



# **EyeLink® 1000 Plus Installation and Training**

***SR Research Ltd.***

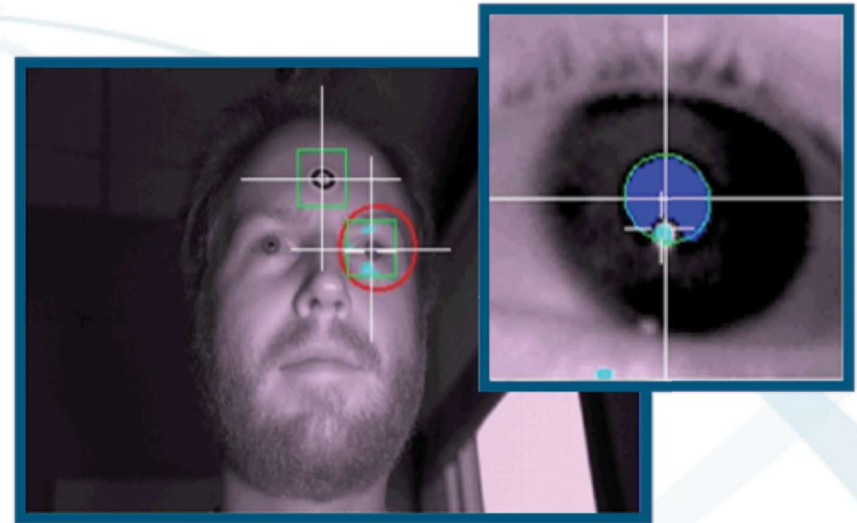
***Toronto / Ottawa, Canada***

# Agenda

- Video-based eye tracking
- The EyeLink Platform
- EyeLink Components
- Terms and Specifications
- System Components
  - Display PC
  - Display API
  - Host PC
- Camera Setup
  - Calibration
  - Validation
- EyeLink Data Structure

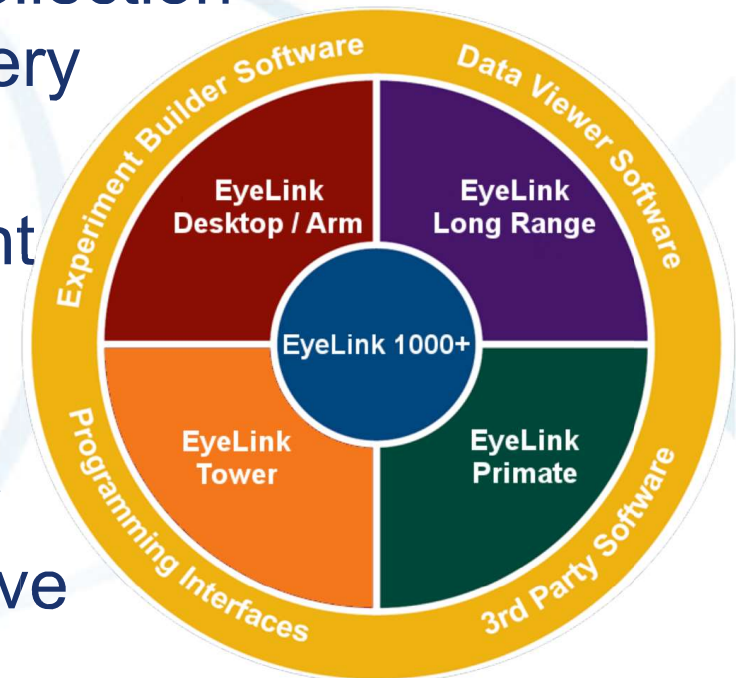
# Video-Based Eye Tracking

- IR camera and illuminator
  - Minimal interference with visual stimulus
- High speed video Image analysis
  - Determine centers of dark pupil and corneal reflection
- Calibration yields predictive model
  - Sample camera image while subject fixates several known locations
  - Induce predictive model



# EyeLink Platform

- Focal Imaging Technology (FIT)
  - Point, focus and track camera
  - Real-time host computer for data collection
  - Display computer for stimulus delivery
- One camera, many mounts
  - Desktop, Tower, Primate, Arm Mount
  - Long range variants for MEG/MRI
- Multiple modes of operation
  - High-precision monocular/binocular
  - Remote mode with head free to move
- Unified software
  - Host eye tracker application
  - Application Programming Interface





# EyeLink Long Range Mount

Camera Head

Infrared Illuminator with Focusing Lens

Camera Lens



Different lenses (75mm, 50mm, 35mm) for  
Different distances (overall range: 60-150cm).



# Long Range Screen Mount

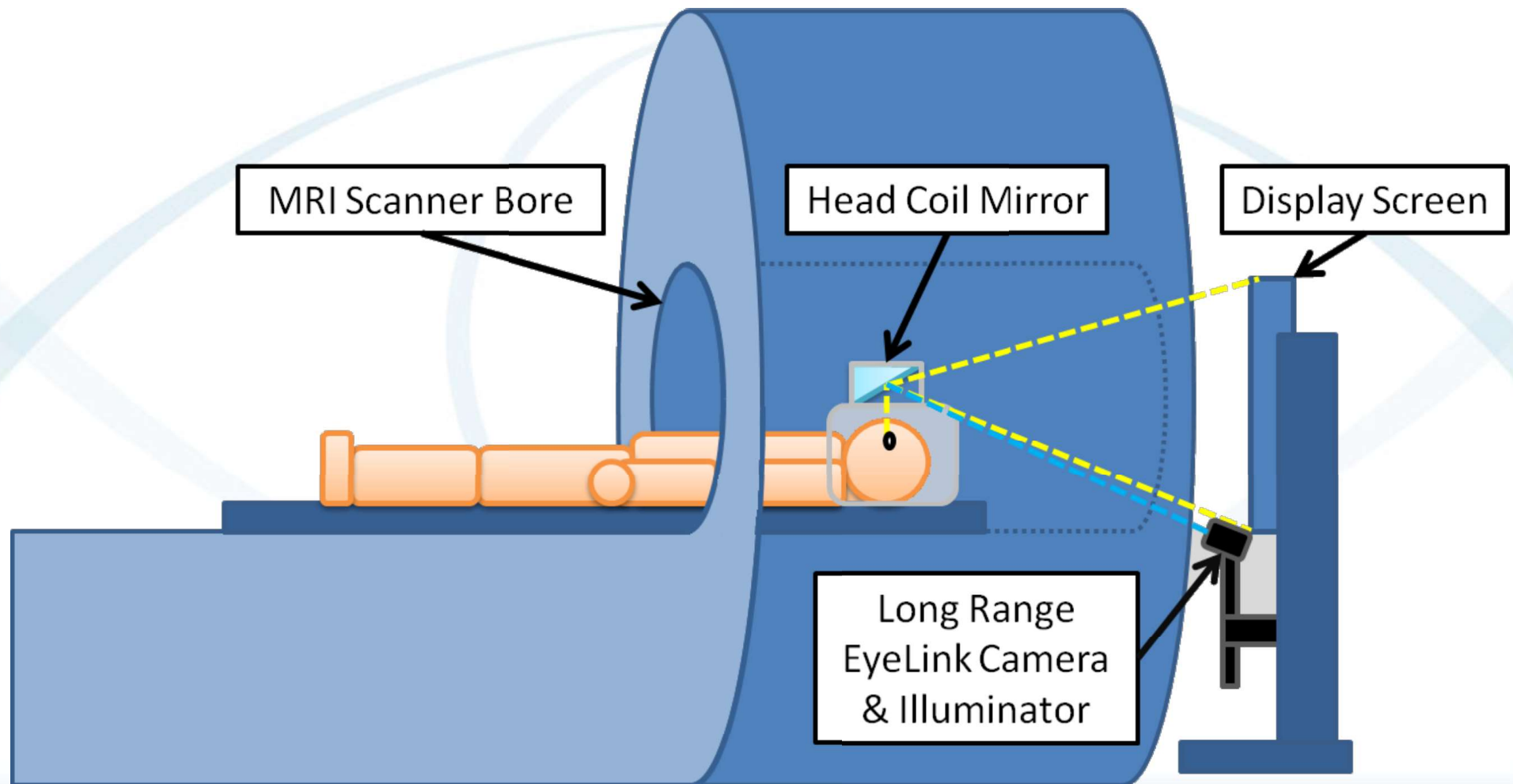


# MRI Head Coil Mirror

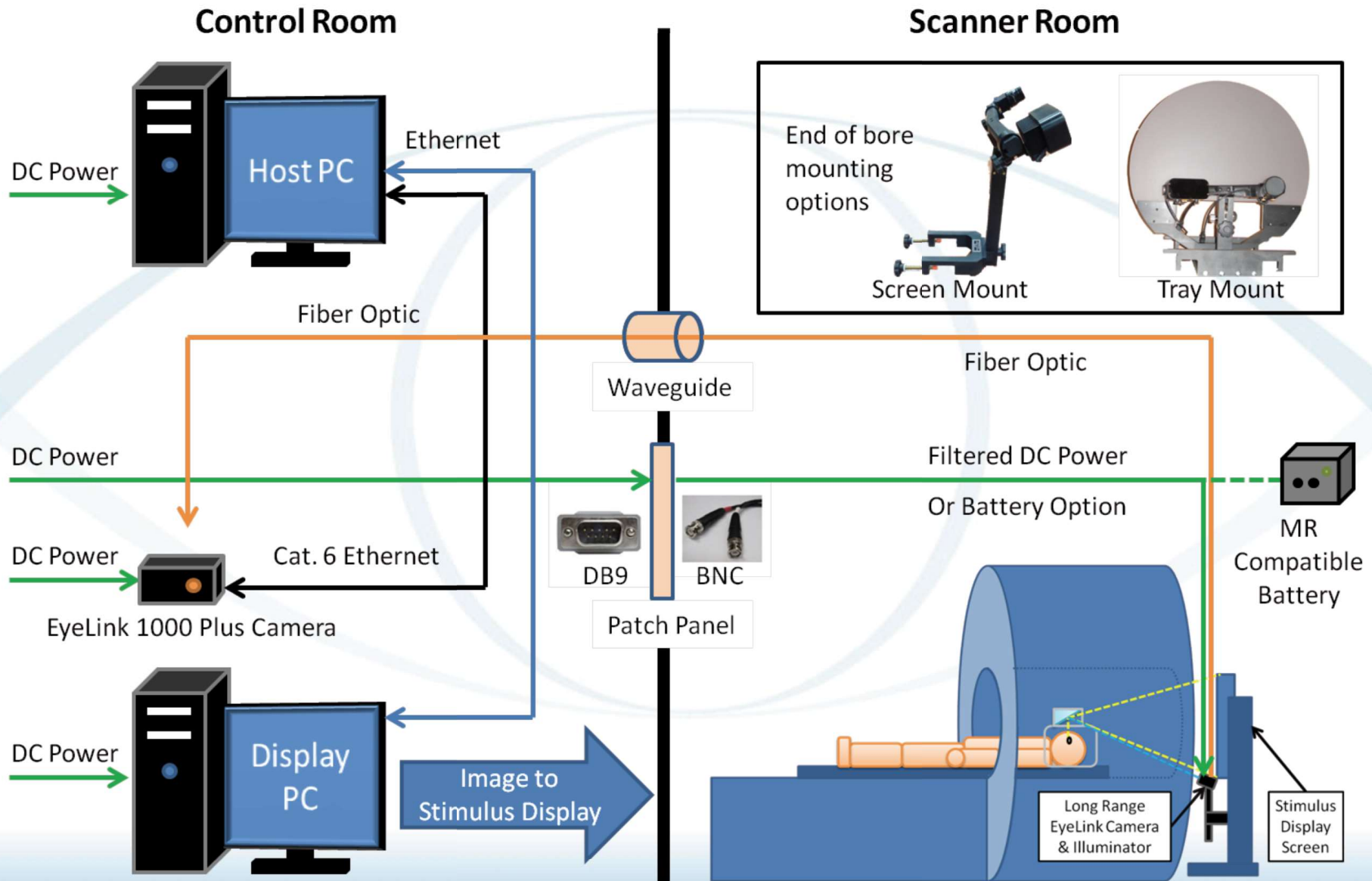


- Make sure you use an approved front surface mirror

# Typical MRI Configuration

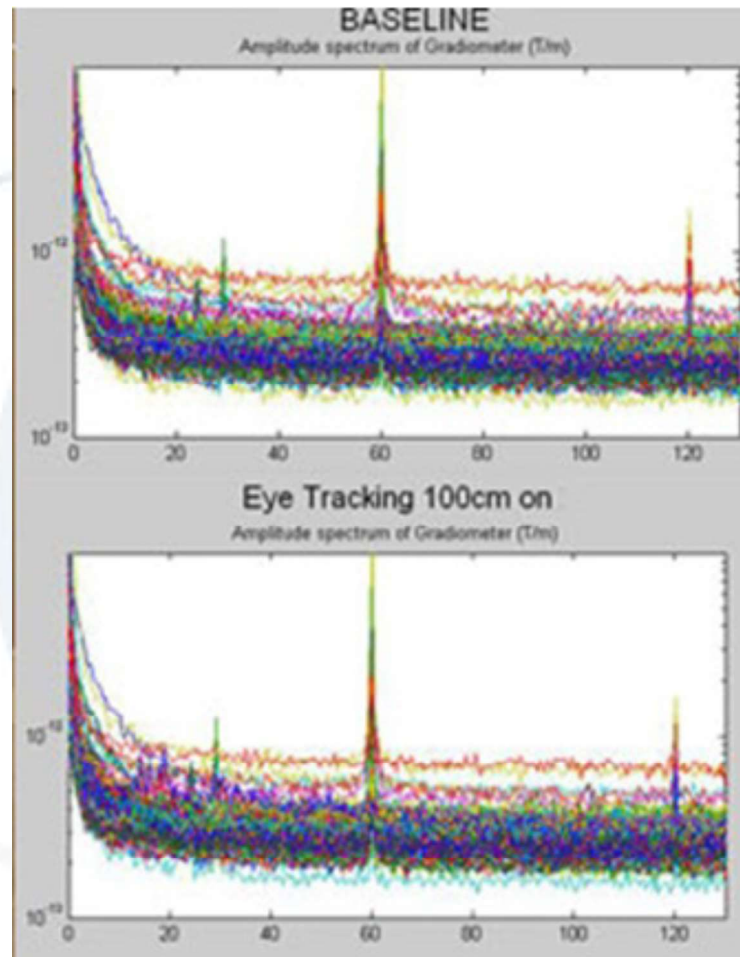


# Long Range System Cabling





# Long Range System Cabling



- No detectable noise with proper cabling  
(Graph from use with MEG)



# Terms and Specifications

- Accuracy
  - Test-retest discrepancy
  - Measure of absolute spatial location
  - Will be best with dominant eye
  - Drift free,  $0.25^{\circ}$  -  $0.50^{\circ}$  typical
- Spatial resolution
  - Smallest measurable movement
  - Measure of relative spatial location
  - $<0.01^{\circ}$  RMS in pupil-CR 1000 Hz tracking mode
  - Glasses increase error by about  $0.01^{\circ}$



# Terms and Specifications

- Temporal resolution
  - How many images processed per second
    - Hz = “samples” per second
  - 2000 / 1000 / 500 / 250 Hz recording
- Tracking Range
  - Portion of subject’s field of view (in degrees of visual angle) that can be accurately tracked
  - Desktop mount: 32° horizontal x 25° vertical
  - Tower mount: 55° horizontal x 45° vertical
- Blink Recovery Time
  - Recover of gaze position after missing data
  - Recover position on next sample



# Terms and Specifications

- Eye Event Resolution
  - Smallest psychological event that is spatially measurable with the system
  - $0.05^\circ$  microsaccades
- Head Movement Compensation
  - Tolerable level of head movements
  - Approximately 2 cm of lateral head movement compensation
- Streaming data delay
  - Time to access gaze data on Display PC via Ethernet
  - 1.4 ms delay (SD=0.4 ms) @ 2000 Hz
  - 1.8 ms delay (SD=0.8 ms) @ 1000 Hz



# The Display PC

- Performs full experimental control
  - Integrate calibration and data collection into one easy step
  - Sets any tracker preference
  - Sends commands to control tracker
- Time stamps experiment events with messages
- Near real-time access to eye sample and event data structures for gaze-contingent paradigms
- Allows focus on stimulus presentation and data processing
  - Ordinary experiment delivery with calls to the underlying EyeLink libraries to interface with the eye tracker

# Display PC API

- Compatible with many stimulus delivery methods
  - Experiment generating packages:
    - Experiment Builder
    - E-Prime
    - Presentation
    - Psychtoolbox (MATLAB)
  - Programming languages:
    - C/C++
    - Python
    - Delphi
    - Any Windows COM language
  - Operating systems:
    - Windows / Mac / Linux



# The Host PC

- Host PC application controls the eye tracker
  - Performs image analysis
  - Performs data recording
  - Performs eye event parsing
  - Configures preferences
- Provides real-time feedback
  - Gaze view: gaze cursor on background image
  - Plot view: eye traces over time
- Send and receive TTL via Parallel Port
  - TTLs received logged directly to EDF



# Gaze View

Call me Ishmael. Some years ago -- never mind how long precisely -- having little or no money in my purse, and nothing particular to interest me on shore, I thought I would sail about a little and see the watery part of the world. It is a way I have of driving off the spleen, and regulating the circulation. Whenever I find myself growing grim about the mouth; whenever it is a damp, drizzly November in my soul; whenever I find myself involuntarily pausing before coffin warehouses, and bringing up the rear of every funeral I meet, I account it high time to get to sea as soon as I can. This is my substitute for pistol and ball. With a philosophical flourish Cato throws himself upon his sword; I quietly take to the ship.

