بسم الله الرحمن الرحیم

AI and digital healthcare

AI-assisted technology for assessment and monitoring of cognitive state

Seyed-Mahdi Khaligh-Razavi, PhD

ROYAN

HamTech همتک

Cognetivity

Cognetivity Neurosciences - transforming cognitive assessment through AI-driven next-generation neuroscience

Cognetivity Neurosciences Ltd
Founded 2013; went public 2018 (CSE: CGN)

همتک
HamTech

شتابدهندهٔ هوش مصنوعی ایران(همتک)

مکانیزم شتاب‌دهی

شروع

ورود تیم‌ها

ارزیابی تیم‌ها

استقرار تیم‌ها

تکمیل تیم‌ها

تخصیص مربی

طراحی بسته آموزشی

ارزیابی دوره‌ای

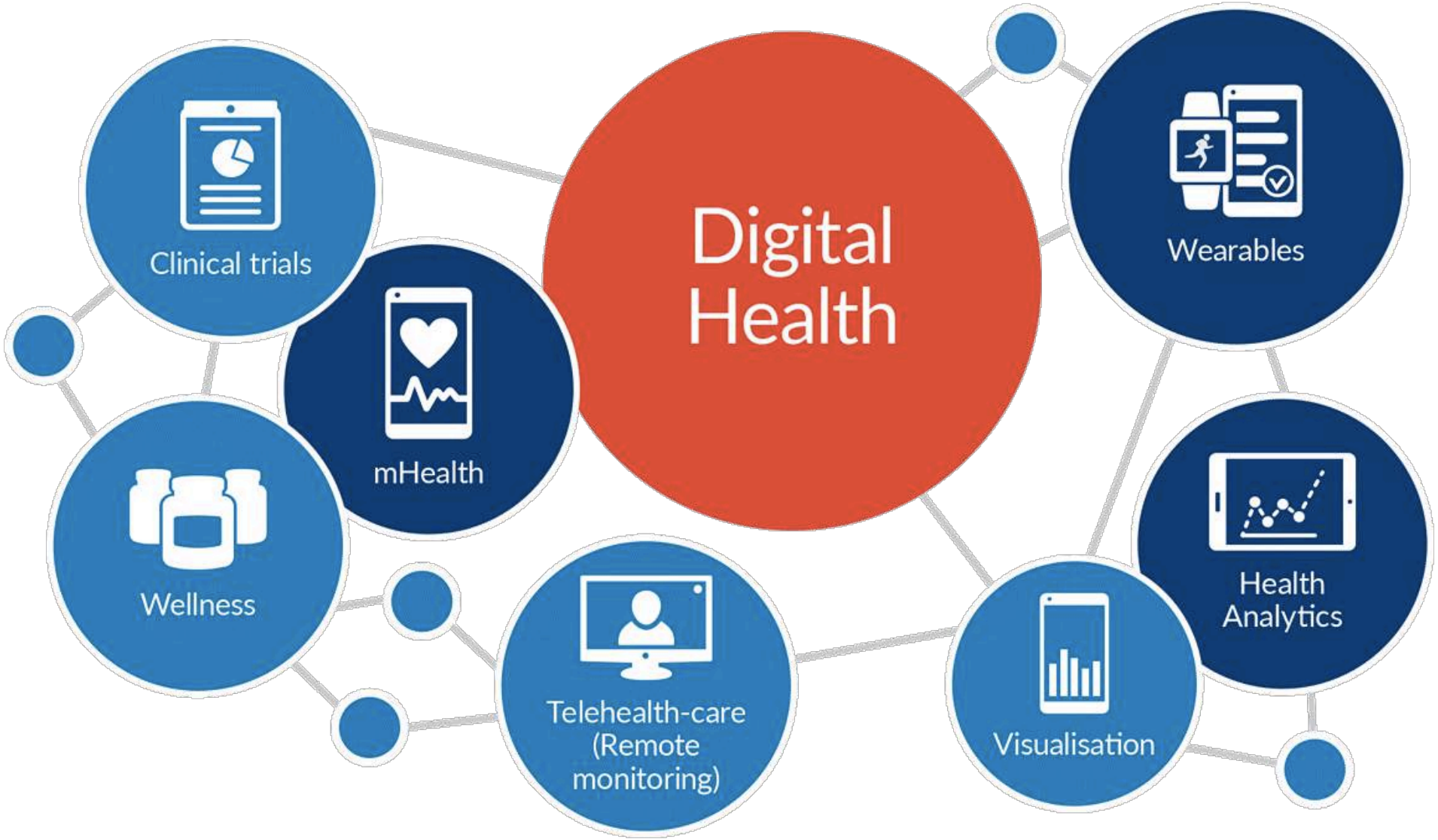
معرفی به سرمایه‌گذار

پایان

12:45
SAMSUNG Health
ME
TOGETHER
DISCOVER
10835/6000 steps
All steps
43 min ago
12 AM
6 AM
12 PM
6 PM
Now
12 AM
7 hr 34 min
10 PM
1 AM
4 AM
Stress
MEASURE
100 %
SpO2
MEASURE
67 bpm
Heart rate
MEASURE
8
Water
TODAY
Healthy
Light
Inactive
Sleep

10:09 AM
100%
Health Data
Heart
H
D
W
M
Y
Aug 27 – Sep 3, 2017
MAX
190
MIN
43
250
200
150
Sun
Aug 27
Mon
Tue
Wed
Thu
Heart Rate
43-190 BPM
Aug 27 – Sep 3, 2017
Today
Health Data
Sources
Resting
10:09
102
55
50
12AM
6
12PM
6
Resting Rate
55 BPM
Today

Digital health landscape

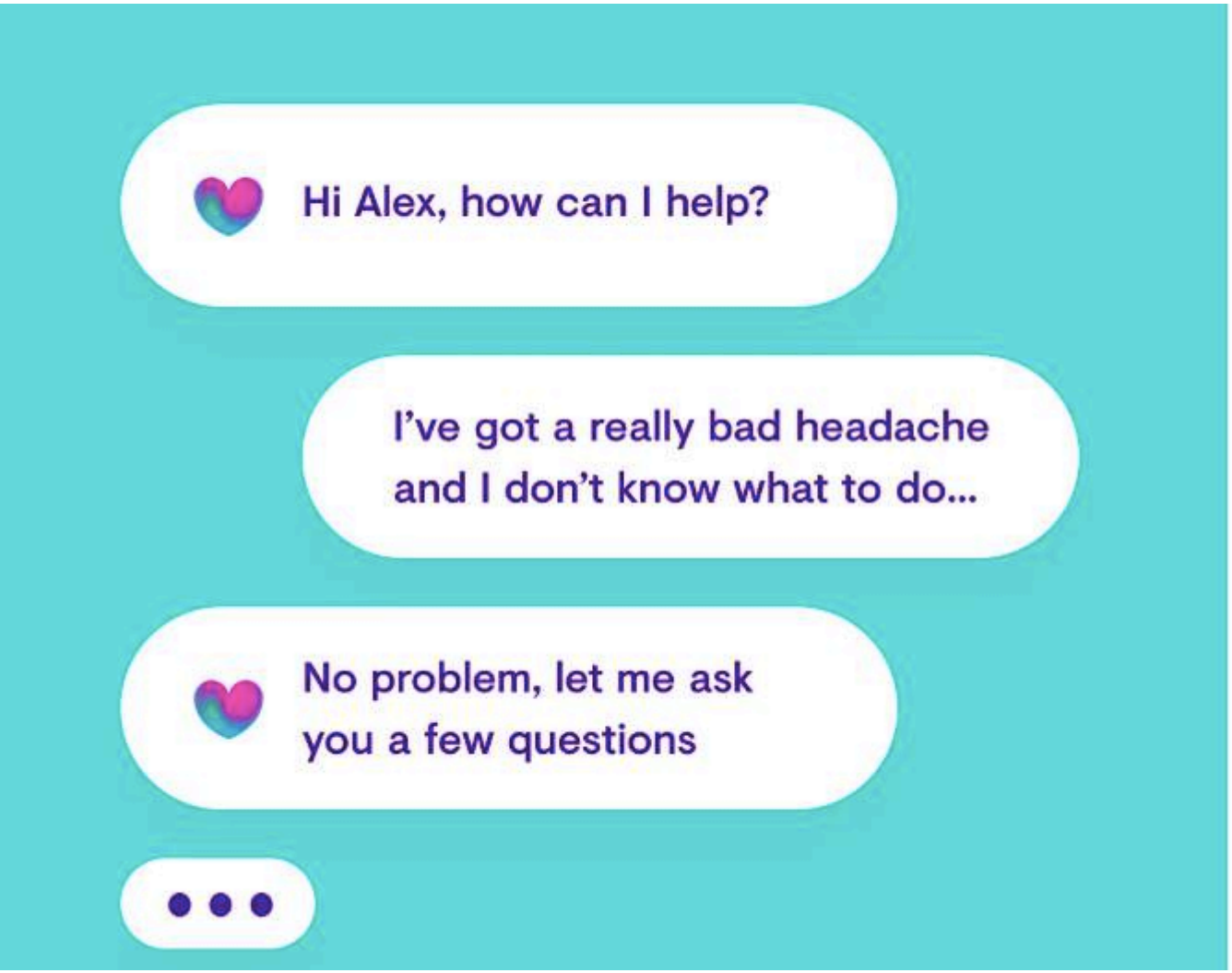


Digital footprint

More data

AI/ML on big data

Babylon

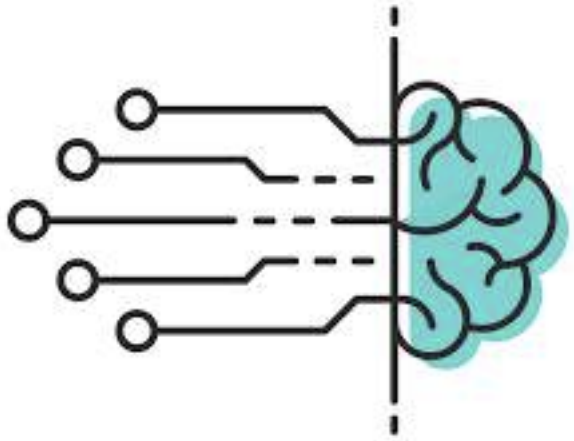


Babylon's interactive symptom checker asks you questions to analyse your condition

Babylon's AI system has been created by experienced doctors and scientists using the latest advances in deep-learning. Much more than a searchable database, it assesses known symptoms and risk factors to provide informed, up-to-date medical information.

