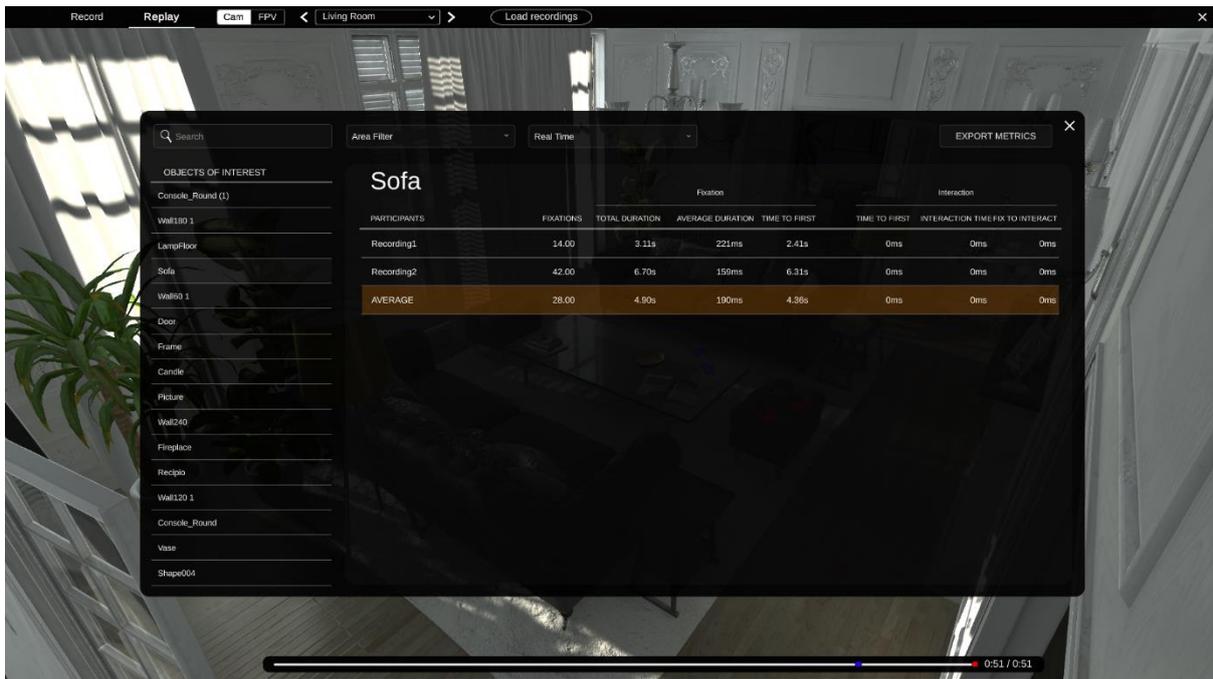
Figure 9. Metrics window with the Object of Interest named "Sofa" selected.

5.3.3. Real-time and Total metrics

There are two options for displaying Metrics, selectable in the top bar of the Metrics window: Real Time or Total. The Objects of Interest list, displayed to the left in the Metrics window, only shows VR assets that have received data. If a VR asset is not on the list it has not received gaze or interaction data.

Real Time: When you use the Real Time setting, metrics get displayed up to the point on the timeline you currently are at. For example, if you set the timeline marker to 10 seconds and pause the replay, the metrics for the first ten seconds of the recordings are shown. If you replay the recordings, the metrics updates continuously. You can play, pause and rewind the replay while checking the metrics. The Objects of interest list shows is populated with VR assets as they get noticed by the participants.

Total: The Total setting displays the complete data set of the selected recordings. All fixated Objects of interest appear, regardless of position in the time line. Keep in mind that if your recordings have very different durations, you might get flawed averages.

5.3.4. Filtering objects of interest for metrics

When you study an environment with many objects of interest, you can filter which ones to display by entering their keywords in the top left box in the metrics window.

You can also use the pre-programmed area filters that are listed in the Area Filters dropdown menu. The Area Filters are implemented in the Integration phase and can only be added or adjusted there. An area could for example be a section of an environment, such as a room, or objects of a certain character.

⚠️ Note that Area filters can be added or adjusted only in the Integration phase. Go back to the Integration phase and add according to the Pro VR Analytics - Integration Manual. If nothing else has changed in the environment, recordings can be moved to the new environment. Check section 2.7 for how to export and import data.