## Record

TCP/IP Link Open

Stop Recording

Stop  
Recording

About Trial

### PUPIL

OK SIZE MISSING

CORNEAL OK MISSING

Plot View

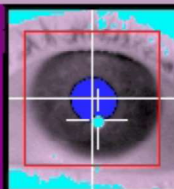
Duration (sec):

21

IMAGE NOT  
AVAILABLE

NOT  
TRACKED

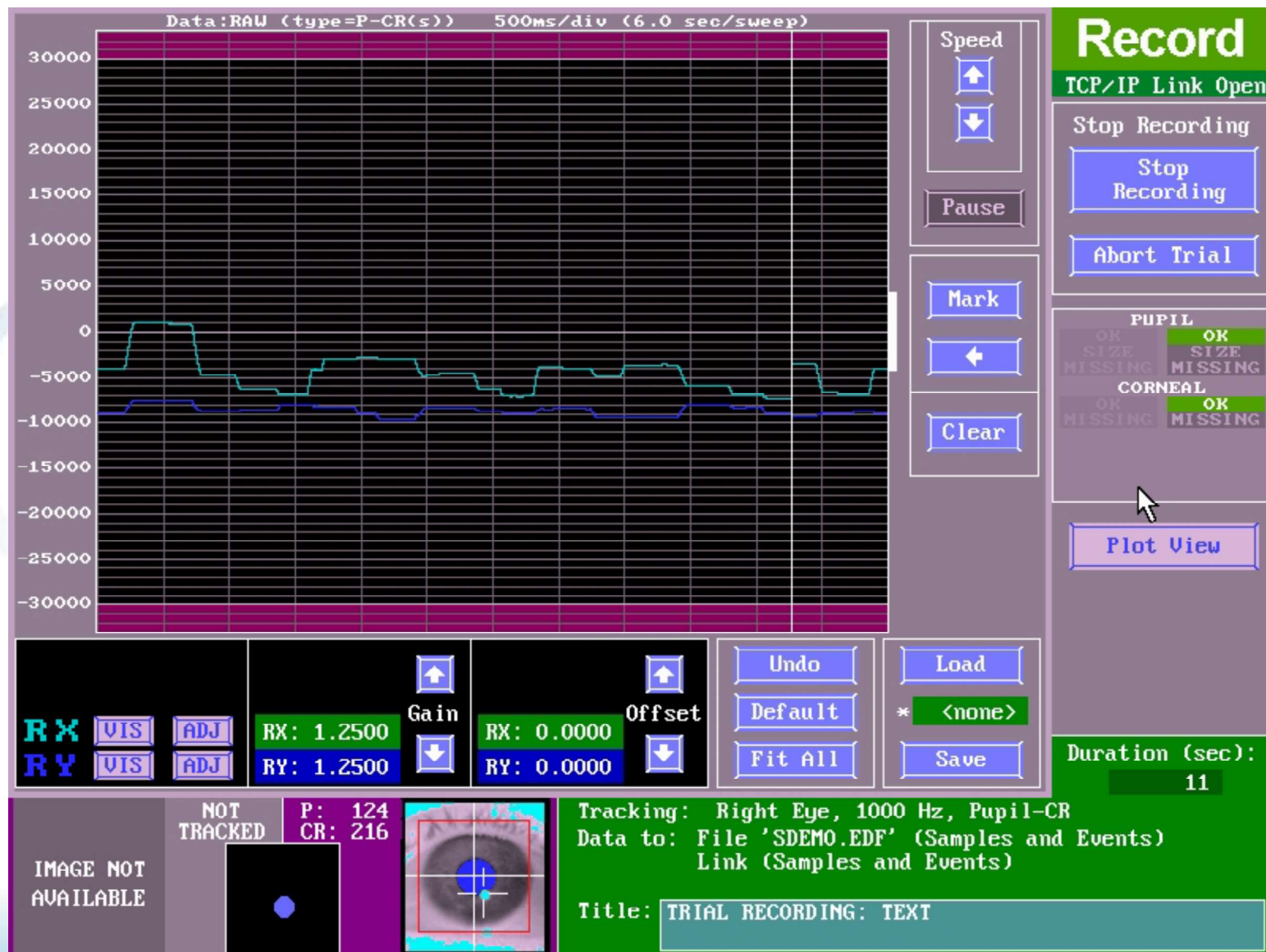
P: 124  
CR: 216



Tracking: Right Eye, 1000 Hz, Pupil-CR  
Data to: File 'SDEMO.EDF' (Samples and Events)  
Link (Samples and Events)

Title: TRIAL RECORDING: TEXT

# Plot View



# Camera Setup

- Position camera image
  - Center subject's eyes in global camera image
- Focus camera lens on surface of the eye
- Adjust Pupil and Corneal Reflection thresholds
  - Let the system know which part of the camera image should be considered as pupil and corneal reflection
- Perform Calibration and Validation
  - Calibration induces predictive model
  - Validation tests accuracy of calibrated model

# Camera Setup

EXP: 101%

Image Thresholds

Auto Threshold

Pupil

↑

↓

Corneal

↑

↓

Tracking Mode

Pupil-CR

Sample Rate

250

500

1K

2K

Pupil Tracking

Centroid

Ellipse

Image Display

Crosshairs

Threshold Coloring

Image->Display PC

Use Search Limits

Mouse Autothresh.

Illuminator Power

100%

75%

50%




IMAGE NOT AVAILABLE

EYE NOT AVAILABLE

Pupil: 124

CR : 216

PUPIL OK

CR OK

Eye Tracked:

Left

Right

Camera Setup

Desktop Monocular

Screens

Exit Setup

Offline

Output/Record

Set Options

Help (F1)

Calibrate

Validate

Drift Correct





# EyeLink Remote Mode

### Image Thresholds

Pupil

↑

↓

Corneal

↑

↓

### Tracking Mode

Pupil-CR

### Sample Rate

250 500

### Pupil Tracking

Ellipse

### Image Display

Crosshairs

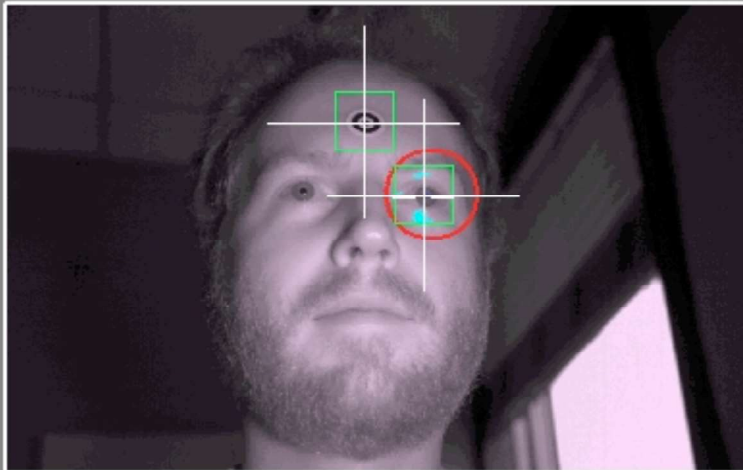
Threshold Coloring

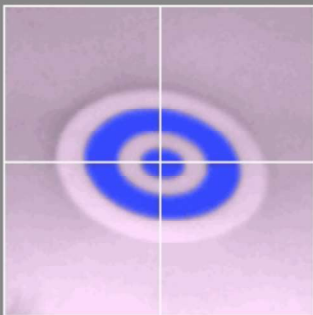
Image->Display PC

Align Eye Window

### Illuminator Power

100% 75%

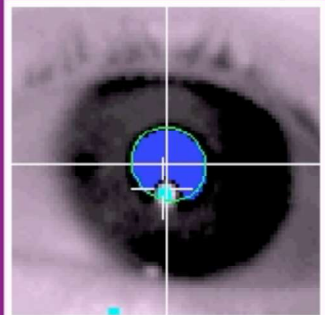




Target Thr: 149  
Distance: 578.1 mm

TARGET OK

DIST OK



Pupil: 107 AUTO x1.00  
CR : 223 AUTO x1.00

PUPIL OK

CR OK

Eye Tracked: Left Right

## Camera Setup

### Desktop Remote

#### Screens

Exit Setup

Offline

Output/Record

Set Options

Help (F1)

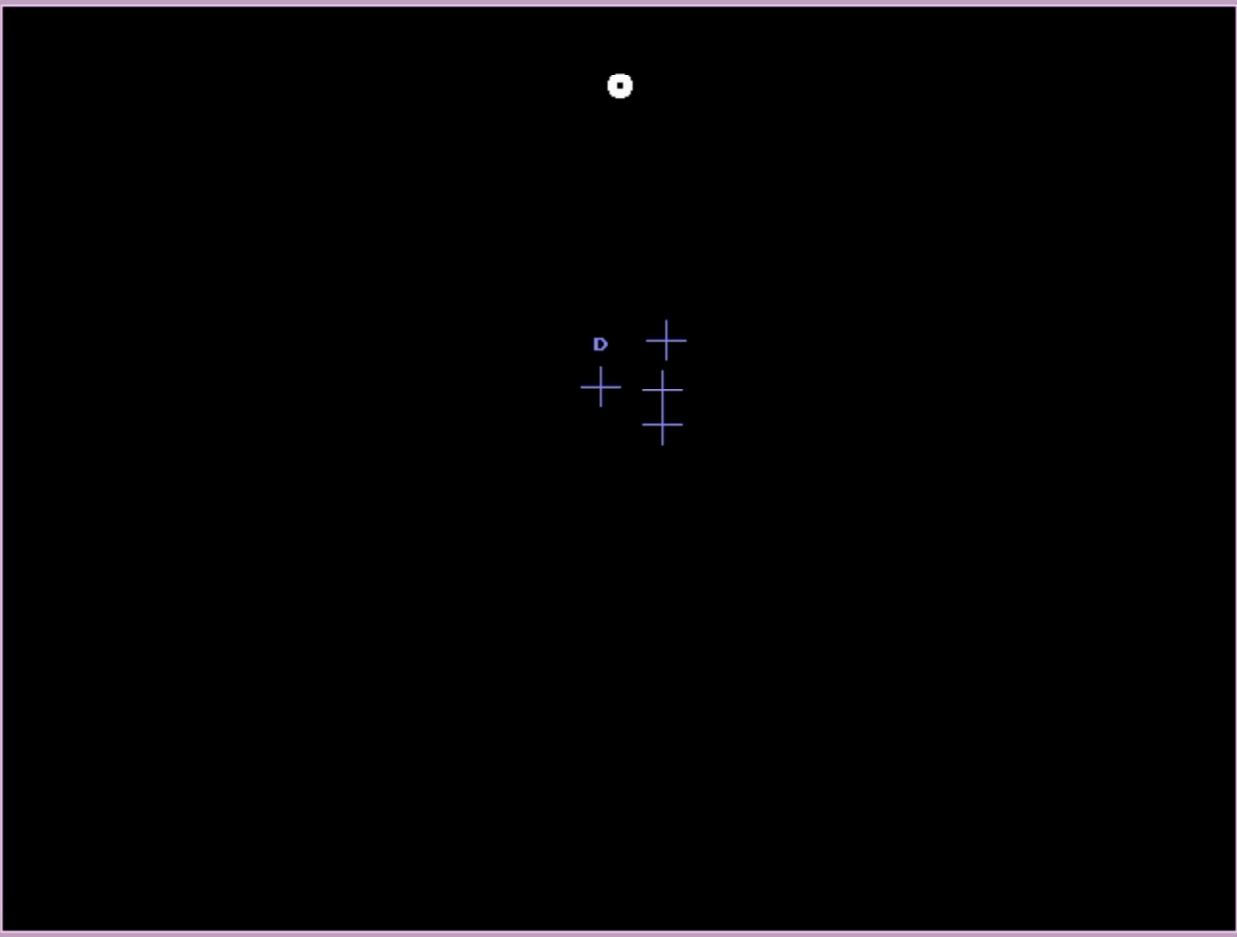
Calibrate

Validate

Drift Correct

# Calibration

*Mapping raw eye data / camera image data to predict gaze position*



## Calibrate

TCP/IP Link Open

Screens

Camera Setup

Help (F1)

PUPIL

OK	OK
SIZE	SIZE
MISSING	MISSING
CORNEAL	
OK	OK
MISSING	MISSING

Sequencing

Restart

Auto Trigger

Undo Last Pnt

Accept Fixation

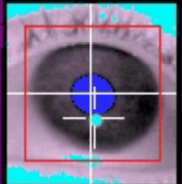
STABLE  
Point 5 of 10

IMAGE NOT AVAILABLE

NOT TRACKED



P: 124  
CR: 216

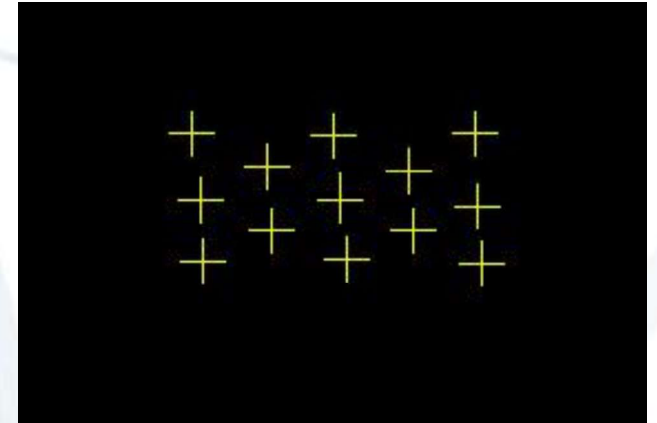
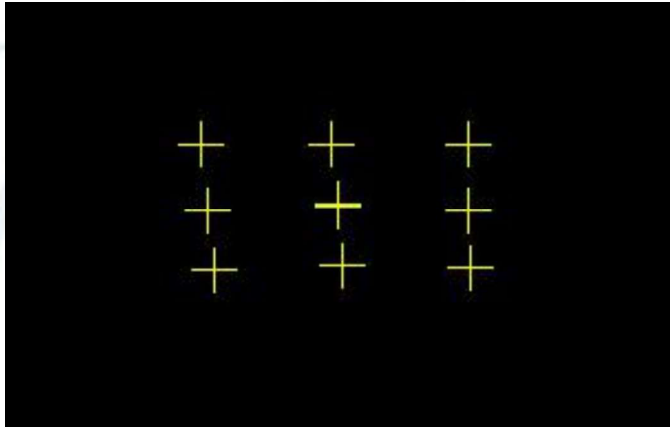
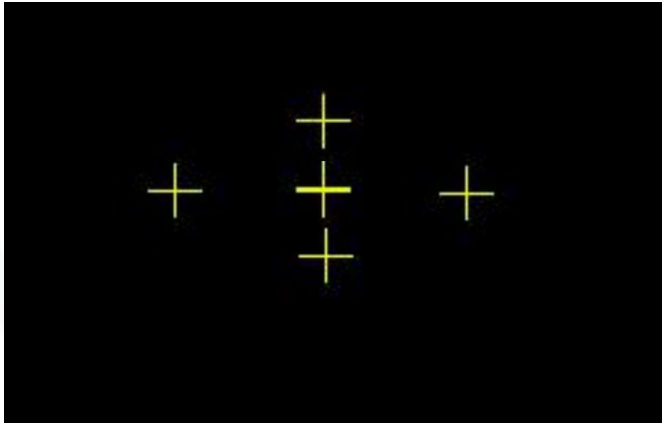


Tracking: Right Eye, Pupil-CR  
Calibration: 9 point grid

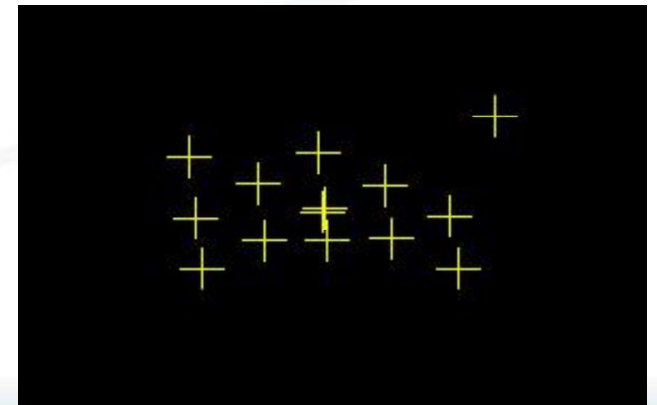
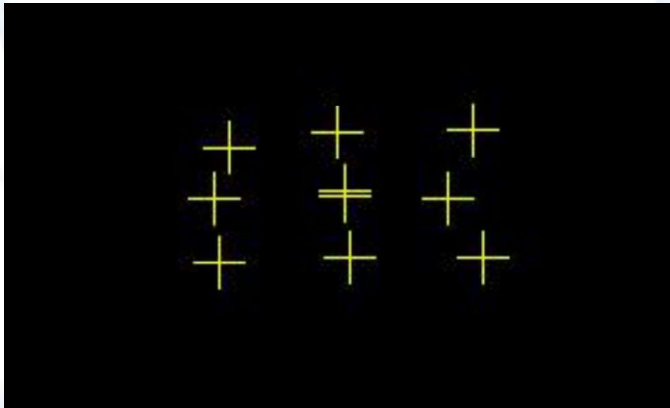
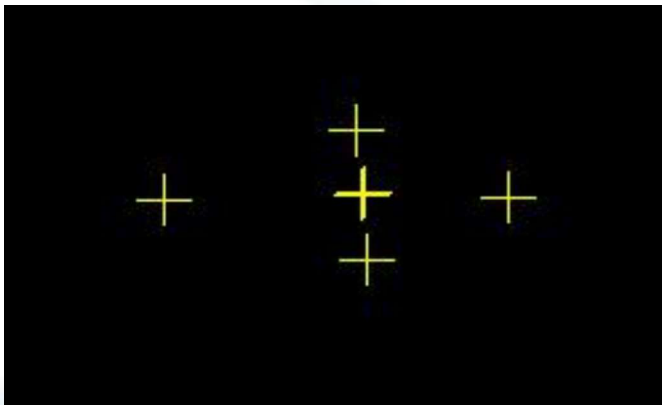


# Calibration

## Good Calibration models (symmetrical)



## Poor Calibration models (asymmetrical)



# Validation

- Evaluate predictive model's test-retest accuracy
- Subject re-fixates known locations
  - Difference between predicted gaze position and validation sample is "accuracy"
- Summarizes calibration accuracy
  - Reveals which spatial positions fit least accurately in degrees of visual angle

# Validation

*Checking accuracy level of the calibration*

## Validate

TCP/IP Link Open

Screens

Camera Setup

Help (F1)

---

PUPIL

OK	OK
SIZE	SIZE
MISSING	MISSING
CORNEAL	CORNEAL
OK	OK
MISSING	MISSING

IMAGE NOT  
AVAILABLE

NOT  
TRACKED

P: 124  
CR: 216

RIGHT Error: 0.42° avg, 0.65° max (GOOD)

Drift Correction \*\*DISABLED\*\*

Accept

Restart

Discard



# EyeLink Data

- EDF file
  - Use EDF2ASC/VisualASC converter to get ASC files
  - Use EyeLink Data Viewer for direct analysis
- What is recorded:
  - Samples
  - Events
    - Saccades, fixations, blinks, messages, buttons

(Please read Chapter 4 of the EyeLink 1000 Plus User Manual)



# EyeLink Recording Data

- Samples
  - System time, x, y, and pupil size
  - Optional velocity, resolution, and CR status

6079861	503.7	680.3	972.0	.....
6079862	503.7	680.1	972.0	.....
6079863	503.8	680.1	972.0	.....
6079864	503.8	680.2	972.0	.....
6079865	503.9	680.2	971.0	.....
6079866	503.7	680.1	971.0	.....
6079867	503.7	680.1	971.0	.....
6079868	503.6	680.0	970.0	.....
6079869	503.6	680.1	970.0	.....
6079870	503.7	680.2	970.0	.....

