Clinical validation of BGaze method supporting ADHD diagnosis

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Introduction

Recent evidence shows a novel role for eye vergence (fig. 1) in orienting visual attention (Solé Puig et al., 2013), and that such attention related eye vergence is disrupted in children with ADHD (Solé Puig et al., 2015). Based on eye vergence, the BGaze method (Braingaze SL, Spain) was developed as an objective tool for ADHD diagnosis.

Objective

Here we applied the BGaze method to classify ADHD patients from healthy controls.

Method

We recorded eye vergence in children using the BGaze method (see fig. 2). The child had to maintain central fixation to an image of a frog while lateral stimuli (fish or tadpole) appeared. Instructions were given to press the response button when detecting a tadpole and refraining when a fish appeared. There were two conditions to the task: cued and uncued, depending on the frog's gaze direction (fig. 3).

Data analysis

The BGaze method was evaluated using 4 classes of supervised machine learning classifiers. In total 138 different models were tested. Nineteen ADHD diagnosed patients (children 7-14 year of age) and 19 aged matched healthy controls were used to build the models. We performed a 30-fold cross-validation with training sets consisting of 80% of the data and test sets of the remaining 20%. This was repeated 30 times, each one with a different randomized split. Finally, all 138 models were tested with a validation set of 232 children, including 22 ADHD patients.

Results

In controls there is a strong increase in the angle of eye vergence, which is stronger in the cue condition than in the no-cue condition (fig. 4a). In ADHD children this pattern is reversed (fig. 4b). Based on these vergence data BGaze is applied to classify ADHD patients from healthy controls. The BGaze method showed an average accuracy of 90.84% (minimum 86.21%; maximum, 95.26%) and an average AUC of 0.95 (minimum 0.90; maximum, 0.97). Best models gave accuracies of 92%, AUCs of 0.96 and FN and FP rates of 4.3% and 7.5%, respectively. Mean scores during the training-testing phase averaged 99.63% .

Conclusions

Our results show that the BGaze method is robust, accurate, and can provide an objective tool supporting the clinical diagnosis of ADHD.

References

Puig, M. S., et al. (2015) Attention-Related Eye Vergence Measured in Children with Attention Deficit Hyperactivity Disorder. *PloS One*. 10(12),e0145281.

Puig, M. S., Zapata, L. P., Aznar-Casanova, J. A., & Supèr, H. (2013). A role of eye vergence in covert attention. *PloS one*, *8*(1), e52955.

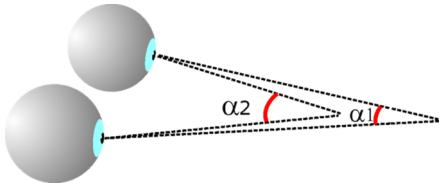

Fig 1. Eye vergence is the movement of both eyes in opposite direction The angle of eye vergence increases when moving the eyes inward (α2), and decreases when they move outwards (α1).

Fig 2. Set-up. Child performs an attention task while a remote eye tracker (Tobii X2-30) records eye movements. Clinician controls test by control panel

Fig 3. Stimuli presented in the task

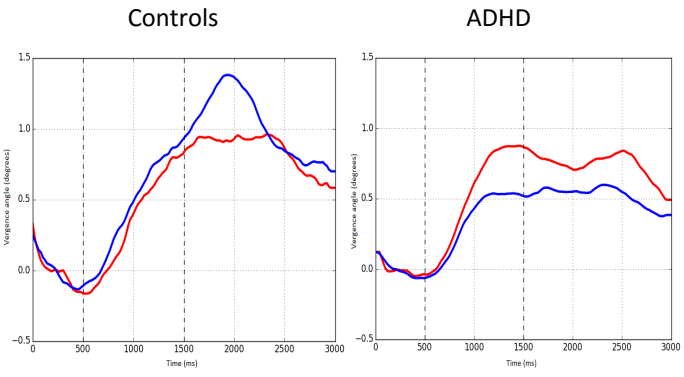

Fig. 4 Modulation in the angle of eye vergence (degrees of visual angle, y axis) throughout time (ms, x axis) for controls and children with ADHD diagnosis. Blue line corresponds to the cued condition, red line to the uncued condition in the visual task. Dotted line at 500ms shows cue presentation and at 1500ms stimulus presentation.

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