CORRESPONDENCE

Ocular disconjugacy cannot be measured without establishing a solid reference [version 1; peer review: 1 approved, 1 not approved]

Jun Maruta

Brain Trauma Foundation, 7 World Trade Center, 34th Floor, 250 Greenwich Street, New York, NY 10007, USA

v1 First published: 17 Mar 2015, 4:71
<https://doi.org/10.12688/f1000research.6162.1>
 Latest published: 22 Apr 2015, 4:71
<https://doi.org/10.12688/f1000research.6162.2>

Abstract

This correspondence points out a need for clarification concerning the methodology utilized in the study “Eye tracking detects disconjugate eye movements associated with structural traumatic brain injury and concussion”, recently published in *Journal of Neurotrauma*. The authors of the paper state that binocular eye movements were recorded using a single-camera video-oculography technique and that binocular disconjugate characteristics were analyzed without calibration of eye orientation. It is claimed that a variance-based disconjugacy metric was found to be sensitive to the severity of a concussive brain injury and to the status of recovery after the original injury. However, the reproducibility of the paper’s findings may be challenged simply by the paucity of details in the methodological description. More importantly, from the information supplied or cited in the paper, it is difficult to evaluate the validity of the potentially interesting conclusions of the paper.

Keywords

Mild traumatic brain injury , mTBI screening , vergence

This article is included in the Eye Health gateway.

Open Peer Review

Approval Status ✓ ? ?

	1	2	3
version 2 (revision) 22 Apr 2015		? view	? view
version 1 17 Mar 2015	✓ view	✗ view	

1. **Johannes van der Steen**, Erasmus Medical Center, Rotterdam, The Netherlands
2. **Christopher Tyler**, Smith-Kettlewell Eye Research Institute, San Francisco, USA
3. **Marcus Nyström**, Lund University, Lund, Sweden

Any reports and responses or comments on the article can be found at the end of the article.

Corresponding author: Jun Maruta (jmaruta@braintrauma.org)

Competing interests: The author holds stock option in SyncThink, Inc.

Grant information: The author(s) declared that no grants were involved in supporting this work.

Copyright: © 2015 Maruta J. This is an open access article distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. Data associated with the article are available under the terms of the [Creative Commons Zero "No rights reserved" data waiver](#) (CC0 1.0 Public domain dedication).

How to cite this article: Maruta J. **Ocular disconjugacy cannot be measured without establishing a solid reference [version 1; peer review: 1 approved, 1 not approved]** F1000Research 2015, 4:71 <https://doi.org/10.12688/f1000research.6162.1>

First published: 17 Mar 2015, 4:71 <https://doi.org/10.12688/f1000research.6162.1>

Correspondence

I wish to point out a need for clarification concerning the methodology utilized in the study “Eye tracking detects disconjugate eye movements associated with structural traumatic brain injury and concussion” by Samadani *et al.*, 2015¹. The authors state that binocular eye movements were recorded using a single-camera infrared-based video-oculography technique (EyeLink 1000, SR Research, Ontario, Canada) and that binocular disconjugate characteristics were analyzed without calibration of eye orientation. The authors claim that their variance-based disconjugacy metric was sensitive to the severity of a concussive brain injury and to the status of recovery after the original injury.

The EyeLink 1000 system is an excellent eye tracker with a single high resolution camera and an infrared light source affixed to the camera. A typical recording setup consists of a computer monitor with which the visual stimuli are presented to the subject and the camera unit (placed in front of the monitor base) with which the eye movement is recorded monocularly or binocularly. The system has an option of easily outputting image-based, uncalibrated eye coordinates with hundreds of units representing 1° of eye rotation.

The concern I would raise with Samadani *et al.*'s paper is the unclearness of the relationship between their metric and binocular disconjugacy. Logically, for an identical amount of eye rotation, any asymmetry in the spatial relationship that the camera or the infrared light source has with the two fellow eyes would result in different extents of relocation of the images of the pupils or corneal reflections. Asymmetries exist because there is a physical separation between the two eyes as well as between the camera and the infrared light source. In addition, although the biometric characteristics of eyes are highly symmetrical within individuals, they are not perfectly symmetrical² and a 1–2% non-conformity in corneal curvature or axial length is not uncommon, which further confounds the relationship between eye rotation and changes in pixel coordinates. Moreover, each of the two fellow eyes has its own function that maps pixel movement to the eye rotation, and this mapping is not linear. Thus, the arithmetic difference between the uncalibrated coordinates of the two eyes is quite removed from a physical representation of gaze misalignment.

