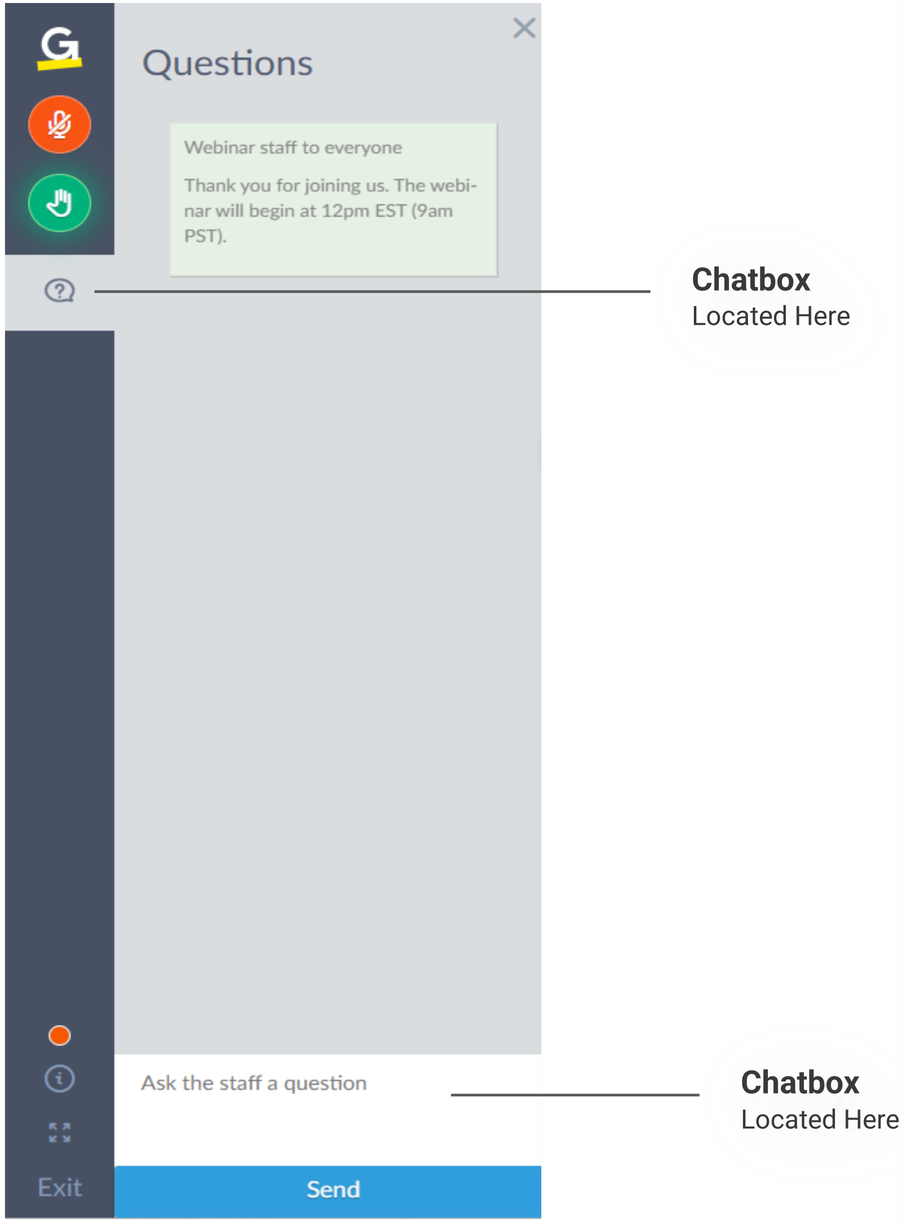
Dynamic Perceptual-Cognitive Functions in Aging and Cognitive Training Tools

Jocelyn Faubert, PhD
Professor
Université de Montreal



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Featured Speaker

Jocelyn Faubert, PhD
Professor
Université de Montreal

- Obtained his PhD in 1991 in experimental psychology at Concordia University and had an FCAR award to pursue his postdoctoral studies at Harvard University
- His work has received extensive media coverage and he has mentored 20 Post-Doctoral Research Fellows in the past and supervised over 20 doctoral students and 70 masters and fellowship students
- Has received funding from the three main national research councils in Canada (NSERC, CIHR, SSHRC) and the Canadian Foundation for Innovation

Dynamic Perceptual-Cognitive Functions in Aging and Cognitive Training Tools

Jocelyn Faubert
Professor, Faubert Lab, École d'optométrie, Université de Montréal

Co-Founder CogniSens 2008
Transfer of 4 technologies from lab including NeuroTracker

Dynamic visual scene
Hanoi

youtube

3D-MOT principles (NeuroTracker)

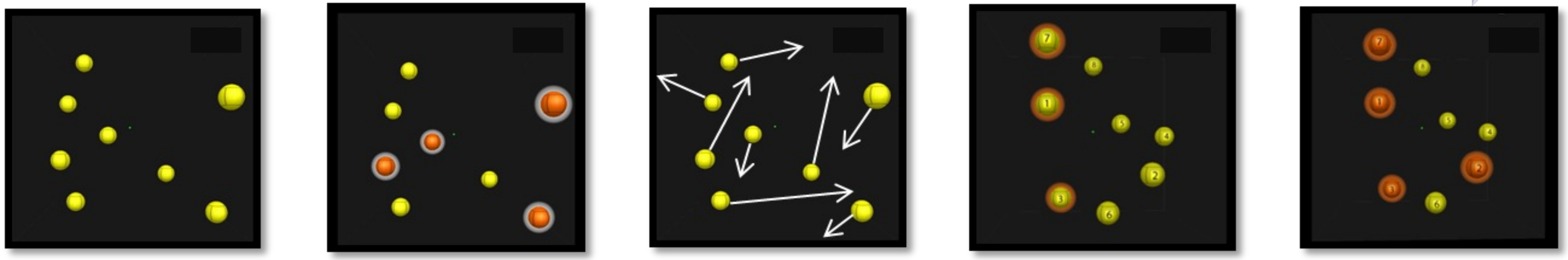
Manage attentional resources in a complex dynamic environment

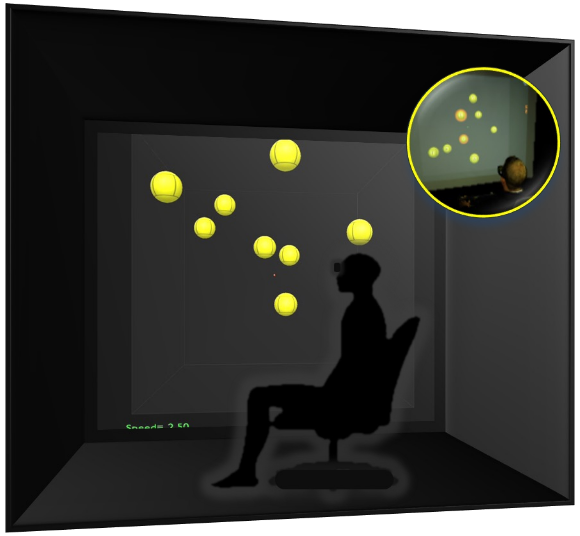
- Multiple object tracking (MOT)
  Pylyshyn 1988
- Significant visual field
- Speed thresholds
- 3D Stereoscopy

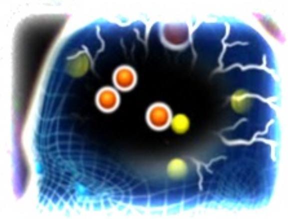
Faubert & Sidebottom (2012)

3D-MOT principles

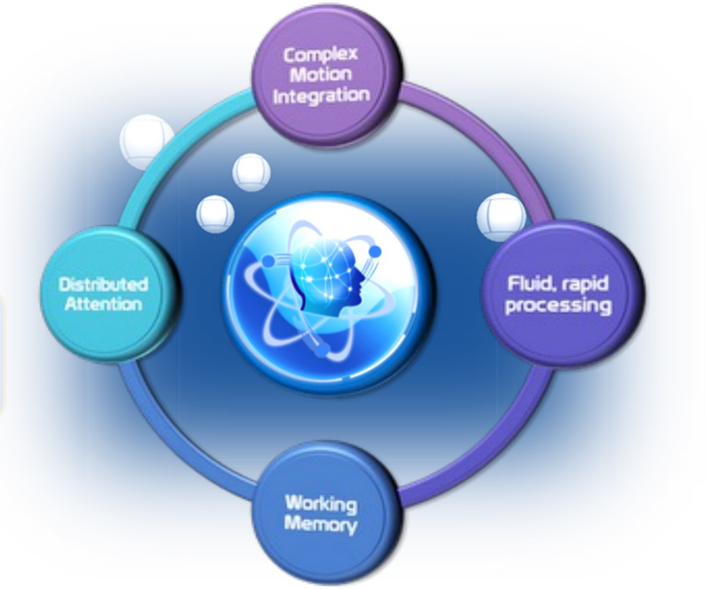
Presentation → Indexation → Movement → Identification → Feedback