5.3.5. Exporting metrics

To export the metrics data for further analysis, click the "Export Metrics" button in the metrics window. This will export all the metrics from the recording that have been loaded. The export always includes the data for the entire recording.

5.3.6. Understanding the metrics

The raw data coming from the eye tracker can be classified into relevant eye movements. In Tobii Pro VR Analytics, this is done with a fixation filter, see Appendix B. Fixations are those times when our eyes essentially stop scanning about the scene, holding the central foveal vision in place so that the visual system can take in detailed information about what is being looked at. The metrics available for export are defined as shown in the table below.

Metric name	Description	Format
Fixation count	The number of fixations on the object of interest.	Number
Fixation duration – Total	The total time the participant has fixated on the object of interest.	Milliseconds
Fixation duration – Average	The average time the participant has fixated on the object of interest.	Milliseconds
Time to first fixation	The time it takes from the start of the recording until the participant fixates on the object of interest.	Milliseconds
Interaction count	The number of times the participant has interacted with the object of interest. Note that this metric is only available in the exported csv file.	Number
Time to first interaction	The time it takes from the start of the recording until the participant interacts with the object of interest for the first time.	Milliseconds
Interaction time	The total time the participant interacts with the object of interest.	Milliseconds
Fixation to Interaction	The time it takes for the participant from fixating on the object of interest for the first time until the participant interacts with the object for the first time.	Milliseconds

5.4. Exporting videos and visualizations

If you want to export videos or visualizations from Pro VR Analytics you can do that by using a 3rd party screen capture software. Replay the visualization that you desire to export while recording or capturing the screen.

5.4.1. Saving a visualization

1. Pause the replay at the desired point.
2. Unselect all visualizations that are not desired to show in the video or image
3. If desired, hide the user interface by pressing U on the keyboard
4. Save the visualization by using the 3rd party screen capturing software.

Appendix A. Setting up your Tobii HTC Vive HMD

This section outlines how to setup your Tobii HTC Vive HMD headset connected to a VR-ready PC to have it ready for is.

HTC's Instructions for the Vive headset

HTC provides information on how to install and set up the Vive headset:

- The installation instructions are available here:
  https://support.steampowered.com/steamvr/HTC_Vive/
- A Vive setup instruction video is available on YouTube:
  https://www.youtube.com/channel/UCiw1w2kYUHWQOkWIZbMqcaQ/

Virtual Reality and your hardware

An immersive VR experience calls for a computer that meets certain system requirements. Check that your computer is VR-ready by using the Steam VR Performance Test at: https://store.steampowered.com/app/323910/SteamVR_Performance_Test/

Making new recordings with Pro VR Analytics calls for a computer that is VR-Ready. However, replay and analysis put less stringent demands on your computer, mainly determined by the complexity of the analyzed environment, such as its size, shading and level of photorealism.

Make sure that your computer utilizes a high-performance power setting and that Tobii Pro VR Analytics runs from the computer's dedicated graphics card and not from its regular processor card. Headset and external monitors must also be connected to the dedicated graphics card.

If your computer has trouble running an environment, check whether you can select a lower graphics setting for it at launch.

Setting Up the Headset

In brief, this is how you get started:

1. Download the Tobii Core Software for VR: http://developer.tobii.com/?wpdmdl=205. It contains the drivers required for running the VR eye tracker.
2. Download and install Steam from the Steam website: https://store.steampowered.com/about/
3. Start Steam.
4. Set up Steam VR by clicking the VR icon in the user interface.
5. Connect your Pro VR Integration headset according to the instructions in Steam VR and set up your lighthouses and hand controllers.

Appendix B. How the fixation filter works

While recording, Tobii Pro VR Analytics collects time-stamped data points, each of which contains the following:

- The position of the research participant in the 3D world
- The gaze position in world space
- The gaze position in object/local space

Tobii Pro VR Analytics then uses a dispersion filter (ID-T) to group the collected data points into fixations. Fixations are those times when our eyes essentially stop scanning about the scene, holding the central foveal vision in place so that the visual system can take in detailed information about what is being looked at. The dispersion filter identifies fixations as spatially dense clusters of gaze positions over a continuous time period.

This fixation filter requires three parameters:

- Dispersion threshold: The maximum allowed angle between two gaze points for both to be considered part of the same fixation.
- Minimum fixation duration: The minimum duration required for a series of gaze points to constitute a fixation.
- Max allowed gap: The maximum allowed time between two consecutive data points for both to be considered part of the same fixation.

