

What Users Have Taught us about Eyegaze Systems

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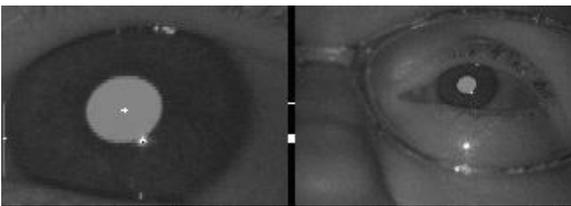
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1. Eyegaze systems use eye tracking technology

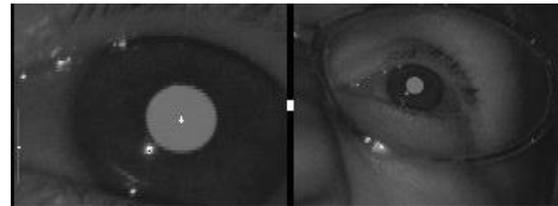
- Eye tracking is a method of determining where someone is looking by processing images of the eye.
- One or more cameras take pictures of one or both eyes and those images are digitized and analyzed to determine the gaze location.
- Gaze data can be passively collect for analysis and research or used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

2. What is calibration?

- All Eyegaze 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 it location in relation to the center of the pupil as the gaze changes it direction. This method, known as the pupil-center/corneal reflection method of eye tracking, is used in all Eyegaze systems.



Gaze is up and to the left of the 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 Eyegaze system

- **Run it yourself!** If you are recommending an Eyegaze system or working with a client using his Eyegaze system you owe it to him 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 his eye muscles so he doesn't have to think about where to direct his gaze to make the correct selection. It's similar to the process of learning how to touch type.

4. What have we learned from Eyegaze users?

- **Avoid fatigue!** Running an Eyegaze 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 Eyegaze system should be comfortable to use all day.
- **Keep the screen low!** *Eyelid* muscles *do* fatigue, particularly if the user has to direct his gaze upward because his Eyegaze screen is position too high. The top of the screen should normally be at eye level or lower.



- **Turn down the light!** Light sensitivity is real, and it can impact Eyegaze use. The amount of pigment present on the choroidal surface behind the retina determines light sensitivity.
- Some people cannot tolerate the amount infrared light emitted by some eye trackers. Avoid bright or white screens to limit eyestrain. Use a non-glare screen. Pay attention to sources of light in the room that may be shining on the user's eyes.
- Some Eyegaze systems use very little infrared light and are often more comfortable to use.
- Blue light and sleep: The 1998 discovery of a new photoreceptor in the eye—which later turned out to be especially sensitive to blue light—has been shown to interfere with sleep. Blue light exposure increased with the introduction of flat screen technology. Eyegaze Edge systems have software installed to decrease blue light exposure.

5. What is midriasis and why should you care?

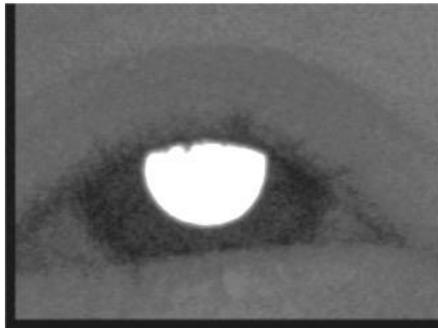
- **Midriasis**, an abnormal dilation of the pupil, is a common side effect common side effect of baclofen. The pupils may be unable to constrict normally when the user is looking at a bright screen or a highly illuminated Eyegaze system.
- Avoid overly-bright screens and over-illuminated systems to decrease the light on the pupils, which may be uncomfortable for the user.



Pupil on the left has midriasis & is unable to constrict when exposed to bright light. Pupil on the right 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 Eyegaze systems if they require a fully visible pupil in order to locate the pupil center. When the eyelid blocks part of the pupil *most* Eyegaze 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 with difficulty.

7. What about dry eyes?

- **Dry eyes** may affect the ability of Eyegaze 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 Eyegaze system any way that's comfortable for them. Eyegaze become a user's voice, and he needs access to it to communicate all day, in any position. A well-designed Eyegaze system, including the Eyegaze Edge, will track the user's eyes accurately no matter their position: sitting, reclining, even side-lying.
- **Never 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.



NO!



YES!

9. Eyegaze 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.

- Strategies to increase pupil size include using screens that are not overly bright, and decreasing room lighting to facilitate some pupil dilation.

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 Eyegaze 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 user with normal eye control it can be somewhat overwhelming for a new user. With practice most users become adept at typing at that rate, but need to be forewarned 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. 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 Eyegaze 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 Eyegaze use.
- A person can have perfect eye control to follow a moving target but have no ability to independently move his eyes to the location of his choosing.



- 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 he is able to control the movements of his eyes independently, an absolute necessity for Eyegaze 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 and click on Assistive Technology, call 1-800-eyegaze or 1-703-385-8800, or send an email to james.brinton@eyegaze.com.