

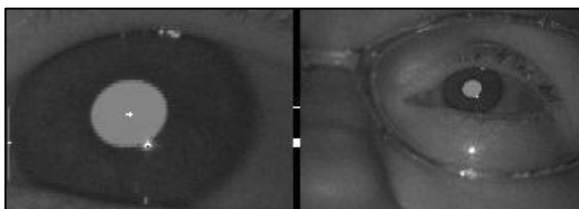
What Eyegaze Edge[®] Communicators Have Taught us about Eye Gaze Systems

1. Eye gaze systems use eye tracking technology

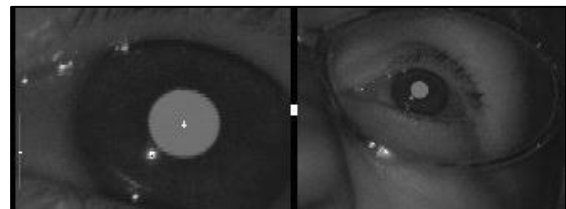
- Eye tracking is a method of determining where someone is looking by processing images of the eye.
- One or more cameras take pictures of one or both eyes and those images are digitized and analyzed to determine the gaze location.
- Gaze data can be passively collected for analysis and research or used immediately as an access method. Eye gaze systems use gaze data to enable the user to make selections on a screen with their eyes.

2. What is calibration?

- All eye gaze systems require some sort of user calibration in order to be able to determine where the user is looking.
- Calibration is the process of mapping the radius of curvature of the eyeball and the location of the macula on the retina by reflected light on the eye.
- A source of infrared light from one or several known locations is directed at the eye. When the bright pupil method is utilized, infrared light reflects off the corneal surface and also shines through the pupil and reflects off the retina, making the pupil appear white.
- The corneal reflection on the surface of the eye changes its location in relation to the center of the pupil as the gaze changes its direction. This method, known as the pupil-center/corneal reflection method of eye tracking, is used in eye gaze systems.



Gaze is up and to the left of the camera:
camera corneal reflection is at 5 o'clock



Gaze is up and to the right of the camera:
corneal reflection is at 7 o'clock

- Eyeballs are uniquely shaped, and each macula is uniquely located.
Your calibration won't work accurately for me.

3. Operating an Eye Gaze system

- **Run it yourself!** If you are recommending an eye gaze system or working with a client using their eye gaze system you owe it to them to try it yourself! Ideally you should operate it for 30 minutes to an hour in order to give the system a fair test. You'll want to pay attention to how accurately it responds to your gaze location, how comfortable it is, and how flexible it is.
- Running a system with your eyes is both easy and difficult. You're using your eyes as both an input device and an output device.
- New users often experience the Midas touch: everything you look at turns to gold (causes an action.)
- Eyegaze operation becomes easier when the user has developed muscle memory in their eye muscles so he doesn't have to think about where to direct their gaze to make the correct selection. It's similar to the process of learning how to touch type.

4. What have we learned from eye gaze users?

- **Avoid fatigue!** Running an eye gaze system does not cause eye muscle fatigue. Ocular muscles, like the heart muscle, are not capable of fatiguing. They work 24 hours a day. A well-designed eye gaze communication system should be comfortable to use all day.
- **Keep the screen low!** *Eyelid* muscles *do* fatigue, particularly if the user has to direct their gaze upward because their eye gaze screen is positioned too high. The top of the screen should normally be at eye level or lower.



Example of low screen positioning

Turn down the light! Light sensitivity is real, and it can impact eye gaze use. The amount of pigment present on the choroidal surface behind the retina determines light sensitivity.

- Some people cannot tolerate the amount of infrared light emitted by some eye trackers. Avoid bright or white screens to limit eye strain. Use a non-glare screen. Pay attention to sources of light in the room that may be shining on the user's eyes.
- Some eye gaze systems use very little infrared light and are often more comfortable to use.
- Research indicates that photoreceptors in the eye are especially sensitive to blue light waves, which have been shown to interfere with sleep. Blue light exposure increased with the introduction of flat screen technology, and it is now common for tablets and phones to have a "night mode" setting where this can be filtered out. Eyegaze Edge® systems have software installed to continuously filter out blue light waves.



Example of a low-light communication keyboard

5. What is mydriasis and why should you care?

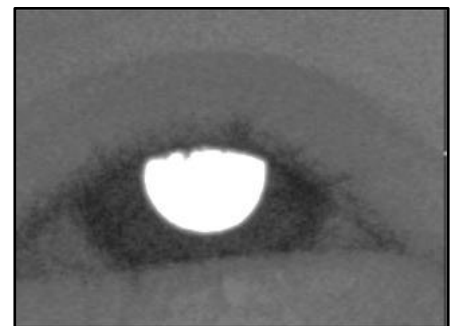
- **Mydriasis**, an abnormal dilation of the pupil, is a common side effect common side effect of baclofen. The pupils may be unable to constrict normally when the user is looking at a bright screen or a highly illuminated eye gaze system.



This boy's right pupil has mydriasis & is unable to constrict when exposed to bright light. His left pupil is constricting normally to protect the eye as it is exposed to the flash of a camera taking the photo.

6. What is Ptosis of the eyelid?

- **Ptosis (drooping) of the eyelid** interferes with many eye gaze systems if they require a fully visible pupil in order to locate the pupil center. When the eyelid blocks part of the pupil *most* eye gaze systems are unable to find the pupil center. Eye tracking degrades or doesn't work at all.
- The Eyegaze Edge® is able to accurately track the eye as long as over 50% of the pupil is visible. The image above shows enough pupil for an Eyegaze Edge® to track the individual's gaze.



