



Braingaze

Interactive Eye-tracking Games for Early Detection and Treatment of People with ADHD



Vision and Mission

Braingaze brings mental health care into the **digital, AI-empowered** age along with **digital biomarkers, digital therapy**, and practice-inspired patient journeys that are convenient and trustworthy.

Cognitive brain afflictions affect a large part of humanity,
and are very often not detected on time

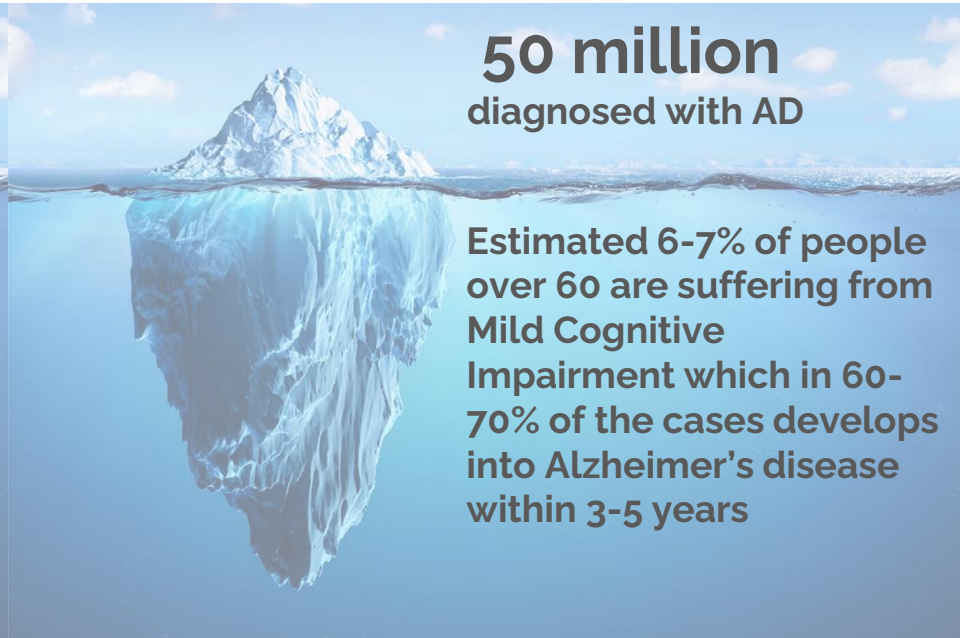
Attention Deficit and Hyperactivity Disorder (ADHD)

An iceberg floating in the ocean. The tip of the iceberg, which is above the water line, represents the 12 million people diagnosed with ADHD. The much larger, submerged part of the iceberg represents the estimated 200 million people worldwide who suffer from ADHD but are not diagnosed.

12 million
diagnosed

Estimated 2-3% of
population = 200
million people
worldwide suffer
from ADHD

Alzheimer's Disease (AD)

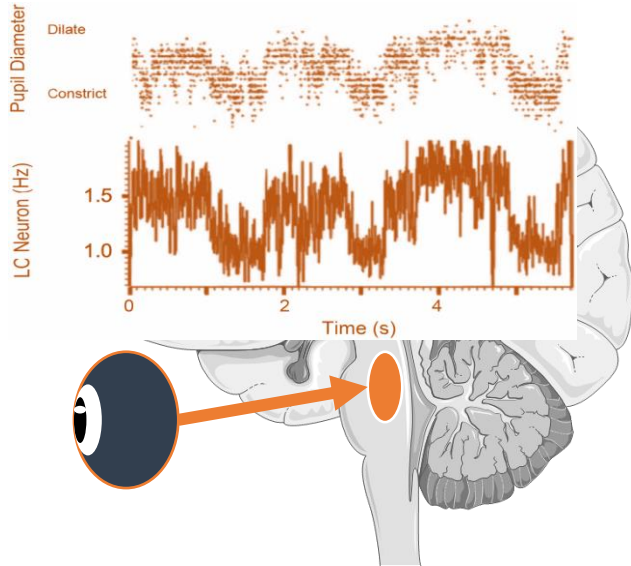
An iceberg floating in the ocean. The tip of the iceberg, which is above the water line, represents the 50 million people diagnosed with Alzheimer's Disease. The much larger, submerged part of the iceberg represents the estimated 6-7% of people over 60 who are suffering from Mild Cognitive Impairment, which can develop into Alzheimer's Disease within 3-5 years.

50 million
diagnosed with AD

Estimated 6-7% of people
over 60 are suffering from
Mild Cognitive
Impairment which in 60-
70% of the cases develops
into Alzheimer's disease
within 3-5 years

Braingaze exploits the connection between eye metrics (Cognitive Vergence) and ADHD & AD

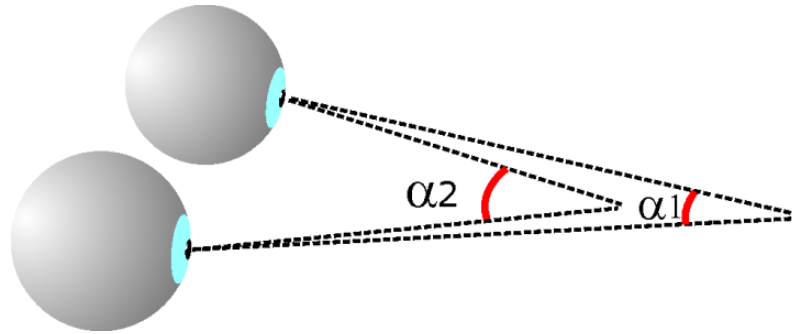
Activity of Brainstem can be assessed by eye metrics



Brainstem is critical in ADHD and AD

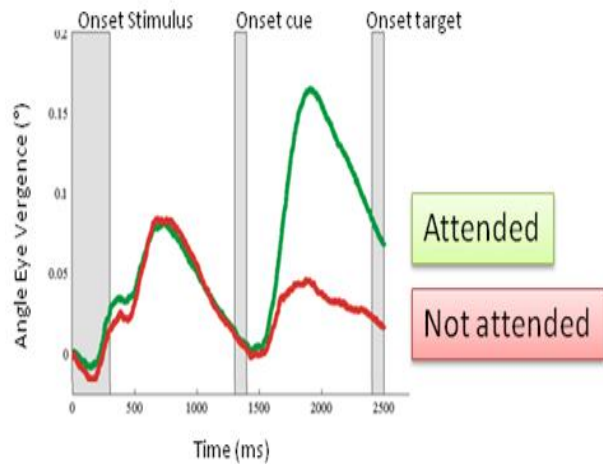
- Bast, N., et al (2018) The locus coeruleus–norepinephrine system as pacemaker of attention – a developmental mechanism of derailed attentional function in autism spectrum disorder *Eur J Neurosci*, 47: 115–125.
- D'Andrea, I., et al. (2015) Lack of kinase-independent activity of PI3Ky in locus coeruleus induces ADHD symptoms through increased CREB signaling. *EMBO molecular medicine*, 7(7), 904–917. <https://doi.org/10.15252/emmm.201404697>
- Mueller A et al., (2017) Linking ADHD to the Neural Circuitry of Attention *Trends Cogn Sci*. 21(6): 474–488.
- Murphy PR, et al. Pupil diameter covaries with BOLD activity in human locus coeruleus. *Hum Brain Mapp*. 2014;35:4140–4154.
- Siddhartha J et al., (2016) Relationships between Pupil Diameter and Neuronal Activity in the Locus Coeruleus, Colliculi, and Cingulate Cortex *Neuron* 89:221–234. <https://doi.org/10.1016/j.neuron.2015.11.028>
- Sparks, D. (2002) The brainstem control of saccadic eye movements. *Nat Rev Neurosci* 3, 952–964. <https://doi.org/10.1038/nrn986>

Cognitive Vergence; the core invention which permits us to measure cognitive functions by just analyzing involuntary eye movement patterns

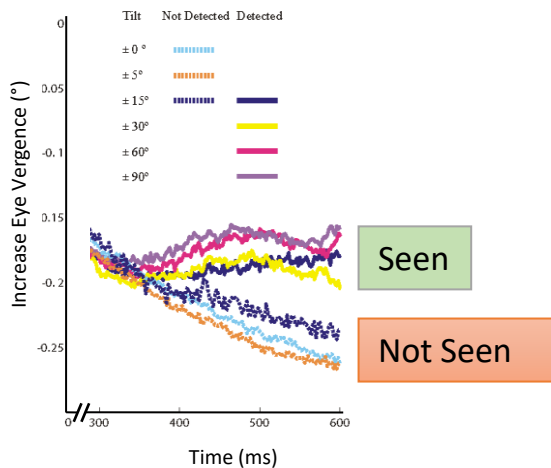


- *Vergence is movement of both eyes in opposite direction*
- *Novel role of vergence in cognitive processing*
- *This method is called Cognitive Vergence is patented world-wide by Braingaze*