(Please read Chapter 4 of the EyeLink 1000 Plus User Manual)



# EyeLink Recording Data

- Saccades
  - SSACC: eye, start time
  - ESACC: eye, start time, end time, duration, start x/y, end x/y, amplitude, peak velocity

SSACC L 6079955

ESACC L 6079955 6079962 8 507.5 682.5 511.9 682.0 0.20 38

...

SSACC L 6080723

ESACC L 6080723 6080763 41 513.8 679.7 633.5 550.5 7.94 285

(Please read Chapter 4 of the EyeLink 1000 Plus User Manual)





# EyeLink Recording Data

- Fixations
  - SFIX: eye, start time
  - EFIX: eye, start time, end time, duration, average x/y, pupil size, resolution

SFIX L 1454748

EFIX L 1454748 1454907 160 510.3 4.1 1187 28.45 27.50

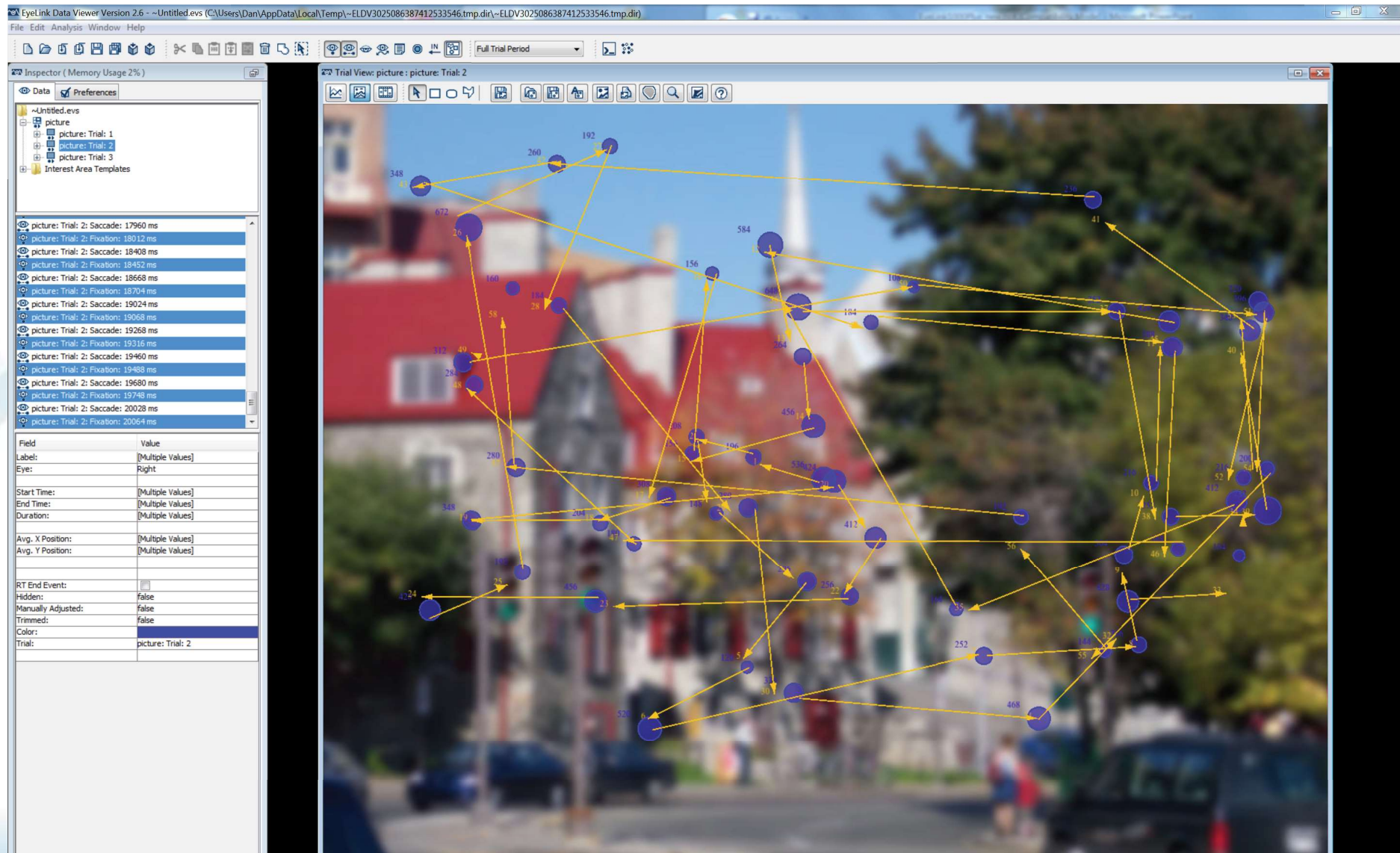
...

SFIX L 1454919

EFIX L 1454919 1455873 955 514.0 0.3 1361 28.40 27.50

(Please read Chapter 4 of the EyeLink 1000 Plus User Manual)

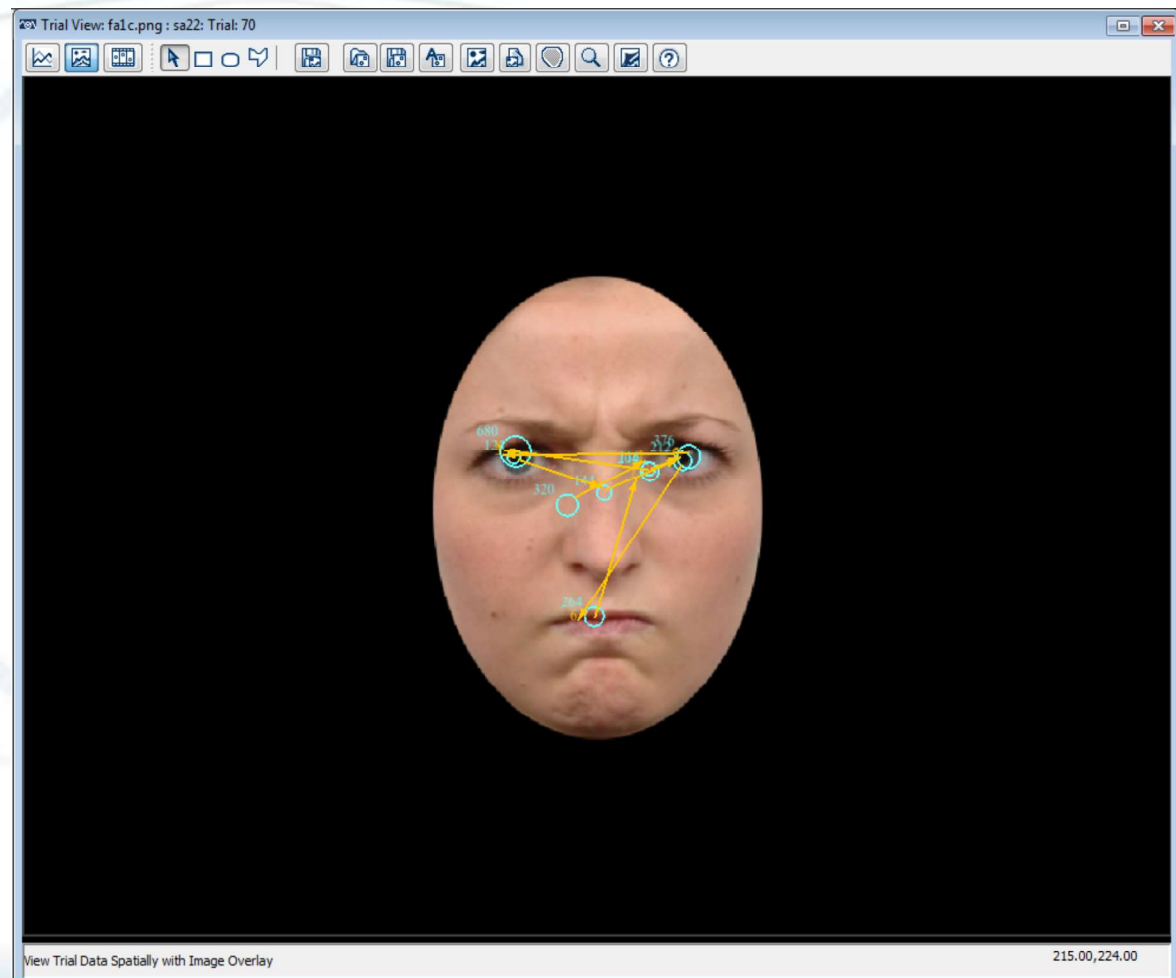
# EyeLink Data Viewer



# EyeLink Data Viewer

Data visualization:

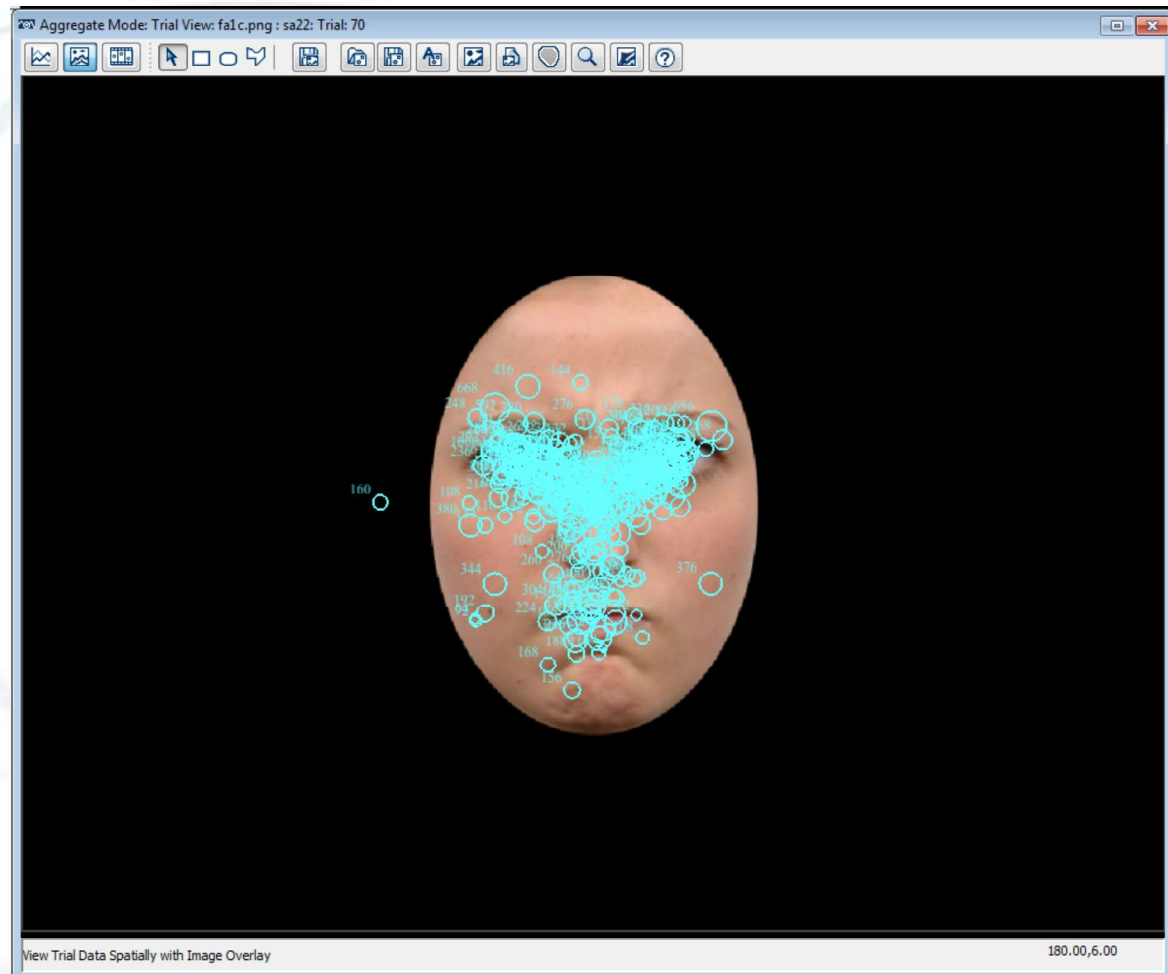
Spatial Overlay View  
superimposes  
saccade and fixation  
scan-path information  
over an image



# EyeLink Data Viewer

Data visualization:

Aggregate Mode  
superimposes data  
from multiple trials /  
participants

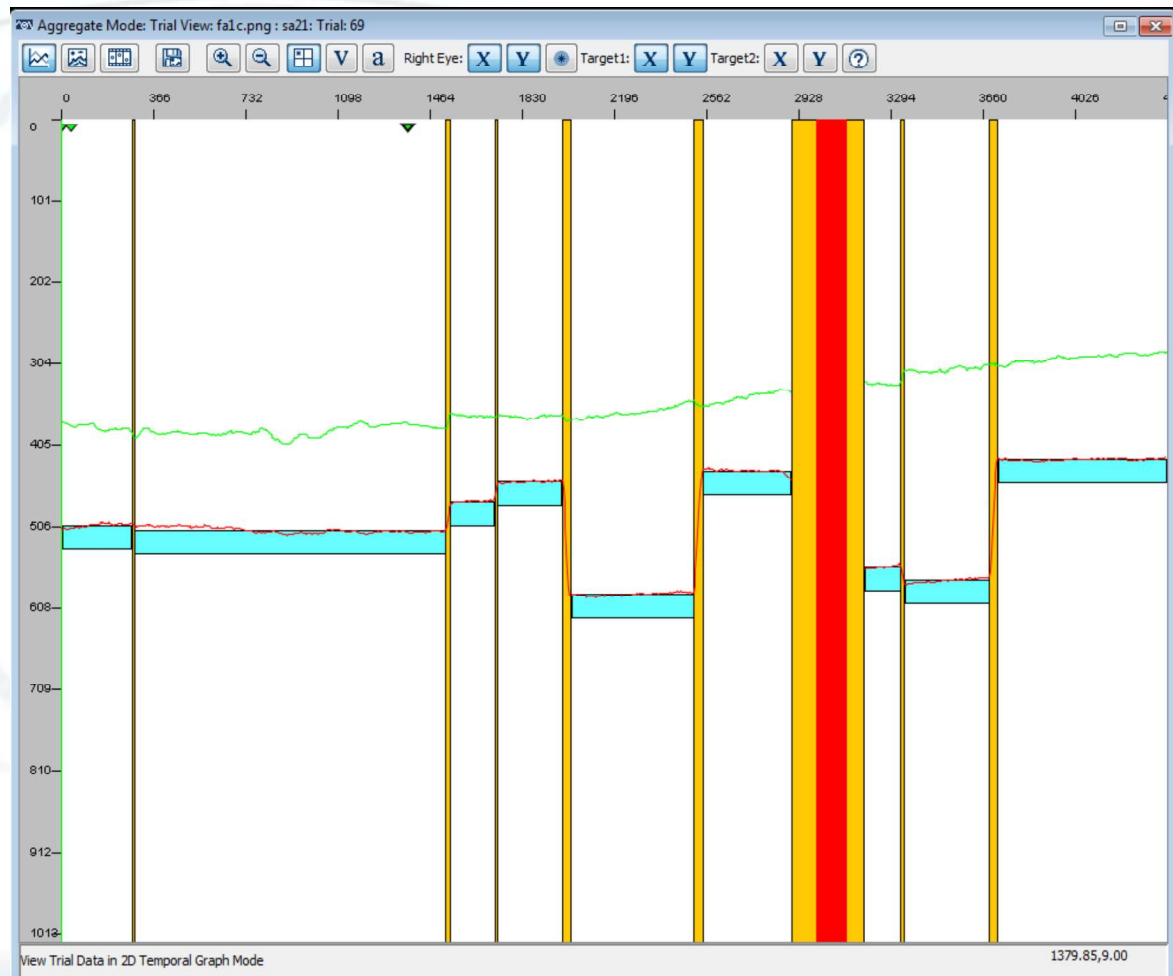


# EyeLink Data Viewer

Data visualization:

Temporal Graph View  
supports visualization  
of eye data over time

Useful for seeing  
when messages  
appear and setting  
Interest Periods





# EyeLink Data Viewer

## Data visualization:

Animation Playback View shows a movie of the trial with eye movements overlaid.

