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Eye Control Hints and Tips

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Communication by Gaze Interaction

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Adaptation of eye gaze communication aids for users with « visual » problems

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Adaptation of eye gaze communication aids for users with visual problems

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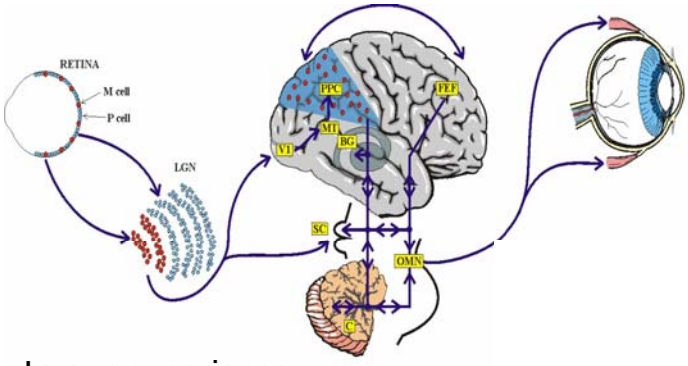
head of the visual function testing center at Lille University Medical Center.

This presentation is part of their contribution to the Cogain European program.

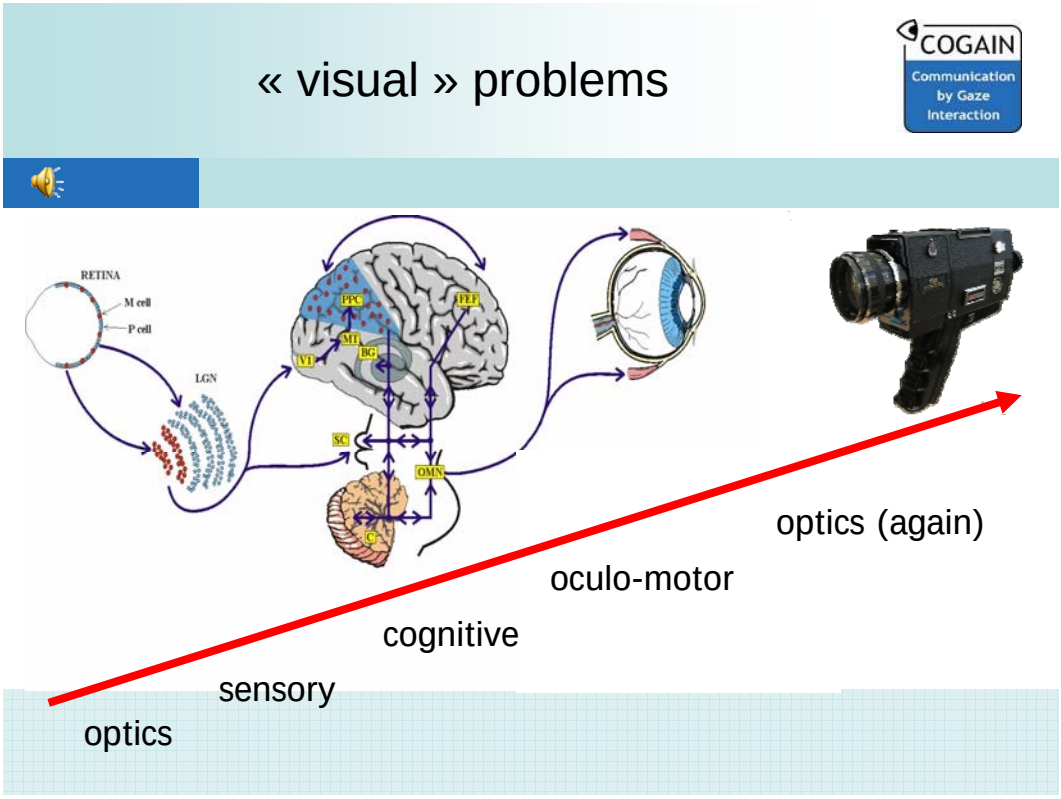
« visual » problems



In our experience,
70 percent of users of eye gaze communication aids have “visual” problems.

