Human Oculomotor Plant Modeling: Is there a significant change or deficit in oculomotor function of mTBI patients compared to normal vision in healthy subjects?

A force or blow to the head can result in traumatic brain injury (TBI). The occurrence of traumatic brain injury (TBI) is around 1.4 – 2.0 million per year with 80 - 90% classified as "mild" or with a Glasgow Coma Scale (GCS) rating of 13 – 15. Although mild TBI is typically nonfatal, clinical management of these patients present a challenge due to the complex nature of associated symptoms involving cognitive, behavioral and physical deficits. Statistics indicate that a head injury occurs every 16 seconds resulting in over 500,000 trauma-related adult disabilities each year [2]. Of interest, is the recent suggested association between oculomotor deficits with mild TBI.

Previous work in our lab has investigated oculomotor function using 2-dimensional position tracking of the eyes when viewing visual targets on a computer screen at 120Hz sampling rate. Both saccadic and smooth pursuit eye movements have been documented in volunteer participants without a head injury. The following metrics were selected for the proposed research work from the vast array of data pertaining to oculomotor function as the most promising for investigation in persons with mTBI. The following set of metrics relate to a specific possible brain lesion.

Saccade latency: The time between the onsets of the stimulus target appearance an oculomotor saccade. Normal onset delays are around 200ms. Persons with TBI may demonstrate higher latencies during normal saccades. Increased latency during express saccades might indicate damage to the Parietal Eye Fields and the Superior Colliculus [3].

Saccadic waveform: This parameter provides a measurement of the amount of undershoot/overshoot in regard to the location of a stationary stimulus. Excessive saccadic amplitude or hypermetria can be related to an abnormality in bilateral cerebellar fastigial nuclei [3]. Oculomotor deficits such as saccadic overshoot undershoot and glissades (post-saccadic drift) can be caused by a mismatch between the sizes of the "step and pull" signal during an individual extraocular muscle's activity. The frequency of this occurrence can be quantified in persons with post mTBI [3], [4].

Saccadic amplitude/duration ratio: This provides a composite functional measurement of both vertical and horizontal control mechanisms. For example, a slow saccade would exhibit a longer duration curve compared to its height. The possible neuro-anatomical areas involved would include the omnipause neurons, premotor burst neurons (PPRF – horizontal saccades, RiMLF – vertical saccades) [1].

I will analyze subject data provided by the Tobiix120 eye tracker which will have the following performance characteristics: Accuracy 0.5, spatial resolution 0.2, drift 0.3, sampling rate 120Hz. The proposed design will include saccade/fixation/smooth pursuit detection, criteria modeling/identification for optimal saccadic latency and hypermetric/hypometric saccadic waveforms. I will use a velocity threshold based (I-VT) eye movement detection algorithm to detect specified eye movements and will use detected velocity observations to model/identify matrices specified for mTBI – oculomotor evaluation. This work will support a larger study including a comprehensive assessment of oculomotor function in persons with mTBI in response to a customized oculomotor training. It is hypothesized that there will be a significant change of oculomotor function after training.

Budget

Item and Description	Purpose	Unit Cost	Total
AN-HDR-300 **Tabletop Chin Rest** Available from ISCAN Inc, Woburn, MA 01801	To stable the subject head w.r.t the Tobii eye tracker interface.	1 x $280.00	$280.00
Reimbursement for human subjects	Participation stipend	(35 subjects) x (2 hour) x $15.00	$1050.00
Tobii x120 eye tracker	**Provided by the HCI Laboratory, TSU CS Department		
All other lab materials	**Provided by the TSU CS department		
Total amount of funding requested			**$1330.00**

References

1. Garbutt, S., Y. Han, et al. (2003). "Vertical optokinetic nystagmus and saccades in normal human subjects." Investigative Opthalmology & Visual Science 44: 3833-3841.
2. Langlois, J. A., Rutland-Brown, W. and Thomas, K. E. Traumatic brain injury in the United States: Emergency department visits, hospitalizations, and deaths. *National Center for Injury Prevention and Control, Centers for Disease Control and Prevention,* 2004.
3. Leigh, R. J. and D. S. Zee (2006). The Neurology of Eye Movements, Oxford University Press.
4. Weber, R. B. and R. B. Daroff (1972). "Corrective movements following refixation saccades: type and control system analysis." Vision Research 12: 467-475.