

Objective testing of both visual fields in 80 seconds



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PURPOSE

We compare the signal-to-noise ratios of a higher-resolution multifocal pupillographic perimetry (mfPOP) method that assess both eyes concurrently in 6 minutes, with two new 80-second tests, that have fewer test regions. The gain control of the pupillary system means that larger responses are given when there are fewer stimuli.¹ The study is in the context of an examination of the effects of sports-related concussion but the main outcome measure is the difference in the SNRs between the mfPOP methods. That being said RNFL losses have been reported in mild sports concussion,² and Matrix field defects in more serious cases.³

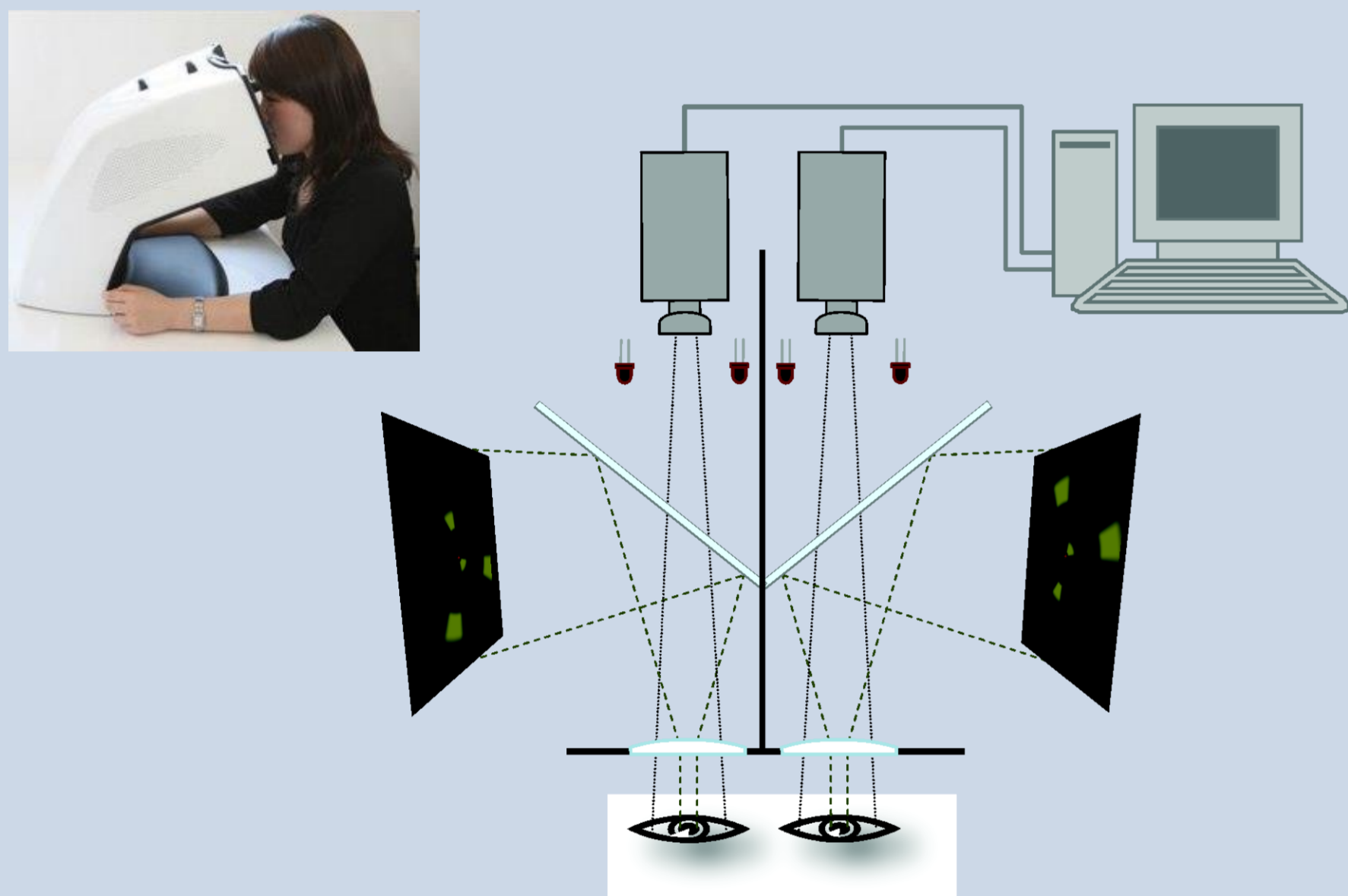


Figure 1 – Dichoptic multifocal pupillographic objective perimetry (mfPOP) device