7. What about dry eyes?

- **Dry eyes** may affect the ability of eye gaze systems to predict a user's gaze point accurately, since the corneal reflection degrades when the eye surface is dry. Blinking bathes the corneal surface with tears, and blink rates are slowed in people who are elderly, and often those with brainstem strokes or injuries or ALS. Artificial teardrops typically alleviate the problem if they are used routinely.

8. Position shouldn't matter!

- Users should be able to operate their eye gaze system any way that's comfortable for them. A communication device is the person's voice, and they need access to it to communicate all day, in any position. A well-designed eye gaze system, including the Eyegaze Edge®, will track the communicator's eyes accurately no matter their position: sitting, reclining, even side-lying.
- **No need to turn an Eyegaze screen sideways!** Our brains are wired to expect everything to be on the same visual plane. It'd be like turning your television on its side because you're lying on the couch. Asking the communicator's preference is important in these cases.

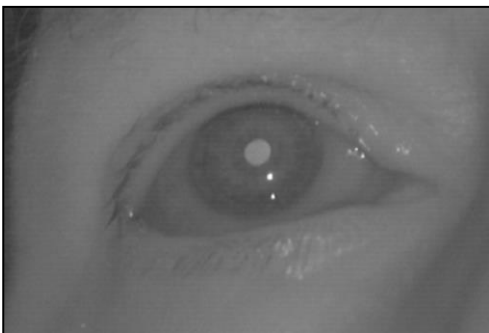


Not ideal (in many cases)



YES!

9. Eye gaze systems may not work well with extremely small pupils.



The retinal reflection may not be sufficiently bright enough to make the pupil edge stand out. This image from the Eyegaze Edge® allows our staff to collect data and make adjustments when possible, allowing for successful eye tracking access.

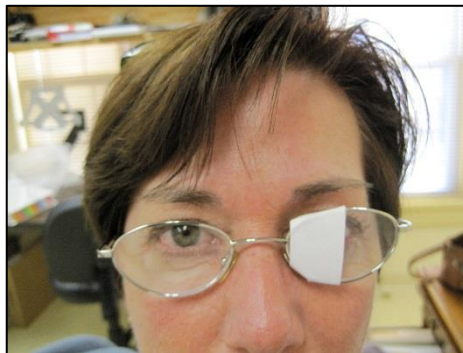
- Strategies to increase pupil size include using screens that are not overly bright, and decreasing room lighting to facilitate some pupil dilation.
- Some systems, including the Eyegaze Edge®, have software accommodations for pupils that are abnormally small or large.

10. Nystagmus (rapid involuntary movement of the eyes) can affect eye tracking accuracy.

- If the “bounce rate” of the nystagmus is less than 3 times per second some eye gaze systems can work accurately. (The Eyegaze Edge® has a special calibration that works well with most nystagmus.)
- Once calibrated, the gaze duration (dwell time) of the eye tracker typically must be set to about .33 seconds in order to capture fixations between bounces.
- While the speed of .33 seconds is quite manageable for a seasoned communicator with typical eye control, it can be somewhat overwhelming for a new eye gaze communicator. With practice most communicators become adept at typing at that rate, but need to be instructed that it will take time to adjust.

11. Strabismus can also affect eye tracking.

- Strabismus is a disorder of the eye in which the 2 eyes never converge to look at the same location. The brain will normally cancel the second image (from the non-dominant eye) so the affected person only sees one image.
- If the brain doesn't cancel one image the user will have diplopia (double vision.)
- A user with *alternating* strabismus (the eyes alternate focus) faces an additional challenge. Commonly the left eye will look at the screen on the left side, and the right eye will look at the screen when the selection is on the right side. In this case, the eye tracker doesn't know which eye to follow.



- Tracking one eye and using a nasal-side eye patch to block the other eye can often help users with strabismus.
- Be sure you *never cover the entire eye* – just cover enough to prevent that eye from seeing the screen. A partial eye patch placed next to the nose will allow the user to have a full field of view.
- A user with diplopia (double vision) may also benefit from a nasal-side eye patch.

12. How do you pre-screen someone for potential eye gaze use?

- The ability to follow a moving target, e.g. your finger, is called *visual pursuit*.
- Visual pursuit is *not* an indication of volitional eye control, which is a requirement of eye gaze use. A person can have perfect eye control to follow a moving target, but have no ability to independently move their eyes to the location of their choosing.



Asking someone to follow a moving target demonstrates visual pursuit only

- Test for *volitional eye control* by asking the intended user to look up, down, left, right, and straight ahead. Hold each position for 3 or 4 seconds.



13. What will you learn from this exercise?

- You'll see if the eyes are conjugate (track together).
- You will know if there's nystagmus as the person looks to the left and right, and can get a sense of where the "bounce" starts. In some cases, nystagmus only occurs when the eyes are extremely far to either side, so it won't occur when the user running an Eyegaze system.
- You'll get some information about the intended user's auditory processing skills and cognition if he is able to follow directions.
- Most importantly you'll see if they are able to control the movements of their eyes independently, an absolute necessity for eye gaze use.
- This test can easily be done using a smart phone and making a short video, which can be sent in advance to the evaluator.

For additional information about the Eyegaze Edge® system please go to www.eyegaze.com or call 1-800-EYEGAZE or 1-703-385-8800. Email inquiries can be directed to james.brinton@eyegaze.com.