A large number of potential users of eye gaze communication aids (EGCA) present visual problems which can restrict or even impede the use of these devices.

In our experience, as many as 70 percent of users of these devices are affected by “visual” problems.

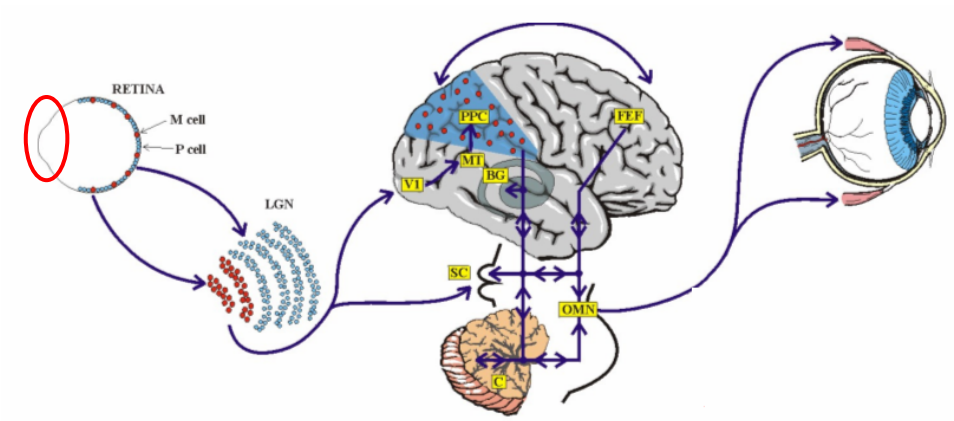


The use of an eye tracker as a communication device involves many visual functions.

What we will refer here as visual functions includes the optics of the eye, the visual sensory functions, the visual cognitive functions, oculomotor functions and again the optics of the eye because most eye trackers rely on the analysis of the image of the eye.

The purpose of this presentation is to identify the most frequent visual problems found during the adaptation of EGCA and to propose solutions to these problems whenever they are available.

Optical problems

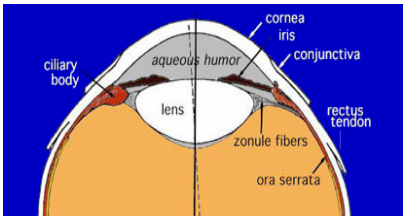


Optics of the eye

First among the list of the visual functions are the optics of the eye.

These functions may reduce vision and consequently not allow the user to use the visual display.

Optical problems



- refractive errors: short distance correction
- diffusion errors, opacities... (cataract, ...)

Optical problems can be due to an inadequate refractive power of the eye Such problems include myopia, hypermetropia, astigmatism and presbyopia.

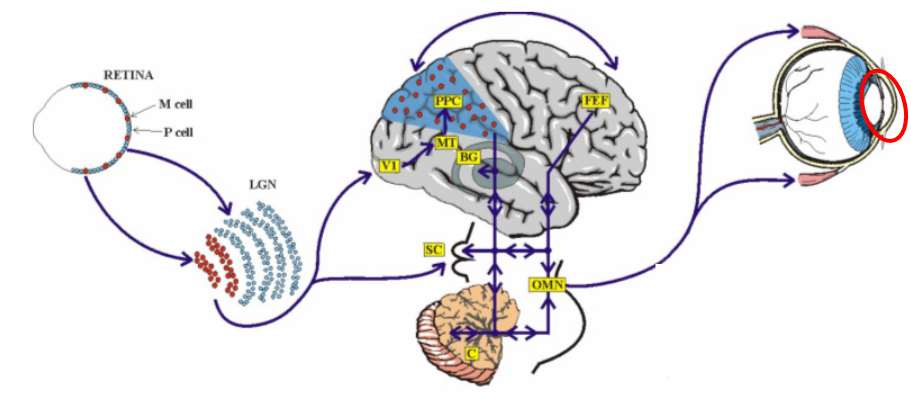
Other optical problems can result from a lack of transparency of the ocular media (cornea or ocular lens).

