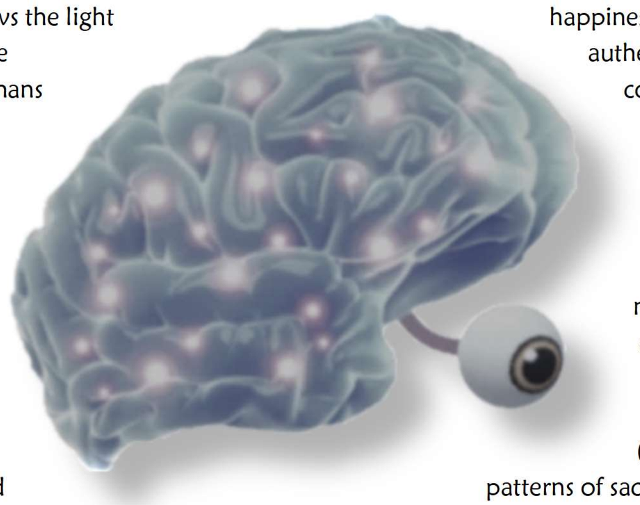
Humanoid Eyes: Perspective & Challenges

Ahmad Yousef[1]
[1]School of Computational Science and Engineering, McMaster University, Hamilton, Ontario, Canada
*Correspondence: mohamas2@mcmaster.ca

We initially have to understand the behaviors of human eye to comprehend its social importance. Four dynamics (dimensions) distinguish human eyes: pupil variations, saccadic eye movements, blinks, in addition to duchenne markers (that is mainly produced by orbicularis oculi pars lateralis). Each of these dimensions represents significant amount of psychological and cognitive [1 - 7], and their corresponding neurophysiological information [8 - 12]. Interestingly, the cones in the retinal peripheries signal the brain 30 milliseconds faster than the central cones (Masland, 2017). Accommodated lens which is associated to dilated pupils allows the light rays to access a bigger area of the retinal peripheries; in which humans will have 'faster' visual awareness (see reference 8). Faster perceptual awareness assist in creating faster actions; as if it is an evolutionary defensive mechanism to allow humans to act timely in unexpected situations. The vice versa could be true; namely, constricted pupils are associated to flattened lens which might disallow the light rays to access the retinal peripheries, thus, slower visual awareness and therefore slower actions.



Psychology may have better explanations of these situations. Noticeably, pupil dilation has the ability to estimate emotional arousal and autonomic activation, (Bradley, 2008). It also betrays the timing of decisions, (Einhäuser, 2010); represents the surprising events, (Preuschoff, 2011); and it can reflect individual upcoming choices and biases, (Gee, 2014). We have to stop here for a moment, and questioning ourselves; why pupil dilates in such events? According to recent findings, when pupil dilates, the lens become more rounded, and this gives the external stimuli greater accessibility to the retinal peripheries, namely, faster visual awareness that seems to be very important for all of the aforementioned situations.

Blinks, however, can estimate the cognitive workload; namely, Blink Rate Variability can determine the IQ-test scores for human subjects, (Paprocki, 2017). Namely, blink rate variability is positively correlated with the intelligence of human subjects. The aforementioned information should be utilized in building up optimal humanoid eyes, namely, in the processing time of the humanoid, the blinking rate variability should be increased.

Needless to say, Duchenne markers noticeably represent significant amount of emotions (Darwin, 1872); it just say what the mouth cannot say! The Duchenne marker has been suggested as a universal marker of smile, happiness, sincere, and sadness authenticities. It therefore should be considered in the design of humanoid eyes for perfect humanizing effects.

The last dimension which actually tells us a lot about the person's interests is saccadic eye movements. Namely, Saccade and microsaccades had been representing the visual exploration and search, (Otero-Millan, 2008). Certain patterns of saccadic eye movements also represent significant signs of imaginations and creativity.

We had discussed all of the previous dynamics in some details to have certain degree of courage to say; proper analysis of these four spatiotemporal dynamics along with their corresponding neural activities (as responses to various perceptual and multisensory stimuli along with their corresponding decisions and possible actions) might eventually allow us to partially read the neural activities of the brain.

Detailly speaking, this might be done after matching the continuum that includes the four previously mentioned dynamics with its corresponding cortical and subcortical neural activities from the data triggered by different external stimuli, and gathered simultaneously through various brain imaging techniques, and eye trackers.

We offer this hypothesis to allow the readers to comprehend the importance of the eye's dynamics. Ultimately, we hope to gather additional evidences to confidentially say; the eye may be considered as a visible brain. Until several fine-tuned psychophysical experiments are achieved, our speculations may still have sensible credibility, by reviewing the current available literature. Eventually, we hope to say it confidentially, the eye might be exhibited as the most valuable visible organ for socialization.