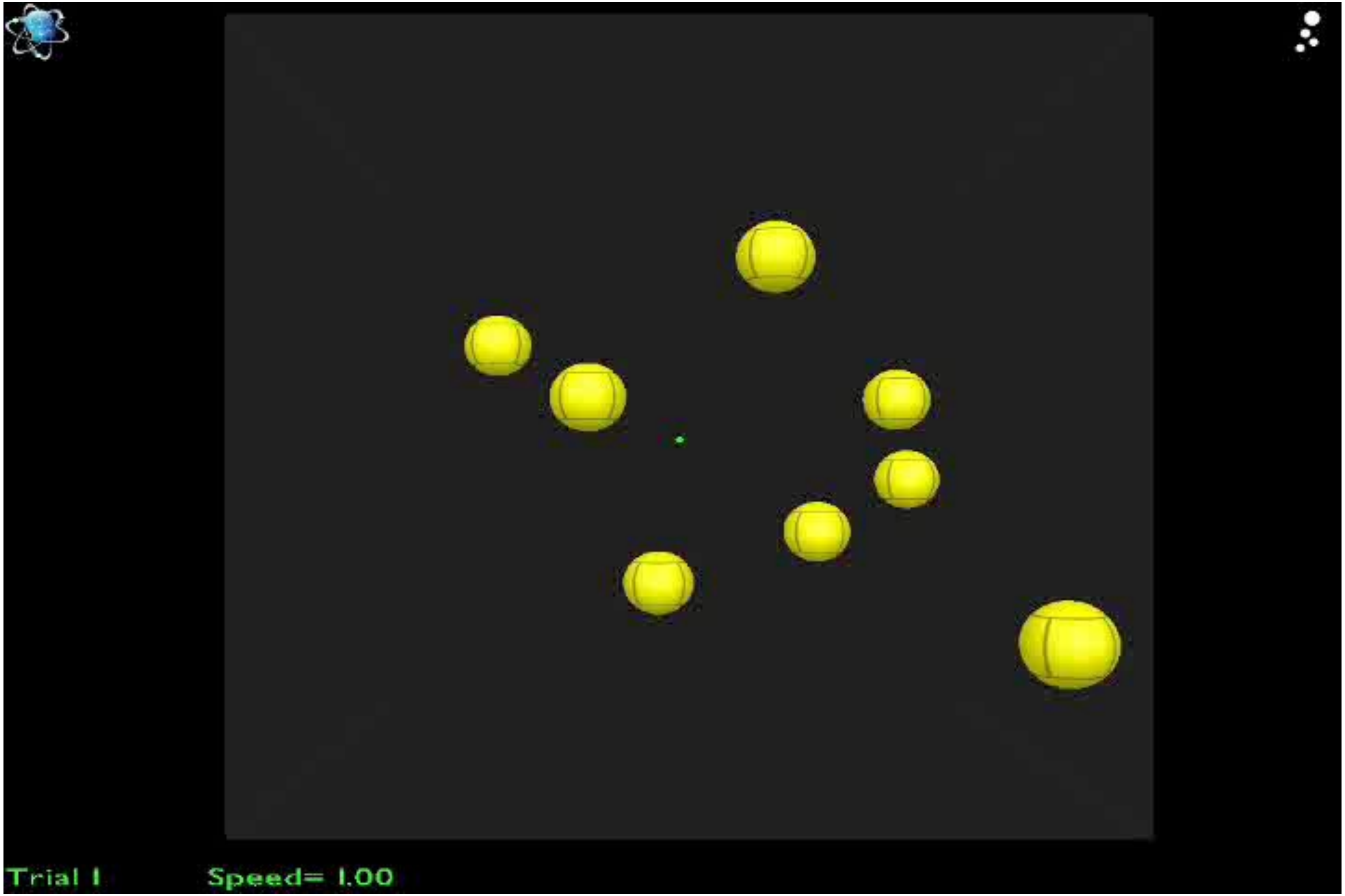


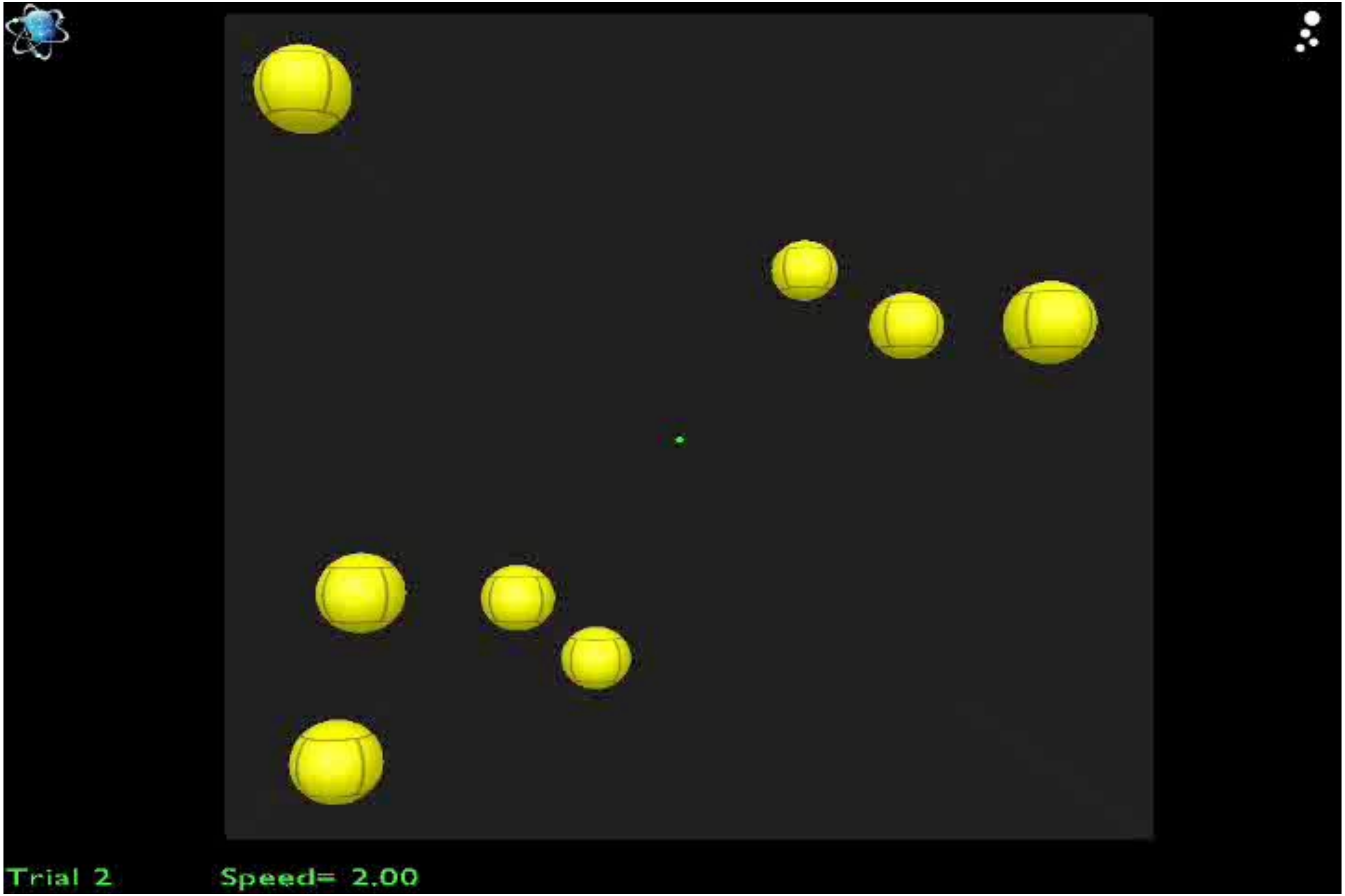


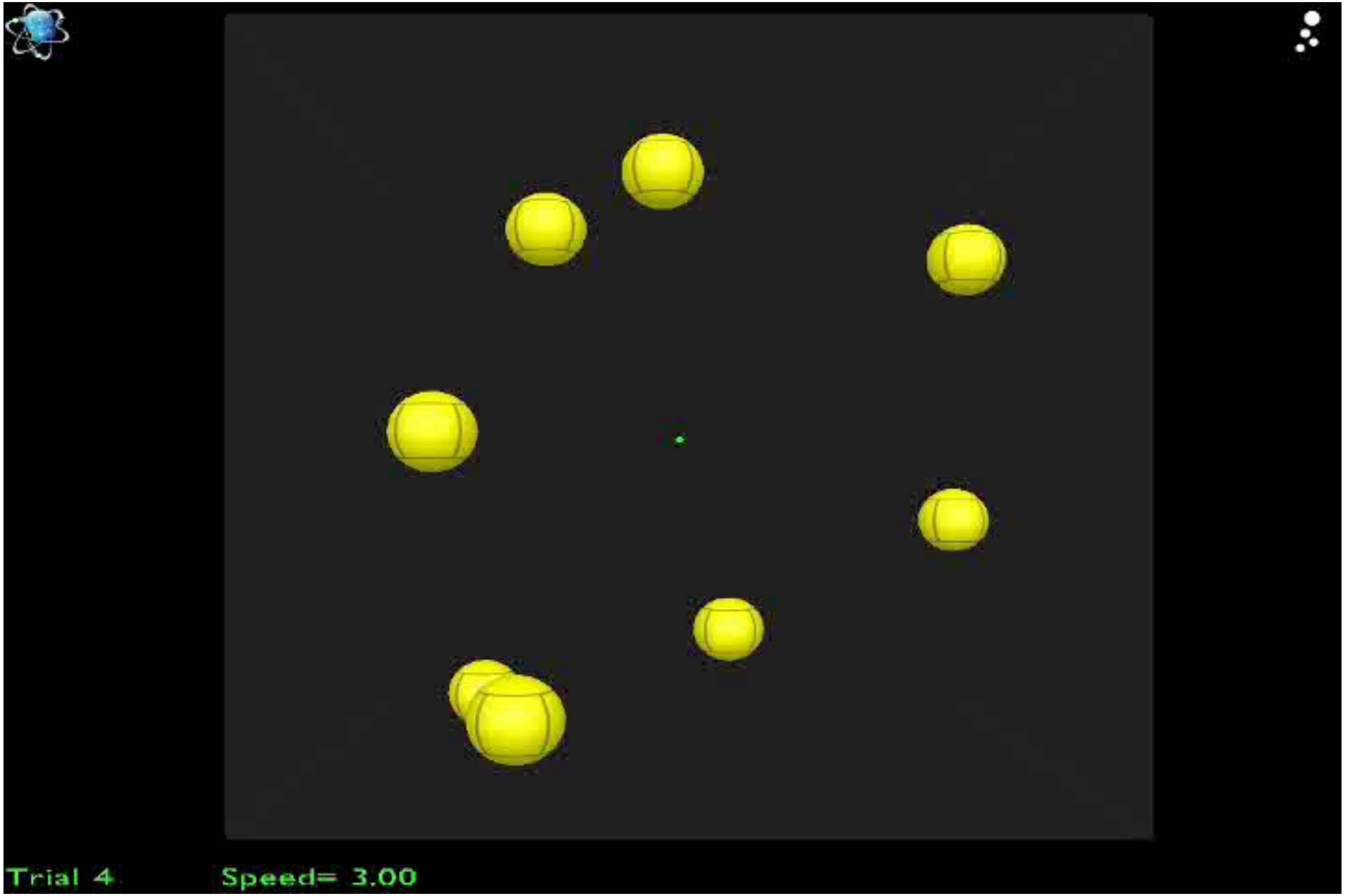


- Perceptual-cognitive measure

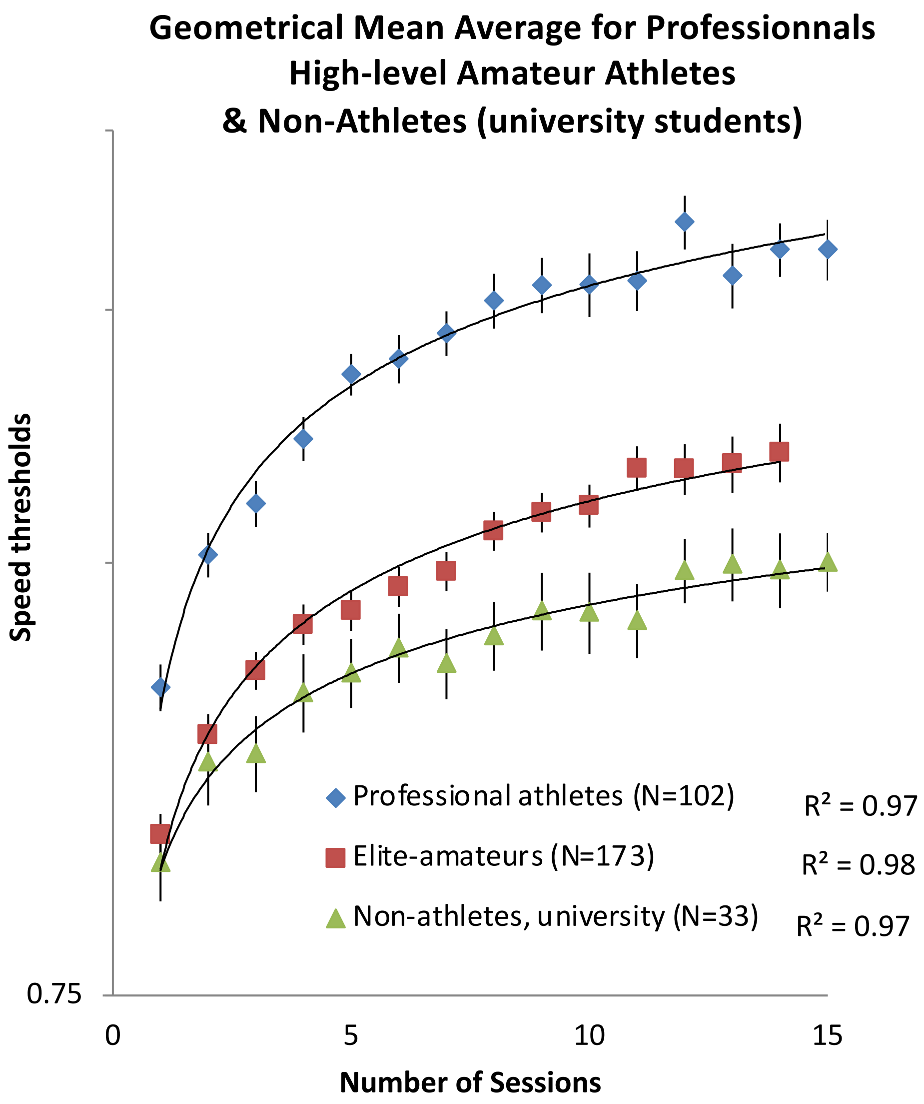



Trial 1
Speed= 1.00

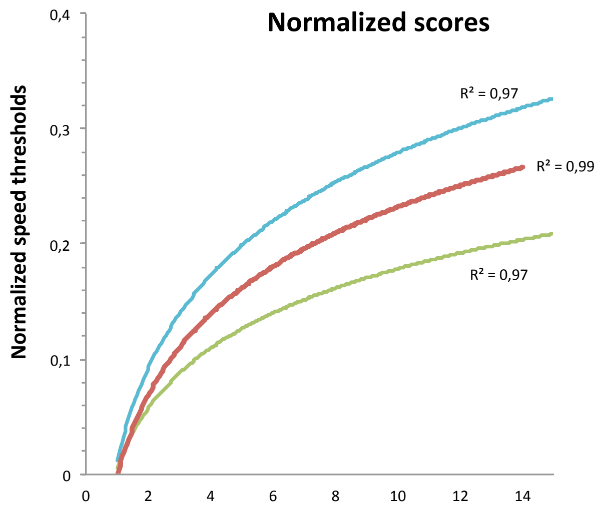

Trial 2
Speed= 2.00


Trial 4
Speed= 3.00

Amateurs vs Professionals vs university



Learning function related to performance level



Faubert, Scientific Reports 2013

Does it relate to performance ?
NeuroTracker NBA *study (Orlando Magic)*

Hoffman group (University of Central Florida)

Study Findings

NeuroTracker

NeuroTracker linked to field performance

99.7% confidence level

Visual field motor reaction time meassures not correlated with performance related to decision making

Results

TABLE 1. Qualitative inferences on the magnitude of the relationship between game-related measures of performance, perceptual-cognitive function, and visual-motor reaction time ($n = 12$).*

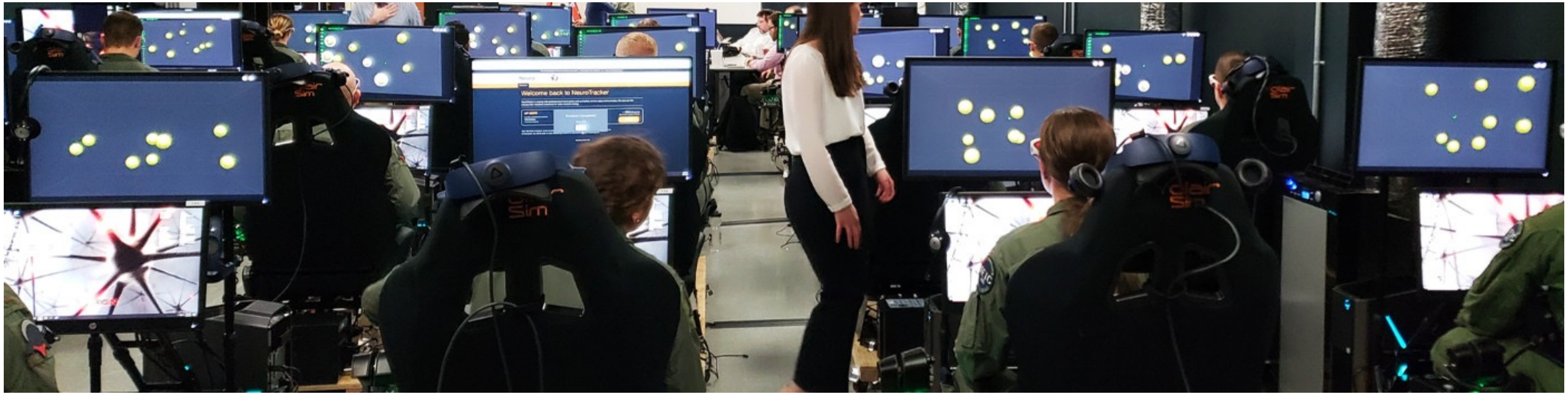
	r	Positive	Trivial	Negative	Qualitative inference†
Visual tracking speed					
AST	0.78	99.7	0.2	0.0	Most likely positive
TO	0.49	90.1	6.9	2.9	Likely positive
STL	0.77	99.7	0.3	0.0	Most likely positive
AST/TO	0.78	99.8	0.2	0.0	Most likely positive
Visual reaction time					
AST	−0.22	16.5	19.0	64.5	Unclear
TO	−0.18	19.8	20.5	59.7	Unclear
STL	0.02	40.9	23.6	35.5	Unclear
AST/TO	−0.16	21.3	21.0	57.7	Unclear
Motor reaction time					
AST	0.04	42.5	23.5	33.9	Unclear
TO	0.29	72.2	16.1	11.7	Unclear
STL	0.19	61.4	20.0	18.6	Unclear
AST/TO	−0.07	30.5	23.2	46.4	Unclear
Physical reaction time					
AST	−0.13	24.6	22.0	53.3	Unclear
TO	0.01	39.0	23.7	37.3	Unclear
STL	0.10	50.0	22.6	27.4	Unclear
AST/TO	−0.14	23.7	21.8	54.5	Unclear
Variable region choice reaction					
AST	0.07	46.1	23.2	30.7	Unclear
TO	0.15	55.7	21.5	22.8	Unclear
STL	0.27	69.9	17.1	13.1	Unclear
AST/TO	−0.05	32.8	23.4	43.8	Unclear

*AST = assists; TO = turnovers; STL = steals; AST/TO = assists-to-turnovers ratio.
†Threshold set to 0.1 for all relationships.