These problems may be difficult to evaluate with people who cannot communicate.

Vision care professionals such as ophthalmologists, optometrists or orthoptists have equipment and techniques allowing a precise and objective evaluation of these potential problems.

Refractive errors can easily be corrected with the classic techniques of eye glasses and contact lenses.

Optical problems

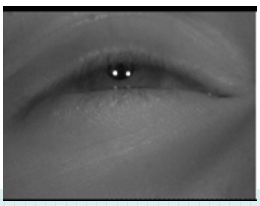


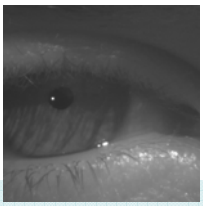
Optics (again)

Finally, the operation of the eye tracker itself can be altered by optical problems.

Optical problems

- Reflections from optical aids
- Masking of the pupil





We show here some examples of images where eye trackers may have some difficulties in providing accurate measurements.

First of all the camera of the eye tracker must have access to the image of the eye in order to properly identify the pupil and corneal reflection (Buquet and Charlier, 1994).

The image can be masked by reflections over eyes glasses, a problem which can be avoided by tilting the frame so that the reflection moves away from the image of the eye.

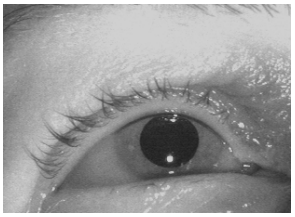
The pupil can also be masked by the eye lids and eye lashes.

The image processing algorithms may take into account an incomplete detection of the pupil contour (Charlier and Hache, 1982).

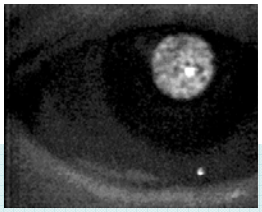
Another possibility is to change the posture of the user relative to the EGCA so that an optimal opening of the eye is obtained.

Optical problems

- Reflections from intraocular lens, respiratory masks, etc



- Defects of the cornea and /or the tear film



The identification of corneal reflections may be a problem when there are other reflections sources creating confusion in the image processing algorithms.

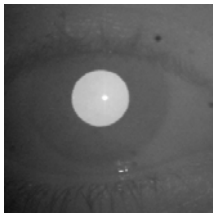
For example: reflections due to tears in the eye, reflections on intraocular lenses or reflections on a respiratory mask close to the eye.

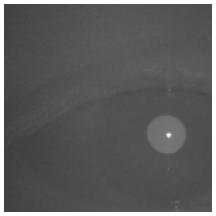
Corneal reflections are also difficult to detect if the tear film is not present, a condition frequently found in persons who are not able to blink.

Some solutions to these problems can be provided by vision care professionals.