Ask Babylon

AI and Digital Biomarkers in Cognitive Sciences



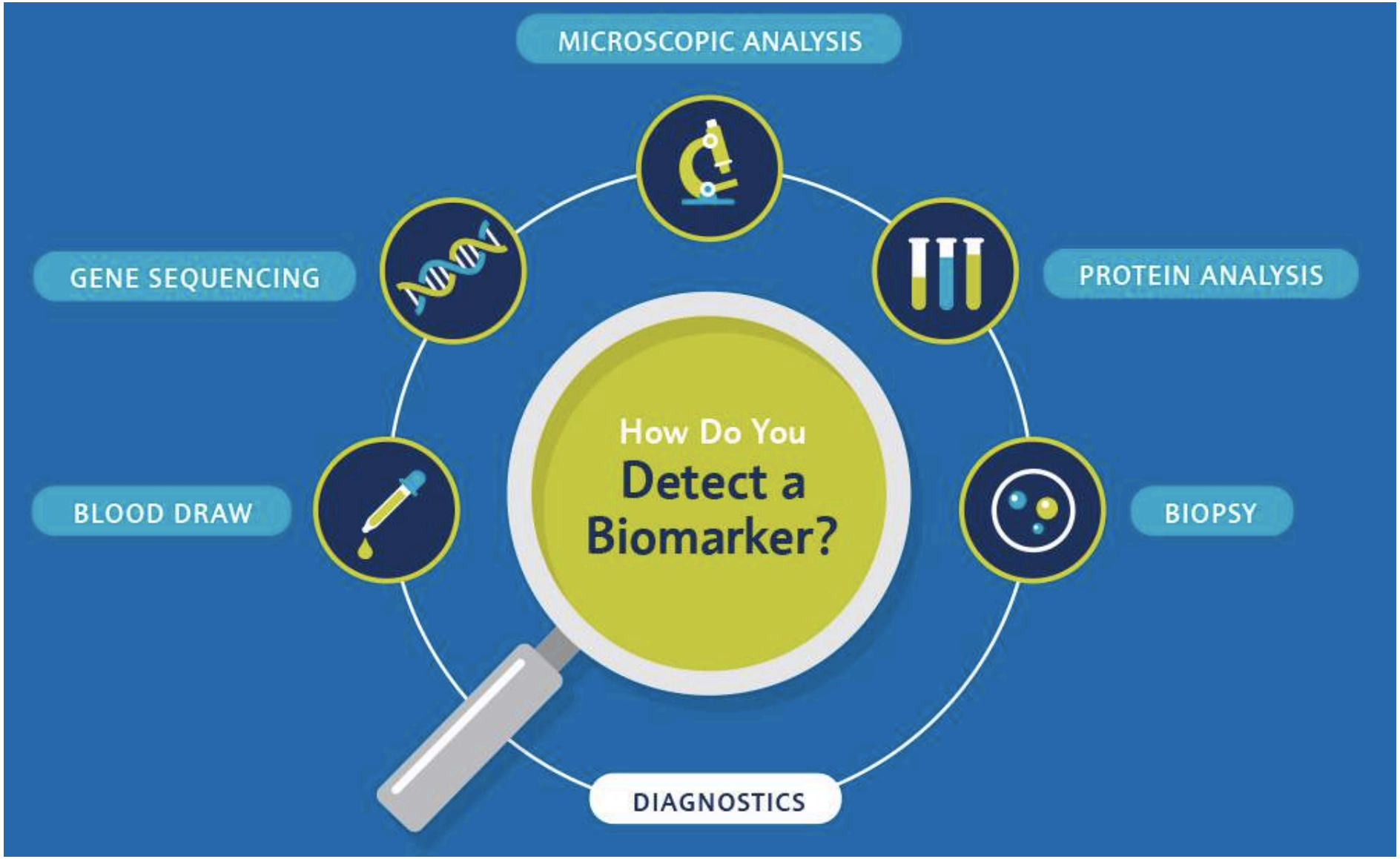
Biomarkers

Biomarker: Definition

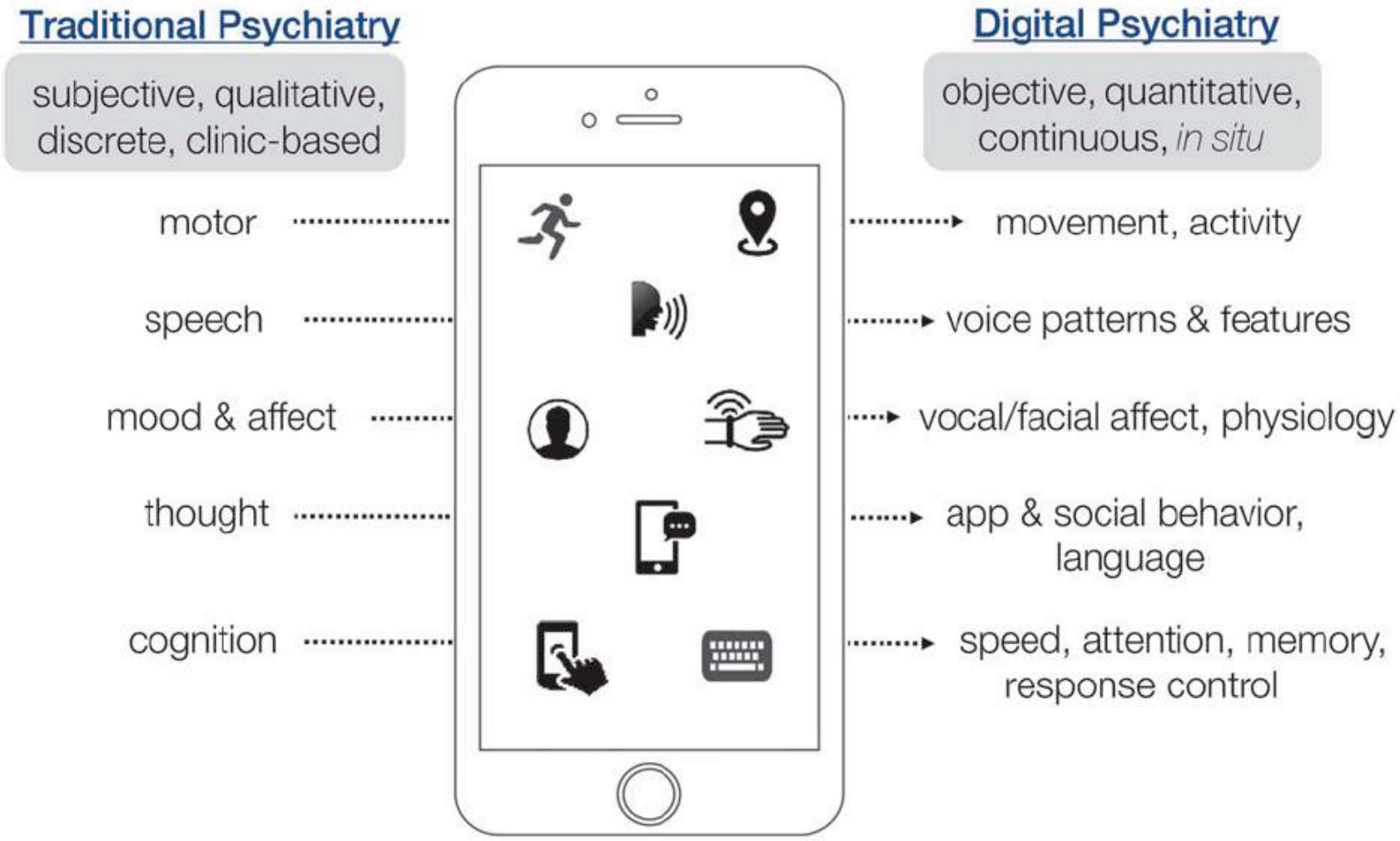
A characteristic that is objectively measured and evaluated as an indicator of normal biologic processes, pathogenic processes, or pharmacologic responses to a therapeutic intervention.

NIH Biomarkers Definition Working Group.
Atkinson, et al. *Clin Pharmacol Ther* 2001

Biomarkers


MICROSCOPIC ANALYSIS
GENE SEQUENCING
PROTEIN ANALYSIS
How Do You
Detect a
Biomarker?
BLOOD DRAW
BIOPSY
DIAGNOSTICS

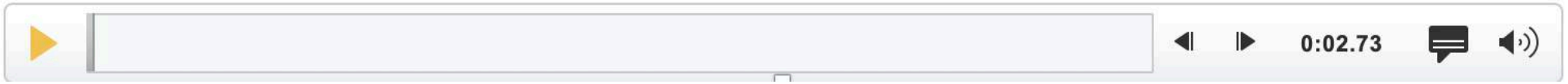
Digital Biomarkers of Cognitive Health



Baker, Justin T., et al. "Digital devices and continuous telemetry: Opportunities for aligning psychiatry and neuroscience." *Neuropsychopharmacology* 43 (2018): 2499-2503.