Some studies showing predictive power of NeuroTracker scores for real-life decision making skills

	Behavior
Jarvis et al 2021	Air traffic controller task performance
Michaels, et al 2017	Driving performance
Harenberg, et al 2016	laparoscopic surgical skill performance
Faubert, 2013	League level in team sports
Woods-Fry, et al. 2017	Driving performance
Mangine, et al. 2014	Basketball decision making performance
Phillips 2022	Soccer performance metrics in games
Hoke, et al. 2017	Jet pilot parameters during flight
Benoit, et al. 2021	League level in in e-sports gaming

Use case example in the wild
(US airforce academy training)



NeuroTracker training
What does it do to the brain

- Improvement of cognitive functions

Original Article

Enhancing Cognitive Function Using Perceptual-Cognitive Training

Clinical EEG and Neuroscience
1–11
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DOI: 10.1177/1550059414563746
eeg.sagepub.com
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Brendan Parsons[1], Tara Magill[2], Alexandra Boucher[3], Monica Zhang[2], Katrine Zogbo[4], Sarah Bérubé[3], Olivier Scheffer[2], Mario Beauregard[5], and Jocelyn Faubert[1]

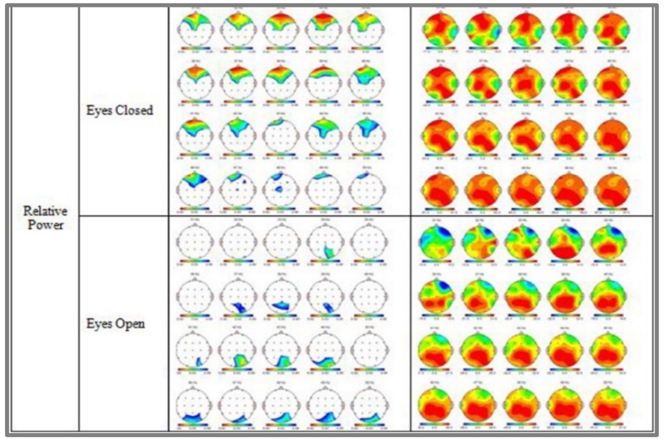
Table 5. Improvements in Cognitive Functions as Measured by Neuropsychological Tests Following 3D-MOT Training.

Cognitive Function	Measure
Attention	
Selective	IVA+Plus (Consistency and Focus[a]), WAIS (Symbol Search), d2
Sustained	IVA+Plus (Stamina[a], Consistency, Focus, and Sustained Quotient), d2
Divided	d2 Test of Attention, D-KEFS (Inhibition/Switching)
Inhibition	D-KEFS (Inhibition and Inhibition/Switching[b])
Short-term memory	N/A
Working memory	WAIS (Spatial Span[a] and Letter-Number Sequencing)
Information processing speed	IVA+Plus (Speed[a]) WAIS (Symbol Search, Code, Block Design), d2, D-KEFS (Color Naming and Word Reading)

[a]Indicates a trend toward significance.
[b]Note that the CON group also demonstrated significant improvement in D-KEFS Inhibition/Switching.