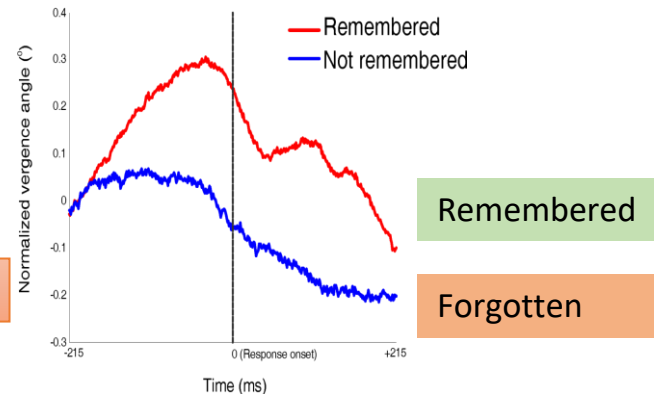
Role of Cognitive vergence in cognitive functions



[Sole et al., PLoS One 2013a](#)
[Sole et al., PLoS One 2013b](#)
[Sole et al., PLoS One 2015](#)
[Jimenez et al., Vis Research 2020](#)

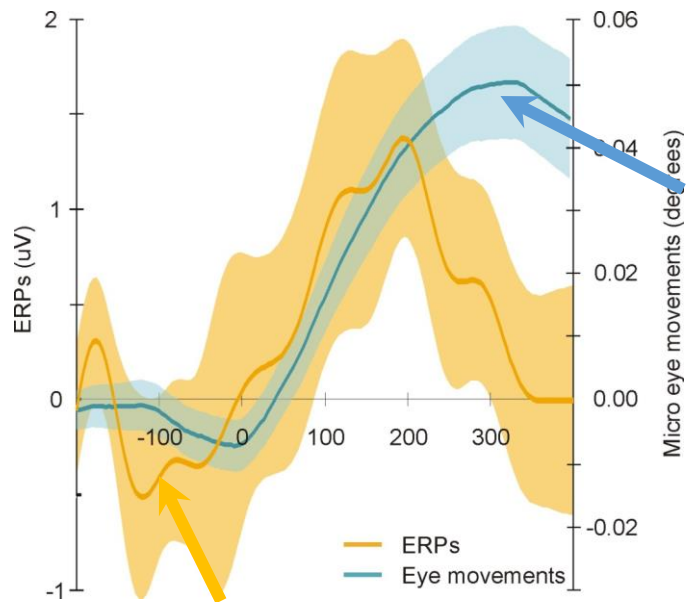
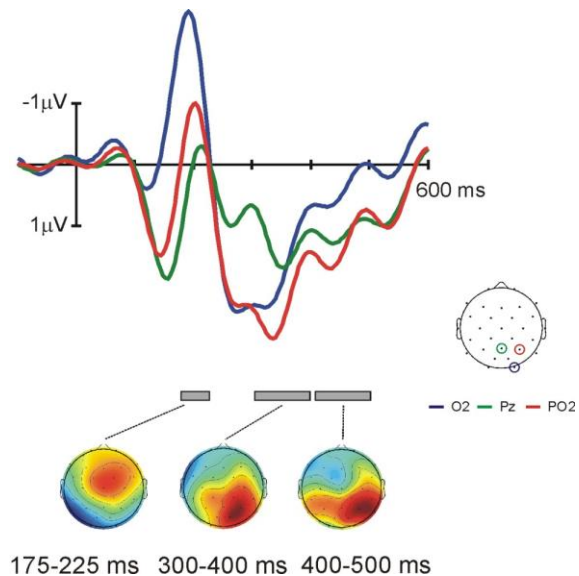


[Sole et al., PLoS One 2013b](#)
[Esposito & Supèr, Acta Psychologica 2019](#)
[Sole et al., submitted](#)



[Sole et al., Neuroreport 2016](#)
[Esposito & Supèr, Neuroreport 2018](#)
[Jimenez et al., in prep](#)

Cognitive vergence correlates with EEG responses



Cognitive
Vergence

Neural activity signaling visual attention

The fundamental tech is patented worldwide

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International Filing Date

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CPC

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A61B 5/168 G08B 21/06

Applicants

UNIVERSITAT DE BARCELONA [ES/ES]; Centre de Patents de la UB Baldri Reixac 4 - Torre D E-08028 Barcelona, ES
INSTITUCIÓ CATALANA DE RECERCA I ESTUDIS AVANÇATS [ES/ES]; Pg. Lluís Companys 23, 3r E-08010 Barcelona, ES

Inventors

SUPER, Hans; ES

Common Representative

UNIVERSITAT DE BARCELONA; Centre de Patents de la UB Baldri Reixac 4 - Torre D E-08028 Barcelona, ES

Priority Data

12380018.7 24.04.2012 EP

Title

[EN] METHOD OF MEASURING ATTENTION
[FR] PROCÉDÉ DE MESURE DE L'ATTENTION

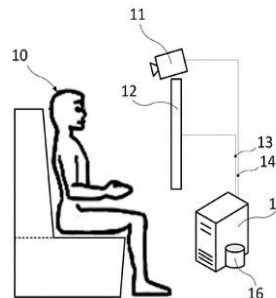


Fig.1a

Abstract**[EN]**

In a first aspect, the present invention provides a method of measuring attention of a person comprising presenting one or more stimulus aimed at attracting attention of the person; and obtaining positions of the eyes of the person. The method further comprises detecting one or more eye fixations from the obtained positions of the eyes; and measuring the angle of convergence of the eyes over time from the obtained positions of the eyes during one or more of the detected eye fixations.

[FR]

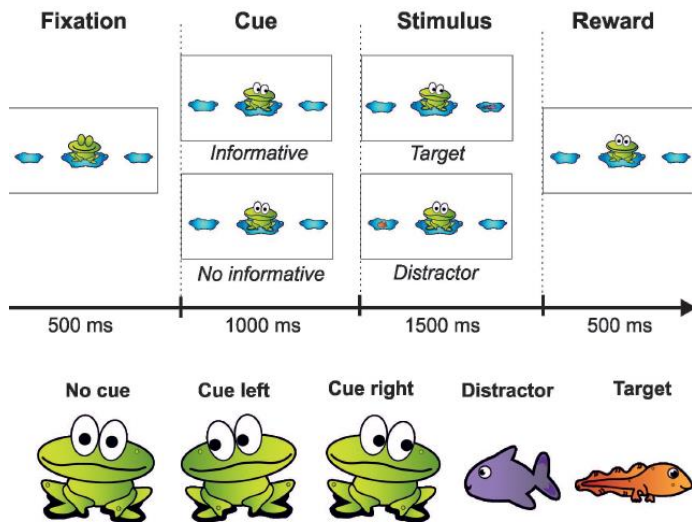
Dans un premier aspect, la présente invention concerne un procédé de mesure de l'attention d'une personne, comprenant la présentation d'un ou de plusieurs stimuli visant à attirer l'attention de la personne; et l'obtention de positions des yeux de la personne. Le procédé comprend en outre la détection d'une ou de plusieurs fixations des yeux à partir des positions des yeux obtenues; et la mesure de l'angle de convergence des yeux au cours du temps à partir des positions des yeux obtenues pendant une ou plusieurs des fixations des yeux détectées.

Also published as

BR112014026072 CN104254281 DK2844146 EP2844146 ES2589000 IN8724/DELNP/2014 JP2015518402 KR1020150013567 US20150112224

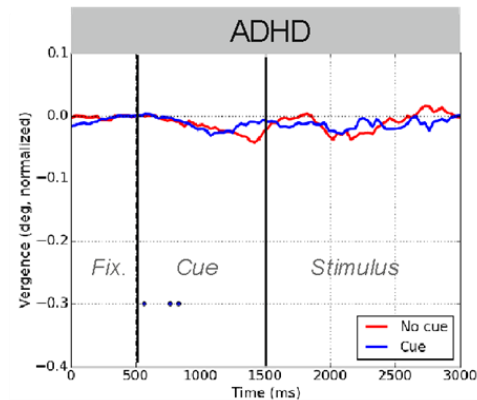
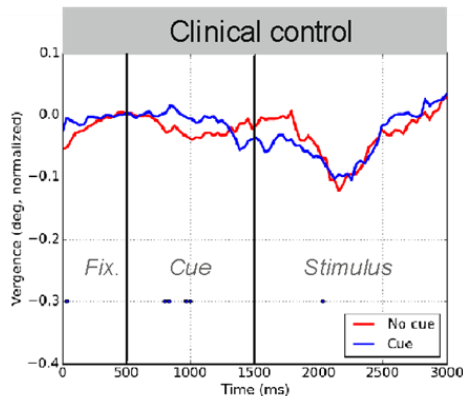
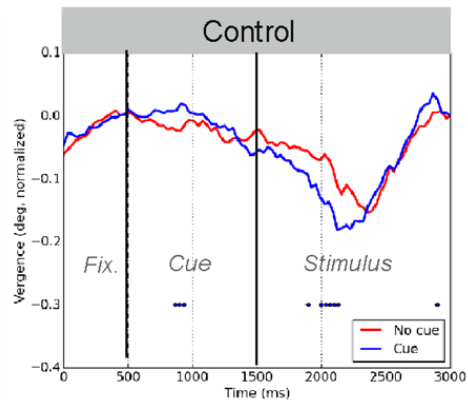