Humanoids are mainly made for socialization purposes; and to humanize them, their eyes (visible brains) should be perfectly designed. Robotics Engineers should therefore understand the importance of the eyes. Namely, they should take the four previously mentioned dynamics into their design considerations. Humanoids might be very important in assisting vulnerable and elderly people in their daily tasks. Needless to say, without humanized eyes, the social relationship between the owners and their humanoids may be impaired. Psychiatrists also might not rely on humanoids with imperfect humanized eyes to treat their patients. For example, children with autism spectrum disorder had been suffering from eye contact avoidance. Those patients, however, might accept to deal with a humanoid and might look at its eye quiet often, but not at a human eye. Humanoid eyes should be therefore perfectly humanized, to promote the recovery of the symptom through near-natural eye contacts. Engineers therefore should collaborate with their colleagues' psychologists and neuroscientists more intensively to figure out the precise continuum of the dynamic of the human eye. Clearly, the biggest challenge for humanoid eyes is to understand the human eye precisely. Once the continuum is precisely calibrated, mathematical model can be developed, and engineers can afterwards implement that algorithm within humanoids and consciousness machines, (see reference 13).

Needless to mention, however, neuroscientists, after having the aforementioned computational model, might be able to read the human brain with cheaper tools; namely, by eye trackers / professional cameras, which is not only assumed to ease cheaper research, but to flourish the entertainment industry.

Inside the humanoid eyes, however, the retina should be also humanized, and this suggestion might be extended to "humanoid wide-angle cameras". The densities, and the processing units' characteristics of the photoresistors 'the pixels' of the current wide-angle cameras do not respect neither the anatomy nor the physiology of the human retina. Humanoid wide-angle cameras might be installed on the portable devices, and the net result should produce more natural images. This could be achieved by implementing an extremely high density of RGB photoresistors in a very small area in the central 'photoresistors board'; approximately 14% of the total area of the board (the relative size of the macula compared to the entire retina in human); whereas the photoresistors must be connected to high-end processing units for optimal output; in order to mimic the delayed processed high-quality outputs of the human central retina. In the peripheral areas of the photoresistors board, however, RGB photoresistors should be way lesser dense; co-exist with high density of grayscale photoresistors and attached to fast processing units.

Essential Notification

Scholars with facilitations to high density EEG machines, professional eye trackers; or who are interested in further details of the humanoid retina are welcome to collaborate. Enquiries should be sent to the author.

Transactional References

[1] Kowler, E., Anderson, E., Dosher, B., & Blaser, E. (1995). The role of attention in the programming of saccades. Vision Research, 1897–1916.

[2] Paprocki and Lenskiy (2017). What Does Eye-Blink Rate Variability Dynamics Tell Us About Cognitive Performance? Front. Hum. Neurosci.

[3] Darwin, C. (1872). The expression of emotion in animals and man.

[4] Otero-Millan (2008). Saccades and microsaccades during visual fixation, exploration, and search: Foundations for a common saccadic generator. Journal of Vision.

[5] Bradley, (2008). The pupil as a measure of emotional arousal and autonomic activation. Psychophysiology, 45(4), 602–607.

[6] A. Urai, A. Braun & T. Donner (2017). Pupil-linked arousal is driven by decision uncertainty and alters serial choice bias. Nature Communications.

[7] Einhäuser, CKoch and O, Carter (2010). Pupil dilation betrays the timing of decisions. Frontiers in Human Neuroscience.

[8] Yousef, Ahmad. 2019. "Linking Dynamics Between Pupil and Lens. 'engrXiv. doi:10.31224/osf.io/9c3vk.

[9] Ivan Smalianchuk, Jagadisan and Gandhi. (2018). Instantaneous Midbrain Control of Saccade Velocity. Journal of Neuroscience.

[10] Rylan S. Larsen and Jack Waters (2018). Neuromodulatory Correlates of Pupil Dilation. Front. Neural Circuits, 2018.

[11] B J. L. Anderson S. I. Head C. Rae J. W. Morley (2002). Brain function in Duchenne muscular dystrophy. Brain, 2002.

[12] Siri Leknes, *etal.* (2012). Oxytocin enhances pupil dilation and sensitivity to 'hidden' emotional expressions. Social Cognitive and Aff. Neuroscience.

[13] Ahmad Yousef, Mohamed Bakr, Shahram Shirani, Bruce Milliken. An Edge Detection Approach For Conscious Machines. In: 2018 IEEE Ninth IEMCON Conference, Vancouver, BC, Canada.