Independent multifocal stimuli are presented concurrently on two LCD displays to both eyes. Cold mirrors allow infrared light to pass through to illuminate pupils permitting two video cameras to record the direct and consensual responses of both pupils. The images are fused, creating a cyclopean view. The device was a prototype of the FDA cleared Konan objectiveFIELD Analyzer (OFA).

RESULTS

- The mean t-SNRs for P129, P137 and P138 were 4.01, 5.59, 5.87 (with SE of 0.18)
- The t-SNRs of P137 and P138 were significantly larger than those of P129 at $p < 1e-13$ (t-stats 8.73 and 10.3 respectively)
- Across the protocols the linear models indicated that:
 - The acute concussion group had t-SNRs - 0.56 lower than controls ($p=0.006$)
 - Those with chronic concussion at a mean of 311 days had greater t-SNRs by 0.47 ($p < 0.021$)
 - Those with long-term concussion at a mean of 1443 days were not different from controls ($p=0.93$)

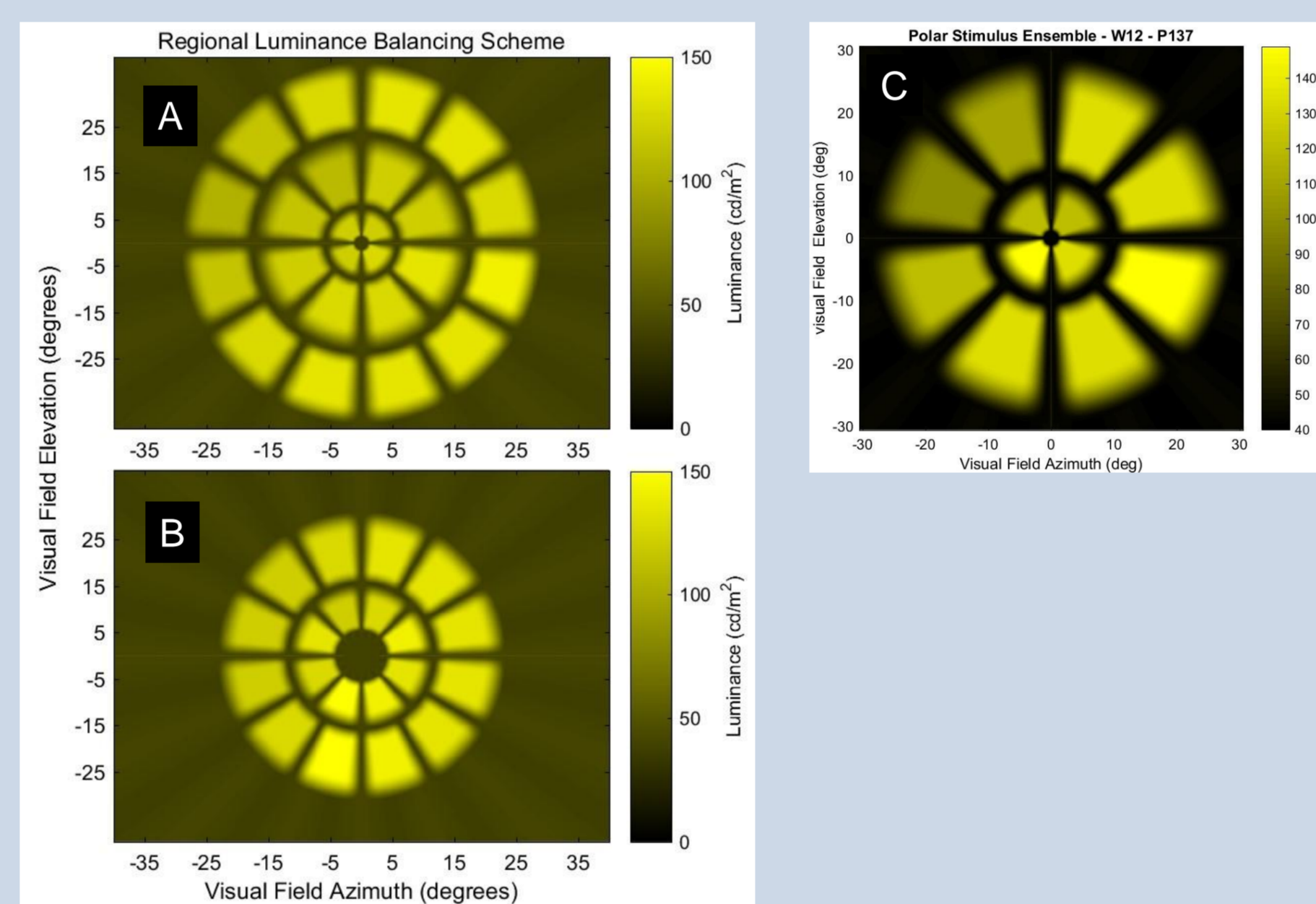


Figure 2 – The two types of spatial layouts of the stimuli. A,B) the 44 regions of the P129 stimulus ensemble overlap somewhat so are present in two parts. The P129 stimulus runs for 240 seconds. C) The quicker P137 and P138 stimuli had only 12 large test regions and ran for 80 seconds.

Extension Analysis

We also measured posterior pole retinal thickness (Heidelberg Spectralis OCT). We mapped the mfPOP data from the central 32 regions of the P129 test onto the ETDRS grid regions of the OCT thickness data. We then correlated the resulting 9 response amplitude and delays (time to peak regional constriction) with the 9 ETDRS thicknesses. For response delays the acute and chronic concussion groups showed significant structure function correlation but of opposite sign. This is explained by thicker retinas in chronic mTBI being significantly associated with significantly shorter delays.⁶