Measuring cognitive issues during orienting visual attention task



- Computerized & engaging task
- Over 100 trials; 10-12 minutes
- Cue and no-cue condition to measure attention
- We record vergence
- Classification by Machine Learning techniques

Detecting ADHD more objectively analyzing cognitive vergence using machine learning classifiers



[Sole Puig et al., PLoS ONE 2015](#)

[Varela et al., J Att Disorder 2018](#)

[Jimenez et al., J Att Disorder 2020](#)

[Boxhoorn et al., J Child Psych Psych 2020](#)

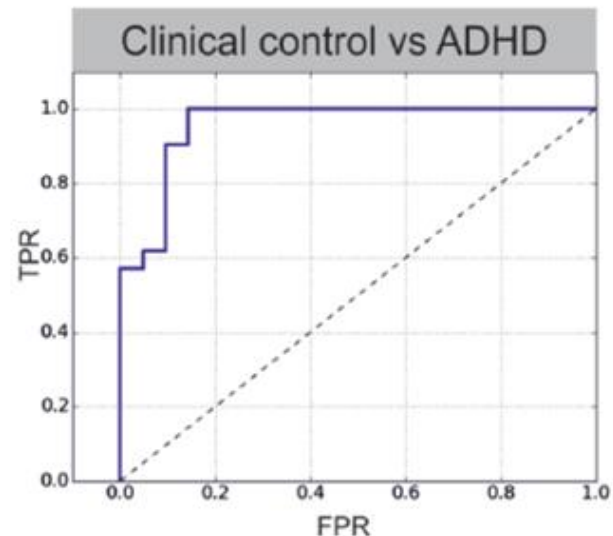
[Morata et al., submitted](#)

[Best et al., submitted](#)

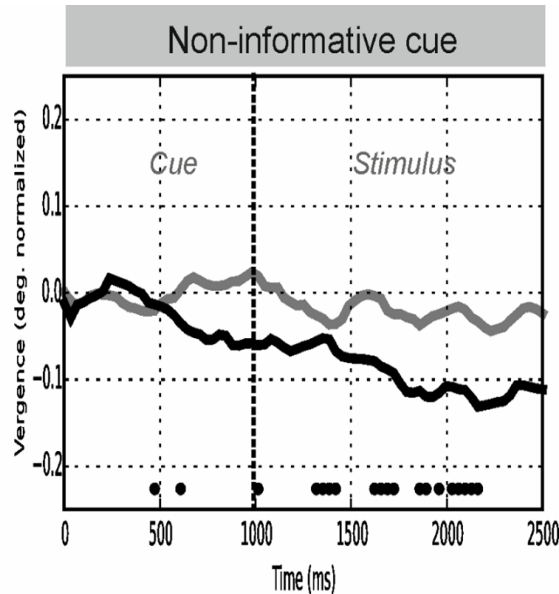
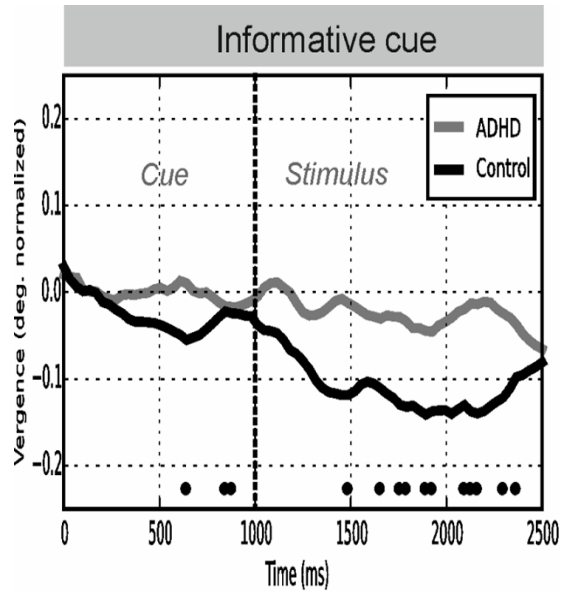
[Steve Faraone et al., in prep](#)

Detecting ADHD in children more objectively analyzing cognitive vergence using machine learning classifiers

	Non-ADHD vs ADHD
N	159
Accuracy	92.83%
AUC	97.42
FP i.e. healthy patient diagnosed as ADHD	5.35%
FN i.e. ADHD patients classified as healthy	8.51%



ADHD classification trial in adults



ADHD group
(N=108; $M \pm SD$: 29.4 ± 12.5 years)

Clinical controls
(N=36; $M \pm SD$: 26.9 ± 8.4 years)

Accuracy: 79% (95%CI= $\pm 6.6\%$)

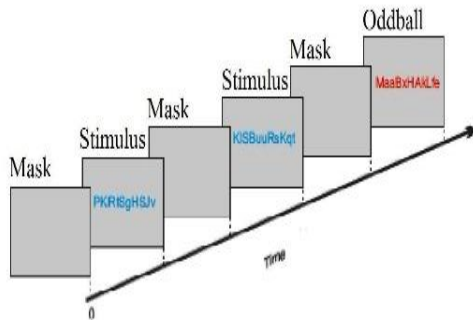
AUC: 0.77

FP rate: 25.00%

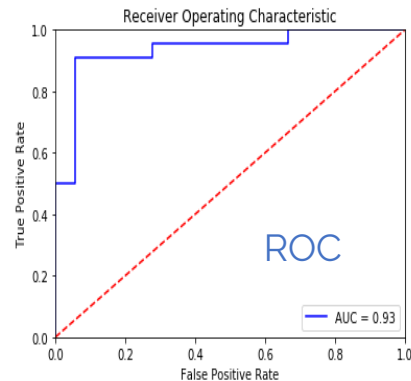
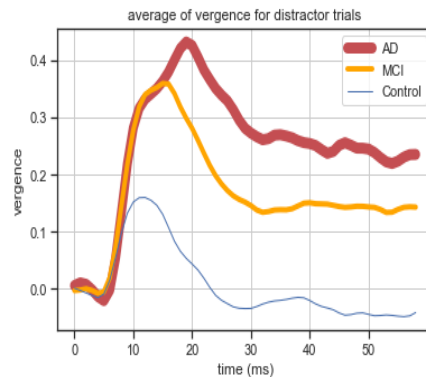
FN rate: 20.55%

Detection of MCI and Alzheimer patients

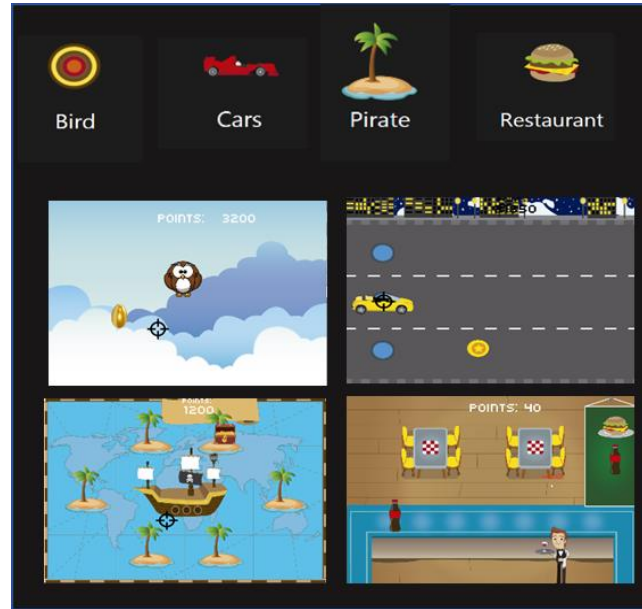
5 min oddball task



Control/MCI/Alzheimer



Digital therapy



Interactive eye tracking serious game to train cognitive behavior

Pre-Training Attention Evaluation		RECOGNeyes Training				Post-Training Attention Evaluation	
Frog Task 	Word Recognition Task	Experimental group				Frog Task 	Word Recognition Task
		Week 1	Week 2	Week 3			
		3x 30 min	3x 30 min	3x 30 min			
		Control group					
		Week 1	Week 2	Week 3			
		 3x 30 min	3x 30 min	3x 30 min			

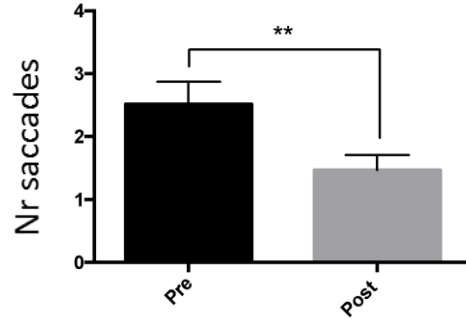
28 ADHD patients (18 boys and 10 girls)

The experimental group played game using the eye-tracker and control group played it using the mouse.