Optical problems

- Images obtained with a bright pupil eye tracker



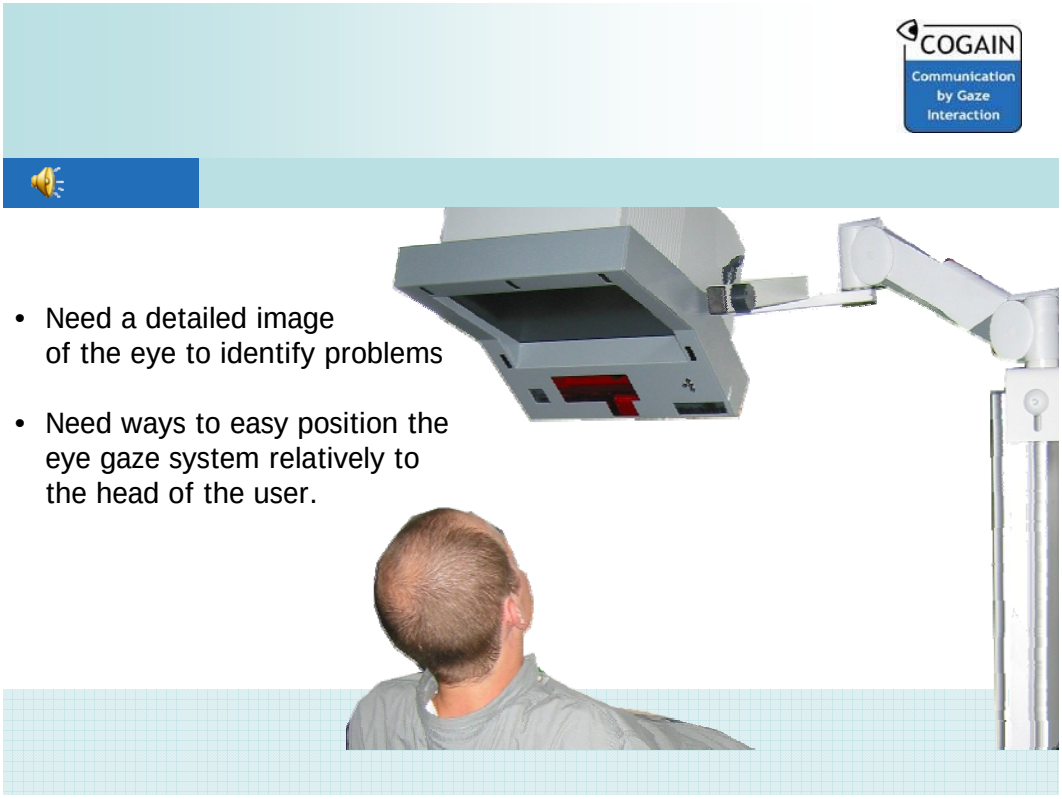


- Image obtained with a dark pupil eye tracker

Pupil size can also be a problem. Small pupil sizes occur under bright illumination. They are more frequent with age and with spinal cord injuries (Thoumies et al, 1998).

Eye trackers using the bright pupil effect are frequently not able to detect small pupils (below about 3 mm in diameter) because of the reduction of contrast between the pupil and its surrounding.

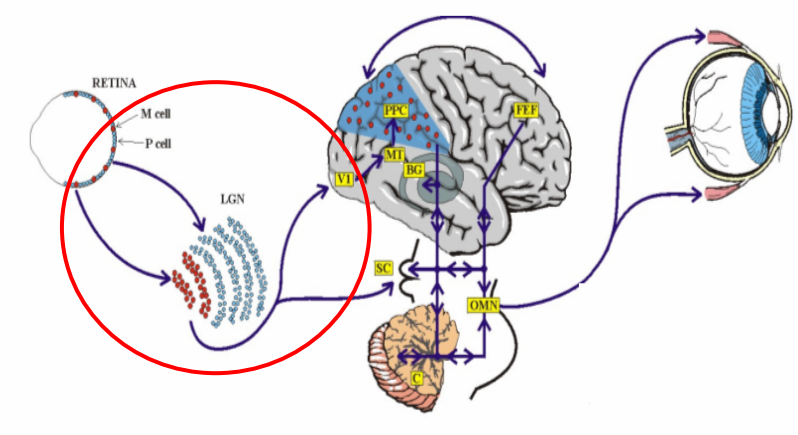
Eye trackers using the dark pupil effect are not affected by this problem.



A video image of the eye of good quality is very useful to help identify these problems. This image can be digitized so that it can be sent to an expert person to help identify the problems.

Another useful feature is the ability to adjust the position of the eye tracker relatively to the user's head so that the best position can easily be found.

Sensory problems



Sensory visual functions

Problems may occur at different levels of the visual system more specifically at the retina, optic nerve or visual cortex.

Sensory problems

- central vision: visual acuity
- peripheral vision: visual field

They may involve central vision (visual acuity) as well as peripheral vision (visual field).

