Starter Eye-Tracking Training Manual

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Introduction

This manual will walk you through the preparation for an in-person training in the eye-tracker room. You must complete all required activities and readings, and pass the quiz at the end of each unit to complete this pre-training. Conducting an eye-tracking session, while not terribly complex, is much more than just pressing play. As such, in order to do this task well, you need a good, solid understanding of the theory and mechanisms behind the eye-tracker to ensure we get top quality data. So, this training will include watching several videos and a few readings.

All underlined text is a clickable link that will take you to the video/reading/quiz.

Reading - estimated time: 1 hour

Before you begin, please read **this paper by Huettig, Rommers, and Meyer (2011)** to get a baseline of knowledge on how eye tracking is used for linguistic research. There will be parts you don't understand, and that's ok. Just do your best and try to get the "big picture" ideas.

Contents

1: The EyeLink Overview: Part 1

1.1 The EyeLink Equipment

The EyeLink eye-tracker system has 5 major components that you should be familiar with. This section will outline each to give you an overview of the system. There are two computers, the display computer and the host computer, each with their own monitors. The display computer (DC) displays the experimental stimuli to the participant on its monitor. This is the screen that the participants see during the experiment. The host computer (HC) runs the EyeLink eye tracker and has its own monitor where the experimenter can manage the eye tracker and keep an eye on the progress of the experiment. The host computer is linked to the display computer and will transmit all of the data to the display computer at the end of the experiment through the Ethernet cable. At no point should any of the computers be connected to the Internet while running the tracker. This could disrupt the Ethernet connection between the host and display computers.

1.2 Vocabulary

Reading - estimated time: 15-20 min

Please review this vocabulary list and then read this blog post from SR Reseacrh.

1. **cornea** - The clear outer surface of the eye
2. **pupil** - the dark center of the eye (actually a hole that allows light into the eye)
3. **saccade** - an eye movement
4. **saccadic suppression** - the idea that the brain suppressed visual information processing during an eye movement (makes things blurry and less defined) so as to not make a person dizzy every time their eye moves.
5. **fixation** - A period of time between saccades where the eye is relatively stable and visual information is processed.
6. **fovea** - the small region of our visual field where everything is clear and perceptible. Eye movements are a result of needing to move the clear overall region around the visual space to perceive relevant visual information.
7. **parafovea** - The region outside of the foveal region where information is perceptible, but out of focus.
8. **peripheral** - the region outside the parafoveal region at the edges of our visual field, generally off to our sides if we are looking striaght ahead.

1.3 How Do Eye Trackers Work?

Video - estimated time: 1 hour

Please watch this video to learn about the history of eye-tracking and how modern eye trackers work.

Watch to 49:32. you do not need to watch the last section of the video.

1.4 Part 1 Quiz

Quiz

Please take this quiz to test your understanding of how the eye tracker works.

You need to score 80% (18/26) or better to pass. The quiz will prompt you to enter the email address where the results should be sent. This should be the person who assigned this work to you, professor, lab manager etc. You may have the video open while you take the quiz, but please watch the whole thing before you open the quiz. You may re-take the quiz up to 3 times to reach this score.

Remember, the quiz is there to asses comprehension, so comprehension of the material is the goal here, not the quiz. If you pay attention to the material, the score will fall out naturally.

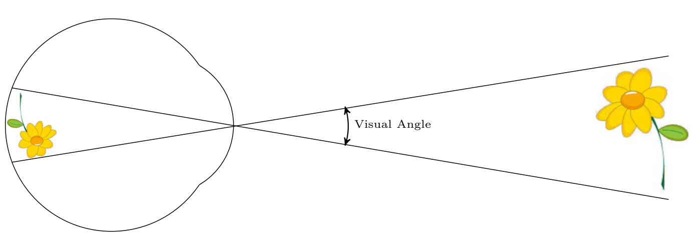
2: Eye-tracking Data Quality: Part 2

As an RA running a participant, it will be your job to ensure that the data you collect is as high as possible in terms of quality. Data quality is in part the job of the person who made the experiment, but thee majority of that job is down to you *as you collect the data.*

2.1 Visual Angle

Reading - estimated time: 15-20 min

To start, please read this page to learn about visual angle before we move on to data quality as you collect the data.