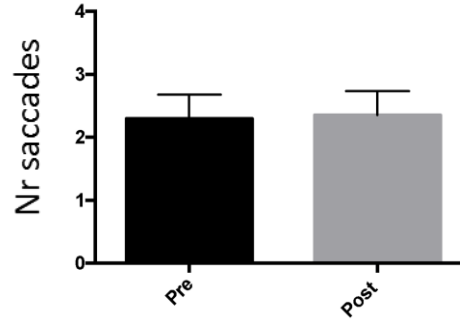
Play game for 3 weeks, 3 times per week for 30 minutes.

evidence shows that it enables reduction of symptoms

*Eye tracking
attention game*

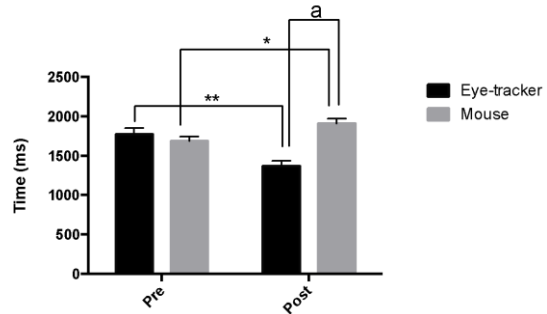


*Mouse controlled
attention game*

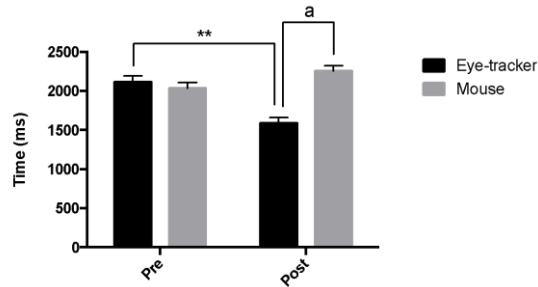


- Better gaze fixations (focus)
- Faster behavioral response
- Improved detection performance

Reaction time in short words (word recognition task)



Reaction time in long words (word recognition task)



Preliminary data on recovery of vergence/pupil responses in ADHD after psychostimulants and digital treatment

Digital treatment

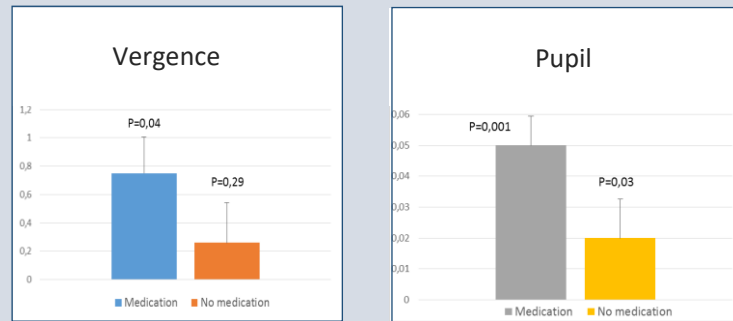
Improvements in ADHD patients treated with gaze-controlled games but not in patients with mouse-controlled games



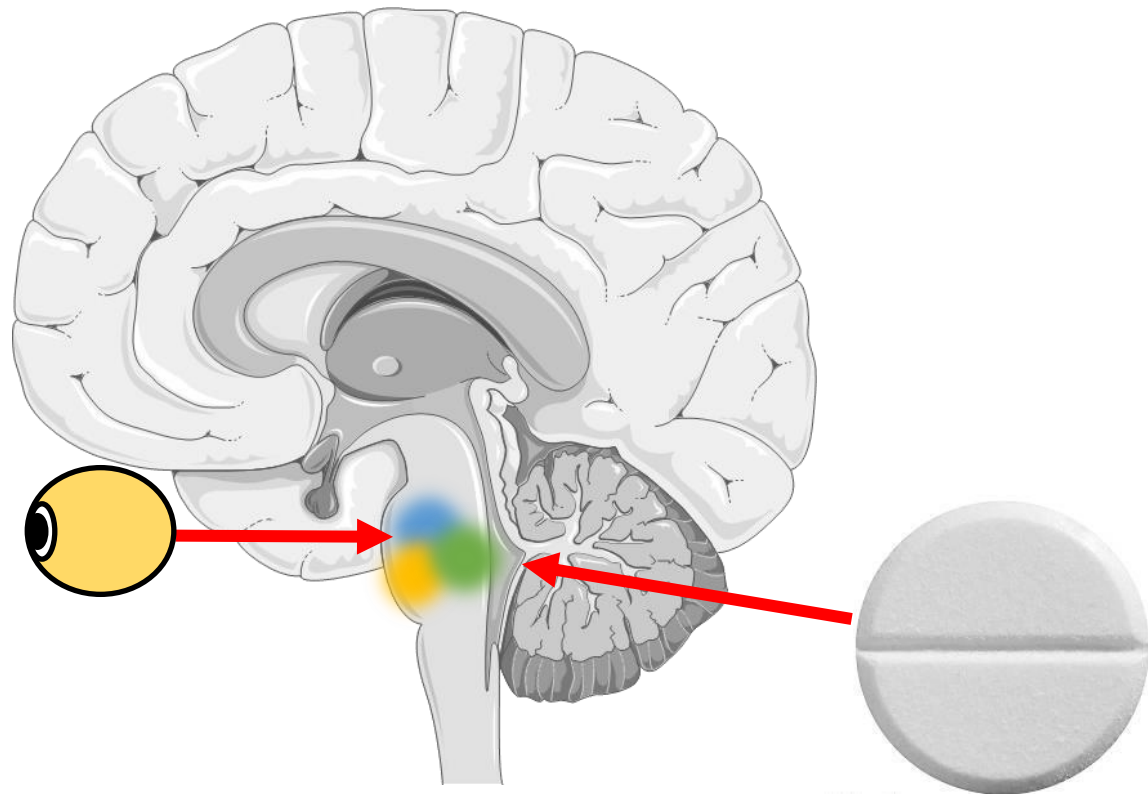
Unpublished information

Psychostimulants

Improvements in medicated ADHD patients but not in unmedicated patients



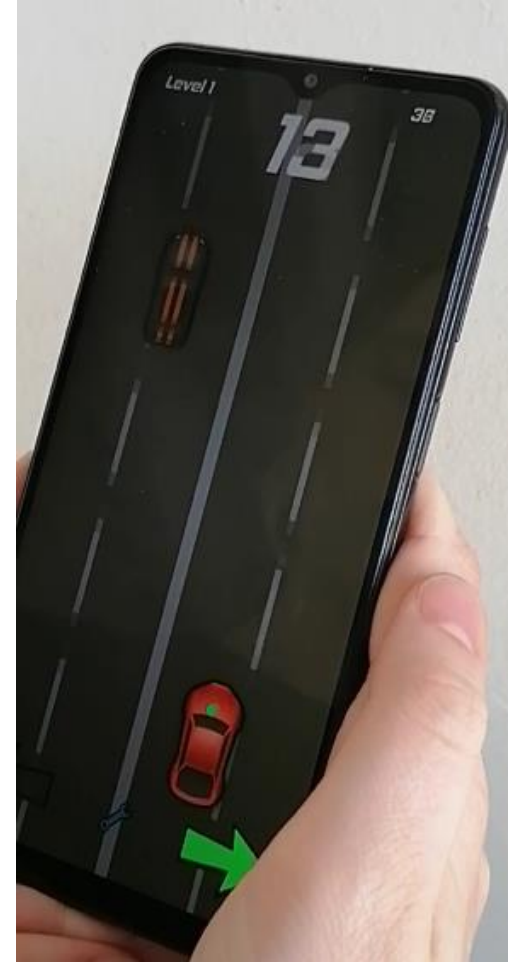
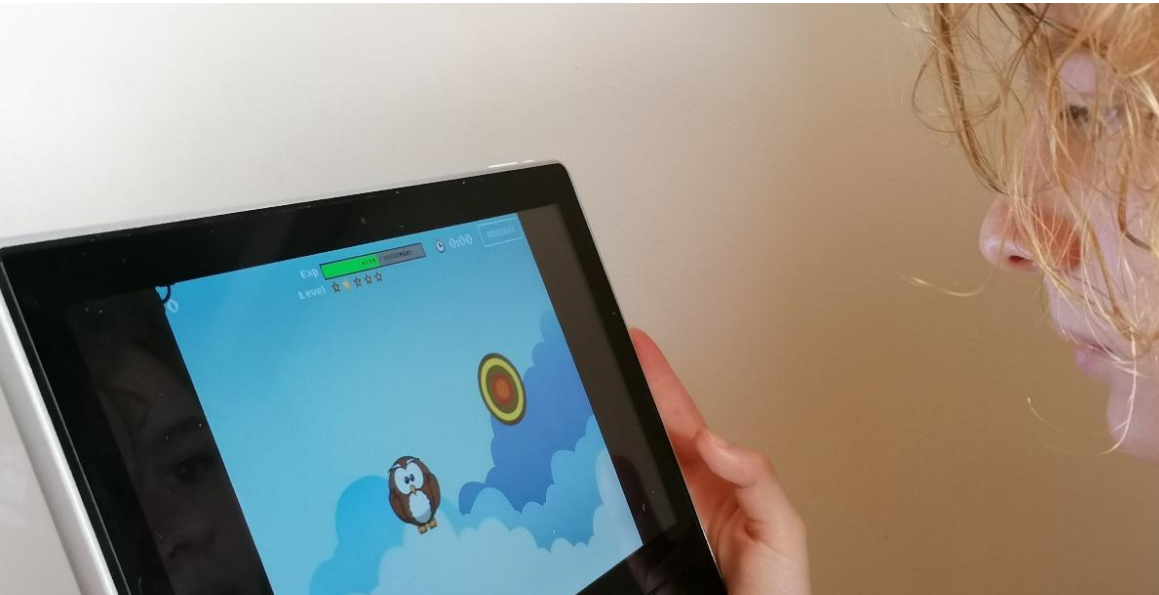
Unpublished information