Playback speed can be adjusted – helpful for the creation of dynamic interest areas using the Mouse Record technique.

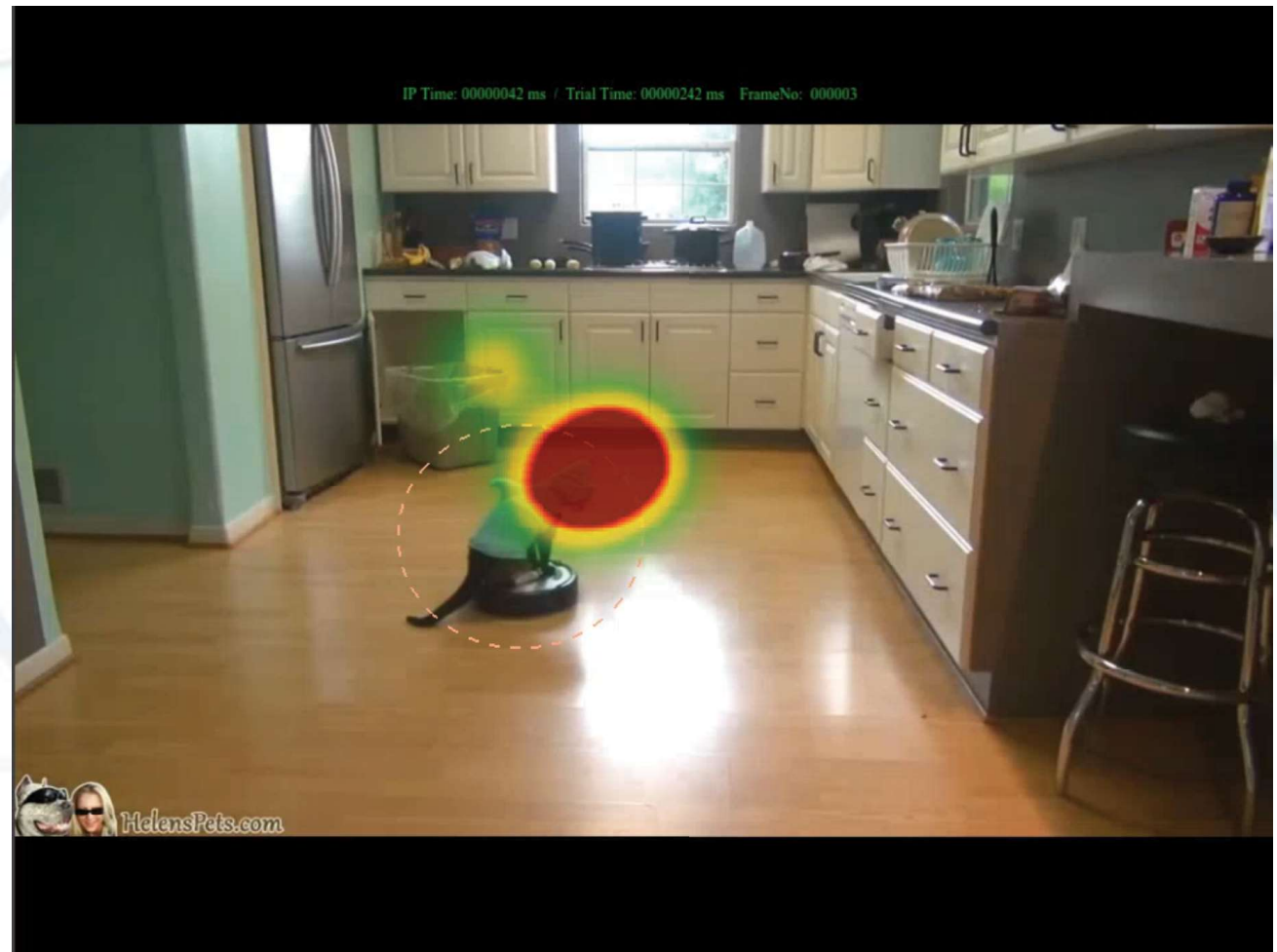
IP Time: 00010793 ms / Trial Time: 00010962 ms FrameNo: 000327





# EyeLink Data Viewer

In Aggregate Mode, Animation Playback view can show bee-swarm and dynamic heat maps.





# EyeLink Data Viewer

- Supports both static and dynamic interest areas (rectangular, elliptical, or freeform polygons)
- Create interest periods for temporal data filtering
- Group data using existing or new variables
- Generate heat maps / dynamic heat maps for selected trials
- Output eye sample, fixation, saccade, interest area, or trial-based reports for statistical analysis
- Output binned data for time-series analysis (Visual World Tasks / Dynamic Stimuli)
- Calculate hundreds of dependent measures including most common reading measures
- Highly integrated with SR Research Experiment Builder, E-Prime, Presentation, and any custom stimulus display solution
- Available on Windows, Mac OS X, and Linux



# EyeLink Data Viewer

*Generates detailed Fixation, Saccade, Interest Area, Sample and Trial reports*

The screenshot shows a dialog box titled "Fixation Output Report". It has two main sections: "Available Variables" on the left and "Selected Variables" on the right. The "Available Variables" list includes: CURRENT\_FIX\_PUPIL, CURRENT\_FIX\_REFIX\_PREV\_INTEREST\_AREA (highlighted), CURRENT\_FIX\_RUN\_DWELL\_TIME, CURRENT\_FIX\_RUN\_INDEX, CURRENT\_FIX\_RUN\_SIZE, CURRENT\_FIX\_START, CURRENT\_FIX\_START\_OTHER, CURRENT\_FIX\_TRIAL\_SPAN, CURRENT\_FIX\_X, and CURRENT\_FIX\_X\_OTHER. The "Selected Variables" list includes: RECORDING\_SESSION\_LABEL, TRIAL\_INDEX, CURRENT\_FIX\_INDEX, CURRENT\_FIX\_INTEREST\_AREA\_ID, CURRENT\_FIX\_INTEREST\_AREA\_LABEL, and CURRENT\_FIX\_REFIX\_INTEREST\_AREA. Between these lists are two arrow buttons: a right-pointing double arrow (>>) and a left-pointing double arrow (<<). Below the variable lists is a "Variable Definition" section with a text area containing the text: "Whether this trial has a previous fixation in an IA with higher IA ID than current fix IA ID." At the bottom of the dialog, there is an "Exclude Trial String" label followed by a text input field. Below this are four checkboxes: "Include Hidden Events in Relative (Previous / Next) Variables.", "Treat Hidden Events as Missing Values in Relative (Previous / Next) Variables", "Place Quotes ( \" ) Around String / Text Variables", and "Create one Report File per EDF File". At the very bottom are four buttons: "Reset", "Undo", "Cancel", and "Next".



# EyeLink Support

- Documents
  - EyeLink 1000 Plus User Manual
  - EyeLink 1000 Plus Installation Guide
  - EyeLink 1000 Plus Quick Start Guide
  - SR Research Experiment Builder User Manual
  - EyeLink Programmer's Guide
  - EyeLink Data Viewer User Manual
- Contact Information
  - Email: [support@sr-research.com](mailto:support@sr-research.com)
  - Phone: 1-613-826-2958 / 1-866-821-0731
  - Support Forum: [www.sr-support.com](http://www.sr-support.com)



# EyeLink Support Forums

SR Research  
Support

Welcome, WDM Notifications My Profile Settings Log Out

Forum

New Posts Private Messages Forum Actions Quick Links

Advanced Search

Forum

SR Research is pleased to announce the newest addition to our EyeLink series of eye trackers, the **EyeLink Portable Duo!** The EyeLink Portable Duo brings the fast, accurate, reliable eye tracking you've come to expect from SR Research into a compact system that's easy to set up for eye tracking in daycares, schools, homes, or hospitals. Check out [sr-research.com](http://sr-research.com) for more info!

Don't miss out on new developments, features and free software updates from SR Research! Sign up for our mailing list now to stay up-to-date on all things SR Research!

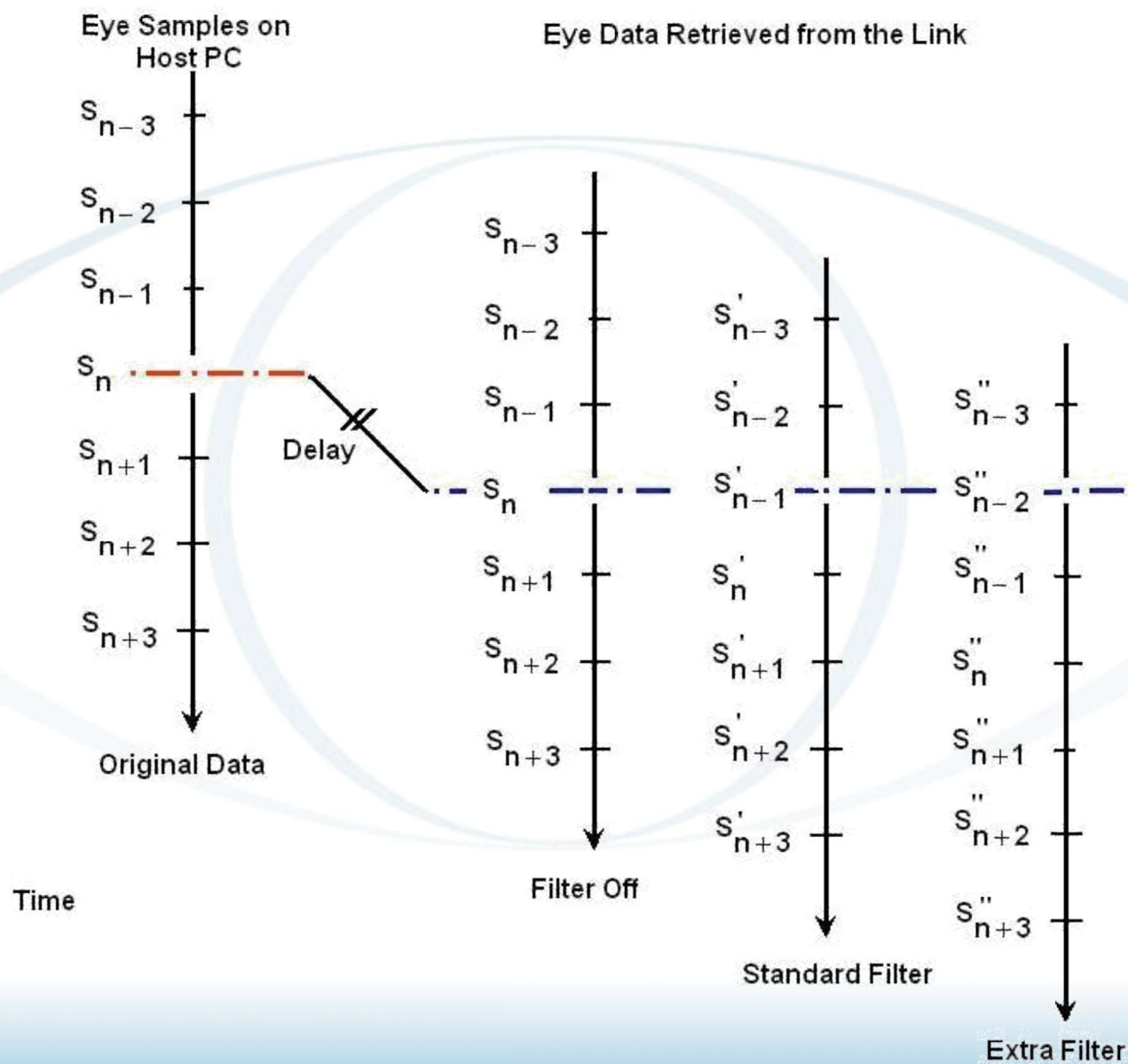
SR Research Support Site

Welcome to the SR Research Support Site.

	Threads / Posts	Last Post
<b>What's New?</b> Updates on the latest software and hardware releases from SR Research Ltd.	Threads: 23 Posts: 23	Introducing Experiment... by Greg 10-21-2016, 02:08 PM
<b>How-Tos</b> Educational Materials		
<b>Video Tutorials</b> Instructional videos	Threads: 1 Posts: 1	Experiment Builder Video... by marcus 07-20-2015, 08:29 PM
<b>Webinars</b> Listings of upcoming webinars and links to recordings of past ones	Threads: 6 Posts: 11	Webinar - Integrating EyeLink... by marcus 12-02-2016, 07:26 AM
<b>Frequently Asked Questions</b> Frequently Asked Questions about EyeLink Usage, Programming, and Data Analysis	Threads: 6 Posts: 140	List of All Data Viewer... by Sam 07-14-2016, 05:35 AM
<b>Experiment Builder FAQ</b>	Threads: 2 Posts: 38	Answers to Experiment Builder... by marcus 02-26-2016, 12:27 AM
<b>Data Viewer FAQ</b>	Threads: 2 Posts: 25	List of All Data Viewer... by Sam 07-14-2016, 05:35 AM
<b>EyeLink Host PC and Hardware FAQ</b>	Threads: 2 Posts: 77	Answers to EyeLink Host PC... by WDM 03-06-2016, 11:06 PM
<b>EyeLink</b> Discussions related to EyeLink system usage		
<b>EyeLink Usage</b> Discussions on using the EyeLink systems and options, including set-up, calibration, etc.	Threads: 1,044 Posts: 4,264	sampling rate by marcus 12-07-2016, 08:18 PM
<b>Programming</b> Discussions related to programming the EyeLink systems	Threads: 882 Posts: 4,196	eyemsg_printf messages not... by philido 12-08-2016, 05:21 PM
<b>Data Viewer</b> Discussions regarding the EyeLink Data Viewer application	Threads: 834 Posts: 3,618	Interest area files from Excel by SR-Brain 12-05-2016, 01:45 PM
<b>General</b> General Discussions not covered in other EyeLink forums	Threads: 344 Posts: 1,563	Host PC Multi Display by WDM 11-29-2016, 12:52 PM
<b>Experiment Builder</b> SR Research Experiment Builder discussions		
<b>E-Builder Usage</b> Discussion on usage of E-Builder software	Threads: 2,014 Posts: 8,327	Problems adding a scale by paige0909 11-10-2016, 07:17 AM
<b>Examples</b> Example E-Builder projects	Threads: 64 Posts: 78	Creating False Memories by dackit1 09-20-2016, 02:56 PM
<b>Downloads</b> SR Research Documentation and Software Downloads		
<b>Manuals</b> Download the latest manuals for the EyeLink systems and applications	Threads: 13 Posts: 14	EyeLink 1000 Plus User Manual by marcus 12-05-2014, 08:36 AM
<b>EyeLink Host Software</b> Download the latest EyeLink Host Software (all versions)	Threads: 5 Posts: 5	EyeLink 1000 Plus Host... by Greg 10-14-2014, 09:16 AM
<b>EyeLink Display Software</b> Download the latest Display Software for the EyeLink System	Threads: 13 Posts: 18	SR Research Experiment... by Greg 08-04-2015, 02:59 PM
<b>Data Analysis</b> Download the latest EyeLink data analysis software	Threads: 4 Posts: 5	EDFMAT - Converting EDF files... by SR-Brain 08-10-2016, 03:24 PM



# Smart Data Filter





# Host Application

- Camera Setup screen
  - Adjust camera image
  - Calibration
  - Validation
  - Drift Check
- Set Options screen
  - Select preferences / options
  - Set method of recording
- Record screen
  - Real-time gaze cursor / Plot View

# Camera Setup screen

EXP: 101%

Image Thresholds

Auto Threshold

Pupil

↑

↓

Corneal

↑

↓

Tracking Mode

Pupil-CR

Sample Rate

250

500

1K

2K

Pupil Tracking

Centroid

Ellipse

Image Display

Crosshairs

Threshold Coloring

Image->Display PC

Use Search Limits

Mouse Autothresh.