RADAR-CNS

https://www.youtube.com/watch?v=pgI02uOLUAY&t=68s



Integrated Cognitive Assessment (ICA)

AI-assisted platform
for cognitive assessment and monitoring
in
Multiple Sclerosis, Dementia
and Healthy Aging

Cognetivity
Neurosciences

STANDARD PEN AND PAPER TESTS

Source: Dementia Collaborative research center

Test	Purpose	Administration Time	Self Administered?	Language / Culture Independent ?
MMSE	Mini-mental state examination	10-15 mins		
ADAS-COG	Cognitive assessment in AD	40 mins		
GPCOG	Screening for dementia at GP	6 mins		
PAS	Cognitive screening tool	20 mins		
MOCA	Quick MCI/AD assessment	15 mins		

Learning Bias -MoCA

News

Donald Trump scores top marks in Montreal cognitive test

share

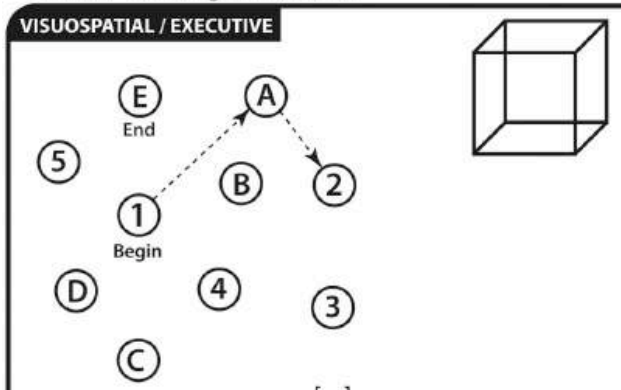
Save 18

Donald Trump received a perfect score in the cognitive test CREDIT: BLOOMBERG

MONTREAL COGNITIVE ASSESSMENT (MOCA)
Version 7.1 Original Version

NAME :
Education :
Sex :
Date of birth :
DATE :

VISUOSPATIAL / EXECUTIVE

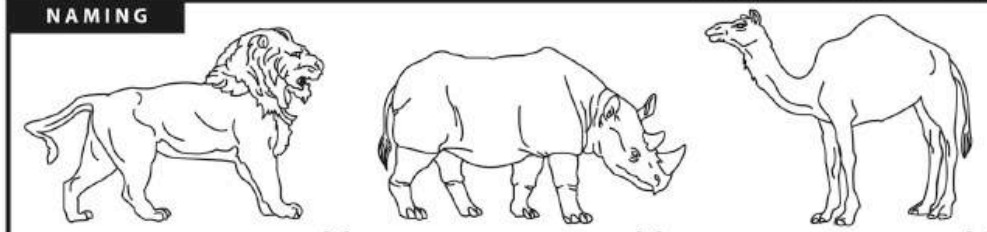


Copy cube [ ]

Draw CLOCK (Ten past eleven) (3 points) [ ] Contour [ ] Numbers [ ] Hands

POINTS __/5

NAMING



[ ] [ ] [ ] __/3

MEMORY Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED
1st trial					
2nd trial					

No points

ATTENTION Read list of digits (1 digit/ sec.).
Subject has to repeat them in the forward order [ ] 2 1 8 5 4
Subject has to repeat them in the backward order [ ] 7 4 2 __/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B __/1

Serial 7 subtraction starting at 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65
4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt** __/3

LANGUAGE Repeat : I only know that John is the one to help today. [ ]
The cat always hid under the couch when dogs were in the room. [ ] __/2

Fluency / Name maximum number of words in one minute that begin with the letter F [ ] _____ (N ≥ 11 words) __/1

ABSTRACTION Similarity between e.g. banana - orange = fruit [ ] train – bicycle [ ] watch - ruler __/2

DELAYED RECALL

	Has to recall words WITH NO CUE	FACE	VELVET	CHURCH	DAISY	RED
		[ ]	[ ]	[ ]	[ ]	[ ]
Optional	Category cue					
	Multiple choice cue					