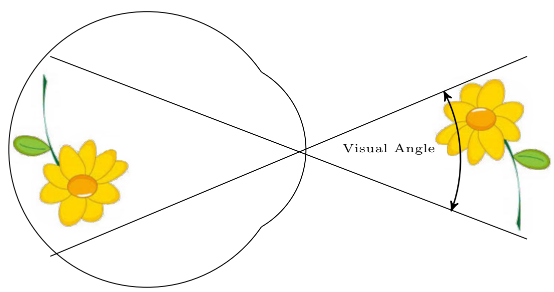


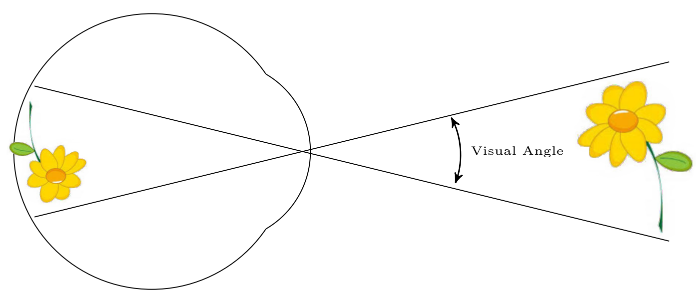
Visual Angle = 2*arctan(Size of Object / 2*Distance to Object)

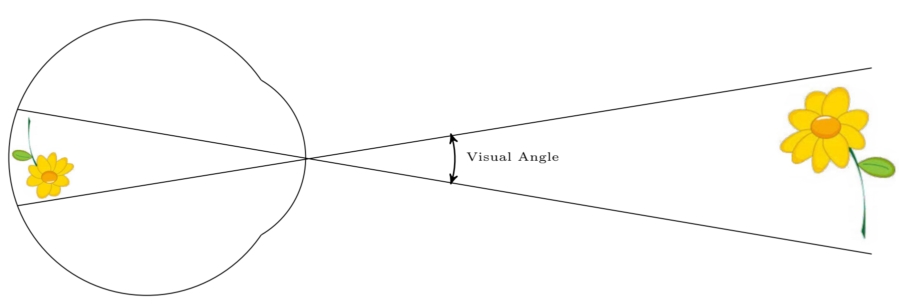
So, the visual angle is the angle created by the vectors stretching from the eye to the top and bottom of the object or area in question. But what factors influence the visual angle?

2.1.1 Visual Angle and Distance

The first variable that influences visual angle is DISTANCE. If an object with a set size moves close the eye, the visual angle increases, and so the object appears larger. If the same object moves farther away, the angle becomes smaller, and so the corresponding perceived image is smaller. It is for this reason that all of thee distances related to thee eye tracker rare kept fixed, such as where the participants head is located and the distance from there to the screen. By keeping the distance fixed, we don't have to worry about it influencing the visual angle. Additionally, the tracker has a set track-able visual angle range, so we need to make sure the the screen is close enough to see, but not so close that the edges of the screen fall outside of the track-able range. You won't even need to worry about this, just understand it so you know not to ever move any of the pieces of equipment on the table. They are exactly where they should be.