Illuminator Power

100%

75%

50%


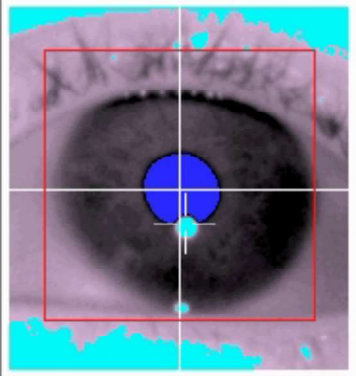


IMAGE NOT AVAILABLE

EYE NOT AVAILABLE



Pupil: 124

CR : 216

PUPIL OK

CR OK

Eye Tracked:

Left

Right

Camera Setup

Desktop Monocular

Screens

Exit Setup

Offline

Output/Record

Set Options

Help (F1)

Calibrate

Validate

Drift Correct

# Set Options screen

Calibration and Validation		Configuration	Set Options
Calibration Type <input type="button" value="..."/> <input type="button" value="· · ·"/> <input type="button" value="· · · ·"/> <input type="button" value="· · · · ·"/> <input type="button" value="· · · · · ·"/>		<input type="button" value="Select Config..."/>	<input type="button" value="TCP/IP Link Open"/>
Pacing Interval <input type="button" value="OFF"/> <input type="button" value="500"/> <input type="button" value="1000"/> <input type="button" value="1500"/>		<b>Desktop (Level)</b> Monocular 35mm lens Stabilized Head Camera Level CAM--ILLUM	<b>Screens</b>
<input type="button" value="Randomize Order"/> <input type="button" value="Force Manual Accept"/>			<input type="button" value="Previous Screen"/>
<input type="button" value="Repeat First Point"/>			<input type="button" value="Camera Setup"/>
			<input type="button" value="Help (F1)"/>
<b>Tracking</b>		<b>File Data Contents:</b>	<b>Settings</b>
<input type="button" value="Search Limits"/> <input type="button" value="Move Limits"/>		<input type="button" value="Samples"/>	<input type="button" value="Revert to Last"/>
<input type="button" value="Mouse Simulation"/>		<input type="button" value="Events"/>	<input type="button" value="Load Defaults"/>
Pupil Size Data <input type="button" value="AREA"/> <input type="button" value="DIAMETER"/>		<b>File Sample Contents:</b>	<b>Video Overlay</b>
<b>Events and Data Processing</b>		<input type="button" value="Raw Eye Position"/>	<input type="button" value="Enable Overlay"/>
Eye Event Data <input type="button" value="Gaze"/> <input type="button" value="HREF"/>		<input type="button" value="HREF Position"/>	
Saccade Sensitivity <input type="button" value="NORMAL"/> <input type="button" value="HIGH"/>		<input type="button" value="Gaze Position"/>	
File Sample Filter <input type="button" value="OFF"/> <input type="button" value="STD"/> <input type="button" value="EXTRA"/>		<input type="button" value="Button Flags"/>	
Link/Analog Filter <input type="button" value="OFF"/> <input type="button" value="STD"/> <input type="button" value="EXTRA"/>		<input type="button" value="Input Port Data"/>	
		<b>Recording Data View</b>	
		Record View <input type="button" value="Gaze Cursor"/> <input type="button" value="Plotting"/>	
		Plot <input type="button" value="Gaze"/> <input type="button" value="Angle"/> <input type="button" value="HREF"/> <input type="button" value="Raw"/>	

# Set Configuration menu

Calibration and Validation

Configuration

Set Options

SET CONFIGURATION

Accept Cancel

Desktop (Level)	Monocular	35mm lens	Stabilized Head	Camera Level	CAM--	MTABLER
Desktop (Level)	Binoc/Monoc	35mm lens	Stabilized Head	Camera Level	CAM--I	BTABLER
Desktop (Remote)	Monocular	16mm lens	Target Sticker	Camera Level	CAM--	RTABLER
Arm Mount (Remote)	Monocular	16mm lens	Target Sticker			ARTABLER
Arm Mount (Level)	Monocular	35mm lens	Stabilized Head			AMTABLER

Search Limits Move Limits

Mouse Simulation

Pupil Size Data AREA DIAMETER

Events and Data Processing

Eye Event Data Gaze HREF

Saccade Sensitivity NORMAL HIGH

File Sample Filter OFF STD EXTRA

Link/Analog Filter OFF STD EXTRA

File Data Contents:

Samples

Events

File Sample Contents:

Raw Eye Position

HREF Position

Gaze Position

Button Flags

Input Port Data

Settings

Revert to Last

Load Defaults

Video Overlay

Enable Overlay

Recording Data View

Record View Gaze Cursor Plotting

Plot Gaze Angle HREF Raw



# Record screen

Call me Ishmael. Some years ago -- never mind how long precisely -- having little or no money in my purse, and nothing particular to interest me on shore, I thought I would sail about a little and see the watery part of the world. It is a way I have of driving off the spleen, and regulating the circulation. Whenever I find myself growing grim about the mouth; whenever it is a damp, drizzly November in my soul; whenever I find myself involuntarily pausing before coffin warehouses, and bringing up the rear of every funeral I meet, I account it high time to get to sea as soon as I can. This is my substitute for pistol and ball. With a philosophical flourish Cato throws himself upon his sword; I quietly take to the ship.

## Record

TCP/IP Link Open

Stop Recording

Stop  
Recording

About Trial

### PUPIL

OK SIZE MISSING

CORNEAL OK MISSING

Plot View

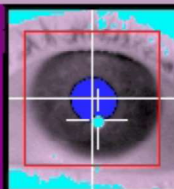
Duration (sec):

21

IMAGE NOT  
AVAILABLE

NOT  
TRACKED

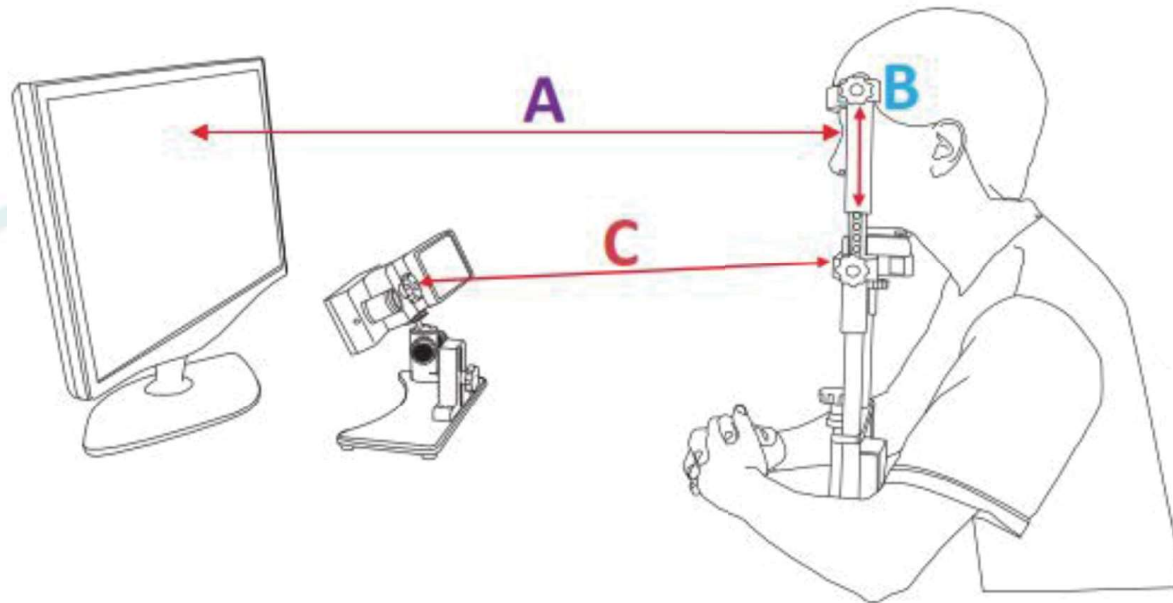
P: 124  
CR: 216



Tracking: Right Eye, 1000 Hz, Pupil-CR  
Data to: File 'SDEMO.EDF' (Samples and Events)  
Link (Samples and Events)

Title: TRIAL RECORDING: TEXT

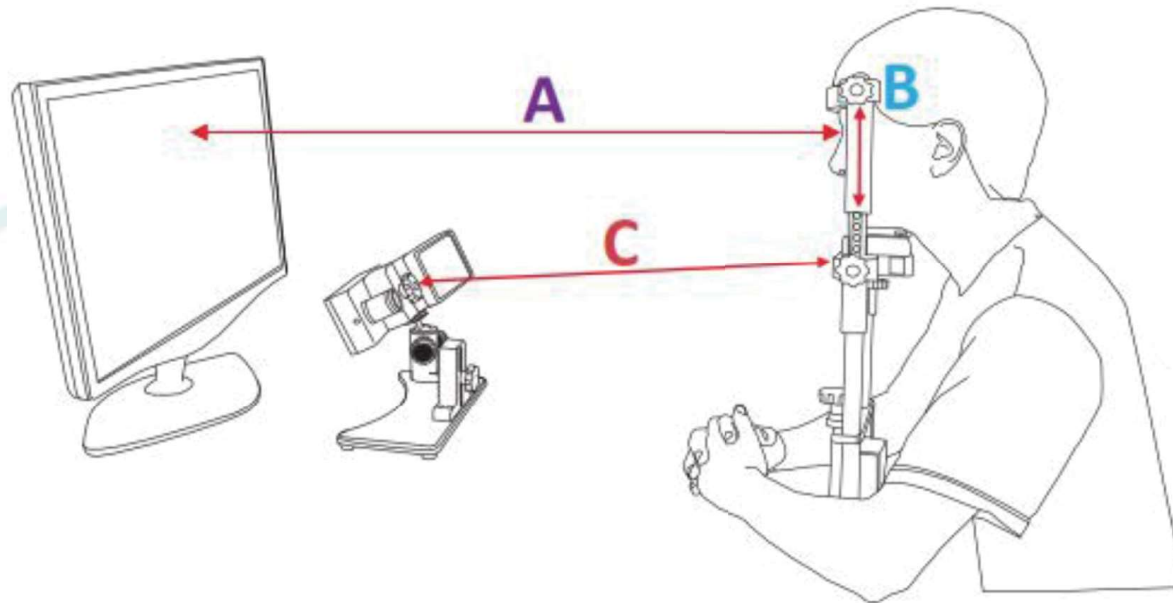
# Physical Setup



- A) Position the monitor so that it subtends no more than 32 degrees of visual angle horizontally and 25 degrees of visual angle vertically for the participant.
- The eye-to-screen distance should be at least 1.75 times the width of the display to ensure that it falls within the trackable range

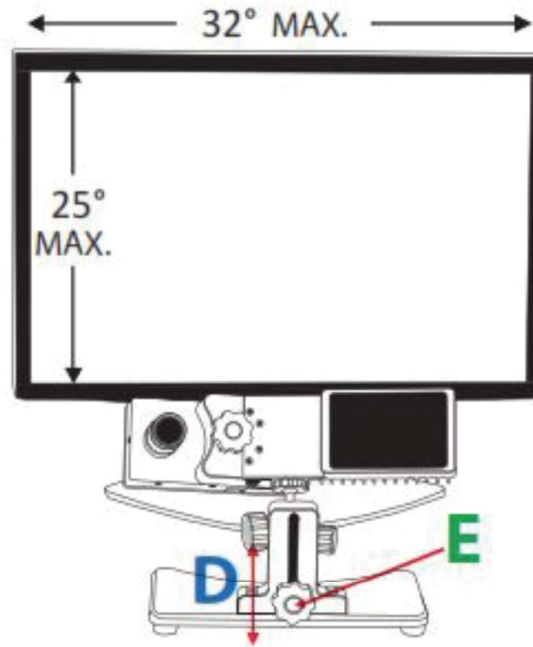


# Physical Setup



- B) Position the participant so that the eyes align with the top quarter of the monitor – adjust the chair and/or the head support to ensure this alignment
- C) Position the eye tracker so that the distance from the top knob on the front of the Desktop Mount to the front of the chinrest is 50-55 cm. If using remote mode make sure that the reported target distance on the Host PC is around 60cm (55-60 is ideal for calibration)

# Physical Setup



- D) Adjust the height of the eye tracker so that it is as high as possible without blocking the participant's view of the display
- E) Position the eye tracker so that its bottom knob is centered horizontally with the front of the display

# File Manager

- For the Host software press CTL+ALT+Q to exit back to the File Manager interface
- To access configuration setting select gear icon in top left corner

# Screen Setting

Screen Dimensions

Display Resolution

Eye-to-Screen Distance

Camera-to-Screen Distance

Optimal Target-to-Camera Distance

width 400 mm

height 300 mm

Width of the viewable portion of the Display PC monitor (in millimeters) : 400

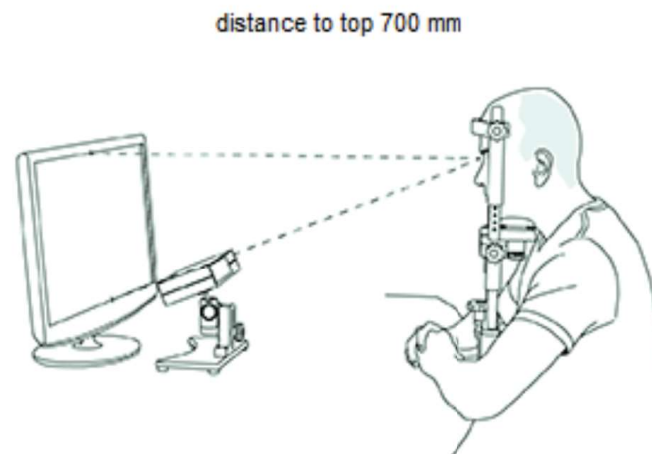
Height of the viewable portion of the Display PC monitor (in millimeters) : 300

Save Next

- Enter the physical dimensions of the stimulus display into the screen settings wizard.

# Screen Setting

Screen Dimensions
Display Resolution
Eye-to-Screen Distance
Camera-to-Screen Distance
Optimal Target-to-Camera Distance



Distance from eye to the top of the viewable portion of the Display PC monitor (in millimeters) :

700

Distance from eye to the bottom of the viewable portion of the Display PC monitor (in millimeters) :

760

Save

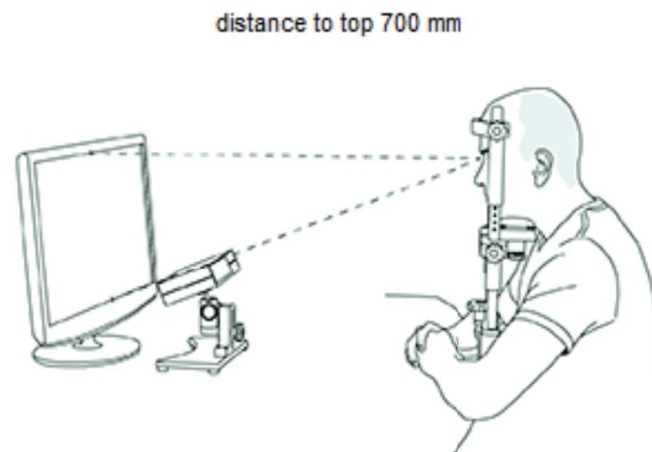
Back

Next

- Enter in the distance from the participant's eye to the top of the display image and the bottom of the display image.

# Screen Setting

Screen Dimensions
Display Resolution
Eye-to-Screen Distance
Camera-to-Screen Distance
Optimal Target-to-Camera Distance



Distance from eye to the top of the viewable portion of the Display PC monitor (in millimeters) :

700

Distance from eye to the bottom of the viewable portion of the Display PC monitor (in millimeters) :

760

Save

Back

Next

- Enter in the distance from the participant's eye to the top of the display image and the bottom of the display image.



# Participant Setup

EXP: 101%

Image Thresholds

Auto Threshold

Pupil

↑

↓

Corneal

↑

↓

Tracking Mode

Pupil-CR

Sample Rate

250

500

1K

2K

Pupil Tracking

Centroid

Ellipse

Image Display

Crosshairs

Threshold Coloring

Image->Display PC

Use Search Limits

Mouse Autothresh.

Illuminator Power

100%

75%

50%

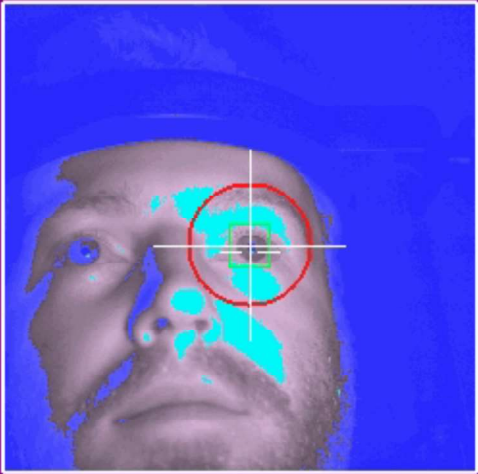


IMAGE NOT AVAILABLE

EYE NOT AVAILABLE

Pupil: 124

CR : 216

PUPIL OK

CR OK

Eye Tracked:

Left

Right

Camera Setup

Desktop Monocular

Screens

Exit Setup

Offline

Output/Record

Set Options

Help (F1)

Calibrate

Validate

Drift Correct



# Participant Setup - Desktop

- 1) Adjust camera angle and position to get a good view of the eye(s)
- 2) Click pupil in the global view to autothreshold (Host or Display PC)
- 3) Focus the camera - minimize size of teal CR circle
- 4) Autothreshold and adjust pupil and CR thresholds
  - If cautious or troubleshooting, check the setup by asking the subject to look at four corners
  - If the CR is smeared move the Desktop Mount toward the problematic corner until CR is tracked
- 5) Calibration
- 6) Validation
- 7) Recording



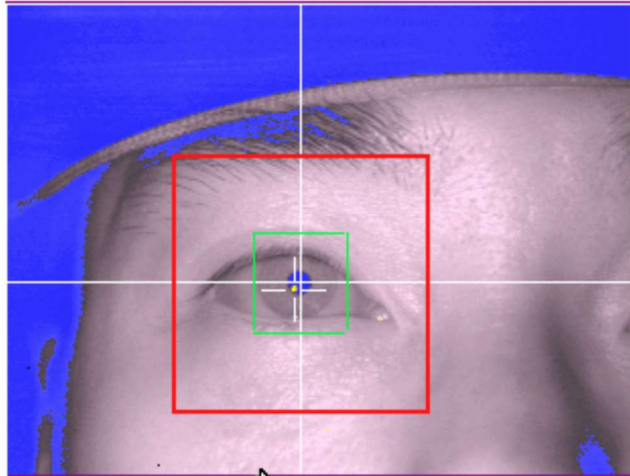
# Participant Setup - Tower

Never adjust the Tower Mount with subject's head in place

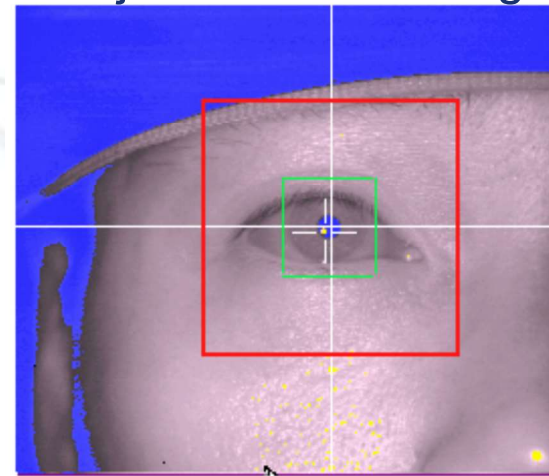
- 1) Set the eye-selection knob to track the dominant eye
- 2) Adjust the mirror angle to get a good view of the eye, or to avoid glasses reflections; adjusting chin position may help too
- 3) Click pupil in the global view to autothreshold (Host Display PC)
- 4) Focus the camera - minimize size of teal CR circle
- 5) Autothreshold and if necessary, adjust pupil and CR thresholds
  - If cautious or troubleshooting, check the setup by asking the subject to look at four corners while monitoring threshold quality at all positions
- 6) Calibration
- 7) Validation
- 8) Recording

# Participant Setup

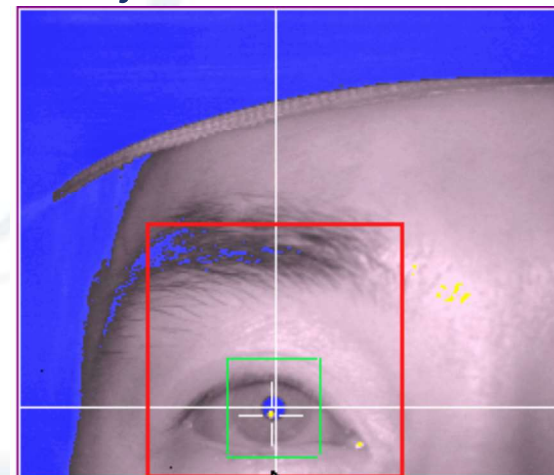
Optimal Eye Position



Subject seated too high



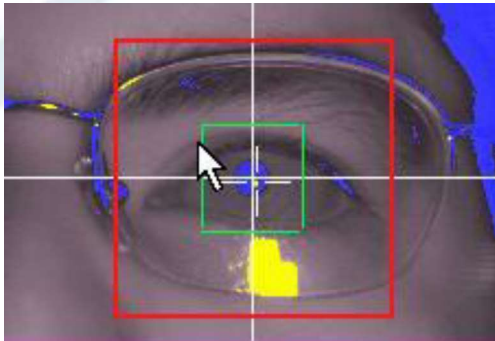
Subject seated too low



- Adjust chair height so the subject is comfortable and has line of sight to upper part of monitor
- Forehead rest should be just above the eyebrow.