Points for UNCUED recall only __/5

ORIENTATION [ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City __/6

© Z.Nasreddine MD www.mocatest.org Normal ≥ 26 / 30

TOTAL __/30
Add 1 point if ≤ 12 yr edu

Administered by: _____

Leaked image: Trump the night before the test

AN INTEGRATED COGNITIVE ASSESSMENT - THE ICA

Demonstrates critical benefits over existing methods…

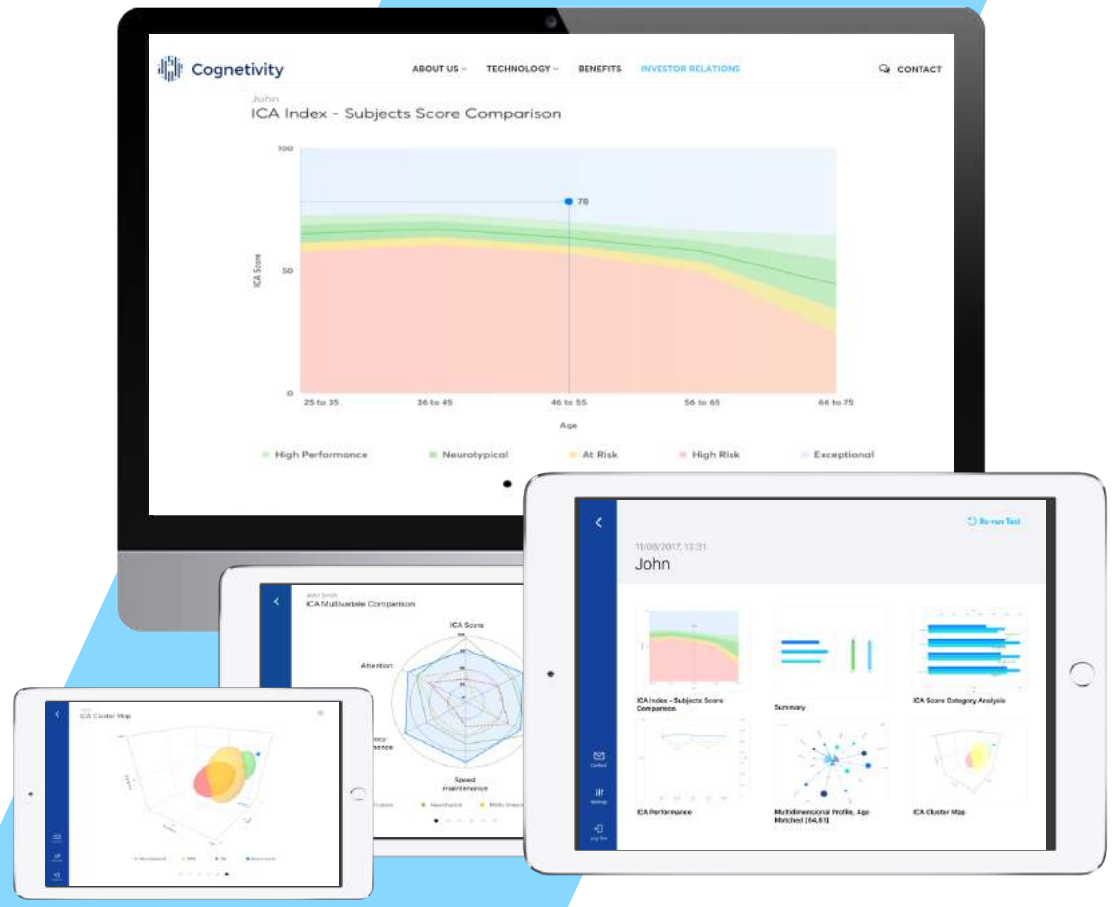
LANGUAGE INDEPENDENT

SELF ADMINISTERED

EDUCATION UNBIASED

NO PRACTICE EFFECT

SENSITIVITY THROUGH AI

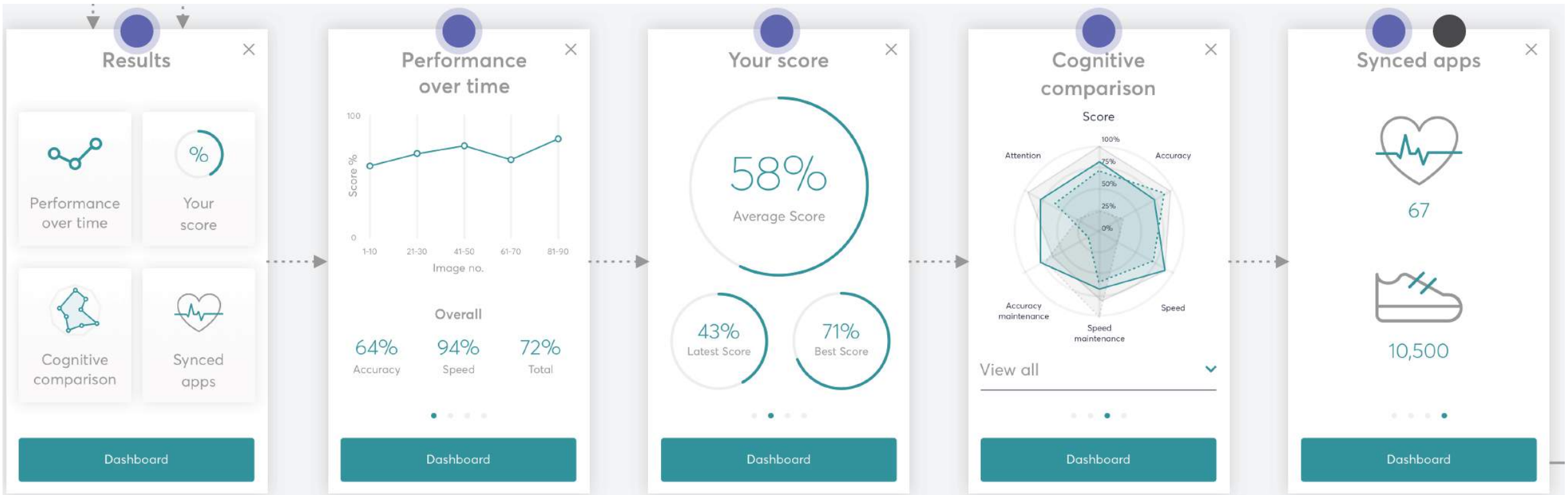


Cognetivity Neurosciences

OptiMind

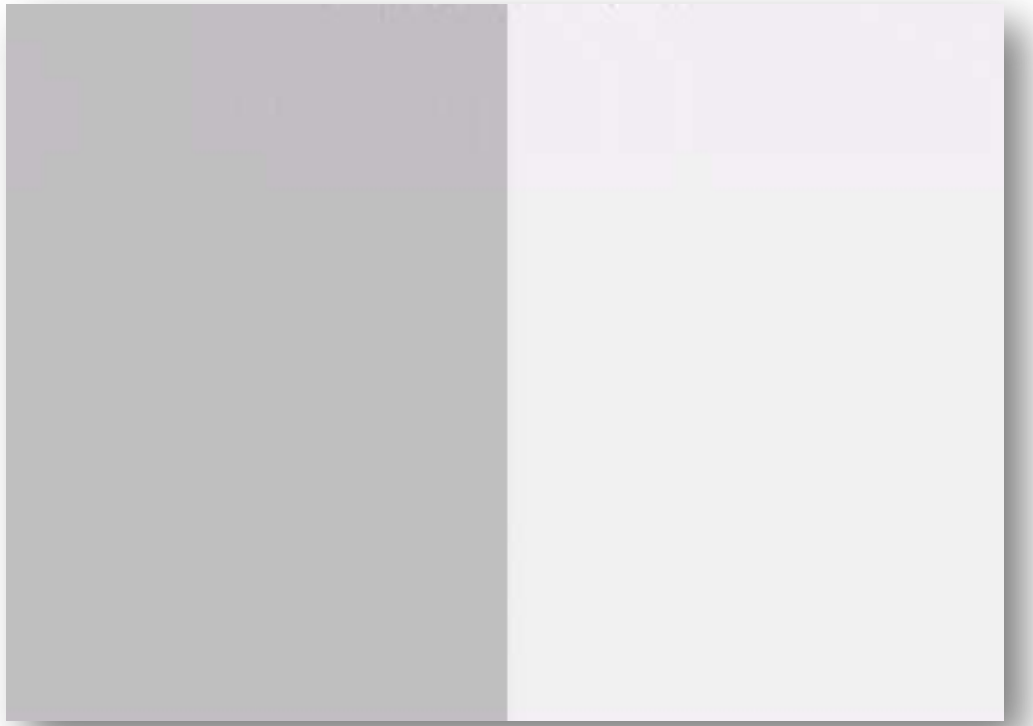
Personalised
Cognition
Tracking

OptiMind


Results
Performance over time
Your score
Cognitive comparison
Synced apps
Dashboard
Performance over time
100
Score %
0
1-10
21-30
41-50
61-70
81-90
Image no.
Overall
64%
Accuracy
94%
Speed
72%
Total
Dashboard
Your score
58%
Average Score
43%
Latest Score
71%
Best Score
Dashboard
Cognitive comparison
Score
100%
75%
50%
25%
0%
Attention
Accuracy
Accuracy maintenance
Speed
Speed maintenance
View all
Dashboard
Synced apps
67
10,500
Dashboard

ICA IN EFFECT

A quick 5 minute, simple and easy to take test, without clinician supervision



- Easy to administer, low stress
- User-needs study highlighted fun nature of test

Cognetivity Neurosciences

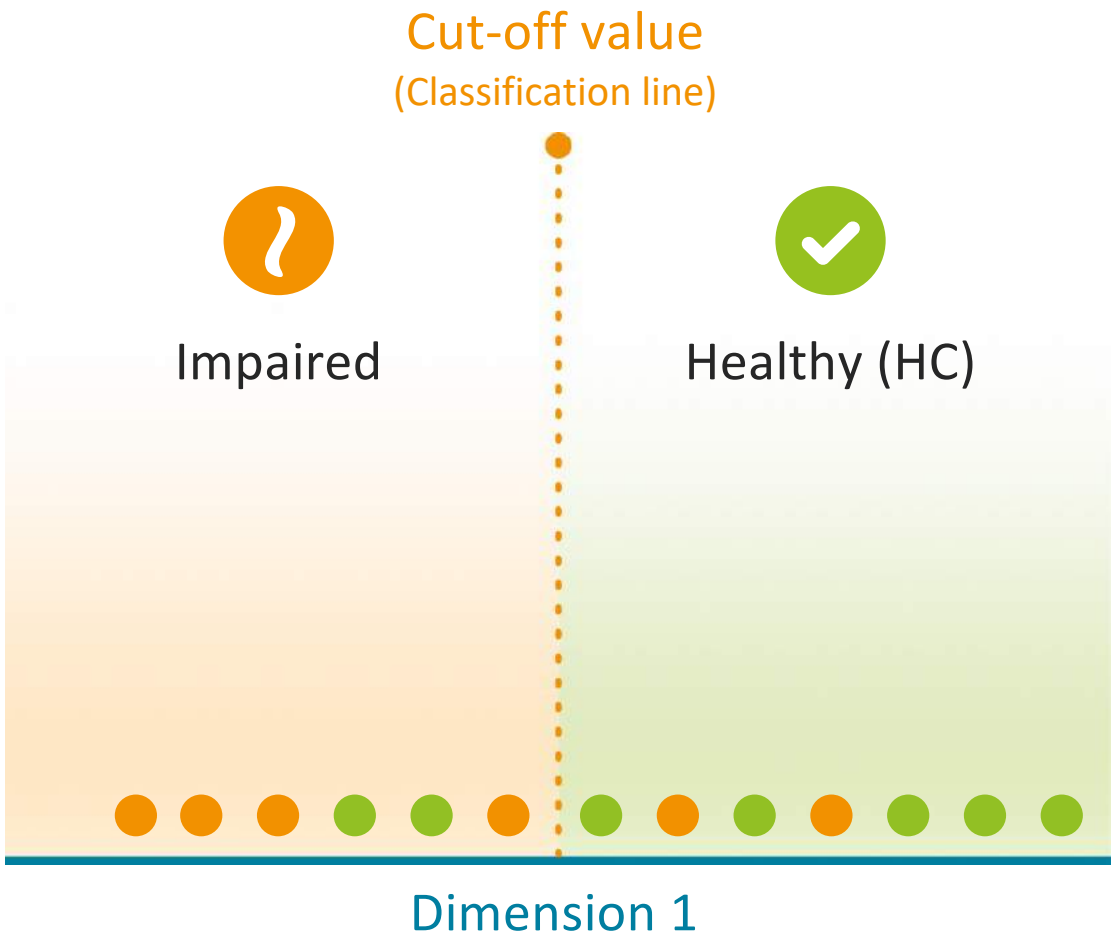
STEP 1

A selection of natural images are shown to the participants

In the ICA test, several natural images are briefly shown to participants and they are asked to respond as quickly and accurately as possible to indicate whether they've seen a pre-specified image category.

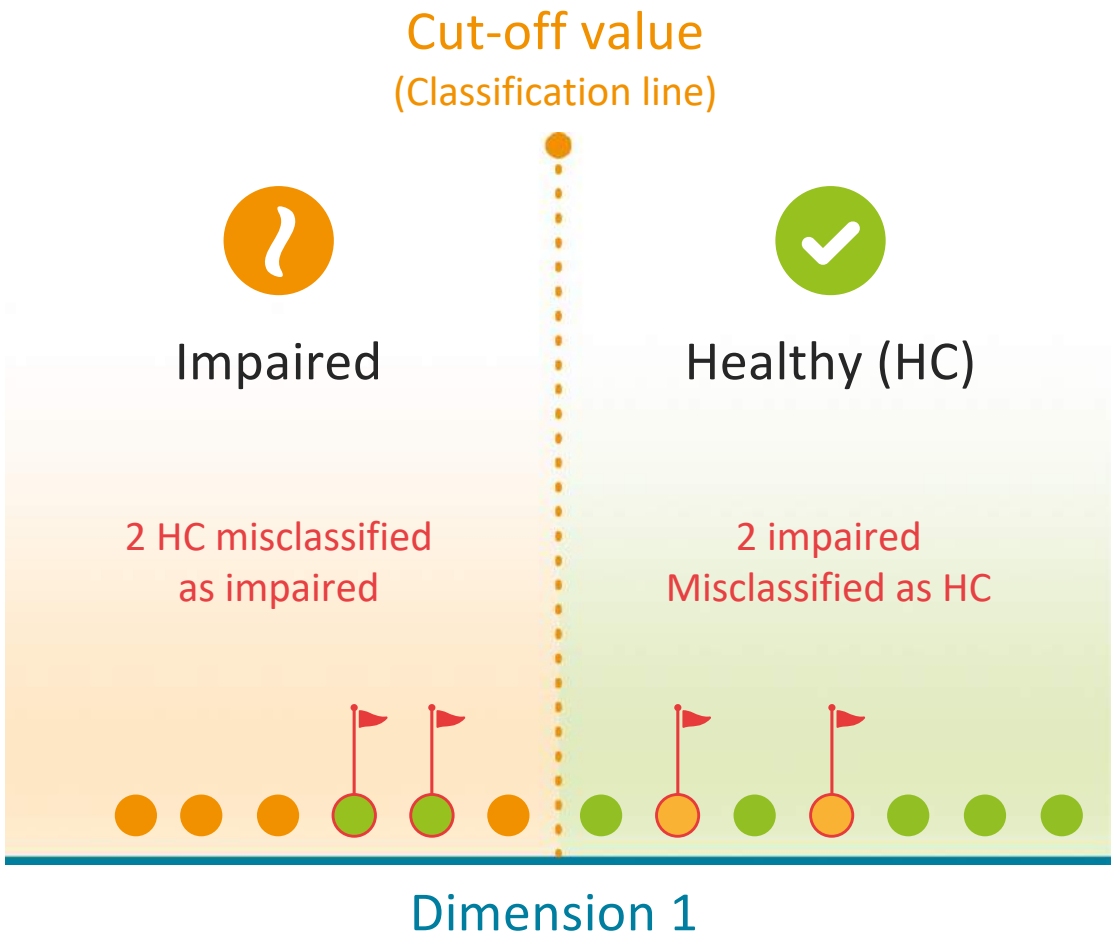
ADVANTAGES OF AI IN DISEASE CLASSIFICATION