Beyond the factors associated with the raw data, the analytic methods in the paper also do not seem to be constructed with a clear intent. It is puzzling why the disconjugacy metric is represented by the variance of the left-right differences after independently averaging for each eye the uncalibrated coordinates over several cycles for a given stimulus position, as opposed to the straightforward variance of the left-right differences at all sample points. Furthermore, the ranges of outcome values presented in the series of figures run from 0 to at most 0.25, but how the value 0 could have been obtained is not clear. The question arises because in the two eyes' uncalibrated coordinates there must be a constant bias related to the interocular distance. Lastly, what the high end of the outcome range represents is not clear. Since one unit in EyeLink's uncalibrated data output is smaller than 0.01° of eye rotation, being able to report differences in 0.25 square units or less seems implausible. If the raw data were numerically centered or scaled, the procedure should have been noted in the text.

The authors discuss some valid points regarding potential pitfalls associated with calibration and phoria. However, these points can be directly addressed by implementing a calibration procedure under monocular viewing^{3,4}. A comparison between the results from thus calibrated and uncalibrated data, and a demonstration of test-retest reliability could have improved the paper.

In summary, the reproducibility of the paper's findings may be challenged simply by the paucity of details in the methodological description. More importantly, however, from the information supplied or cited in the paper it is difficult to evaluate the validity of the potentially interesting conclusion that deficits in conjugacy of eye movements may quantitate physiologic impact of brain injury.

Competing interests

The author holds stock option in SyncThink, Inc.

Grant information

The author(s) declared that no grants were involved in supporting this work.

References

1. Samadani U, Ritlop R, Reyes M, *et al.*: **Eye tracking detects disconjugate eye movements associated with structural traumatic brain injury and concussion.** *J Neurotrauma*. 2015.
[PubMed Abstract](#) | [Publisher Full Text](#)
2. Li Y, Bao FJ: **Interocular symmetry analysis of bilateral eyes.** *J Med Eng Technol*. 2014; **38**(4): 179–187.
[PubMed Abstract](#) | [Publisher Full Text](#)
3. Kapoula Z, Bucci MP, Eggert T, *et al.*: **Impairment of the binocular coordination of saccades in strabismus.** *Vision Res*. 1997; **37**(19): 2757–2766.
[PubMed Abstract](#) | [Publisher Full Text](#)
4. Bucci MP, Kapoula Z, Yang Q, *et al.*: **Binocular coordination of saccades in children with strabismus before and after surgery.** *Invest Ophthalmol Vis Sci*. 2002; **43**(4): 1040–7.
[PubMed Abstract](#) | [Publisher Full Text](#)

Open Peer Review

Current Peer Review Status:

Version 1

Reviewer Report 08 April 2015

<https://doi.org/10.5256/f1000research.6606.r8105>

© 2015 Tyler C. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Christopher Tyler

Brain Imaging Center, Smith-Kettlewell Eye Research Institute, San Francisco, CA, USA

Overall, this Correspondence does not offer a significant criticism of the paper of Samadani *et al.* (2015). The author does not specify what kinds of asymmetries exist due to the camera/source geometry. Usually the subject is centered in the Eyelink viewing aperture, so the view of the eyes would be symmetric. The attempt to argue that a 1-2% asymmetry between the eyes would significantly degrade the assessment capability does not seem plausible.

The criticism of methodological unclarity may be justified in itself, but it has no bearing on the outcome of the paper since all patients would be equally subject to the same degree by the effects of asymmetry and lack of calibration. As stated, none of the criticisms suggest a systematic bias between the different patient categories. The significant differences among categories cannot therefore be attributed to any of the factors raised by the author, and controlling these factors should only improve the significance of the Samadani *et al.* results. The author's challenge to the findings of the paper is thus easily refuted.