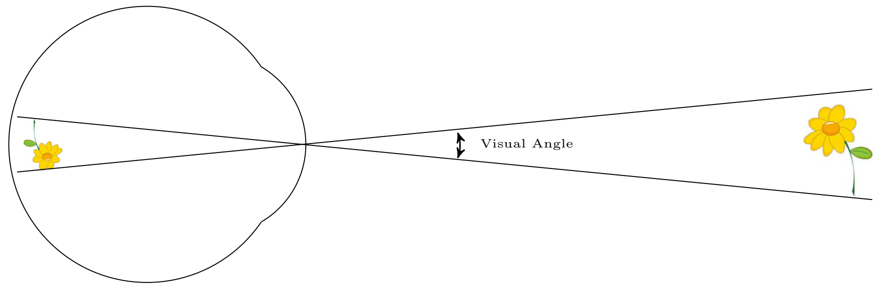


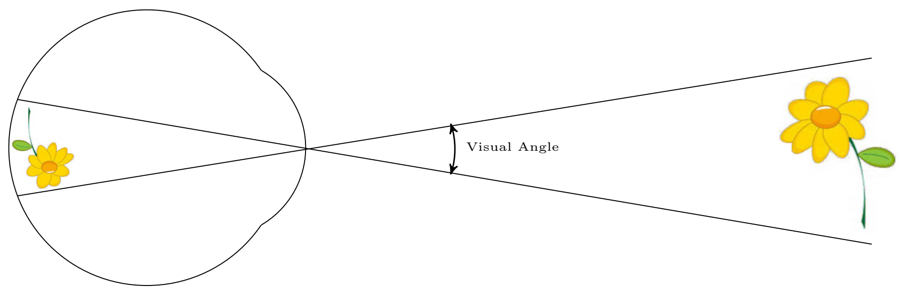


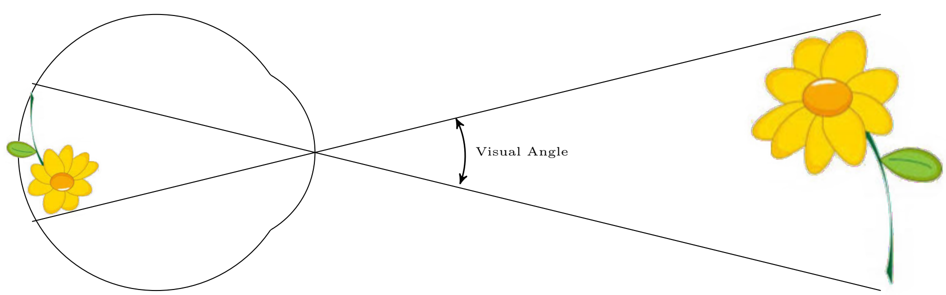


2.1.2 Visual Angle and Size

The other variable the can influence visual angle is the SIZE of the object or the distance between 2 points on a screen. So, the visual angle from the left and right sides of the screen is very large, but the visual angle from the right to left of a small picture centered on the screen would be very small.







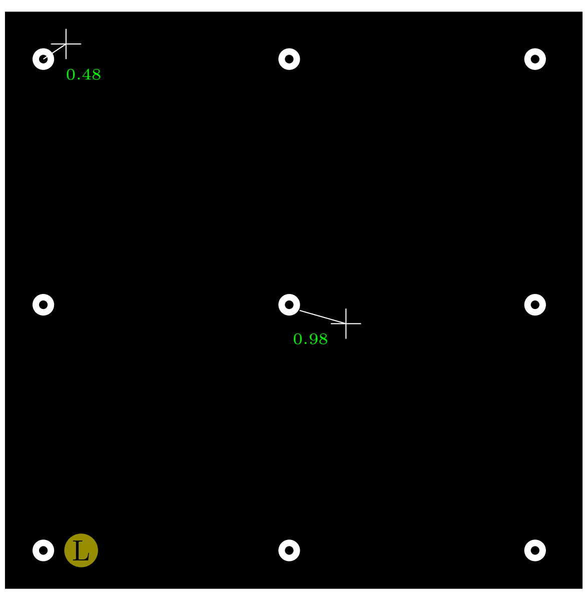
2.2 Visual Angle and Data Quality:Error in the Tracking

Visual angle in terms of size of an object or distance on a screen is extremely relevant to the calibration process of setting up the eye tracker and to data quality. The video you watched in the last section discussed the calibration process of the eye tracker which takes the eye position relative to the corneal reflection and translates that to pixel on the screen using a regression (you don't need to know more about that yet). What the video *didn't* discuss was what comes after the calibration, which is a validation process. We will get into the specifics of this later, but for now we will just say that it is basically a test to see how well the regression did in creating that mapping.