Many existing cognitive assessments use a simple, single cutoff



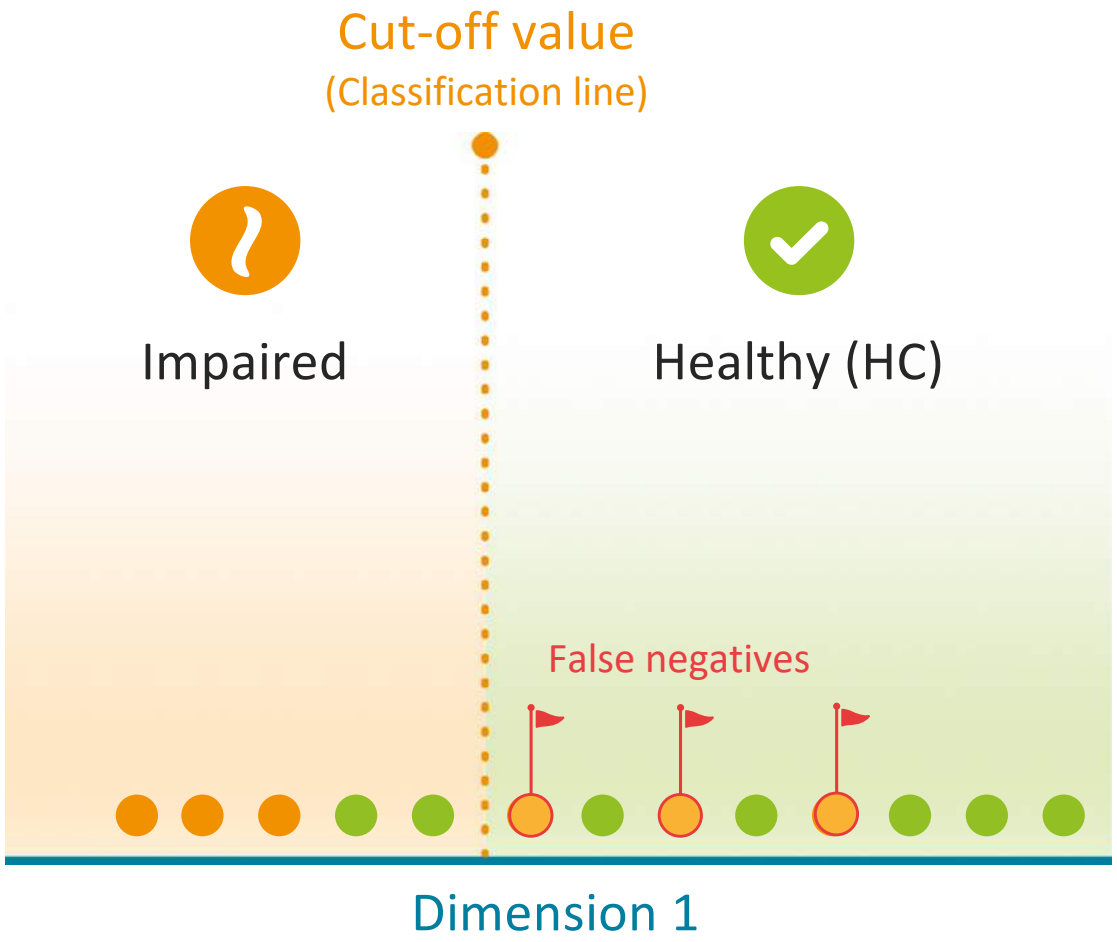
ADVANTAGES OF AI IN DISEASE CLASSIFICATION

This can lead to misclassification



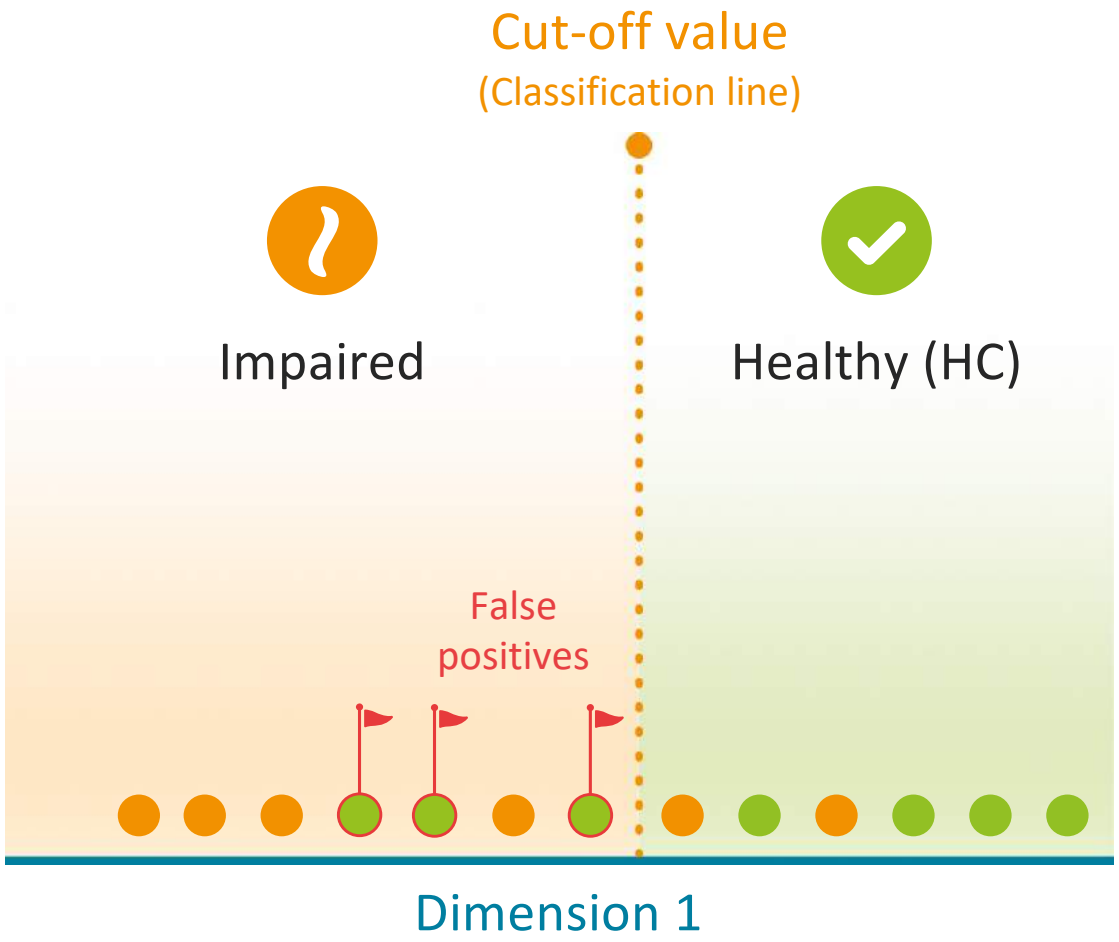
ADVANTAGES OF AI IN DISEASE CLASSIFICATION

If the, single, cut off line is adjusted; one can either get false negatives….



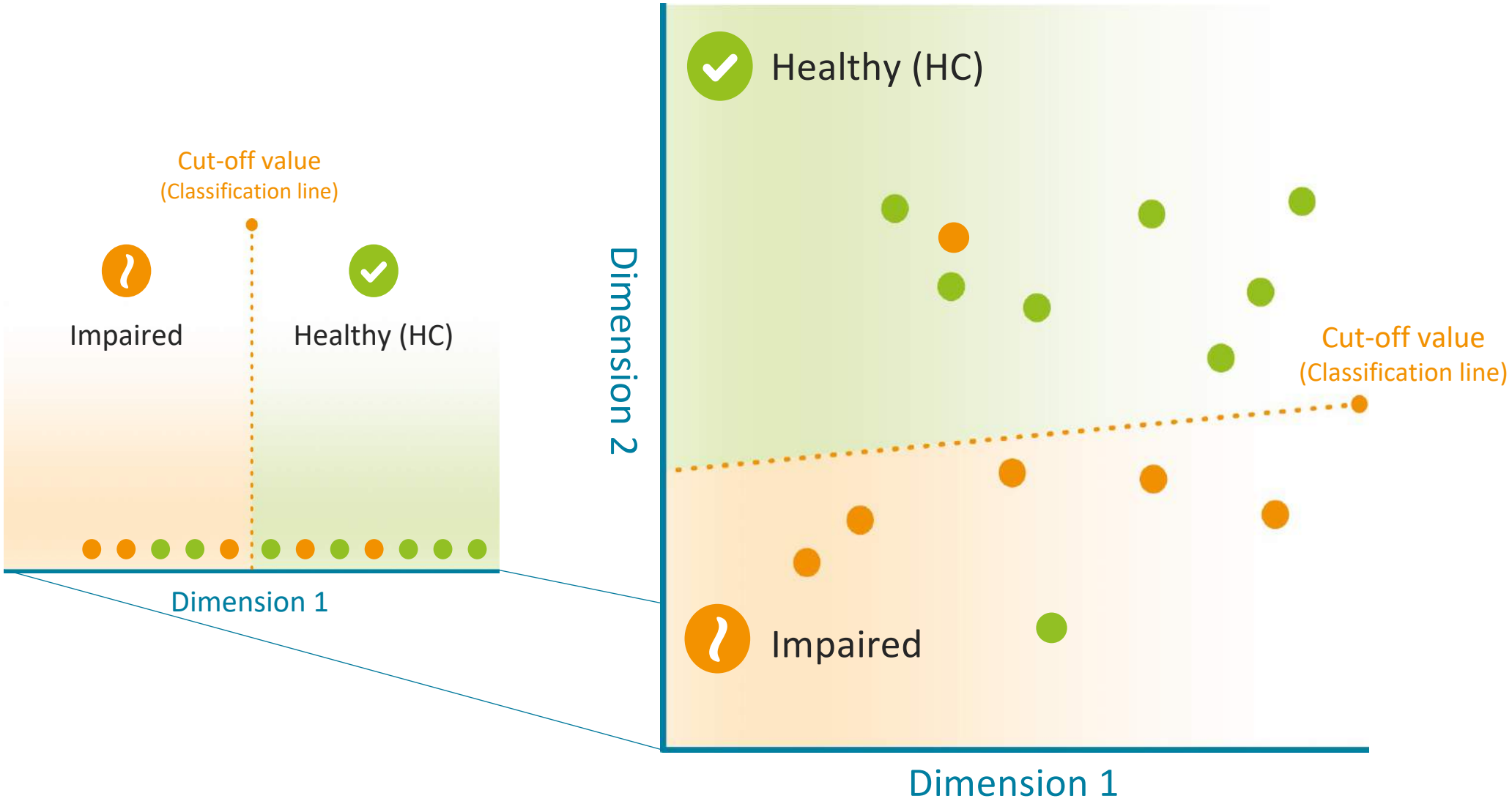
ADVANTAGES OF AI IN DISEASE CLASSIFICATION