# Participant Setup

Use Search Limits

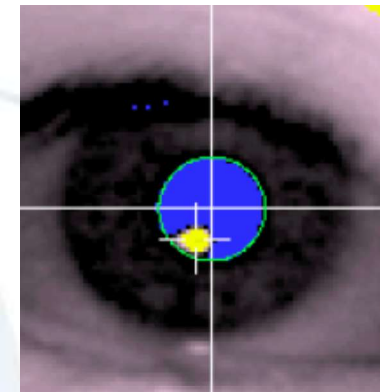
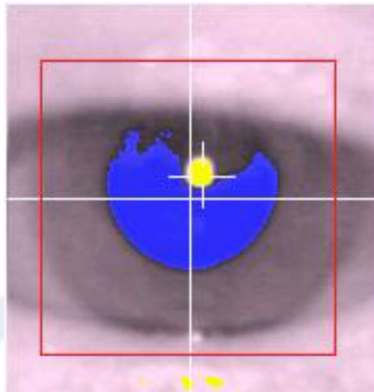


- Search Limits (red box) can be used to reduce the area of the image that is searched to find the eye.
- Prevents system from switching to opposite eye.
- You can hold ALT + arrow keys to adjust the size and shape of the search limits.
- Use SHIFT + arrow keys to adjust the position of the search limits



# Participant Setup

## *Centroid vs. Ellipse pupil tracking modes*



### Centroid model fitting:

- Tracks center of a circle fit to thresholded pupil
- Advantages:
  - Highly stable
  - Low noise
- Disadvantage:
  - Position drift if pupil is occluded by eyelid

### Ellipse model fitting:

- Tracks center of an ellipse fit to thresholded pupil.
- Advantages:
  - Decreased drift
  - Overcomes pupil occlusion
- Disadvantage:
  - Slightly higher noise level

# Participant Setup

## *Setting Pupil Threshold*

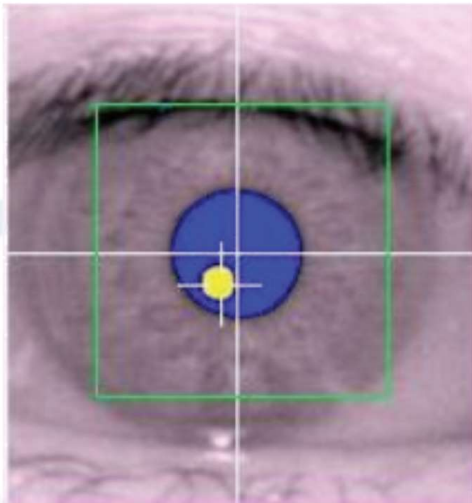


Fig. 1

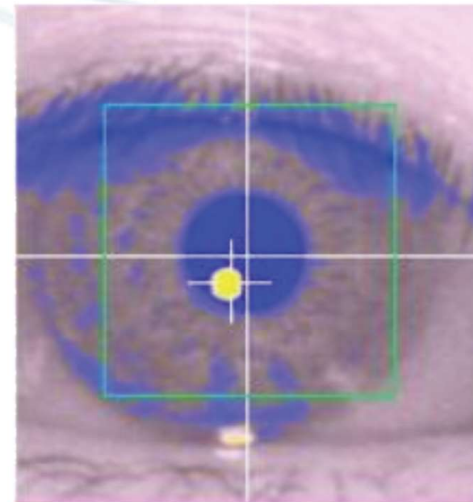
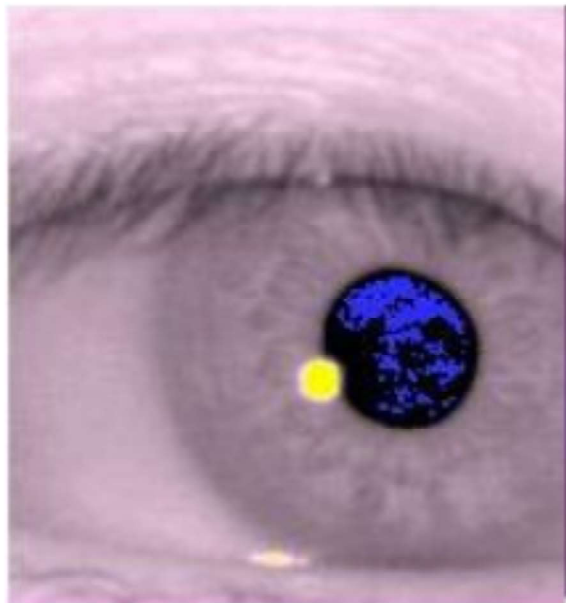


Fig. 2

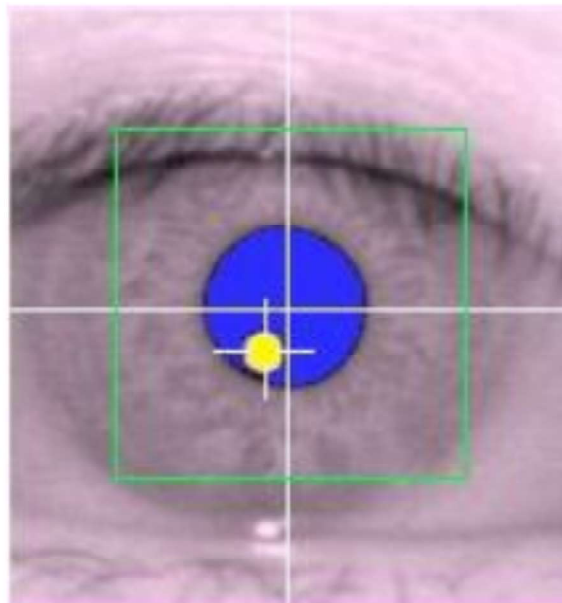
Pupil threshold can be adjusted automatically, through the Auto-Threshold command, or manually, through the up and down arrows. A threshold too high will result in shadows (Fig. 1), while a threshold too low will result in a noisy signal (Fig. 2).

# Participant Setup

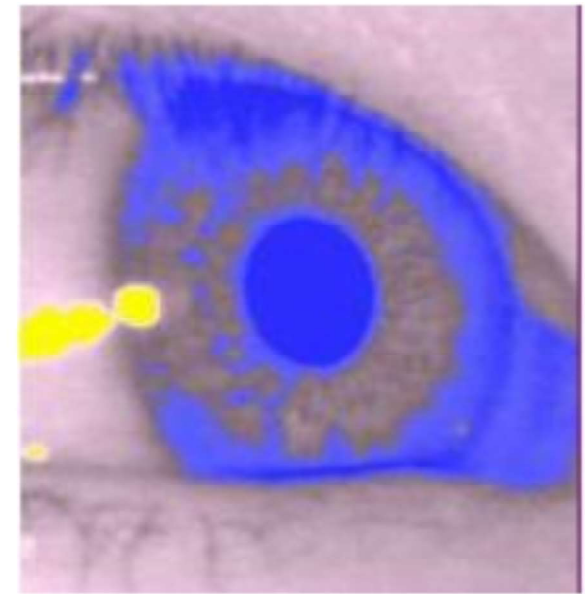
## *Symptoms of Poor Pupil Threshold*



Pupil clipped and lost



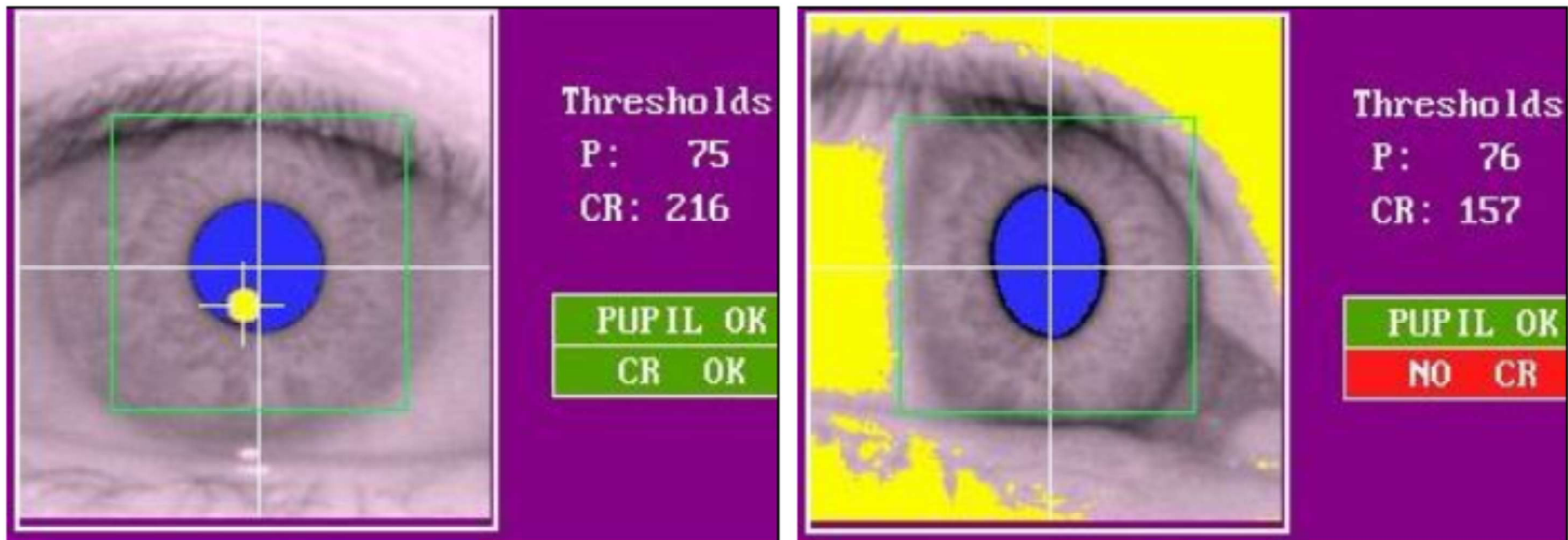
Good



Corner shadow captures pupil

# Participant Setup

## *Setting Corneal Reflection (CR)*



Good corneal reflection

Poor corneal reflection

Adjust corneal reflection using + and – keys. Note that the – key increases the thresholded area.



# Participant Setup

*Binocular Mode*

**Image Thresholds**  
Auto Threshold

Pupil  
Corneal

Tracking Mode  
Pupil-CR

Sample Rate  
250 500

Pupil Tracking  
Centroid Ellipse

Image Display  
Crosshairs  
Threshold Coloring  
Image->Remote

Use Search Limits  
Mouse Autothresh.

Illuminator Power  
100% 75% 50%

**Camera Setup**  
TCP/IP Link Open

Screens  
Exit Setup  
Offline  
Output/Record  
Set Options  
Help (F1)  
Calibrate  
Validate  
Drift Correct

Pupil: 70  
CR : 216  
PUPIL OK  
CR OK

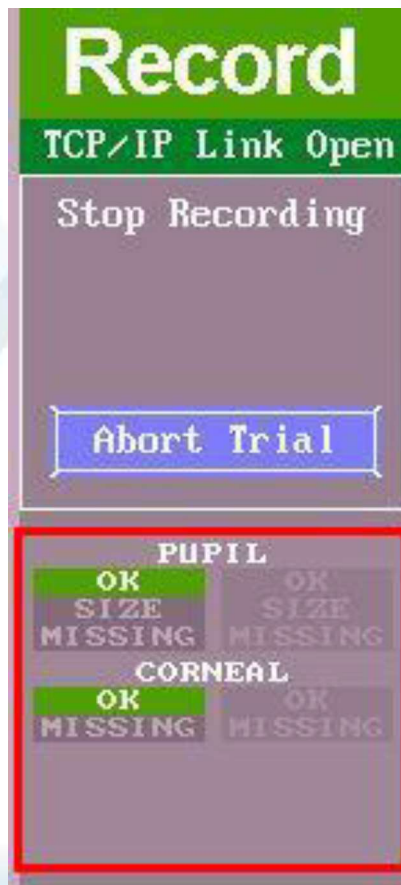
Pupil: 71  
CR : 220  
PUPIL OK  
CR OK

Eye(s) to Track  
Left Both Right



# Status Panel

Monitor the status of camera image of the tracked eye throughout setup, calibration, validation and recording phases.



## Pupil:

**OK:** Pupil present and can be tracked at selected sample rate

**SIZE:** Occurs when pupil size is larger than the maximum allowed pupil size

**MISSING:** Pupil not present

## Corneal reflection:

**OK:** CR present and can be tracked

**MISSING:** CR is not present

# Participant Setup - Remote

- 1) Place the target on the subject's forehead
- 2) Adjust camera angle and position to get a good view of the eye and sticker; capture as wide a range of subject movement as possible
- 3) Click pupil in the global view to autothreshold (Host Display PC)
- 4) Focus the camera - minimize size of teal CR circle
- 5) Adjust thresholding bias for pupil and CR
  - If cautious or troubleshooting, check the setup by asking the subject to look at four corners
  - If the CR is smeared move the Desktop Mount toward the problematic corner until CR is tracked
- 6) Calibration
- 7) Validation
- 8) Recording



# Participant Setup - Remote

### Image Thresholds

Pupil

↑

↓

Corneal

↑

↓

### Tracking Mode

Pupil-CR

### Sample Rate

250 500

### Pupil Tracking

Ellipse

### Image Display

Crosshairs

Threshold Coloring

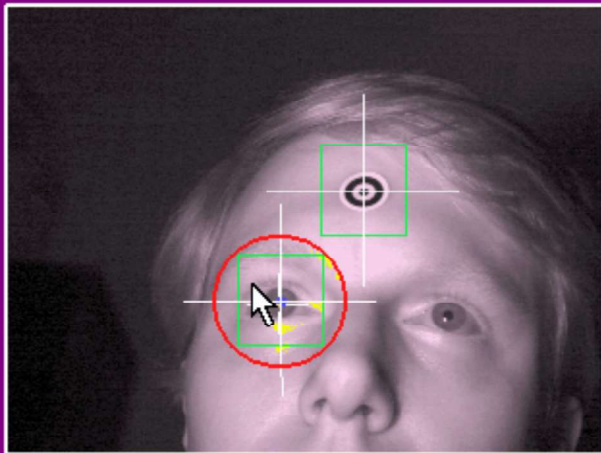
Image->Remote

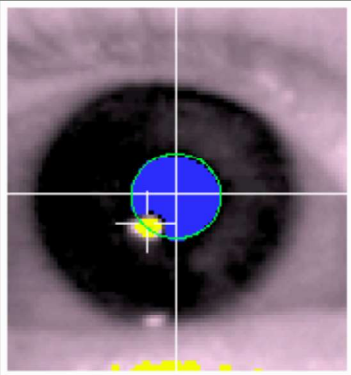
### Align Eye Window

Align Eye Window

### Illuminator Power

100% 75%



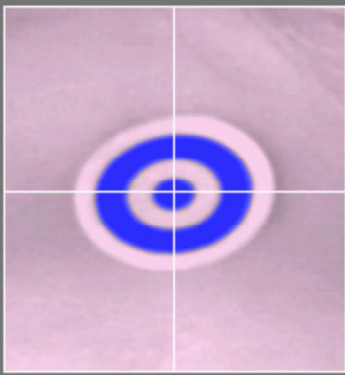


Pupil: 86 AUTO x1.05  
CR : 203 AUTO x1.00

PUPIL OK

CR OK



Target Thr: 142  
Distance: 594.6 mm

TARGET OK

DIST OK

Eye Tracked: Left Right

### Camera Setup

TCP/IP Link Open

#### Screens

Exit Setup

Offline

---

Output/Record

Set Options

Help (F1)