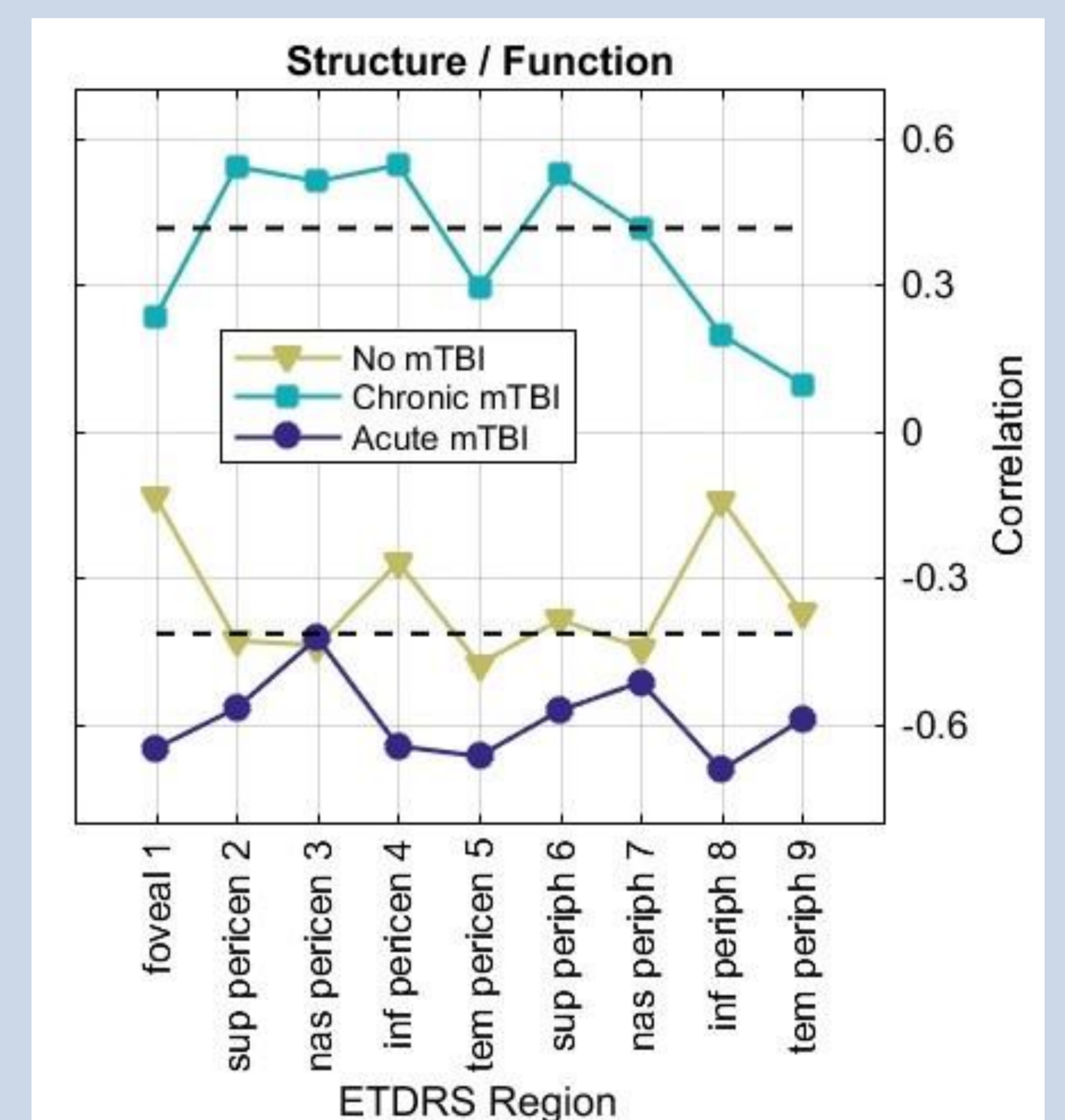


Figure 3 – Correlations between pupillary response delay and total retinal thickness by ETDRS region. Region numbers run central to peripheral. As indicated by the legend results are stratified for athletes with acute (dark purple), chronic (blue) and no history of mTBI (gold). The two dashed horizontal black lines represent levels beyond which correlations are significant ($p < 0.05$).

METHODS

We enrolled 54 men, 36 of which were rugby players with a history of concussion that was serious enough to warrant removal from the field. The 18 normal control subjects were aged 22.3 ± 2.38 y and the concussed athletes 21.6 ± 2.11 y (mean \pm SD). The concussed athletes were divided into 3 groups (12 per group) that had mean periods since concussion of 16, 311, and 1443 days (**acute, chronic, long-term**). We also recruited 10 athletes with no history of head injury (22.3 ± 2.4 years).

All three stimulus arrays occupied the central 60 degrees of each eye. The high resolution test (P129) had 44 regions per eye (**Fig. 2A**) and duration 6 minutes. The two 80-second methods (P137 and P138) tested 12 regions/eye (**Fig. 2B**) and had highest luminances of 156 and 216 cd/m^2 respectively. The multifocal response estimation process provided a t-statistic based SNR (t-SNR) for each tested region. The input variable for analysis (Matlab 2016b) was the mean t-SNR for each subject (computed across test-regions, eyes, and pupils). Linear models estimated the differences in SNRs between mfPOP methods and the independent effects of concussion.

CONCLUSIONS

The coarser 80-second stimuli provided significantly higher signal-to-noise ratios than the higher resolution mfPOP test. This greater accuracy might balance the effects of coarser resolution somewhat. All the tests seemed to have some capacity to detect concussion occurring within 34 days.

There is good evidence of pupillary responses to transient stimuli being driven by extra-striate cortex^{4,5} Thus it is not surprising to find effects of concussion. However see the Extension Analysis above.

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