Combining wearable diffuse optical tomography and immersive virtual-reality for the reliable study of neurodevelopmental conditions: a proof-of-principle study to open new avenues of research on neurodiversity

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Respect4Neurodevelopment
Pump-Prime Feasibility Projects 2023

Neurodevelopmental conditions:

- estimated to affect **up to 10% of the UK population**
- have **detrimental and long-lasting effects** on mental health.

Neuroimaging research aims at **informing strategies of interventions**. So far it has not identified relevant biomarkers for these disorders.

This might be due to the characteristics of **traditional empirical studies**

This set-up does not capture the complexity of children's real lives and might therefore evoke **impoverished responses.**

- most neurodivergent children are known to struggle with **executive functions (EF)** in their everyday life (Rizeq, 2020).
- This has not always been **replicated in experimental studies** (Goldberg, 2005).
- The traditional experimental set-up might facilitate the children's EF performance by **reducing the sensory demand** which might be related to EF poor performance in everyday scenarios (White, 2009).

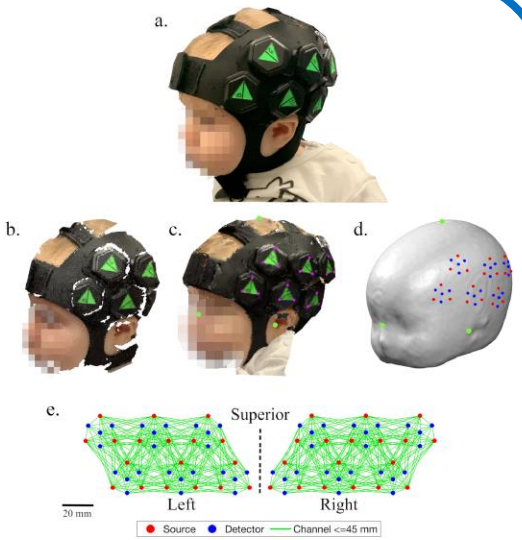
ADVANCES IN TECHNOLOGIES
allowed to assess children in more naturalistic settings

VIRTUAL-REALITY
mid-point between the controlled laboratory and the real world

- child-friendly scenarios
- wearable neuroimaging

Diffuse optical tomography, DOT

- optical imaging, near-infrared light
- good spatial resolution and possibility to reduce superficial contamination
- image reconstruction
- recently validated for developmental populations



Frijia et al., 2021

CHALLENGES OF PERFORMING NEUROIMAGING IN NATURALISTIC SET-UPS

- no **reliability tests** of neuroimaging data
- **bias of the research sample** → inclusion of children compliant with the equipment

results significantly less generalizable

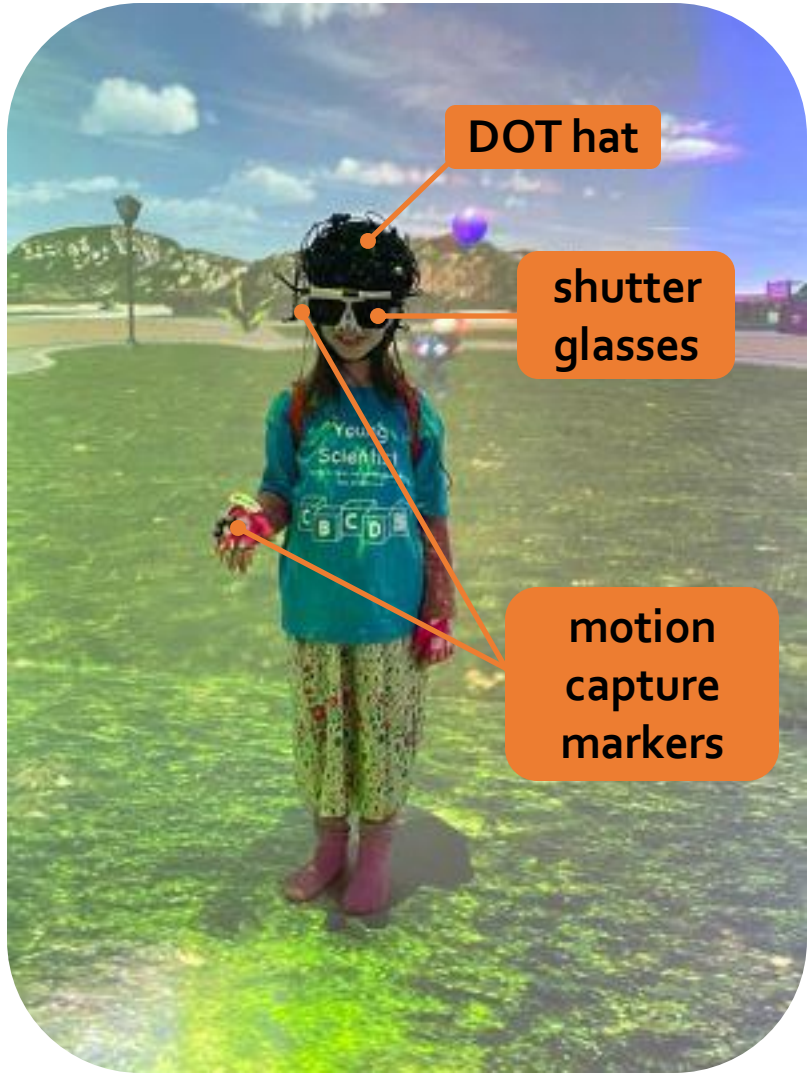
RESEARCH QUESTION:
can we validate a new VR/DOT set-up for a reliable and personalised assessment of neurodivergent children?