- ✓ Transfer on intelligence metrics
- ✓ Gains on: Attention, working memory, executive functions
- ✓ Improves cerebral activity

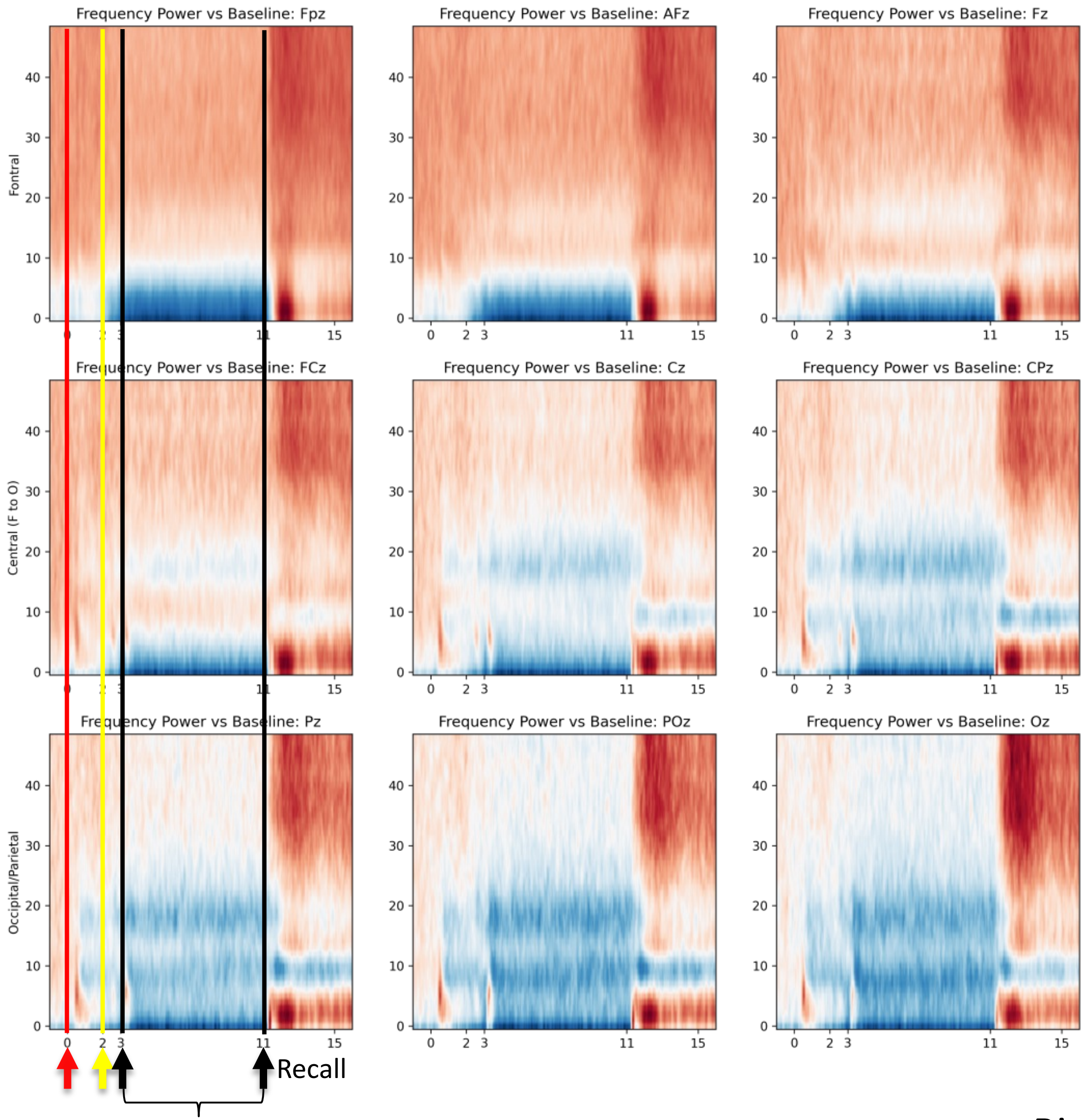
qEEG



↑ Beta & Gamma

↓ Theta

Frequency Power vs baseline (entire trial)



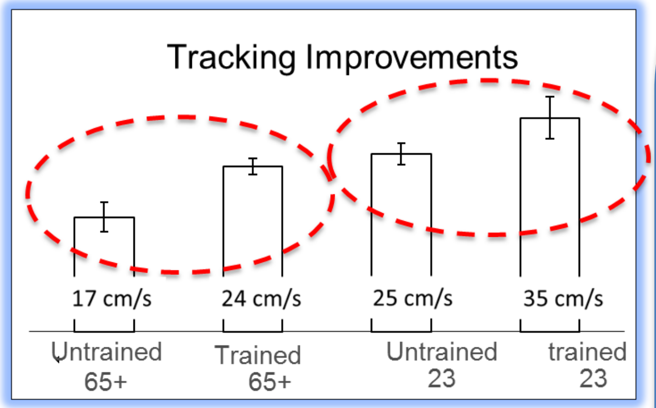
Roy & Faubert, In Preparation

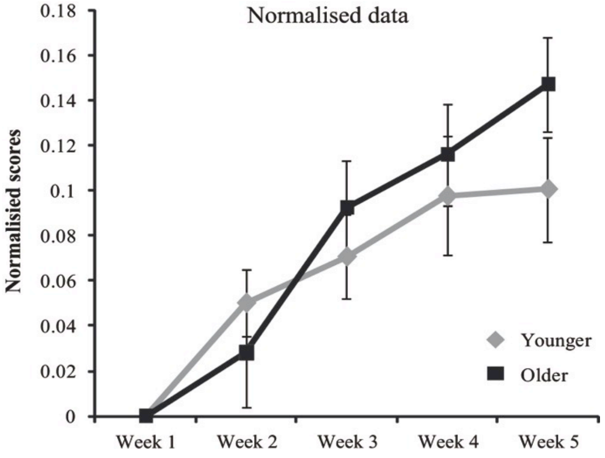
Time (seconds)

Biosemi EEG (64 channel)

Aging work

Plasticity in the elderly

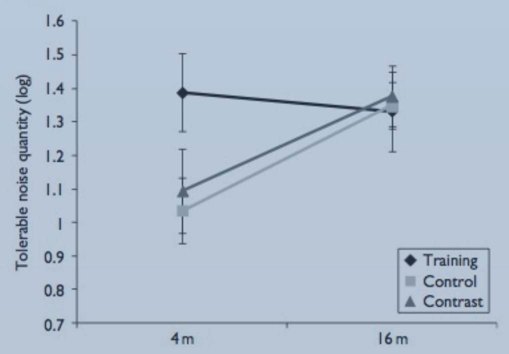




Legault, Allard & Faubert., 2013

Socially relevant transfer

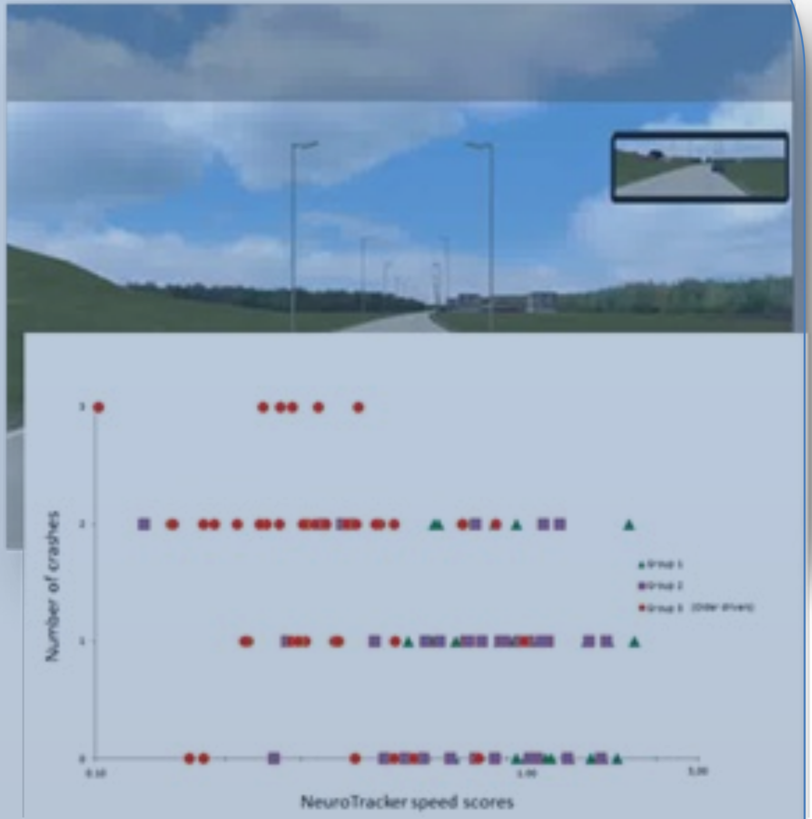
Fig. 2



Older adults' noise tolerance level at 4 and 16 m distance.

Legault & Faubert, 2012

Relates to driving ability



Michaels et al., 2017

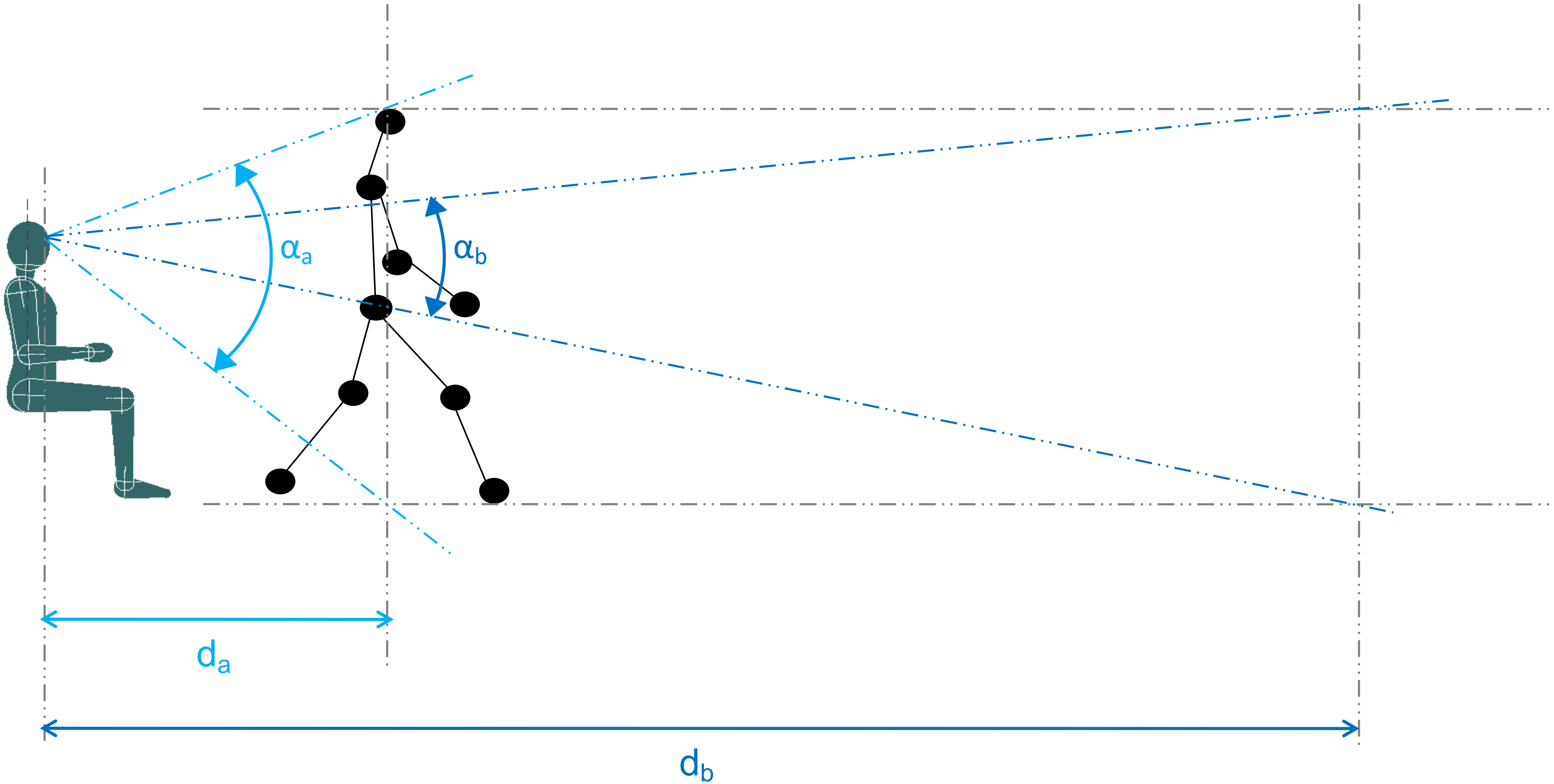
Introduction Biological Motion Perception