---

Calibrate

Validate

Drift Correct



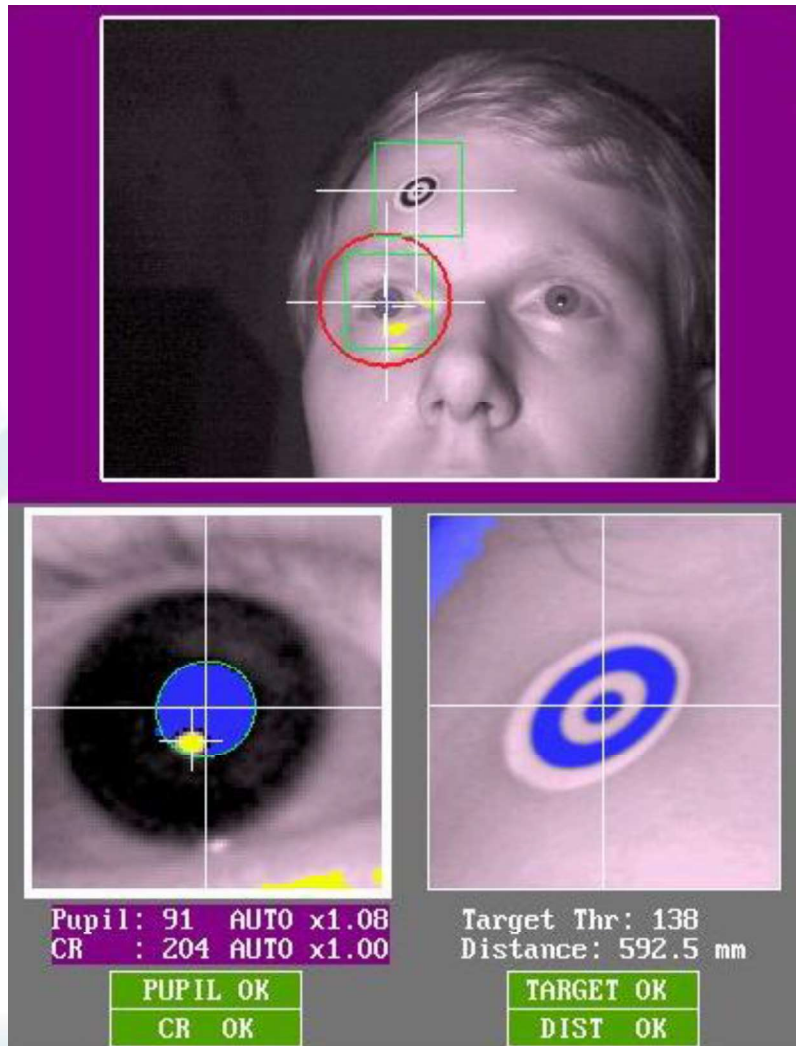
# Participant Setup - Remote

Participant setup becomes a smooth and fast procedure with practice. Follow these steps:

- 1) Use proper lens and set ELCL configuration to “Desktop (Remote)”
- 2) Set the height of the monitor; eye-to-screen distance of about 70 cm
- 3) Place camera right in front of the monitor
- 4) Raise desktop mount to maximize tracking range
- 5) Seat the subject and place the target sticker
- 6) Find the pupil by clicking on the eye image
- 7) Adjust the thresholding bias for pupil and CR
- 8) Check setup by asking subject to look at four corners
- 9) Calibration, validation and recording



# Participant Setup - Remote



- Place target sticker on the subject's forehead
- The eye and sticker should stay within the camera image when the subject moves
- Ideal target-to-camera distance is 550mm to 600mm for calibration
- For highest accuracy use 13-point calibration

Target Thr: 178  
Distance: 499.2 mm

TARGET OK  
DIST CLOSE

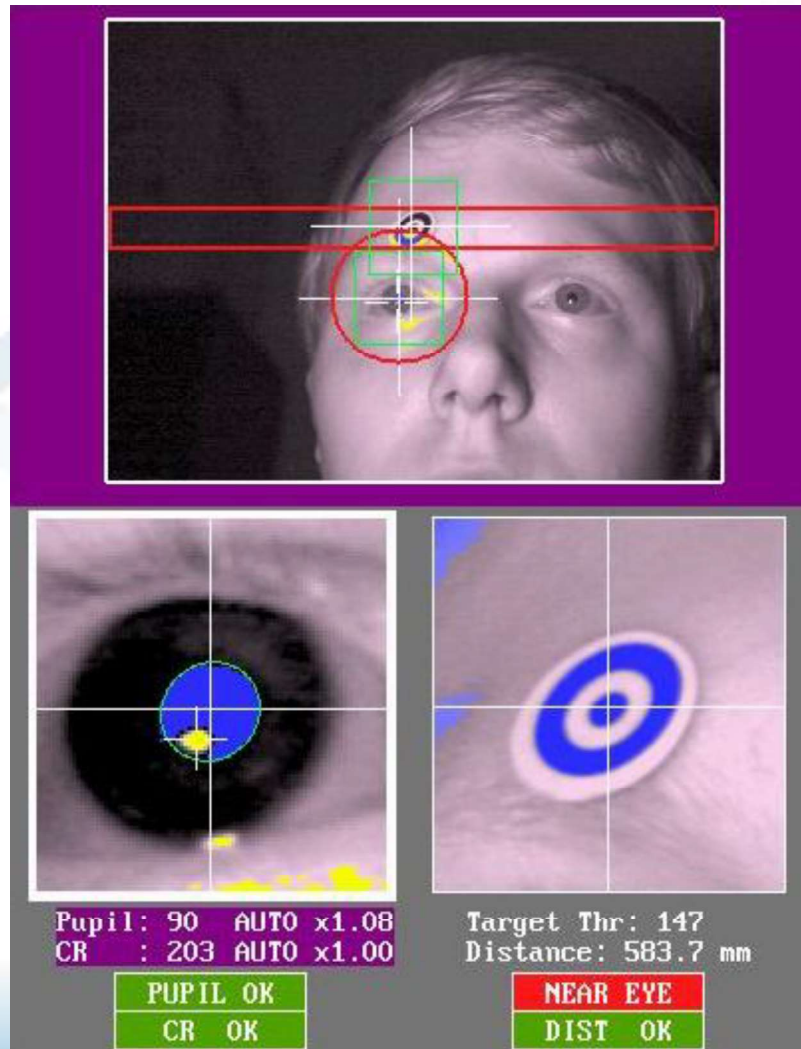
Target Thr: 123  
Distance: 716.4 mm

TARGET OK  
DIST FAR

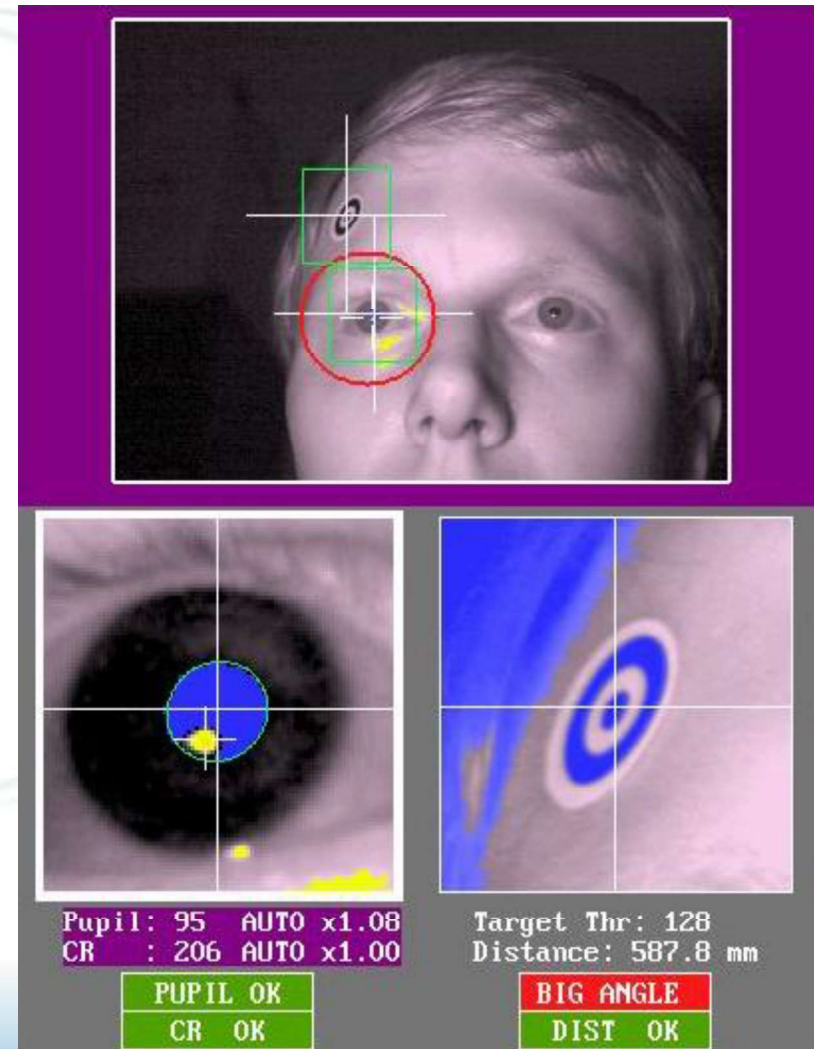


# Participant Setup - Remote

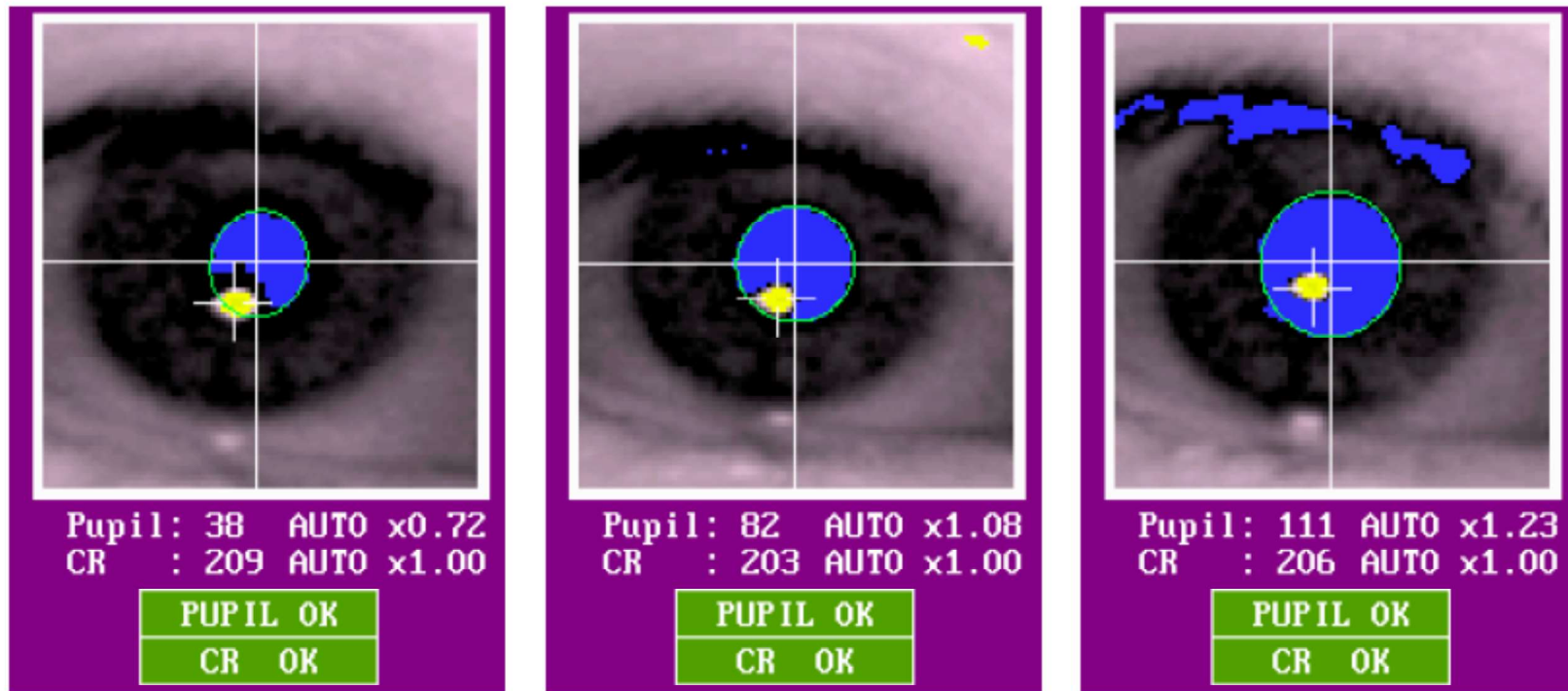
*Target too close to the eye vertically*



*Target has a large angle*



# Participant Setup - Remote



Threshold bias too low

Properly thresholded

Threshold bias too high

Pupil threshold bias adjusted by up and down arrow keys  
(1.08 typical)

CR threshold adjusted by + and – keys (1.00 typical)

# Participant Setup - Remote



- Monitor the thumbnail camera images at the lower left corner of the tracker screen.
- The two dots in the middle panel reflect the target dot and eye position in the camera image
- For reliable tracking, both dots should stay within the red box

# Participant Setup - Remote

## Pupil

- OK:** Pupil present and can be tracked at selected sample rate
- SIZE:** Occurs when the pupil size is larger than the maximum allowed
- MISSING:** Pupil not present

## Corneal

- OK:** Corneal reflection is present and can be tracked
- MISSING:** Corneal reflection is not present

## Target

- OK:** Target is present and can be tracked
- MISSING:** Target is not present
- NEAR EYE:** Target is placed too close to the eye on the vertical dimension
- ANGLE:** Target has too low an angle to be recognized properly

## Status Panel

PUPIL	
OK	OK
SIZE	SIZE
MISSING	MISSING
CORNEAL	
OK	OK
MISSING	MISSING
TARGET	
OK	OK
MISSING	MISSING
ANGLE	ANGLE



# Calibration



## Calibrate

TCP/IP Link Open

Screens

Camera Setup

Help (F1)

PUPIL

OK	OK
SIZE	SIZE
MISSING	MISSING
CORNEAL	
OK	OK
MISSING	MISSING

Sequencing

Restart

Auto Trigger

Accept Fixation

STABLE  
Point 7 of 10



Thresholds:

P: 101  
CR: 221

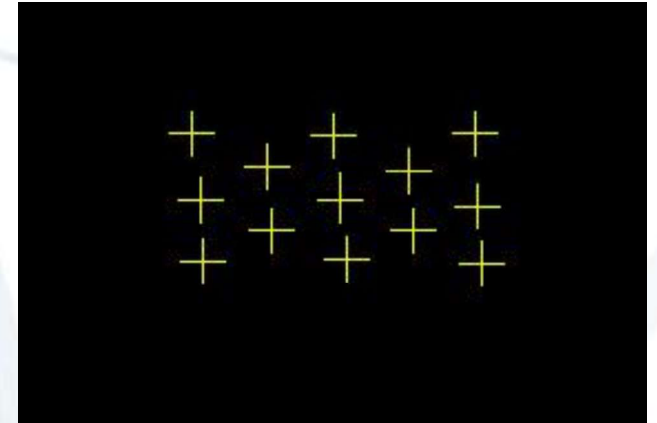
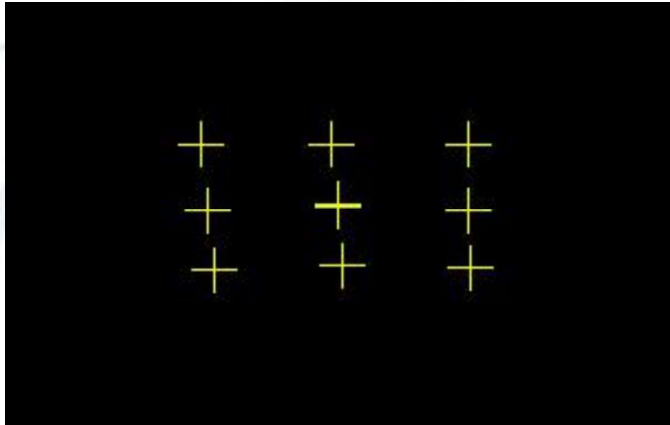
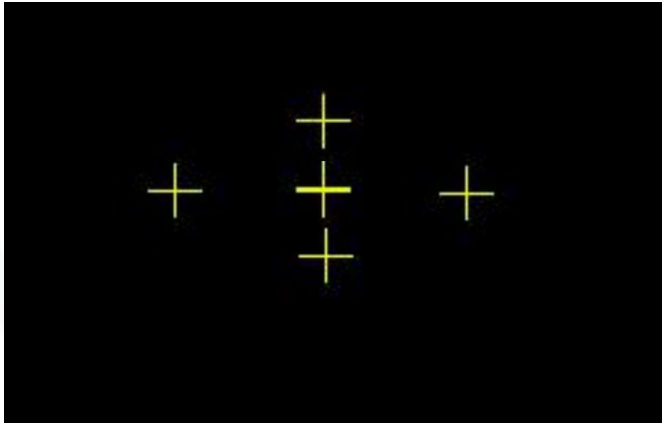