Central and peripheral vision are both necessary for reading, for the exploration of images, for recognizing faces and many other visual tasks.

Again these problems may be difficult to identify with persons who lack communication.

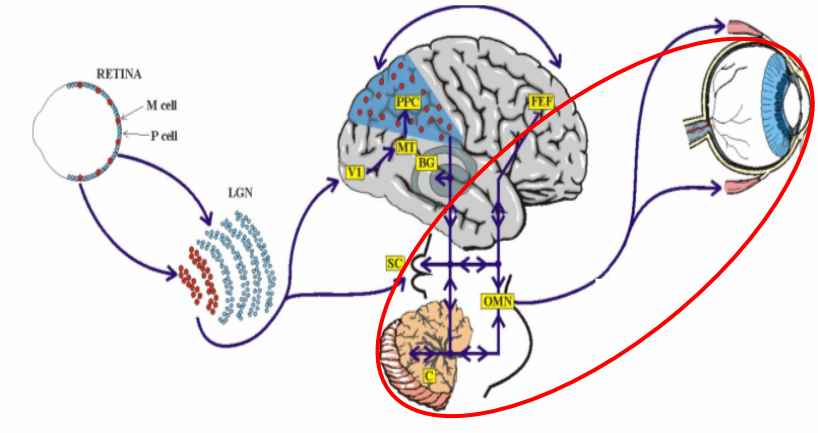
With these persons, subjective techniques which rely on the person's voluntary response are frequently inadequate.

Eye fundus examination may allow the assessment of some but not all possible problems.

Objective techniques such as visual electrophysiology are available but only in a limited number of medical centers.

Solutions to these problems may involve for example the use of enlarged text and higher contrast on the display of the communication device.

Oculomotor problems



Our next topic is oculomotor functions.

There are different types of eye movements which are controlled by different neurological circuits within the brain.

The operation of an EGCA involves primarily the ability to move the eye, which is done by fast eye movements (saccades) and the ability to maintain the eye stable for some time (fixations).

Oculomotor problems (1/2)

- neural control of eye movements:
  - fixation: strabismus, phoria, **nystagmus**
  - saccades: **paresis**
  - visual pursuit
- mechanical (muscle, ...)

There are many possible alterations of eye movements

Oculomotor paresis results in a limitation of saccades in specific directions relative to the head (rightward, leftward, upward and downward).

One possible solution is to adapt the head position relative to the display so that the entire display remains accessible with eye movements.

Ocular nystagmus is a constant oscillation of the eye which results in an inability to maintain a stable fixation.

One possible solution is to find the head position which minimizes the amplitude of the oscillation.

Alternatively or in addition, filtering of eye movements can be introduced in the processing algorithms of the EGCA

and the clicks can be triggered by prolonged eye blinks instead of prolonged fixations.

Oculomotor problems (2/2)

- neural control of eye movements:
  - fixation: **strabismus**, **phoria**, nystagmus
  - saccades: paresis
  - visual pursuit
- mechanical (muscle, ...)

Strabismus is another condition where only one eye is fixating while the other eye is deviating from that direction.

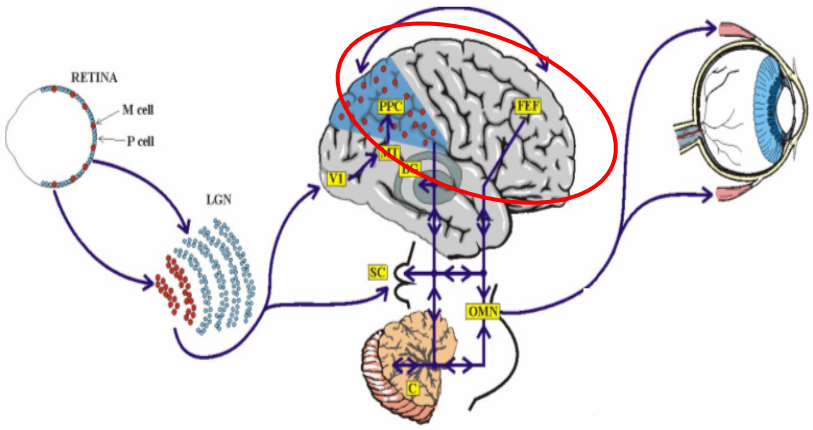
In that situation it is important to calibrate the EGCA on the dominant eye (i.e. the one which is fixating).