Action
Dittrich (1993)

Gender
Troje (2002), Pollick & al. (2005)

Identity
Loula & al. (2005)

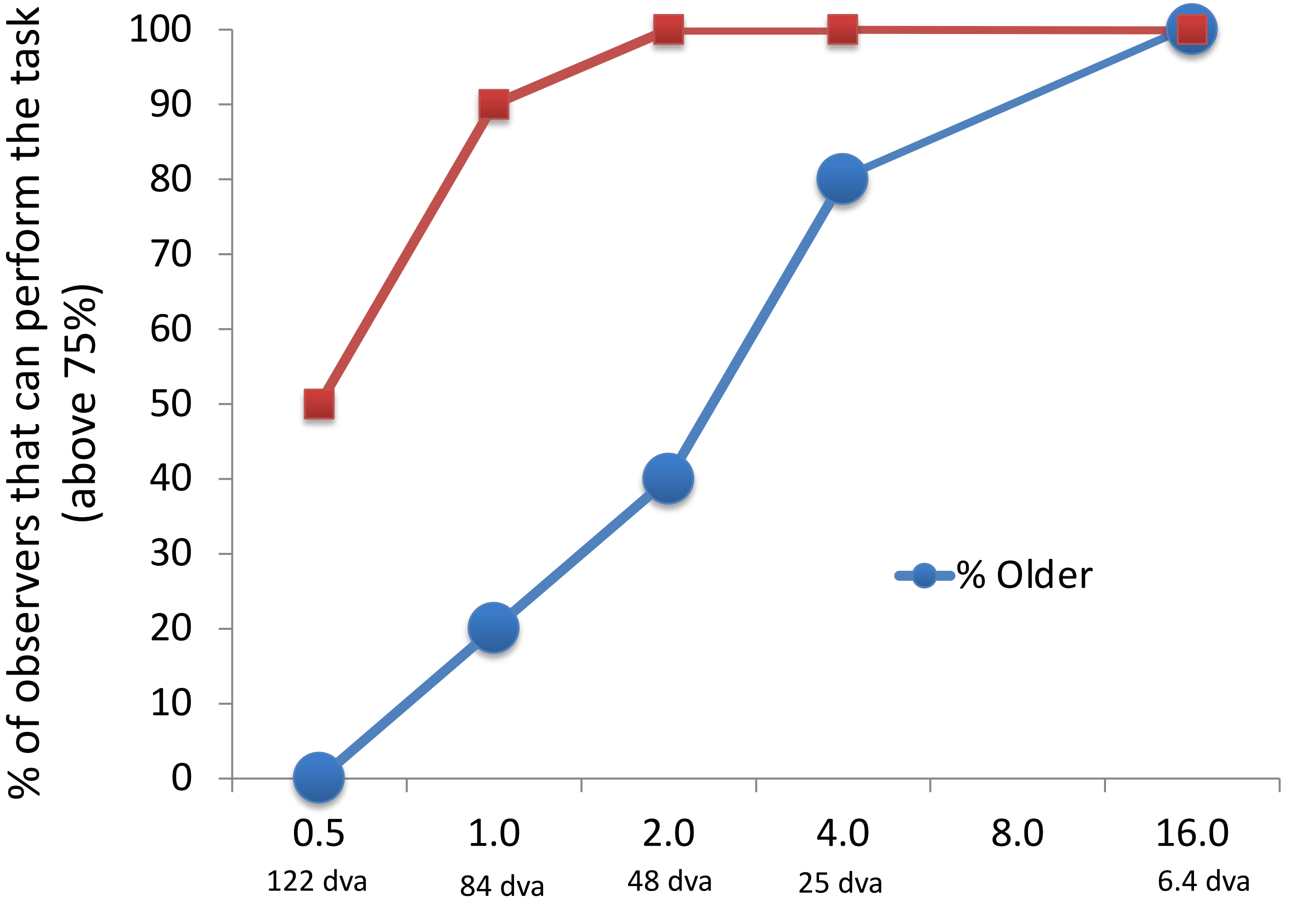
Using peripheral vision



Large visual angle = larger neural network = harder for the older brain

Faubert (2002)

Effect of virtual distances on biological motion perception



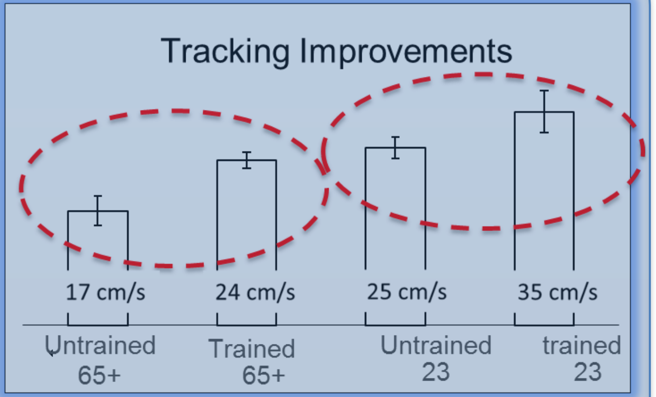
Healthy older observers cannot use biological-motion point-light information efficiently within 4 m of themselves

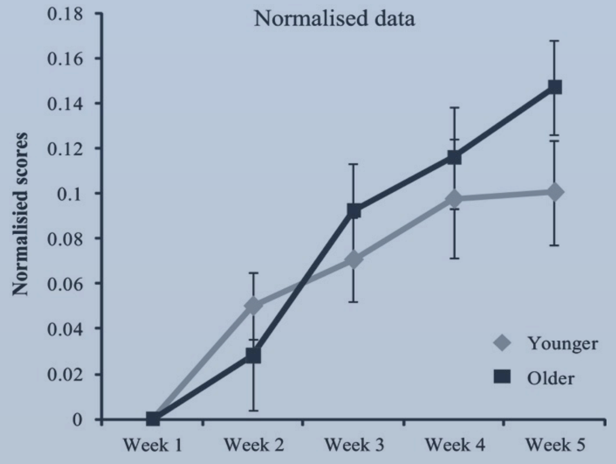
Legault, Troje & Faubert, 2012

i-Perception (2012) volume 3, pages 104 – 111

Aging work

Plasticity in the elderly





Legault, Allard & Faubert., 2013

Socially relevant transfer

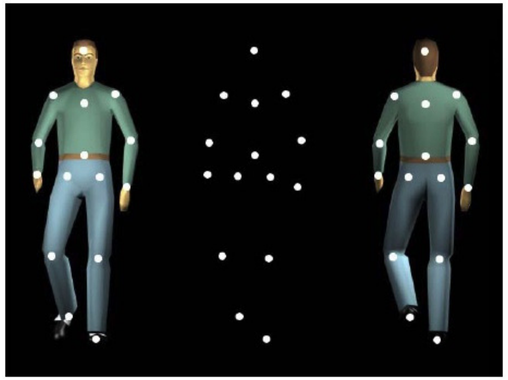
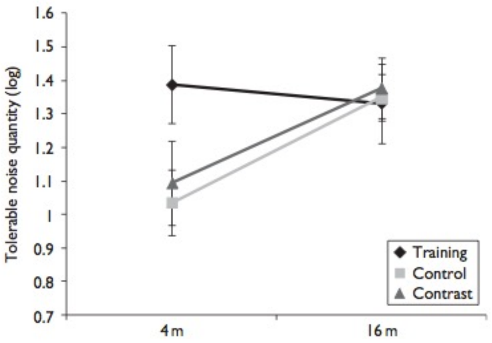


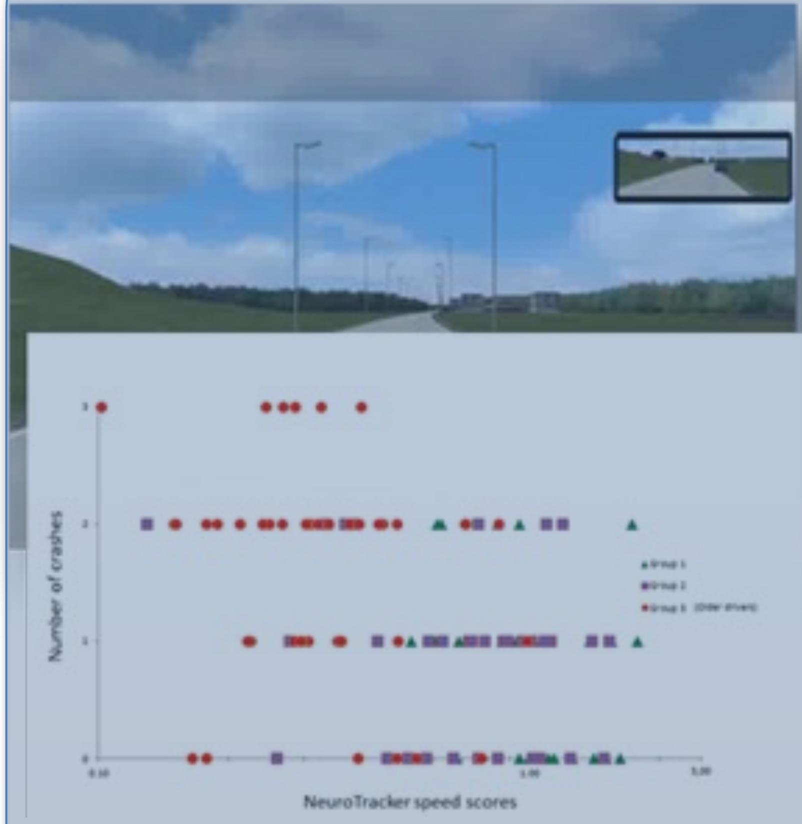
Fig. 2



Older adults' noise tolerance level at 4 and 16 m distance.