Moreover, despite the fact that this Correspondence is entirely concerned with calibration, it neglects to mention the fact that a core motivation for the Samadani *et al.* paper is the issue of a misleading spatial calibration metric. They are making the point that restrictions of eye movement may restrict the array of calibration positions, providing a false assessment that the subsequent test movements are normal. Their goal is thus to use the *uncalibrated* differences between the two eyes (which they term "temporal calibration") as a probe for deficits that would be masked by the spatial calibration procedure. It is this strategy that the author should have addressed directly.

On a stylistic note, I do not favor using the English possessive "s" on the Latin phrase "et al(ia)" and recommend the form above, as in "the Samadani *et al.* paper".

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of

expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 10 Apr 2015

Jun Maruta, 7 World Trade Center, 34th Floor, 250 Greenwich Street, USA

I thank Dr. Tyler for his comments and the opportunity to think through what I had written again. One revision I can make in the second paragraph of the original text is to add “a side of” to “an infrared light source affixed to the camera” so that the phrase reads “an infrared light source affixed to a side of the camera.” This revision would make it clearer that the camera may be centered in front of the subject but the infrared light source cannot be centered simultaneously, the consequence of which is an asymmetric view of the corneal reflections. I can also specify that EyeLink 1000 uses a dark pupil-corneal reflection principle for tracking eye movements.

Another clarification I can offer is to point out that the physical separation of the two eyes is individually variable [1,2]. This variability contributes to variations in the extent of asymmetry in the camera view of the landmark features of the eyes. With this consideration, Dr. Tyler’s assertion, that all subjects would be equally subject to the same degree by the effects of asymmetry, may be only partially correct. A systematic bias may indeed be created when the demographic composition of the subject groups are different. For example, having a larger male-to-female ratio in one group could increase the extent of binocular asymmetry in uncalibrated data since men tend to have a larger interpupillary distance [1,2]. Incidentally, Samadani et al. note a tendency toward the positive head CT group having more males than the non-injured control, with the positive head CT group of 13 patients being 35.9% female and the control group of 64 subjects being 47.9% female. (Curiously, the percentage of female subjects times the group size does not yield a whole number in any of the four subject groups in the Samadani et al. paper.)

The assessment capability claimed by Samadani et al. appears to be variability of binocular alignment on the order of 0.01° magnitude. This value seems too small in light of the two sources of asymmetries discussed above in uncalibrated gaze-associated binocular measures, and also in light of 1-2% asymmetry between the two eyes.

Regarding the problems that Samadani et al. point out in terms of spatial calibration, my intent is not to dispute the existence of alternatives to eye movement assessments based on spatial calibration. Rather, my emphasis is that disconjugacy itself is spatial in nature, and thus its quantification requires a solid spatial reference frame. This intent may be made clearer by including the term “spatial” in the title so that it reads “Ocular disconjugacy cannot be measured without establishing a solid spatial reference.”

Finally, in my future writing I will keep in mind your recommendation regarding mixing the English possessive on the Latin phrase “et al.”

References:

1. Pryor HB: Objective measurement of interpupillary distance. *Pediatrics*. 1969; 44(6): 973-7.
2. Gordon CC, Churchill T, Clauser CE, et al.: 1988 anthropometric survey of U.S. Army

personnel: methods and summary statistics. U.S. Army Natick Research, Development and Engineering Center, Natick MA. 1989.

Competing Interests: No competing interests were disclosed.

Reviewer Report 31 March 2015

<https://doi.org/10.5256/f1000research.6606.r7999>

© 2015 van der Steen J. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Johannes van der Steen

Department of Neuroscience, Erasmus Medical Center, Rotterdam, The Netherlands

The author makes a justified appeal for clarification of methodological issues concerning the study "Eye tracking detects disconjugate eye movements associated with structural traumatic brain injury and concussion" by Samadani *et al.*, 2015. The arguments raised by J. Maruta are very valid. Apart from clarification there is also a need for validation before this technique can be introduced in e.g. emergency rooms to quantify the severity of a concussive brain injury and the degree of recovery.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

The benefits of publishing with F1000Research:

- Your article is published within days, with no editorial bias
- You can publish traditional articles, null/negative results, case reports, data notes and more
- The peer review process is transparent and collaborative
- Your article is indexed in PubMed after passing peer review
- Dedicated customer support at every stage

For pre-submission enquiries, contact research@f1000.com

F1000Research