Phoria is a condition where deviation appears only after some delay, for example as a result of fatigue.

Some persons may also change of dominant eye from time to time!

The only solution in these cases is allow the user to recalibrate the EGCA on demand.

Cognitive problems



Vision involves also cognitive functions

Visual cognitive functions imply higher levels of processing in the brain needed for attentive tasks, for the recognition of objects, etc.

Cognitive problems

- visual agnosia
- lack of understanding
- lack of appetence for communication

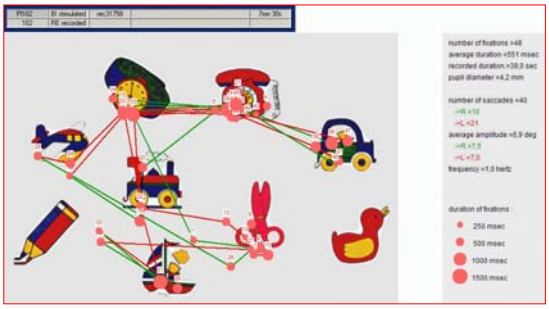
Cognitive problems may occur for example in cases of cerebral palsy, brain infarct or brain injury.

Problems such as visual agnosia, or the lack of understanding or the lack of appetence for communication

need to be identified when one wants to adapt an EGCA.

Again these problems may be quite difficult to identify with persons who cannot communicate.

Which is which?



8 years old girl Rett syndrome

One possibility is to use the EGCA to record the scanning strategy while the subject is asked to look at specific objects in images.

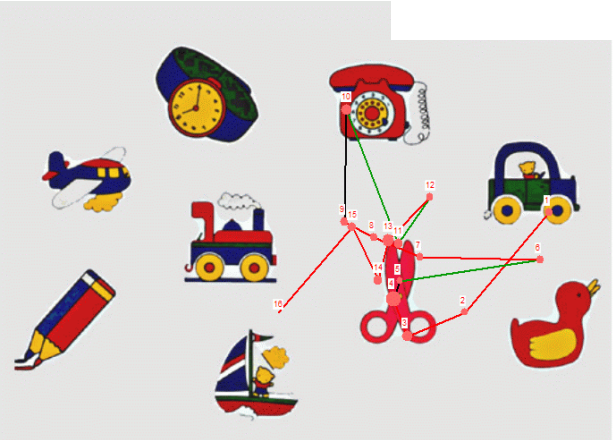
Such a test provides rapidly an evaluation of cognitive abilities as well as oculomotor functions (Defoort at al, 1996).

Here we show the example of a little girl with a Rett syndrome. On the left is shown the recording of her eye gaze

strategy while we were asking her to look at different objects on the display.

Thanks to this recording, we were able within a few seconds to evaluate and document that her ability to use an eye tracker.

Which is which?



Large refractive error?
Hemianopsia?
Paresis?
Hemineglect?
Understanding?
Appetence?

The case of this little girl was an ideal one.

Now there are many cases such as the one I am showing here where we fail to get such clear responses,

In those cases we need to go step by step to identify the reason why we do not get a response.

Conclusions

- Awareness of visual problems affecting the operation of EGCA is important to achieve successful adaptations.

- Solutions are frequently available in these situations which can be provided by vision care professionals

Conclusion

Many of the potentials users of EGCA are affected by visual problems.

Awareness of visual problems affecting the operation of EGCA is very important to achieve the highest possible rate of successful adaptations.

Solutions are frequently available and a good cooperation with vision care professionals may be of great help in those cases.

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