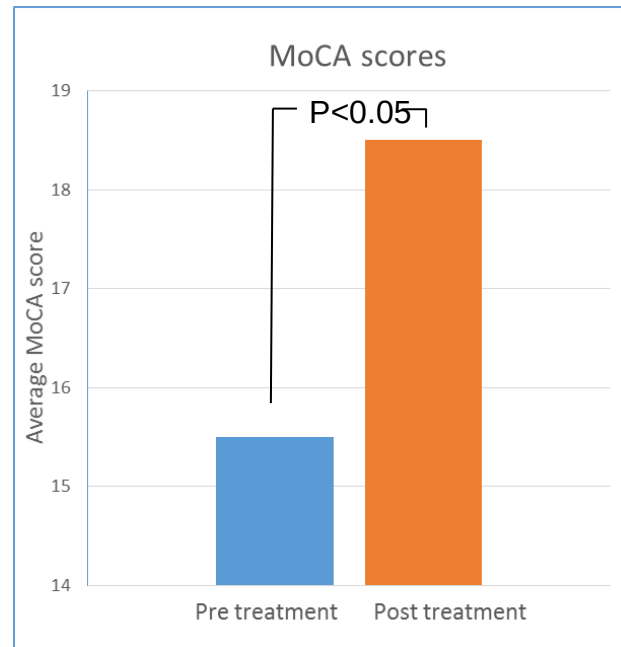
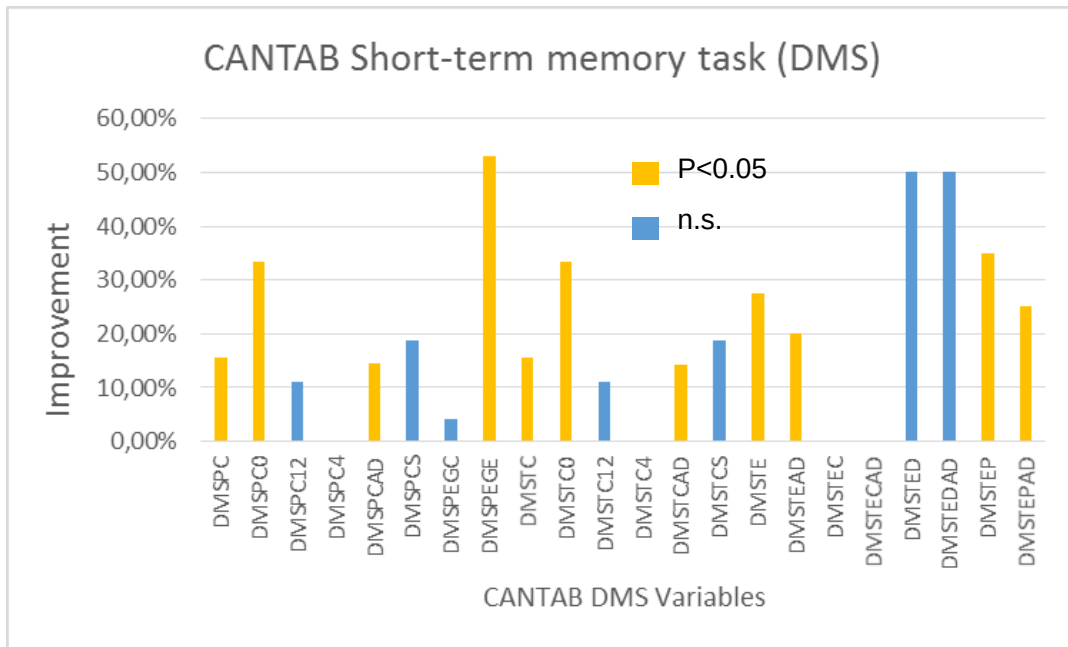
At home therapy uses mobile devices



Google Play



Preliminary data on Alzheimer patients treatment after 2 weeks interactive eye tracking game play



Clinical studies using our method



University of London

[Boxhoorn et al., J Child Psych Psych 2020](#)

[Best et al., submitted](#)

[Bustos et al., in prep](#)



Syracuse University

[Steve Faraone et al., in prep.](#)

>1300 people

involved in

13 clinical studies



University of Nottingham

UK | CHINA | MALAYSIA

[Garcia et al 2018](#)



[Varela et al., J Att Disorder 2018](#)

[Jimenez et al., J Att Disorder 2020](#)

[Morata et al., submitted](#)

[Jimenez et al., Vis Research 2020](#)

[Sole et al., PLoS One 2015](#)



PARTE DE Bupa



[Jimenez et al., submitted](#)

[Hashemi et al., submitted](#)



UNIVERSITAT DE BARCELONA

[Sole et al., PLoS One 2013a](#)

[Sole et al., PLoS One 2013b](#)

[Sole et al., Neuroreport 2016](#)

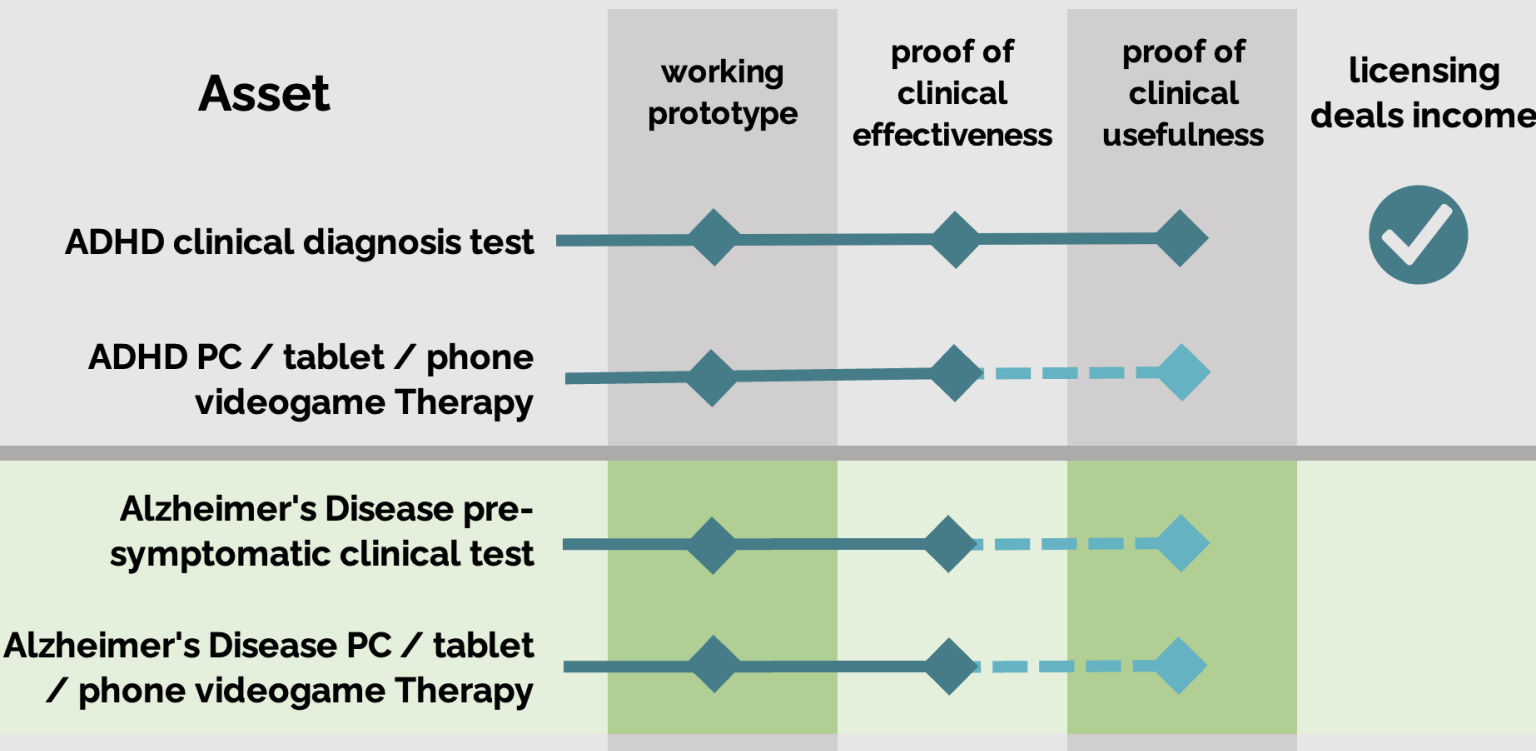
[Sole et al., PLoS One 2016](#)