Or false positives



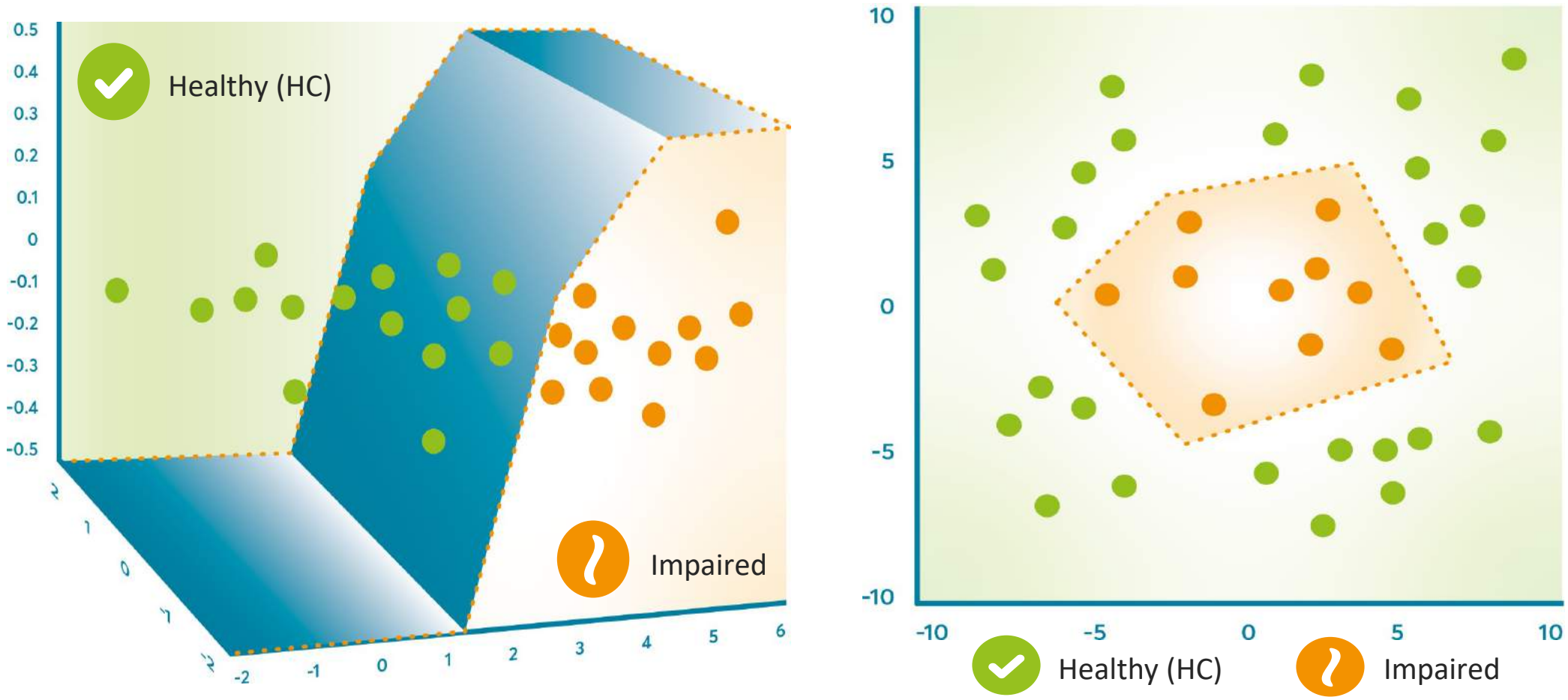
ADVANTAGES OF AI IN DISEASE CLASSIFICATION

AI can help with by expanding one dimensional classification into two….



ADVANTAGES OF AI IN DISEASE CLASSIFICATION

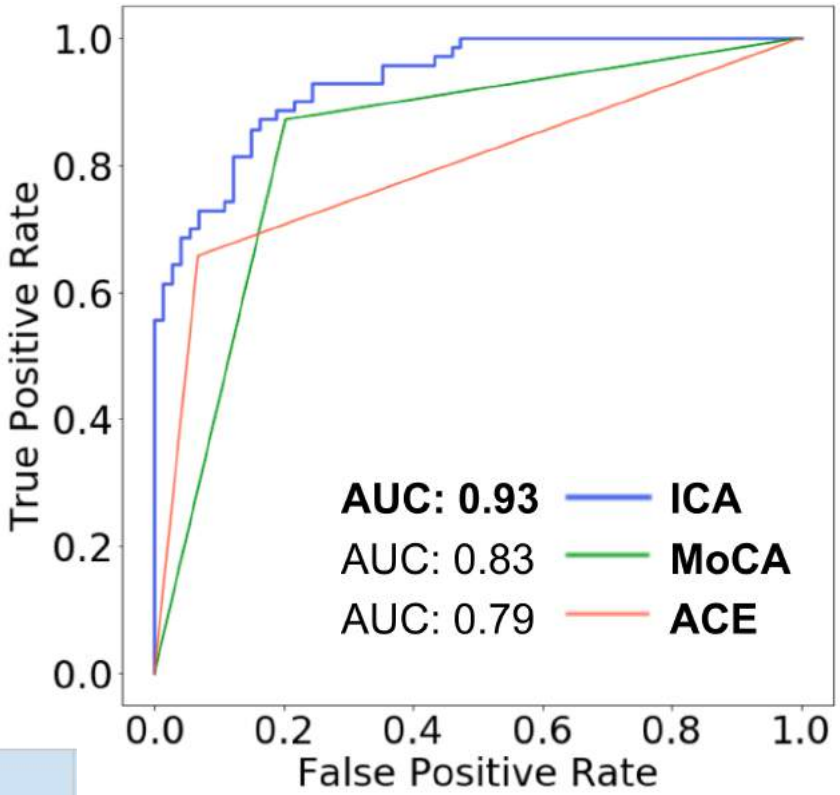
Or even n-dimensions



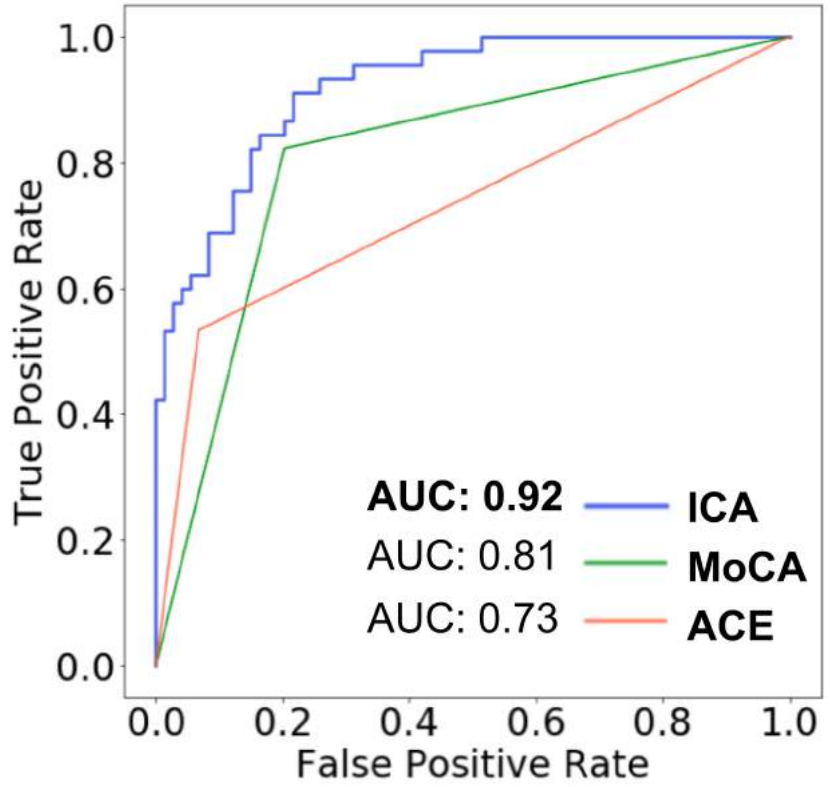
ESTABLISHING CONSTRUCT VALIDITY

The ICA has been validated against current standard of care neuropsychological tests

Healthy vs cognitively impaired



Healthy vs MCI



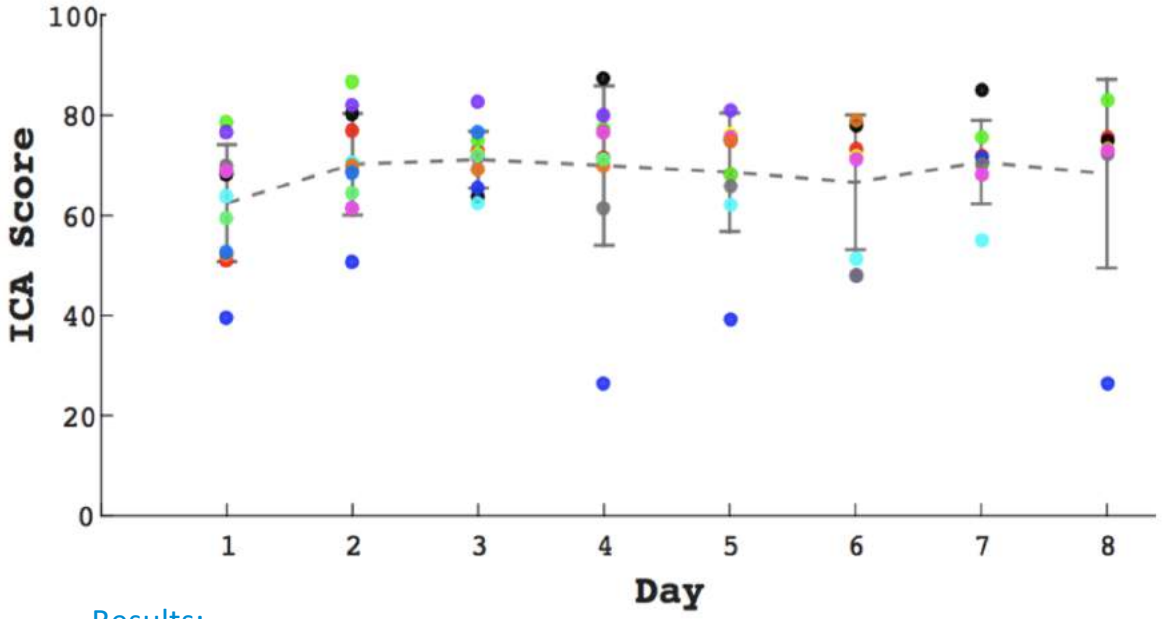
	# Subjects
Healthy	74
MCI	45
mild AD	25

- In head-to-head comparison with MoCA and ACE, ICA shows significantly better accuracy in detection of MCI and mild AD