AIMS OF THE PROJECTS

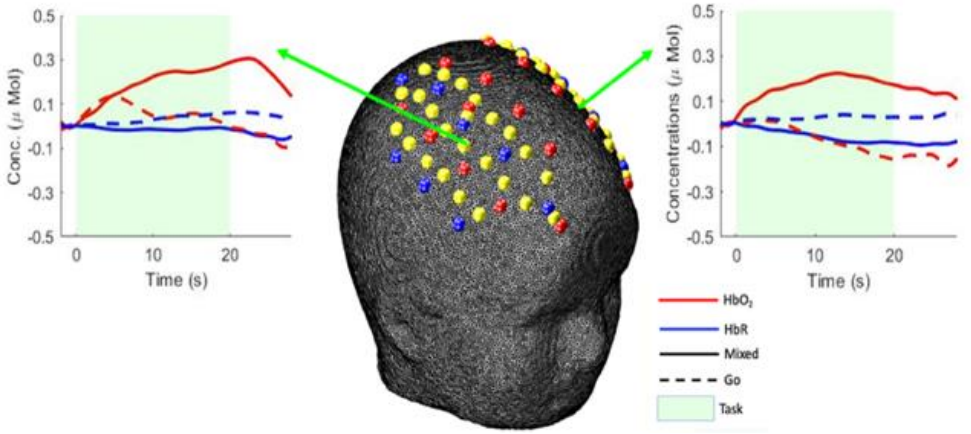
1. to work with families and industries to guide the personalization of neurotechnologies
2. to assess the test-retest reliability of a new combined VR-DOT set-up
3. to develop analysis pipelines to increase the reliability of neuroimaging data