[Esposito & Supèr, Neuroreport 2018](#)

[Esposito & Supèr, Acta Psychologica 2019](#)

[Sole et al., submitted](#)

Pipeline status now



Our team



Laszlo Bax

CEO & co-founder



Prof. Dr. Hans Supèr

CTO & co-founder



Ed van de Logt

Business Development Manager



Ana López

Clinical Liaison Officer



Oleksii Leonovych

AI Machine Learning specialist



Rafael Fernández

Software Development Lead

KOLs Advisory Board



Dr Toni Ramos-Quiroga

Chief Psychiatry Dept Vall d'Hebron University Hospital.
President of Innovation Commission of Vall d'Hebron



Dr Susan Young

Clinical Senior Lecturer in Forensic Clinical Psychology in the Centre for Mental Health, Imperial College



Dr José Alda

Head of Psychiatry Section in the Barcelona Children's Hospital Sant Joan de Déu



Dr Marta Giral

Lead psychiatrist at the Clinic Hospital of Barcelona



Dr Paloma Varela

Coordinator child psychiatry Hospital de Mataró



Dr José Cañete

Director Mental Health of Consorci Sanitari del Maresme





hans@braingaze.eu

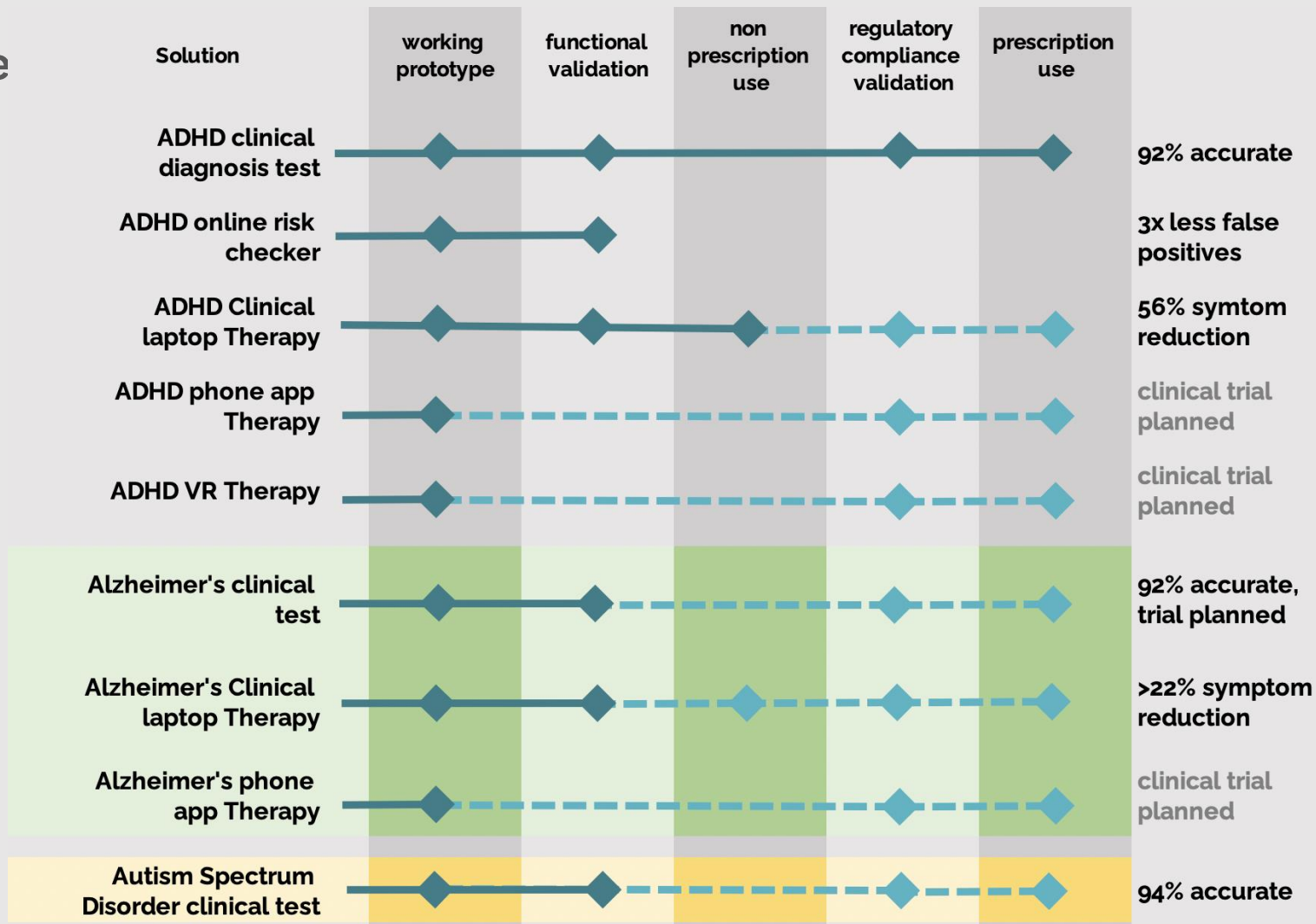


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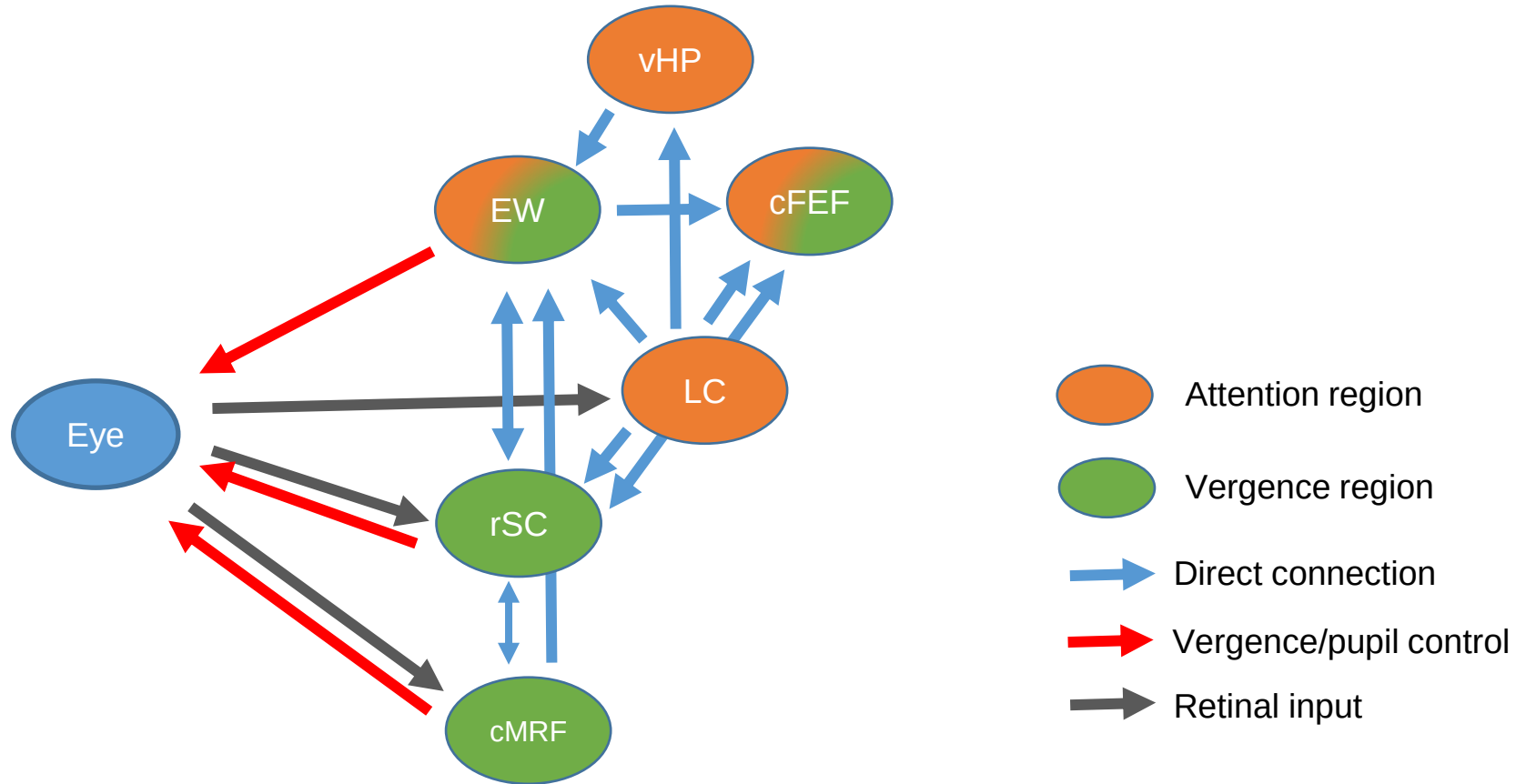