Legault & Faubert, 2012

Relates to driving ability



Michaels et al., 2017

PLOS ONE

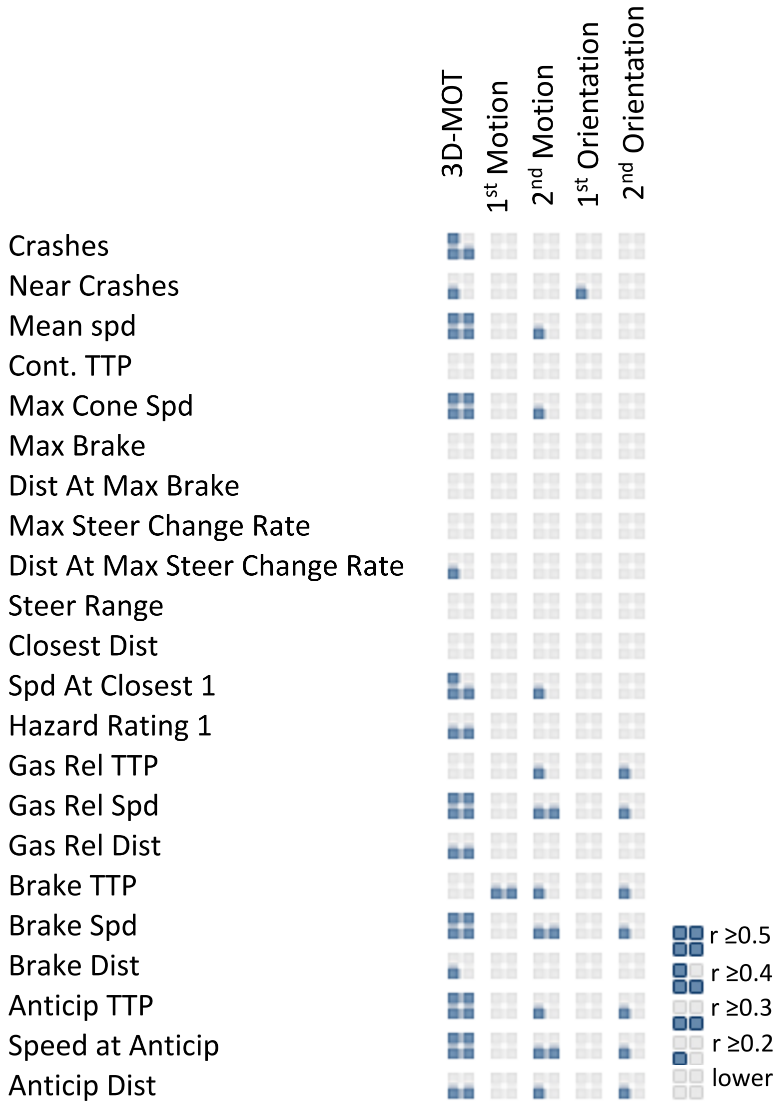
Driving simulator scenarios and measures to faithfully evaluate risky driving behavior: A comparative study of different driver age groups

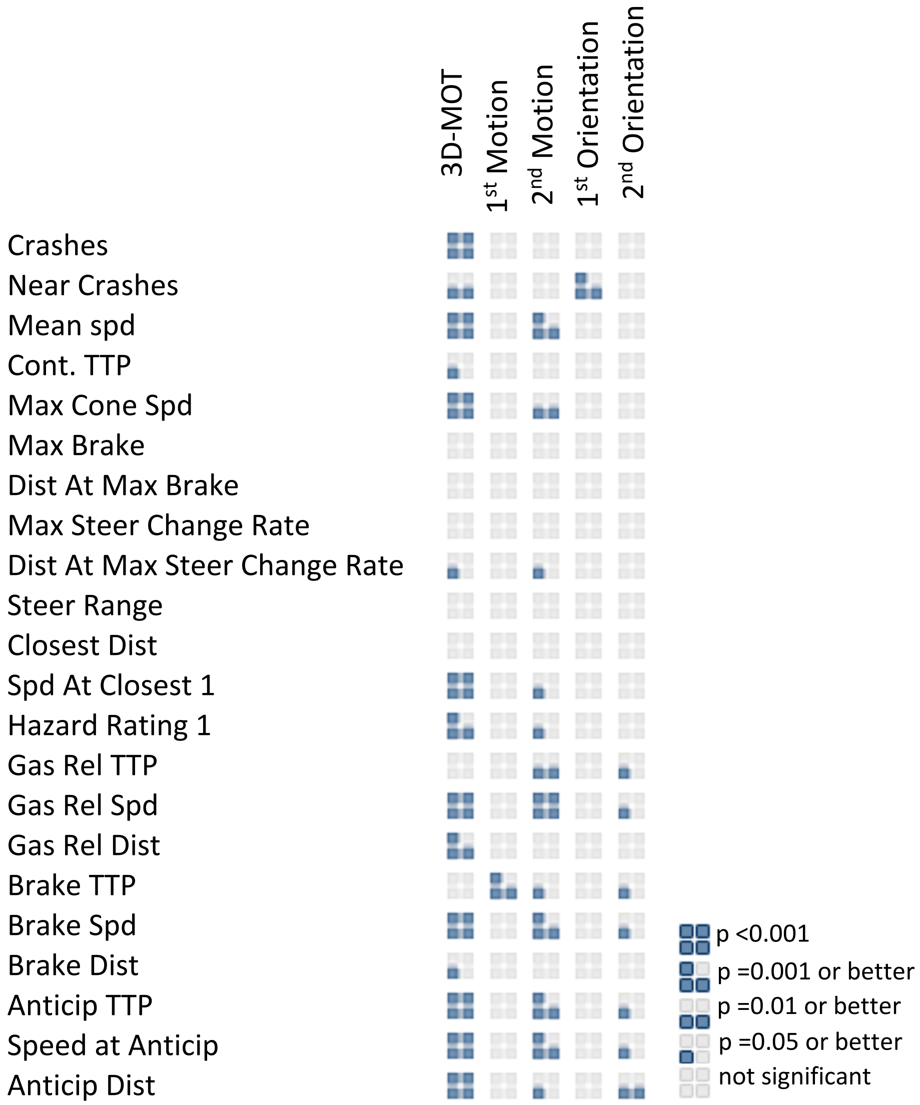
Jesse Michaels, Romain Chaumillon, David Nguyen-Tri, Donald Watanabe, Pierro Hirsch, Francois Bellavance, Guillaume Giraudet, Delphine Bernardin, Jocelyn Faubert

- 180° vision
- Blind spots
- Cockpit movements and vibrations

Virage Simulation™

Correlations
Aggregated data for all driving scenarios





Can three-dimensional multiple object tracking training be used to improve simulated driving performance? A pilot study in young and older adults

Michaels J, Chaumillon R, Mejia-Romero S, Bernardin D, Faubert J (accepted for publication) Journal of Cognitive Enhancement

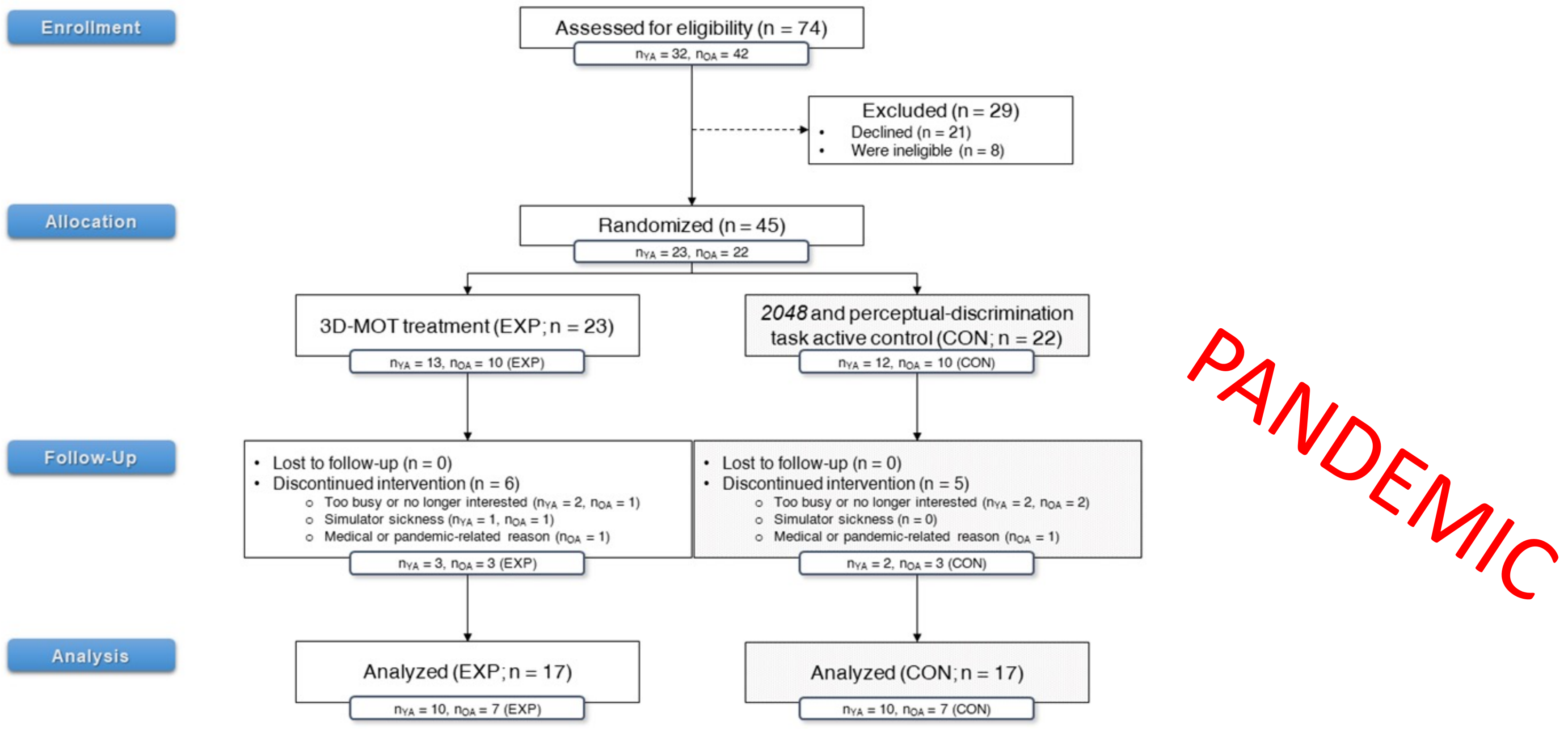


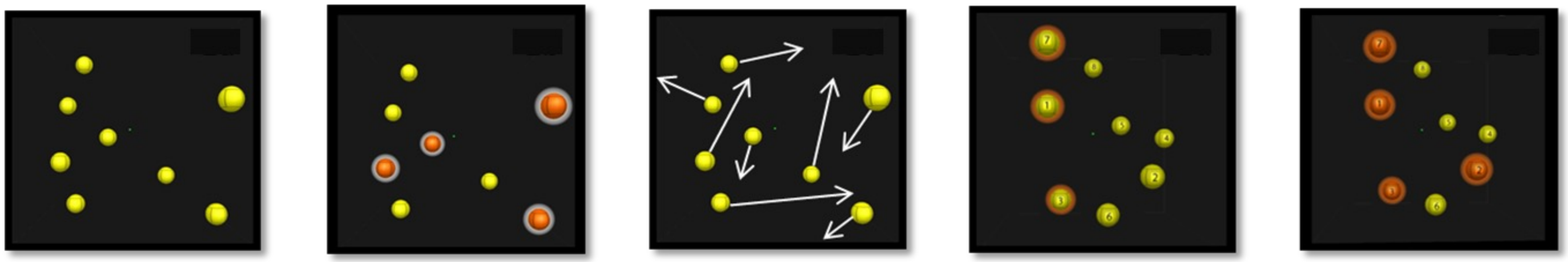
Fig. 1. Flow diagram outlining participant inclusion and randomization process. Sample size information about young adult (YA) and older adult (OA) and their distribution in experimental (EXP) and active control (CON) treatments is provided for each step.