Tracking: Left Eye, Pupil-CR  
Calibration: 9 point grid

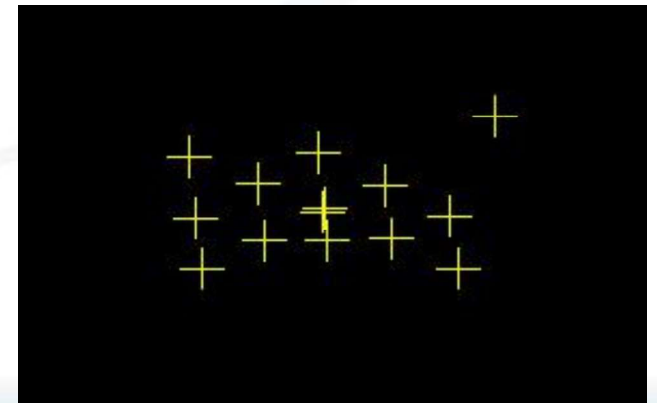
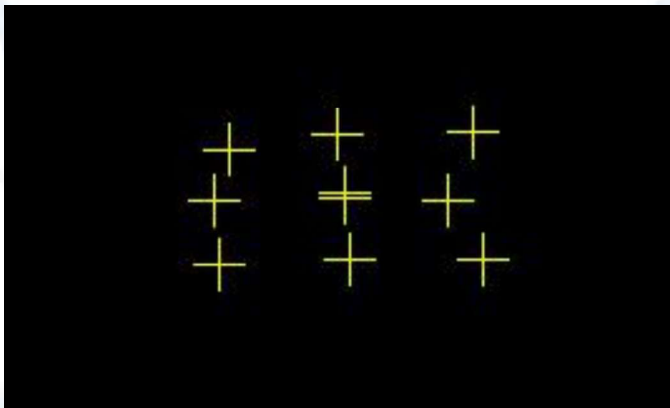
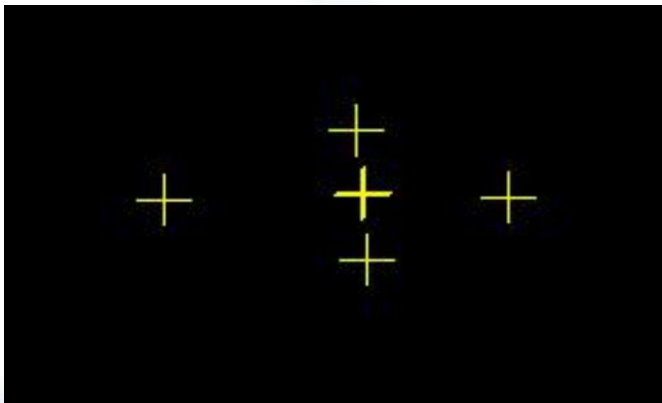


# Calibration

## Good Calibration models (symmetrical)



## Poor Calibration models (asymmetrical)



# Calibration

- To improve calibration accuracy:
  - Check pupil and CR as the subject looks at all four corners of the display. They should always be visible, well-thresholded, and tracked.
  - Encourage subject to sit still—no head turning!
  - Redo targets by pressing the backspace key
  - Turn on manual accept mode by pressing the SPACE key twice to ensure subject is fixating calibration target
  - Match background color of calibration/validation screen to test displays—change in pupil size due to large brightness differences can cause drift

# Validation

*Checking gaze accuracy of the calibration*



The screenshot displays the EyeLink Validation software interface. The main window is a black rectangle with eight green crosshair markers at various positions, each labeled with a decimal value representing gaze error: 0.62, 0.41, 0.58, 0.76, 0.24, 0.40, 0.13, and 0.20. A large, faint blue 'X' is overlaid on the background.

On the right side, there is a vertical panel titled "Validate" in green. Below the title, it shows "TCP/IP Link Open". Under the "Screens" section, there are buttons for "Camera Setup" and "Help (F1)". A "PUPIL" section contains a table with status indicators for "OK", "SIZE", "MISSING", and "CORNEAL".

At the bottom of the interface, there is a status bar. On the left, a small inset shows a camera view of an eye with a red square and a blue circle. Next to it, the text "Thresholds:" is followed by "P: 101" and "CR: 221". To the right of this is a small black square with a white dot. Further right, a green box displays the text "LEFT Error: 0.35° avg, 0.76° max (GOOD)" and "Drift Correction \*\*DISABLED\*\*". On the far right of the status bar are three buttons: "Accept", "Restart", and "Discard".

PUPIL	
OK	OK
SIZE	SIZE
MISSING	MISSING
CORNEAL	CORNEAL
OK	OK
MISSING	MISSING

Thresholds:  
P: 101  
CR: 221

LEFT Error: 0.35° avg, 0.76° max (GOOD)  
Drift Correction \*\*DISABLED\*\*

# Validation Results

## Validation Results

- GOOD (green background): Level of error is acceptable
- FAIR (grey background): Error is moderate; calibration should be improved
- POOR (red background): Error is too high for useful eye tracking

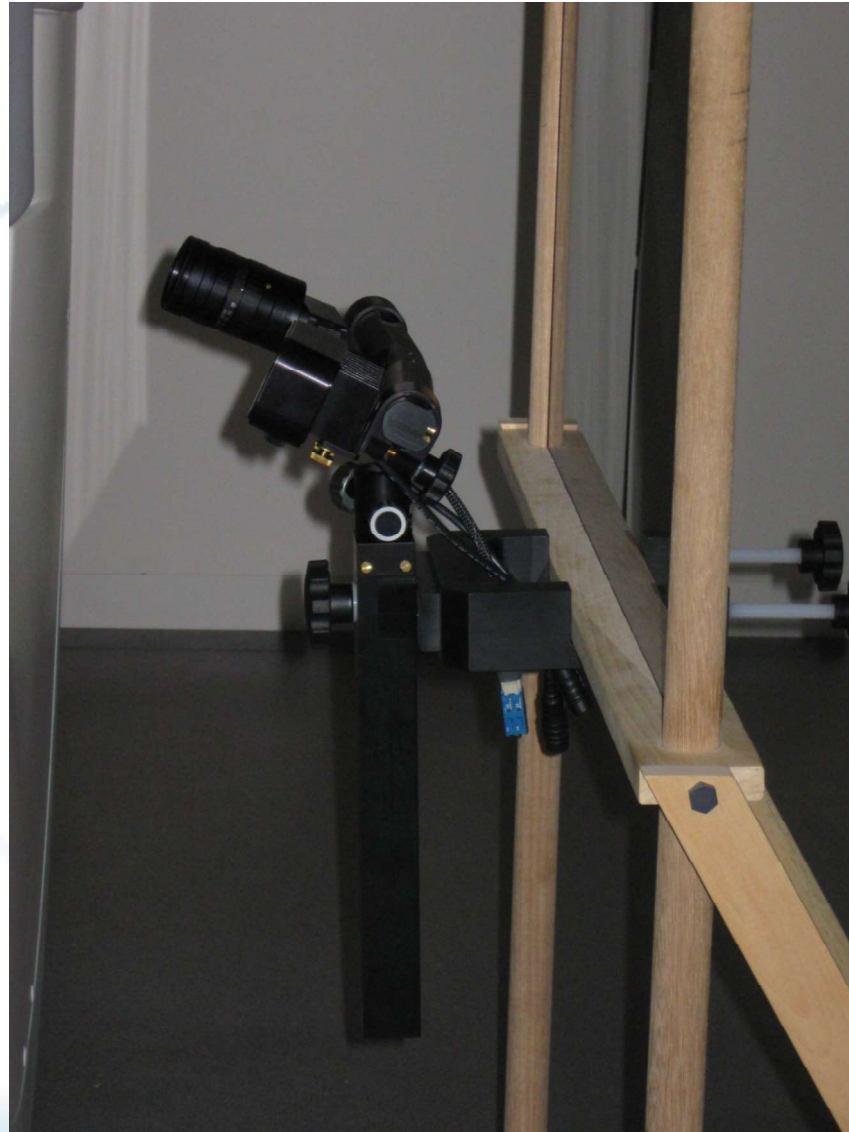
In general, ensure that the average gaze error is within  $0.5^{\circ}$  and maximum error is within  $1.0^{\circ}$

# Validation Results

- Optional card for Host PC – usually used for devices like EEG
- Converts Digital Data to Analog Voltages
- Output Gaze X, Y, and Pupil size as voltages over BNC connectors
- Voltage range configurable
- Three Channels per eye being tracked
  - Horizontal Position
  - Vertical Position
  - Pupil Size
- Also allows for extra Digital In/Out (in addition to Parallel Port)
- Quick –
  - Data can be inserted into empty EEG channels
  - Allows for easy alignment with EEG data
- Dirty –
  - Noise is added by D/A and A/D conversion
  - Saccade/Fixation information is lost



# Long Range Screen Mount



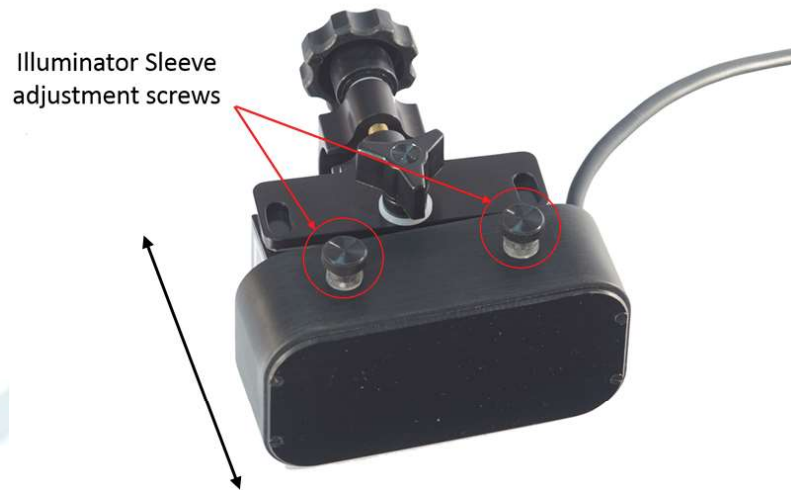
# Long Range Tray Mount



# Long Range Tripod Mount



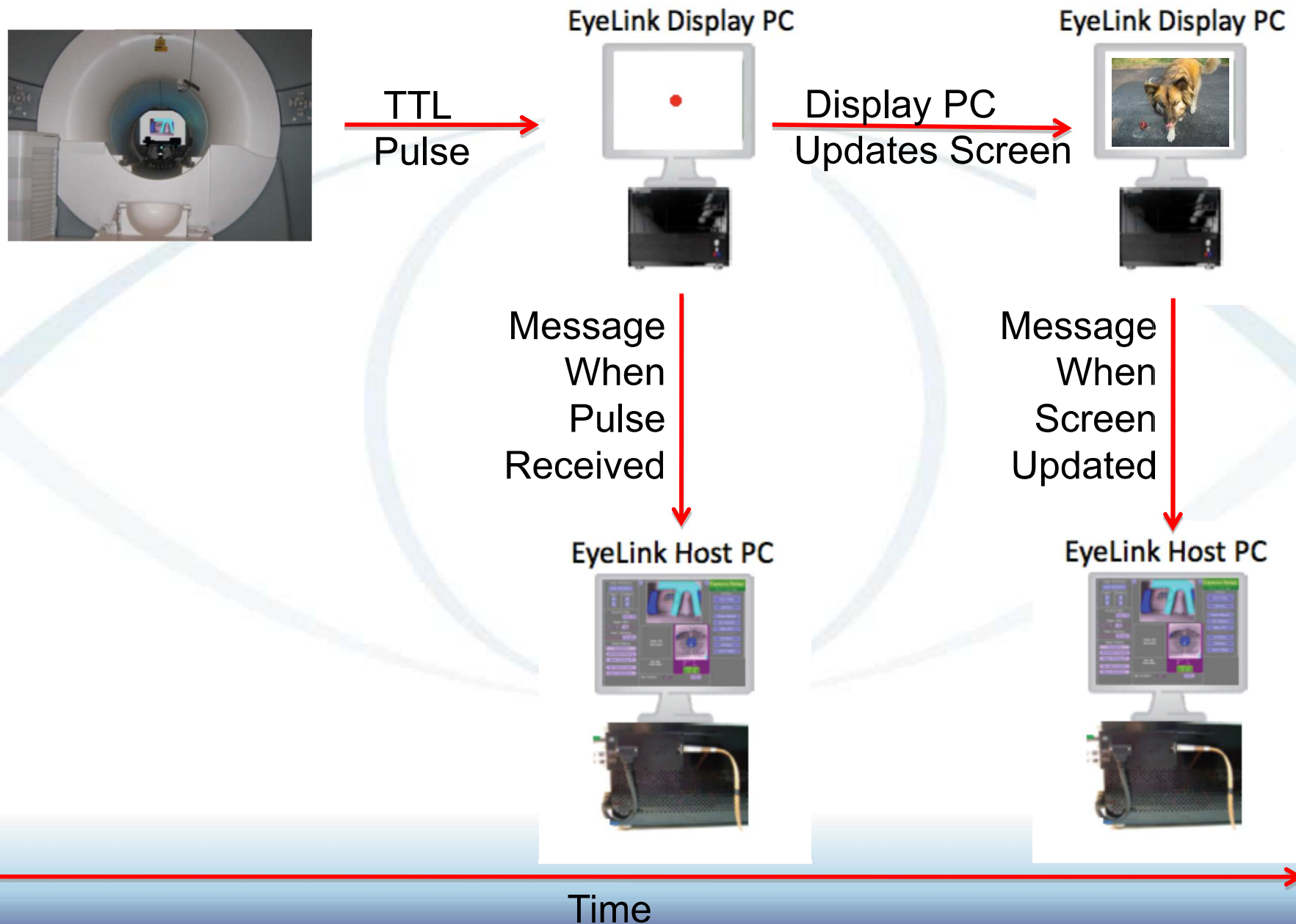
# Long Range Illuminator



- Adjust illuminator sleeve to furthest position.
- Adjust horizontal position.
- Adjust vertical position.
- Adjust illuminator sleeve to prescribed distance.

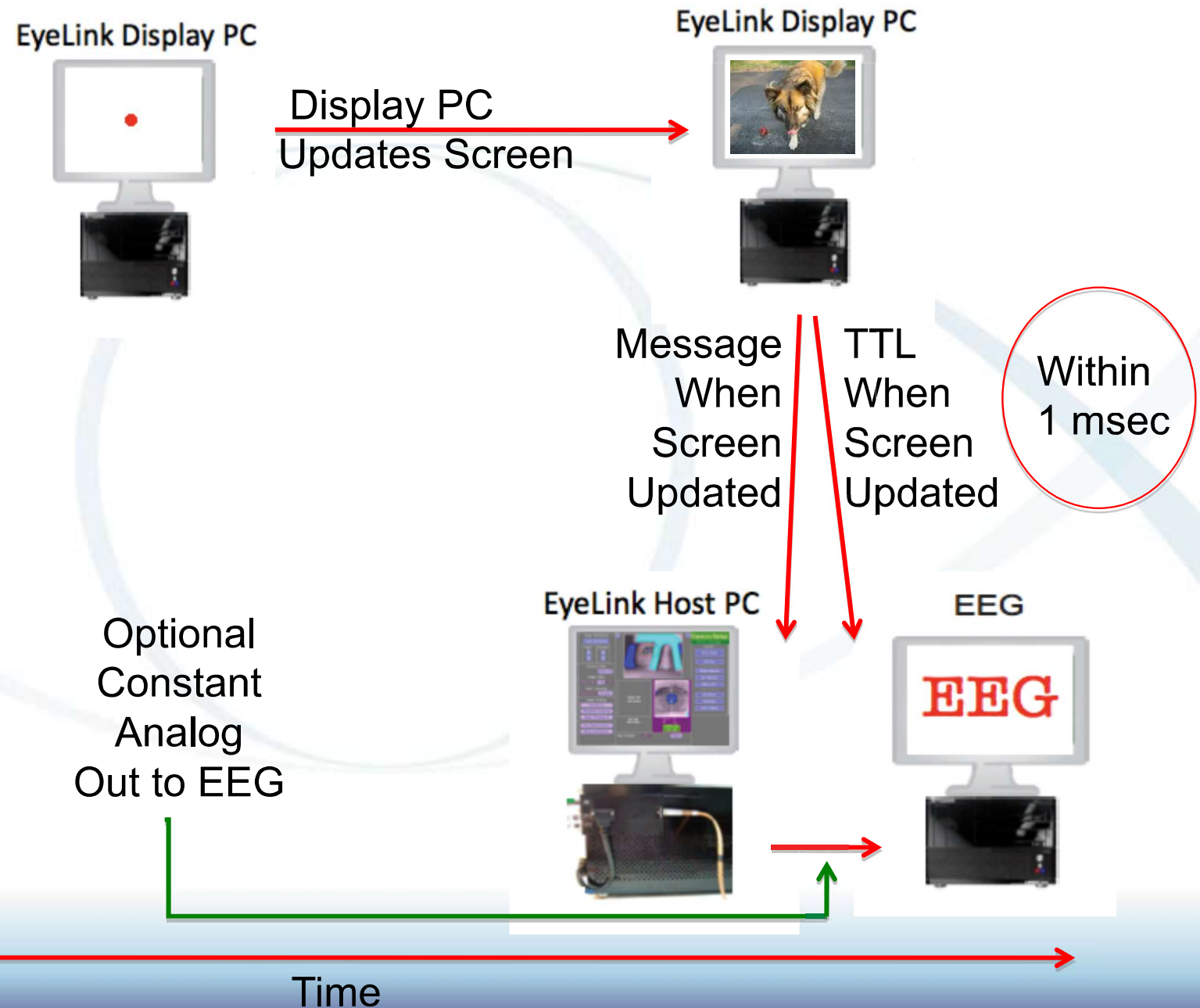


# MRI / Eye Tracker Setup





# EEG / Eye Tracker Setup



# EEG / Eye Tracker Setup