<https://braingaze.com>

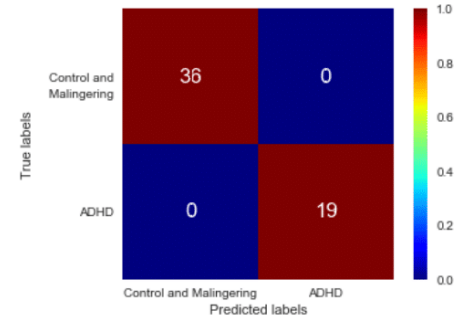
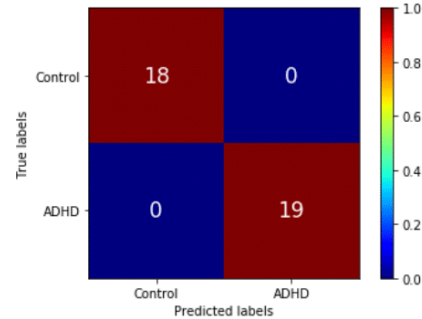
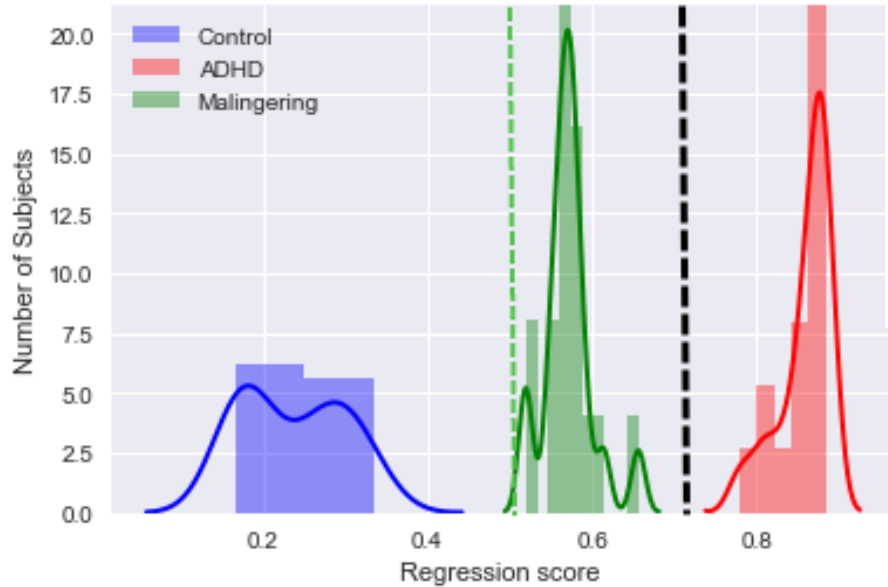
Pipeline



Overlap of attention network and network of cognitive vergence



Detection of malingering ADHD in young adults

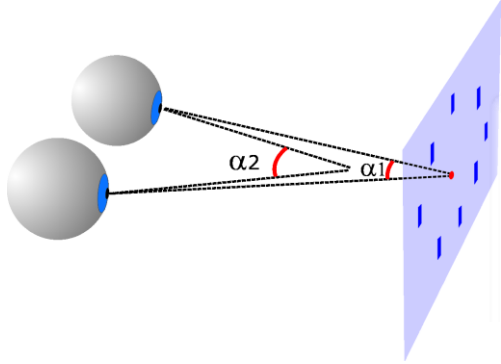


System to measure cognitive vergence

- Non-invasive and contactless
- Plug and play set-up
- Easy to administer
- Easy and short visual task
- Automatic collection of data
- AI classification of patients
- Low-cost



Attention can be measured by cognitive vergence

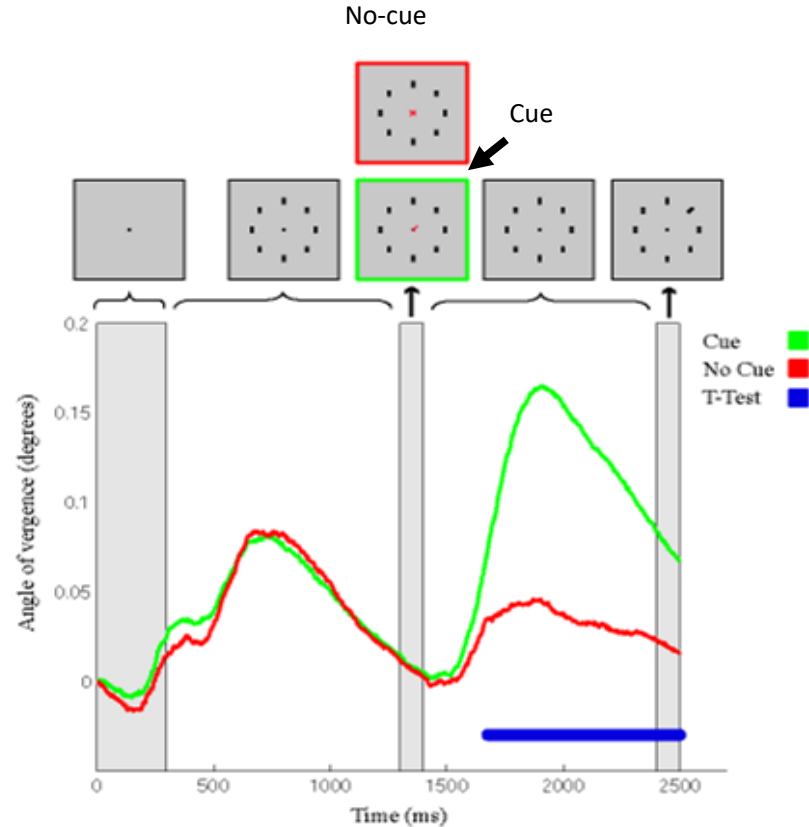


Cue: you know which bar is about to change.

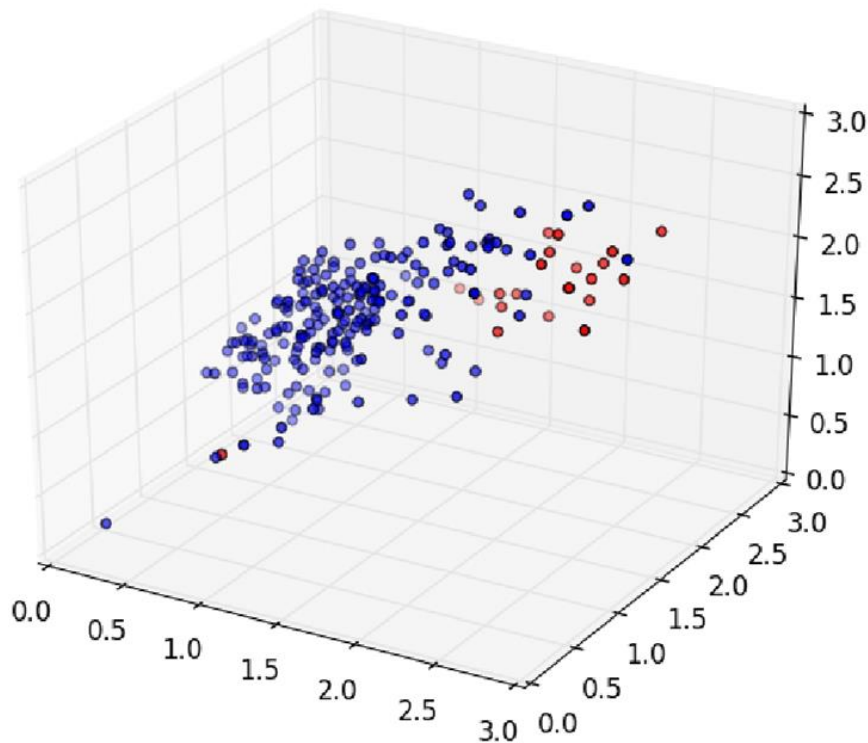
You focus your attention.