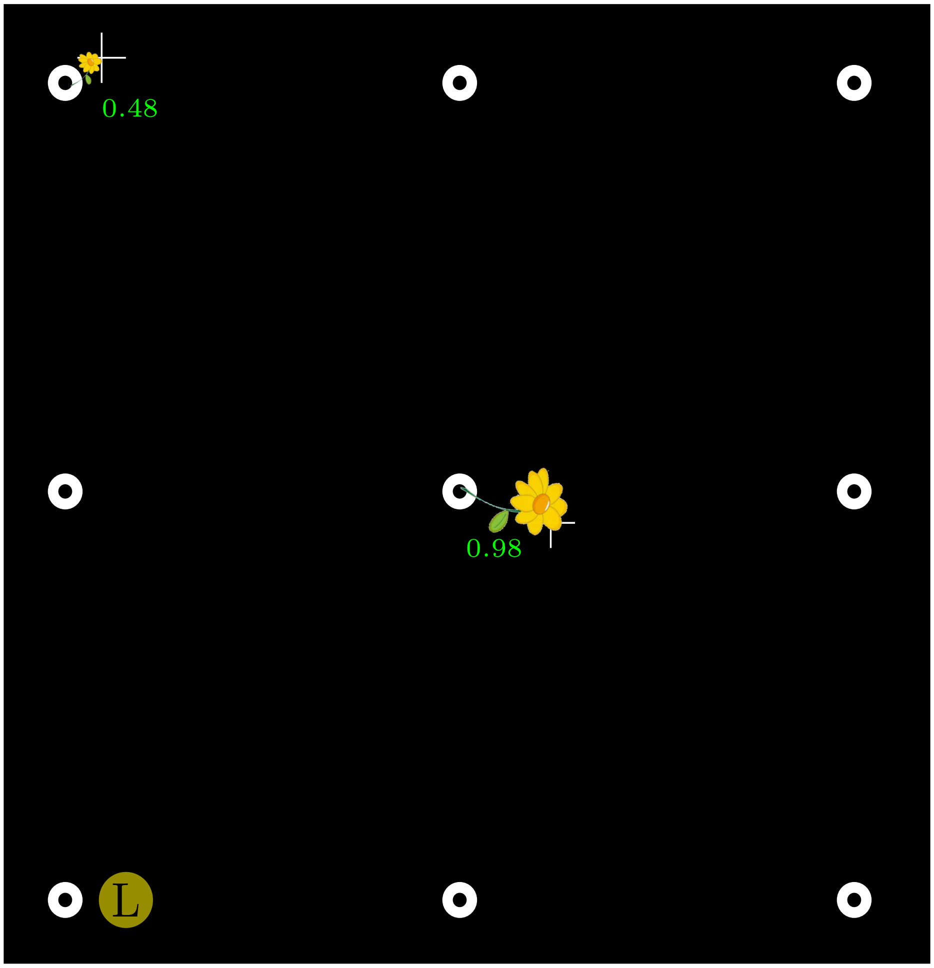
So, it presents the participants with points on a screen, and the tracker does it's video processing of the participant's eyes and tells us where it thinks the participant was looking in terms of pixel coordinates. Then, it gives us a measure of the visual angle of the distance on the screen that the tracker's prediction was off. Let's break this down a bit.

The validation process is our check to see how good the tracking is. This means, we are giving the participant *known* pixel coordinates to look at, and then seeing where the tracker thinks they are looking. If the tracking is perfect those points will be on top of each other, but if the tracking isn't perfect there will be some space between the intended point and the tracker point. This difference is the ***error*** in the tracking.

No tracking is error free, but we do want to do everything we can to reduce the error in the tracking, because error in the tracking translates to error in our data. If we look at the following picture, we will see white circles with black dots in them which are the fixed points we ask participants to look at. The white crosses are showing where the tracker predicted that they were looking based off of the video image of the eye. The white line connecting the two therefor shows the distance on the screen or the "size" of the error in the tracking. It will also report numbers. These numbers are reporting the degrees of visual angle for the "size" of the error. Larger numbers mean larger error: smaller numbers mean smaller error. So, an error of 0.48 means that the visual angle created by those two points back up to the eye was 0.48 degrees.