	Measure	Unit	Description
1	Crash	n	Whether a collision occurred or not during the event.
2	Near Crash	n	When within an event: • Subject brakes harder than a given threshold while driving at a speed greater than 5 m/s (18km/h) • The steering wheel is turned more than 60 degrees while driving faster than a speed threshold (5 m/s) • The participant drives within 3m of an object while travelling at a speed greater than 10m/s (36km/h).
3	Mean Speed	km/h	Average speed of all driving. Data points where speed was inferior to 10km/h or recorded 300m before and 100m after an event were discarded from the averaging.
4	SDLP	m	Standard deviation of lateral position. Identical exclusion criteria as mean driving speed were applied. Additionally, for each data point, lateral positions recorded 10 seconds before and after a lane change were excluded from the averaging.
5	Max Brake	n	Hardest amount of braking applied during event of interest. Ranges between 0 (= no braking applied) and 1 (= brake pedal is fully depressed)
6	Distance at Max Brake	m	Distance from event of interest at which “Max brake” is recorded.
7	Max Steer Change Rate	º/s	Most extreme (in terms of range and speed) left or right steering wheel position change during event of interest.
8	Distance at Max Steer Change Rate	m	Distance at which “Max steer change rate” is recorded during event of interest.
9	Steer Range	º	Difference in degrees between leftmost and rightmost steering wheel position for event of interest.

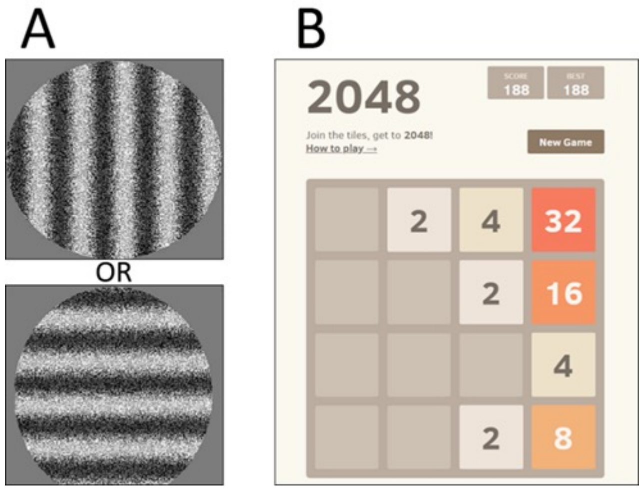
Table 1. Definition of the most pertinent measures identified by Michaels et al. 2017 and the units in which they were recorded. *n* corresponds to an undefined unity, *km* to kilometers, *h* to hours, *m* to meters, º to degrees, and *s* to seconds.

Can three-dimensional multiple object tracking training be used to improve simulated driving performance? A pilot study in young and older adults

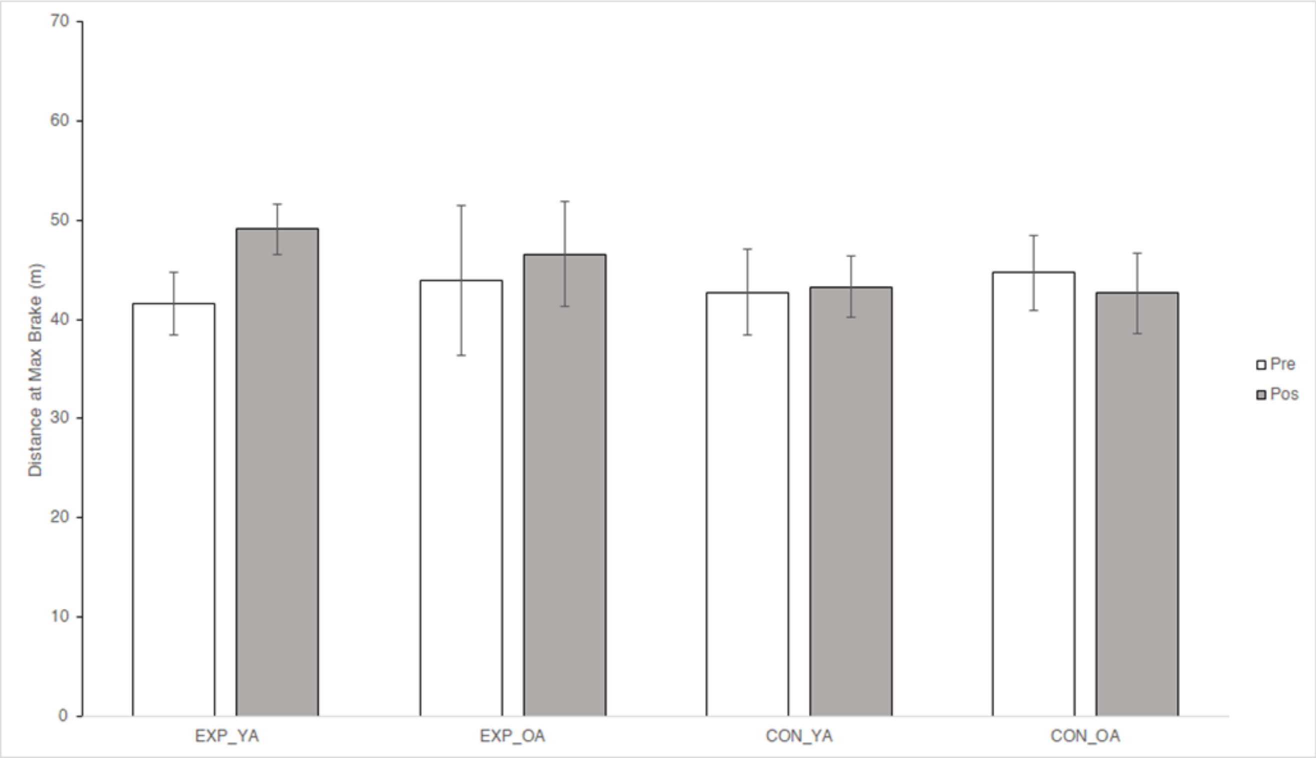
Experimental training (5 weeks)



Active control training (5 weeks)



Can three-dimensional multiple object tracking training be used to improve simulated driving performance? A pilot study in young and older adults



Pre- and post-training mean values for Distance at Max Brake separated by training and age group. Error bars represent standard error of the mean (SEM).

APPLIED NEUROPSYCHOLOGY: ADULT
https://doi.org/10.1080/23279095.2023.2169884

Effect of 3D-MOT training on the execution of manual dexterity skills in a population of older adults with mild cognitive impairment and mild dementia

Laura P. Burgos-Morelos[a], José de Jesús Rivera-Sánchez[a], Ángel Daniel Santana-Vargas[a], Claudia Arreola-Mora[b], Adolfo Chávez-Negrete[b], J. Eduardo Lugo[c,d], Jocelyn Faubert[c], and Argelia Pérez-Pacheco[a,e]

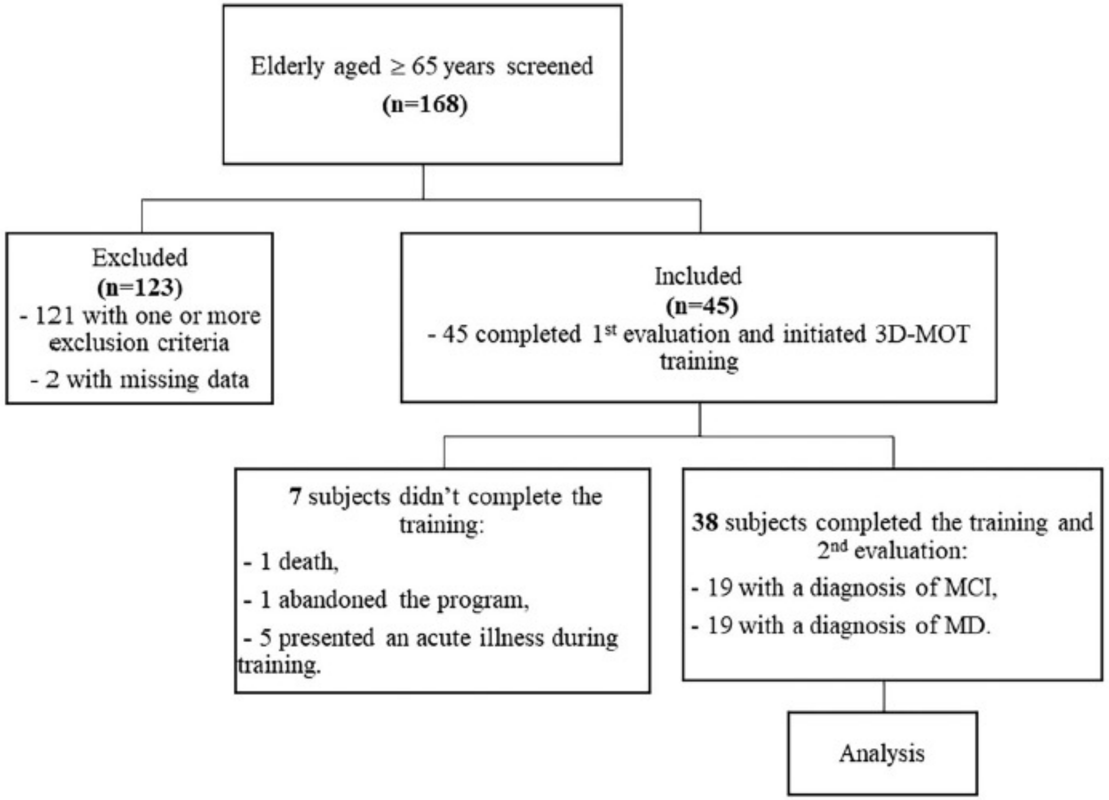


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Table 1. Demographic, functional, and cognitive characteristics of MCI and MD groups.

	MCI $n=19$, $M \pm SD$	MD $n=19$, $M \pm SD$	*df*	*t*	*p*-Value
Age (years)	74.11 ± 6.47	75.74 ± 6.15	36	-.796	.431
BMI	23.99 ± 3.46	23.52 ± 2.21	36	.499	.621
Education	8.95 ± 5.9	4.26 ± 1.45	36	3.360	.0019*
Lawton Brody	7.26 ± 0.93	6.05 ± 1.39	36	3.146	.0033*
Barthel	87.11 ± 6.08	82.11 ± 7.13	36	2.325	.0258*
GDS	1.79 ± 1.75	2.79 ± 1.44	36	1.925	.062
MoCA	20.79 ± 2.02	14.32 ± 3.54		6.921	<.001*
				χ^2	
Gender (% female)	73.7%	84.2%	1	.633	.426†
CCI			2	1.556	.459†
0 (*n*, %)	9 (47.4)	11 (57.9)			
1 (*n*, %)	8 (42.1)	6 (31.6)			
2 (*n*, %)	2 (10.5)	2 (10.5)			

M: mean; *SD*: standard deviation; *df*; degrees of freedom; MCI: mild cognitive impairment; MD: mild dementia; BMI: body mass index; GDS: Geriatric Depression Scale; CCI: Charlson Comorbidity Index; MoCA: Montreal Cognitive Assessment.
*Significant *t*-test for independent groups, $p < 0.05$.
†Chi-square test.