The basic idea behind the dispersion filter's algorithm is that if the angle between two gaze points is within the set maximum value (dispersion threshold), then they are allocated to the same fixation.

The dispersion filter is in its core based on the algorithm described by Widdel (1984). Widdel tested the algorithm using 0.5--3.0 degrees of dispersion and used a 200 ms temporal threshold. This algorithm was later popularized by Salvucci & Goldberg (2000) under the name Identification by Dispersion Threshold (I-DT), and they noted a dispersion range of 0.5--1.0 degrees, and a minimum fixation duration of 100--200 ms. Although it is unclear what exact combination of thresholds are optimal, Blignaut (2009) suggests 1.0 degrees as a reasonable dispersion threshold. Regarding the minimum fixation duration, although 100 ms is a common choice, other researchers have argued for lower thresholds (Nyström & Holmqvist, 2010: 40 ms; Andersson et al., 2017: 55 ms).

Our fixation algorithm uses a dispersion threshold of 1.0 degrees, a default minimum fixation duration of 60 ms and a max allowed gap of 75 ms, as suggested by Komogortsev [6].

The user can change the minimum fixation duration in the "Select recordings to load" dialog illustrated in the figure below. Depending on if you are interested in all fixations or if you want to separate engagement from scanning/involuntary attention, you might want to use different values for the minimum fixation duration. As suggested in the text above, the value should be between 40 and 200 ms.
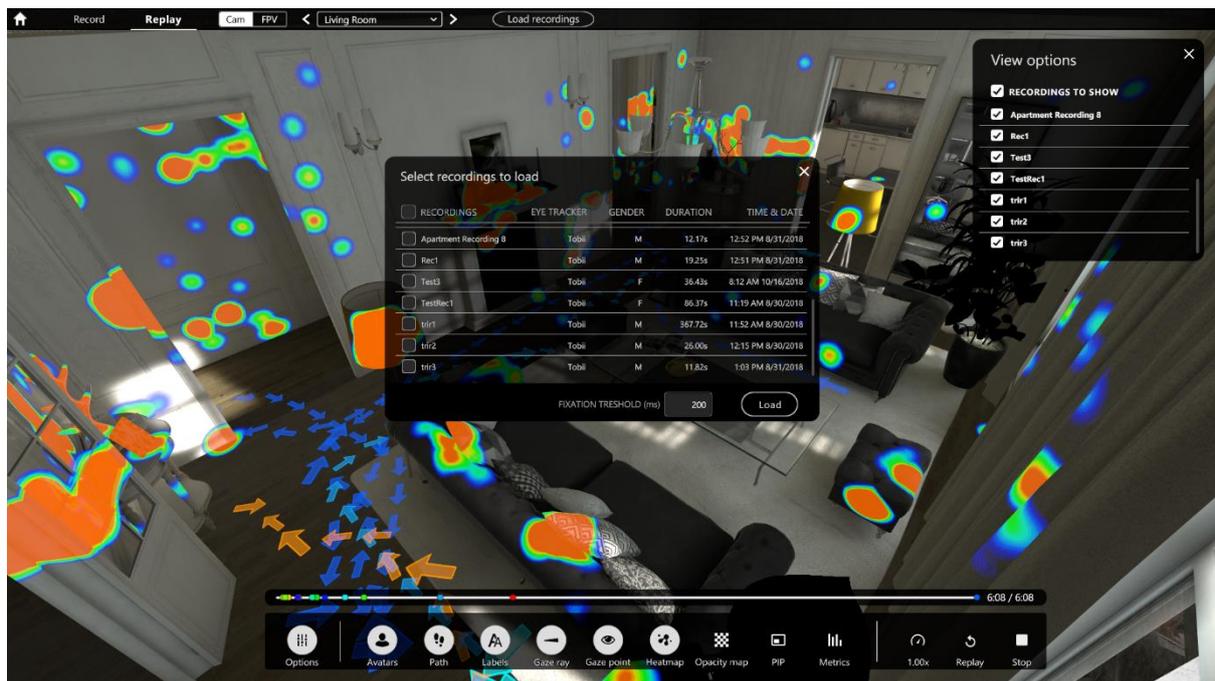
The fixation threshold can be set by the user at the bottom of the "Select recordings to load" dialog.

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