No-cue: you don't know which bar will change.

You don't focus your attention.



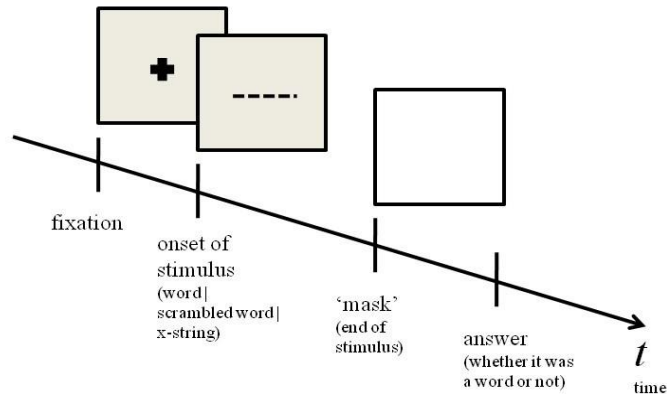
ADHD classification trial in school cohort



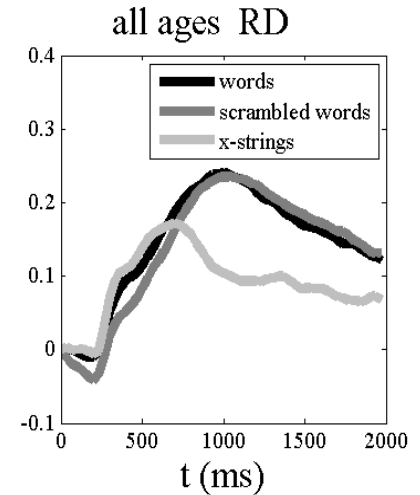
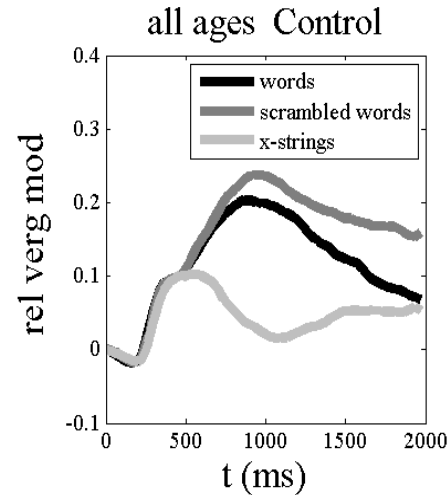
	Non-ADHD vs ADHD
N	270
Accuracy	92.0%
AUC	96
FP i.e. healthy patient diagnosed as ADHD	6.5%
FN i.e. ADHD patients classified as healthy	6.4%

Detection of reading difficulties

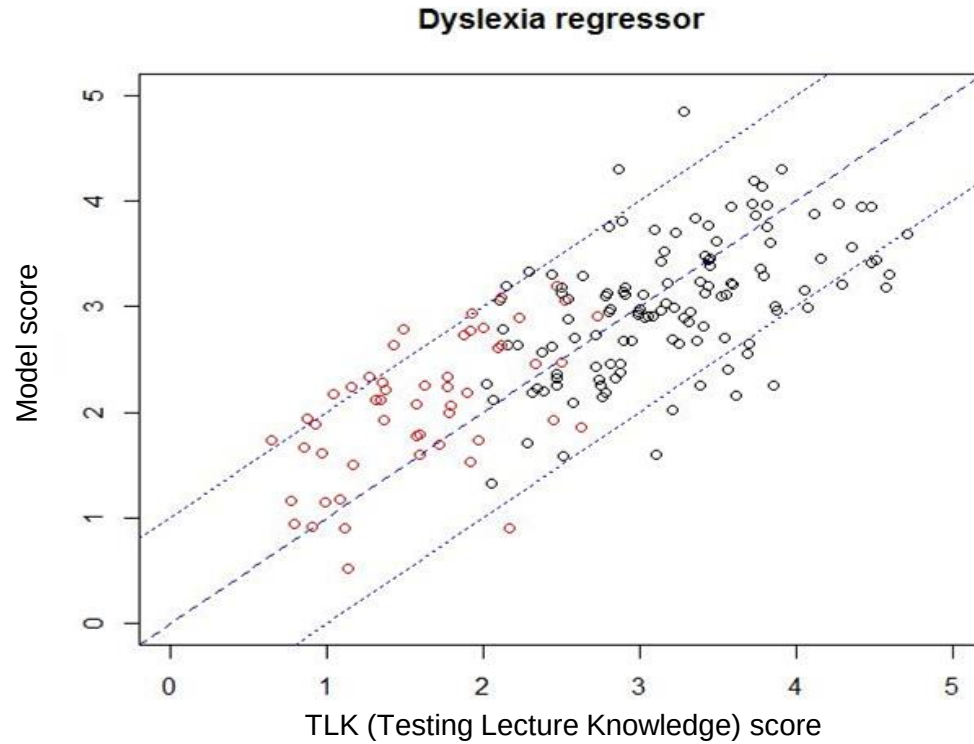
Word detection task



Children (N=215; M $\pm$ SD:
9.1 $\pm$ 1.8 years of age)



Detection of reading difficulties





Psychostimulants recover vergence/pupil responses in ADHD patients towards normal levels

Supporting evidence that cognitive vergence could be used to measure effect of medication

- Wainstein G, Rojas-Líbano D, Crossley NA, Carrasco X, Aboitiz F, Ossandón T. (2017). **Pupil Size Tracks Attentional Performance In Attention-Deficit/Hyperactivity Disorder** Sci Rep. 7(1):8228. doi: 10.1038/s41598-017-08246-w.
- Fried M, Tsitsiashvili E, Bonnef YS, Sterkin A, Wygnanski-Jaffe T, Epstein T, Polat U. (2014) **ADHD subjects fail to suppress eye blinks and microsaccades while anticipating visual stimuli but recover with medication** Vision Res. 01:62-72. doi: 10.1016/j.visres.2014.05.004.
- Dolder PC, Müller F, Schmid Y, Borgwardt SJ, Liechti ME. (2018). **Direct comparison of the acute subjective, emotional, autonomic, and endocrine effects of MDMA, methylphenidate, and modafinil in healthy subjects** Psychopharmacology (Berl). 235(2):467-479. doi: 10.1007/s00213-017-4650-5.
- Grönlund MA, Aring E, Landgren M, Hellström A. (2007) **Visual function and ocular features in children and adolescents with attention deficit hyperactivity disorder, with and without treatment with stimulants** Eye (Lond). 21(4):494-502. doi: 10.1038/sj.eye.6702240.

Preliminary data on Control, ADHD, ASD, and ADHD+ASD



Sad



Disgusted

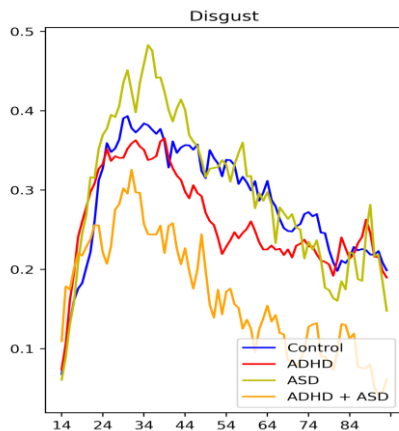


Fearful

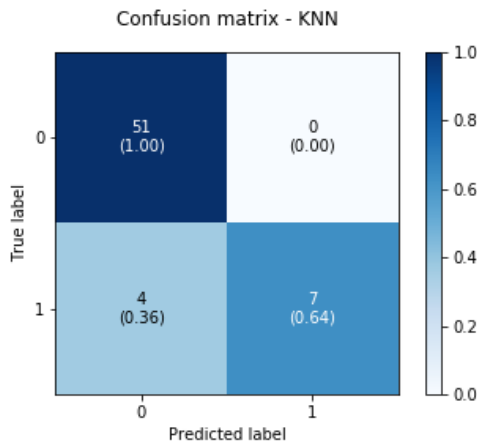


Angry

Vergence responses



ADHD+ASD vs rest



ROC