APPLIED NEUROPSYCHOLOGY: ADULT
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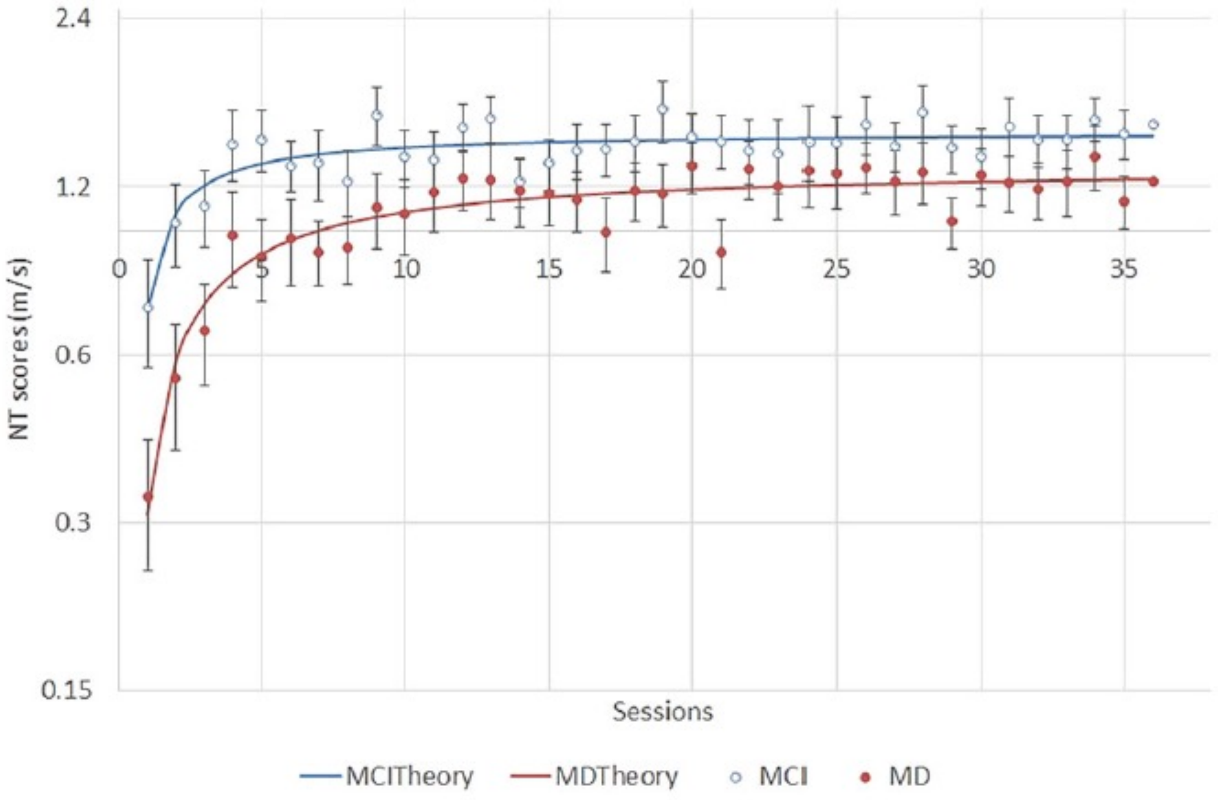

Figure 2. Average speed threshold scores as a function of 3D-MOT training sessions for MCI and MD group. Error bars represent SEM.

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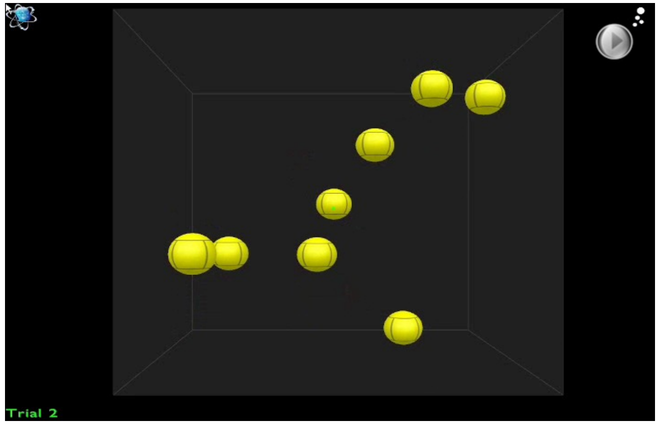
Table 2. Manual dexterity scores of tests: GPT and MMDT, pre and post the 3D-MOT training from MCI and MD groups.

Group	Test	Pre-training (s) Me (IQR)	Post-training (s) Me (IQR)	Z	p-Value
MCI	GPT	138 (65)	93 (49)	−3.824	<.0001*
$n=19$	MMDT-P	250 (68)	230 (50)	−3.622	<.0001*
	MMDT-T	282 (140)	240 (75)	−3.823	<.0001*
MD	GPT	158 (187)	124 (166)	−3.140	<.002*
$n=19$	MMDT-P	277 (89)	241 (80)	−3.162	<.002*
	MMDT-T	294 (178)	239 (121)	−3.703	<.0001*

Me: median; IQR: interquartile range; MCI: mild cognitive impairment; MD: mild dementia; GPT: Pegboard Grooved Test; MMDT-P: Minnesota Manual Dexterity Test-Placing Test; MMDT-T: Minnesota Manual Dexterity Test-Turning Test.
*Significant Wilcoxon signed rank test, $p < 0.05$.

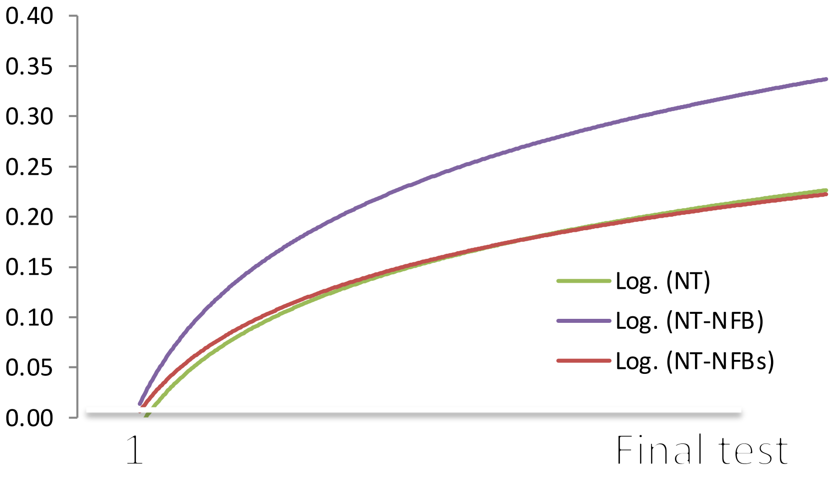
NeuroTracker/EEG return
Closing the loop

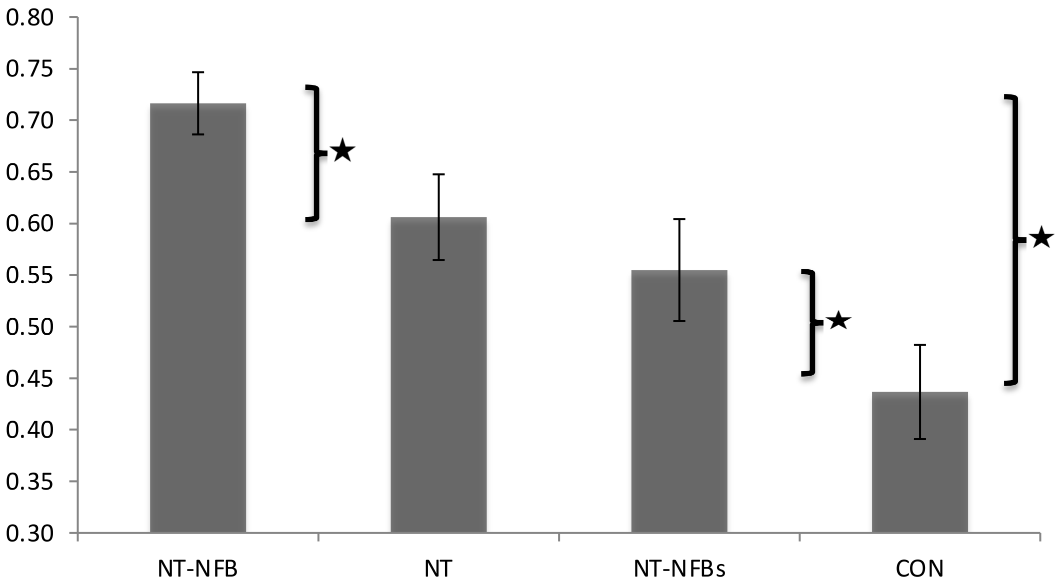
Parsons & Faubert, (2021) Enhancing learning in a perceptual-cognitive training paradigm using EEG-neurofeedback. https://www.nature.com/articles/s41598-021-83456-x.pdf



- **Used « peak alpha » frequency (PAF) at Pz (Threshold = 95% baseline)**

- **Feedback while spheres in motion (red indexing)**





Potential: Big data (NeuroTracker global use)
June 2016

Merci!

Performance Validations

Manchester United
United States Olympic Committee
FFR
FFF
Olympique Lyonnais
Orlando Magic

Providence Friars
Baylor Bears
Oregon
Red Bull Racing Formula One Team
United States Naval Special Warfare Command
United States Special Operations Command
United States Marine Corps Forces Special Operations Command

Medical Validations

Fondation Léopold Bellan
Kyutech Kyushu Institute of Technology
University of Victoria
I CARE Department of Veterans Affairs
ClearView Communities

McGill
Holland Bloorview Kids Rehabilitation Hospital Foundation
Arts et Métiers ParisTech
Hamilton Health Care System
Houston Methodist Leading Medicine

Questions & Answers

Type in your questions using the chat box at the bottom of the control panel on the right side of your screen

Jocelyn Faubert, PhD
Professor
Université de Montreal

Additional Questions

Use this contact information
if you have additional questions
from today's webinar

Jocelyn Faubert, PhD
Professor
Université de Montreal
Email: jocelyn.faubert@umontreal.ca

MoCA COGNITION

Merci!

Performance Validations

MANCHESTER UNITED

US

UNITED STATES OLYMPIC COMMITTEE

FFR

FFF

OLYMPIQUE LYONNAIS

OL

ORLANDO MAGIC

PROVIDENCE FRIARS

BAYLOR BEARS

OREGON

Red Bull Racing FORMULA ONE TEAM

UNITED STATES NAVAL SPECIAL WARFARE COMMAND

UNITED STATES SPECIAL OPERATIONS COMMAND

SPECIAL OPERATIONS COMMAND UNITED STATES MARINE CORPS FORCES

Medical Validations

FONDATION LÉOPOLD BELLAN

Kyutech Kyushu Institute of Technology

University of Victoria

I CARE DEPARTMENT OF VETERANS AFFAIRS

ClearView COMMUNITIES

McGill

Holland Bloorview Kids Rehabilitation Hospital Foundation

ARTS ET MÉTIERS ParisTech

Hamilton Health Care System

HOUSTON Methodist LEADING MEDICINE