Age range 55-90 ISRCTN: 95636074 doi.org/10.1186/ISRCTN95636074

ESTABLISHING LEARNING INDEPENDENCE & RELIABILITY

The ICA shows no effect of learning for repeated tests



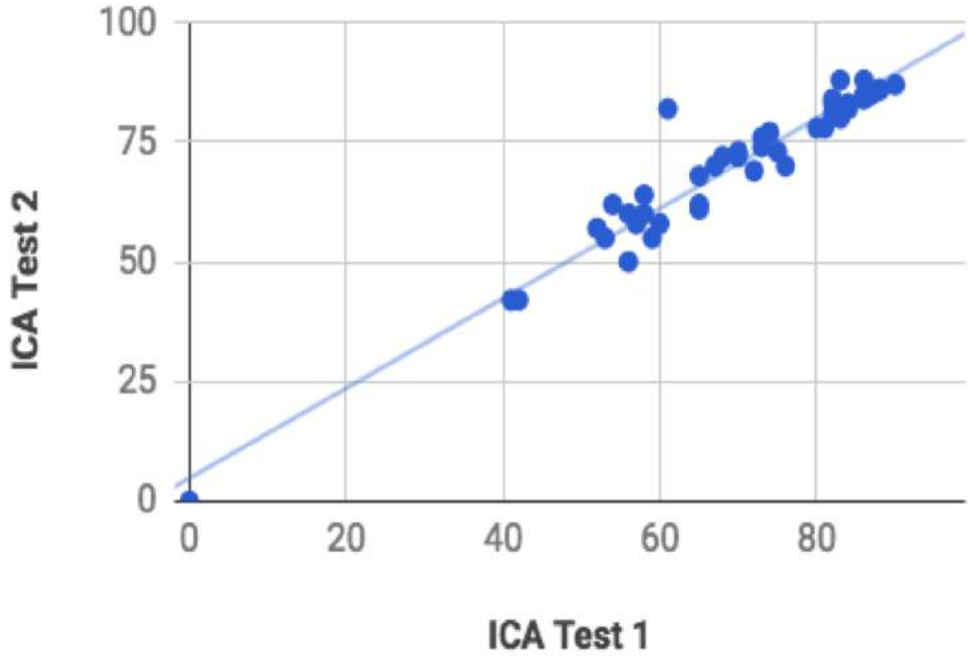
Results:

None of the points on the curve are significantly higher than any other point (Anova at $p < 0.05$)

There is no statistically significant effect of learning in repeated exposure to the ICA test

ICA test / retest on iPad platform

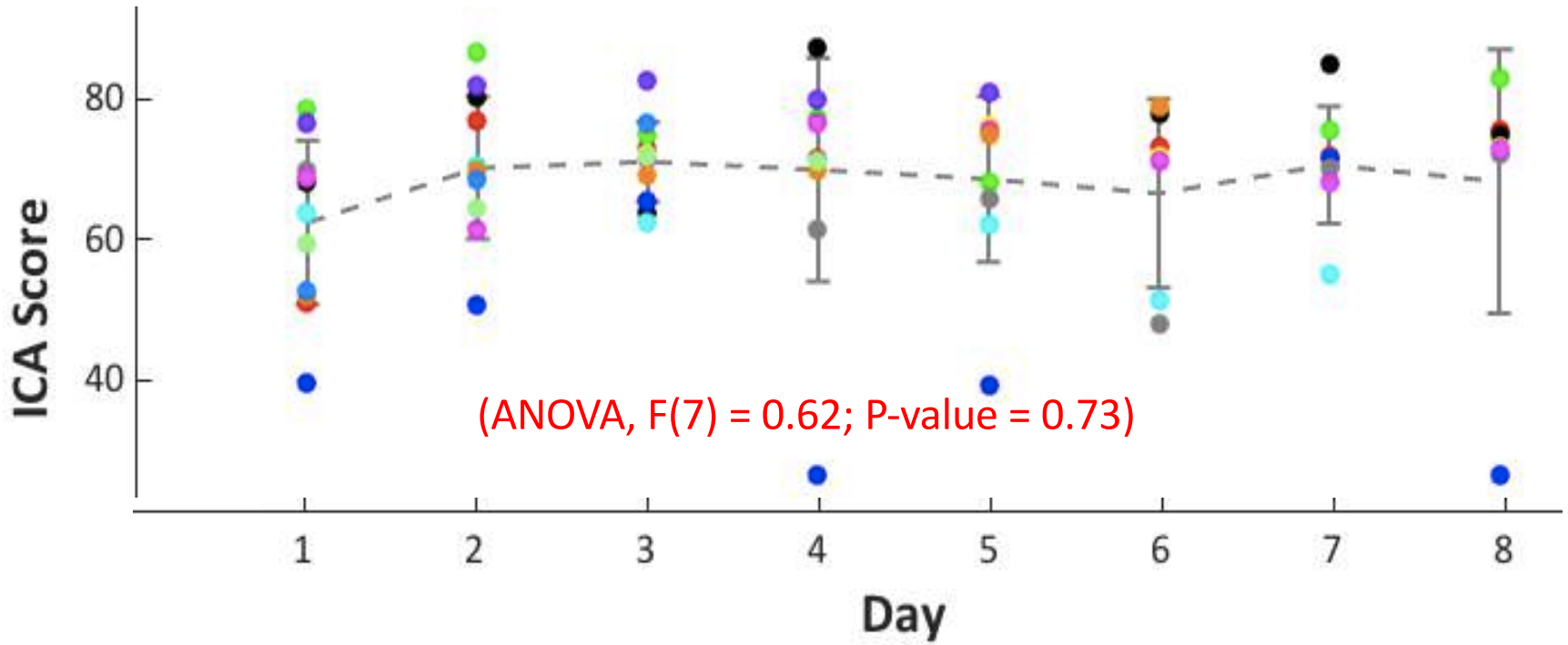
iPad: $r=0.96$ ($p<10^{-7}$)



SM Khaligh-Razavi et al, Scientific Reports, volume 9, Article number: 1102 (2019)

ICA LEARNING EFFECT TRIAL

There is no statistically significant effect of learning in repeated exposure to the ICA test



The learning effect curve does not increase monotonically

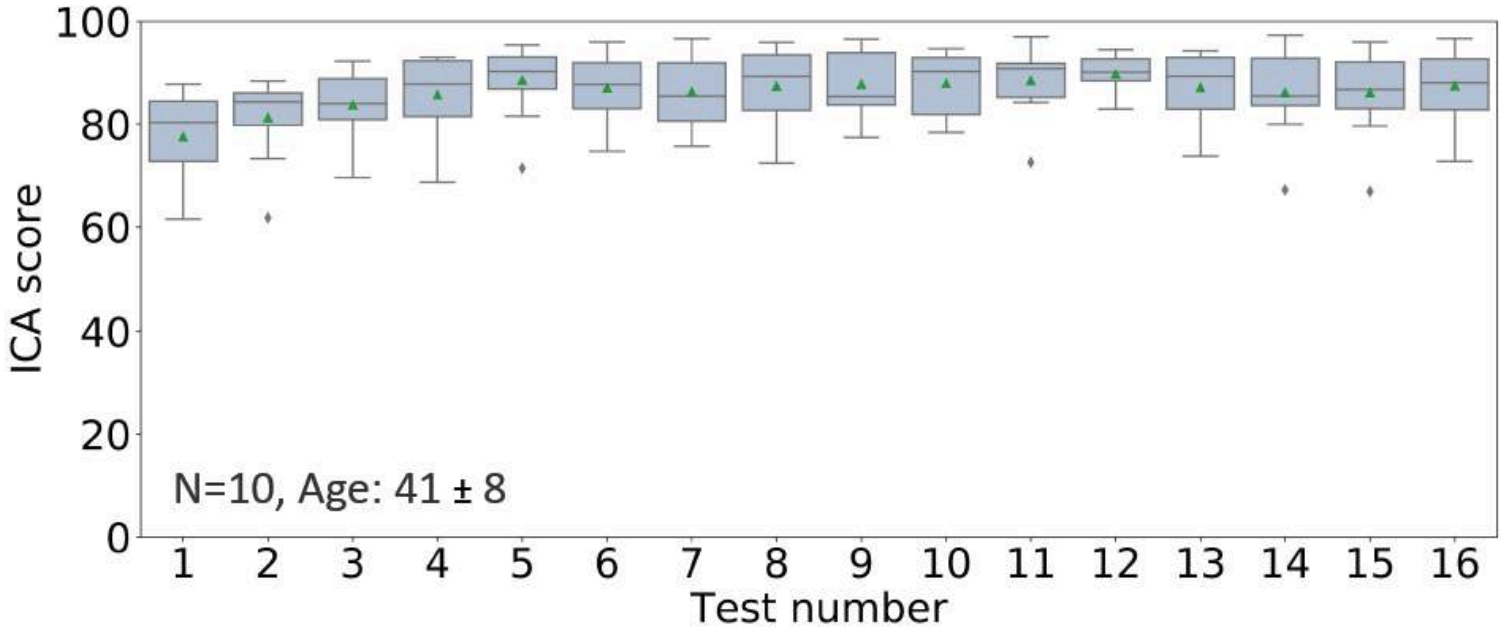
None of the points on the curve are significantly higher than any other point

Young Healthy Participants took the ICA every other day for 8 Days

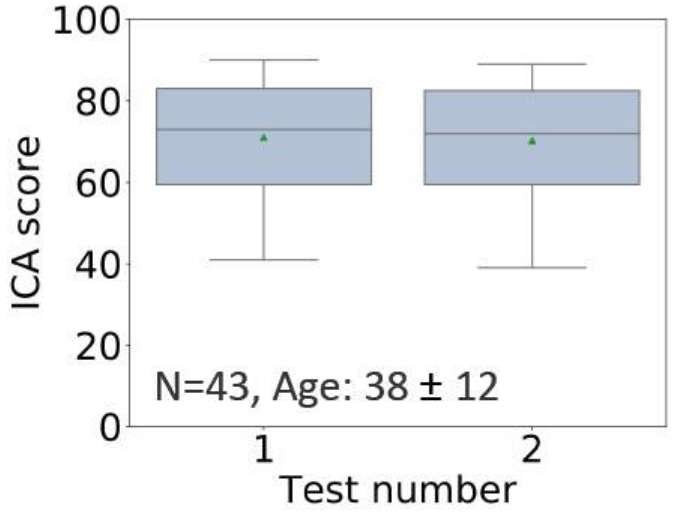
(N = 12; age range = 20 to 36)