If I replace those white lines showing the distance on the screen with our flower from before, hopefully we can see now how size of an object is relevant to the calibration/validation. An error term of 0.48 means that the tracker recorded the participant as looking 0.48 degrees of visual angle away from where they were actually looking. Similarly, an error terms of 0.98 means that the tracker recorded the participant as looking 0.98 degrees of visual angle away from where they were actually looking.



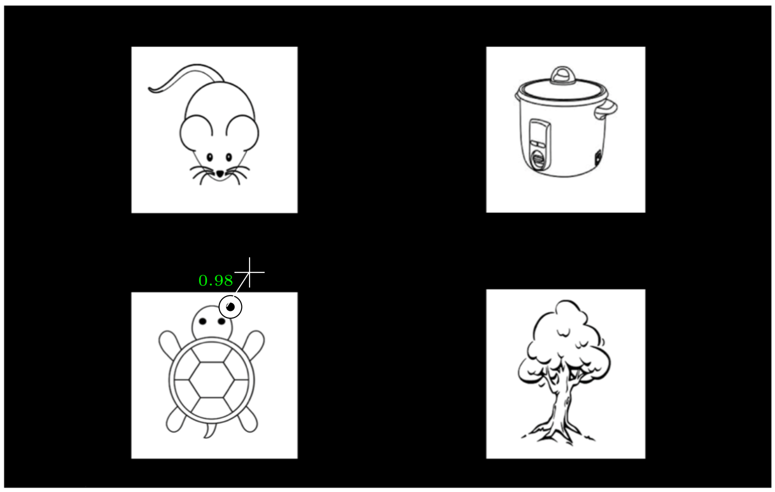
The larger the error term the more error is in the data! So we want those numbers as small as possible. How small, you ask? In our lab we use the criterion listed below for each type of method.

Visual World
Average <0.5 Max <1.0

Reading
Average <0.3 Max <1.0

2.3 Why Does Error Matter?: Isn't close enough good enough?

At this point you may be thinking, "What's the big deal? why do we care about precision down tot he pixel in these experiments? Isn't close enough good enough?" In many cases you may be right, but eye-tracking is such a valuable method *because it is so precise.* We *want* precision down to the pixel in many cases. Even when we have pictures on the screen as in below, if the tracking of off by 0.98 as in our previous example, that could mean that when a participant is actually looking at a picture we care about, the tracker might think they are looking at the black space above the picture, and not register it as a look to one of the pictures. In this way, we lose a lot of data, and it makes our results difficult, or even impossible, to interpret. That woudl render all of the work collecting the data useless.



In reading experiments, this becomes even more relevant. Take the example below. The participant is actually looking at the word "cried" but due to the small error of .48 in the tracking, the tracker records that as a look to the word "baby". If this sort of distortion is allowed to continue, it will drastically skew our results. This is why we have a maximum error term that we will allow when doing the calibration. No tonly can we lose data due to bad tracking, but it can distort our data and hide critical effects we are looking for, or worse, create effects that don't actually exist.

2.4 Data Quality

Video - estimated time: 30 min

Please watch the first 30 min of this video to learn more about data quality.

Watch to 34:00. You do not need to watch the last half of the video.

2.5 Part 2 Quiz

Quiz

Please take this quiz to test you understanding of how the data quality.

You need to score 80% (12/14) or better to pass. The quiz will prompt you to enter the email address where the results should be sent. This should be the person who assigned this work to you, professor, lab manager etc. You may have the video open while you take the quiz, but please watch the whole thing before you open the quiz. You may re-take the quiz up to 3 times to reach this score.

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3: Participant Setup: Part 3

Video - estimated time: 10 min

Please watch this video to learn more about setting up a participant.

It's ok if you are still unsure about what buttons to press and the whole procedure. Don't worry. We will go over it several more times in person. This is just to give you a head start.

3.1 Part 3 Quiz

Quiz

Please take this quiz to test your understanding of setting up a participant.

You need to score 80% (15/18) or better to pass.

And...you are done! Hopefully you enjoyed learning about eye tracking!