Cognetivity

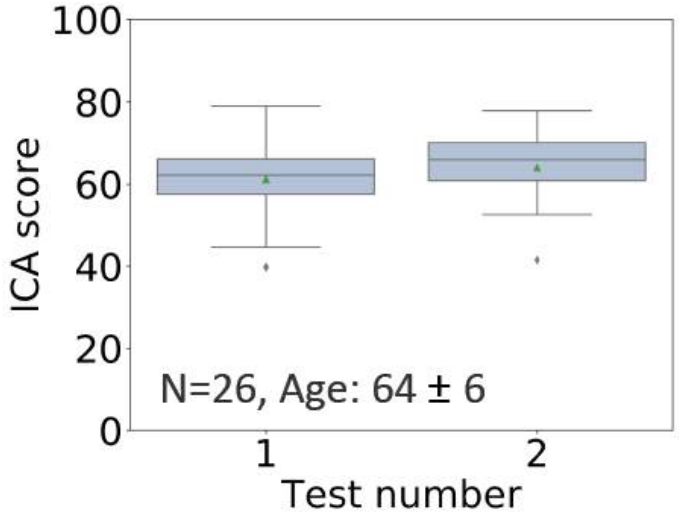
Learning Bias -ICA



=> **appropriate for frequent assessment**



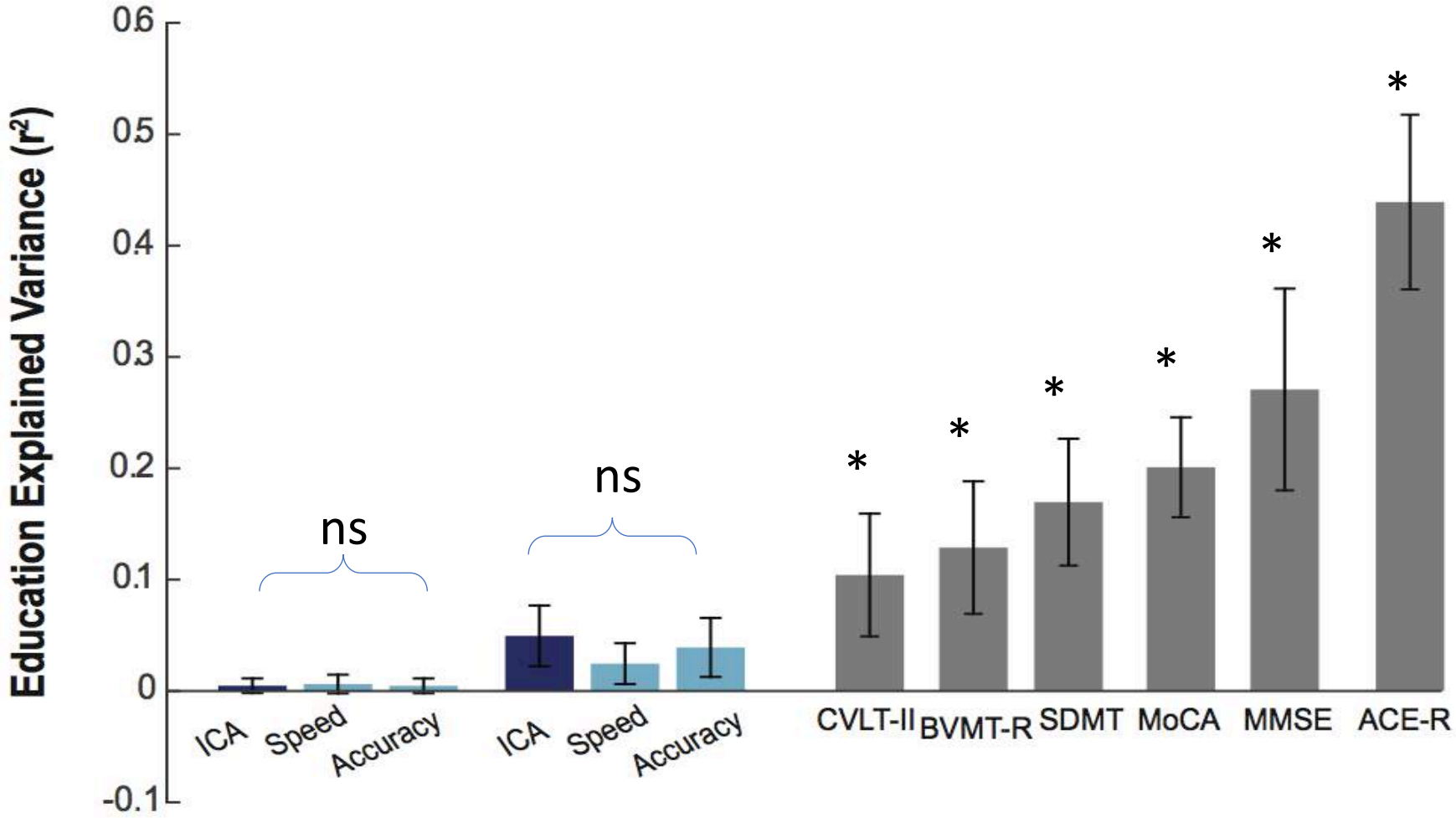
MS/HC



HC/MCI/AD

ICA NOT CONFOUNDED BY EDUCATION

Non-parametric test of independence indicates that the ICA is independent of education



* P<0.01 [Permutation Test, Bonferroni Corrected]
ns: not significant

Cognetivity

Monitoring disease activity in MS

quantifying disease progression or treatment efficacy

Cohen's d= 1.01 *

Monitoring disease activity in MS

quantifying disease progression or treatment efficacy

Cohen's d= 0.61 *

Monitoring disease activity in MS

quantifying disease progression or treatment efficacy

ICA score

57

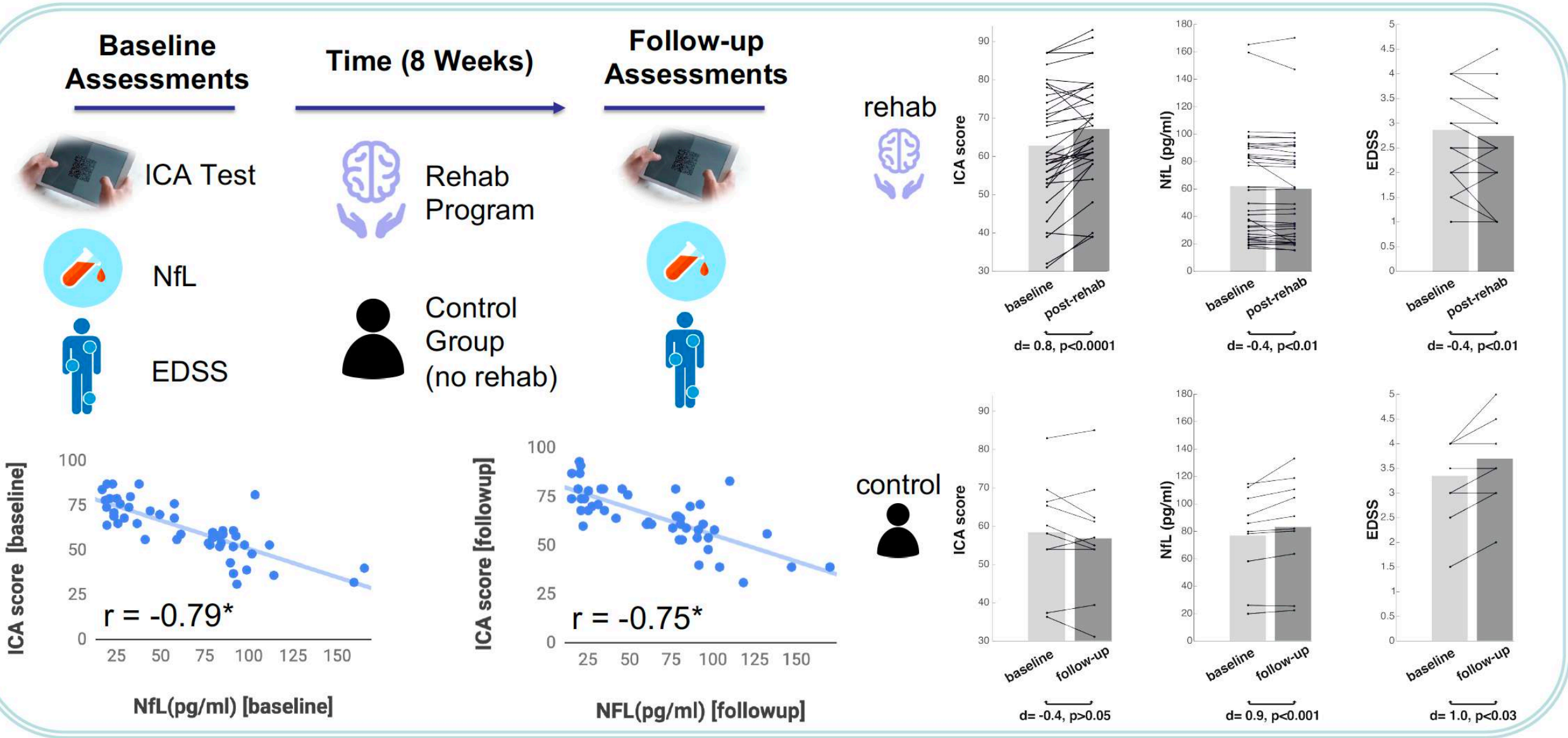
ICA score

55.8

Control Group

8 weeks

Cohen's d= -0.4 *


Baseline Assessments
Time (8 Weeks)
Follow-up Assessments
ICA Test
NfL
EDSS
Rehab Program
Control Group (no rehab)
rehab
control
ICA score
NfL (pg/ml)
EDSS
baseline
post-rehab
follow-up
d= 0.8, p<0.0001
d= -0.4, p<0.01
d= -0.4, p<0.01
d= -0.4, p>0.05
d= 0.9, p<0.001
d= 1.0, p<0.03
ICA score [baseline]
NfL(pg/ml) [baseline]
r = -0.79*
ICA score [followup]
NFL(pg/ml) [followup]
r = -0.75*

Acknowledgments

Cognetivity's team

Alzheimer's team

- Hanyieh Marefat
- Hamed Karimi
- Mahdiyeh Khanbagi
- Dr Zahra Vahhabi
- Dr Chris Kalafatis

MS and Rehab team

- Maryam Sadeghi
- Dr Nabavi
- Dr Mehdi Daemi
- Seyed Maziar Tabasi