BabyLab & ToddlerLab

LUMO GOWERLABS



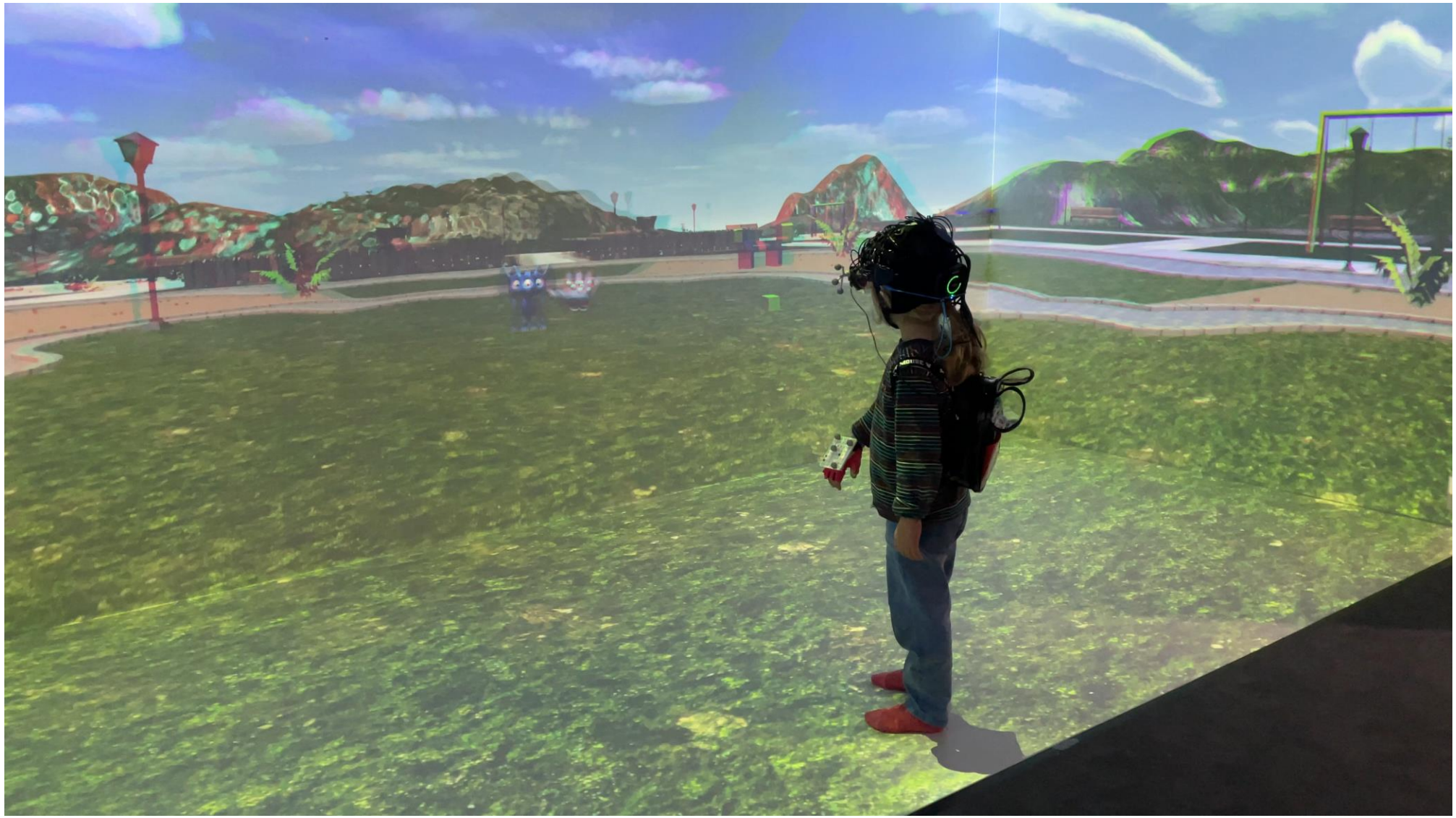
Go-NoGo task
Inhibitory Control



Group-average (N=30) hemodynamic responses to Go-only (dashed) and mixed Go-NoGo (solid) stimuli.

60 4-to-6-year-olds tested twice

- 20 neurotypical
- 20 ASD/ADHD
- 20 low-empathy

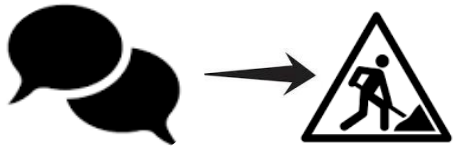


video courtesy of Dr. Paola Pinti

PERSONALISATION

WP1

personalise the VR/DOT set-up based on families' feedback



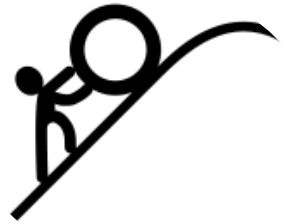
PERSONALISATION tailoring neurotechnologies to individual's children needs and characteristics

1. **connect with parents of neurodiverse children** before the testing sessions to understand possible challenges
2. ask parents to fill in **an ad-hoc questionnaire** to collect feedback and suggestions after the testing session
3. **dialogue with our industry partner** to tune the equipment

EXPECTED CHALLENGES:

A. related to the **DOT cap** (i.e., too tight)

B. related to the **CAVE** (i.e., don't want to wear the glasses, find the CAVE overwhelming)



Poster presented by **Giulia Serino** today!

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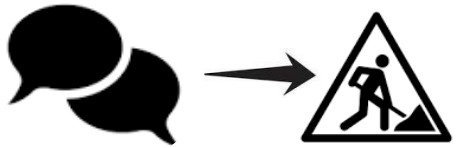
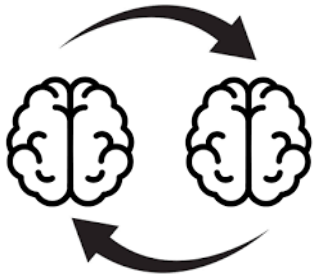


guidelines on using the VR/DOT set-up with neurodivergent children

RELIABILITY

WP2

assess the **reliability** of VR/DOT with a Go/No-Go task



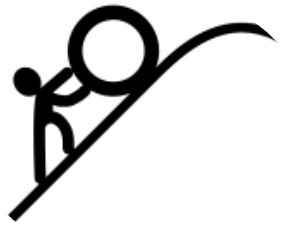
RELIABILITY assess the reliability of VR/DOT with a Go/No-Go task

1. test **all participants twice** with the same task
2. test different **data analysis algorithms**

EXPECTED CHALLENGES:

A. **variability of the testing sessions** in the CAVE might affect reliability measures

B. define data analysis parameters which maximise data inclusion and SNR even if data are collected on **freely moving children**



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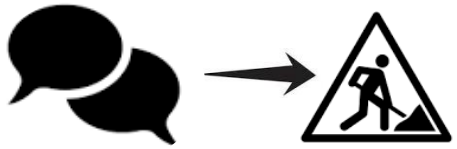

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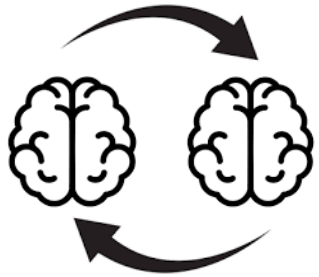


guidelines on using the VR/DOT set-up with neurodivergent children

RESPONSIBILITY

WP3

responsibly disseminate findings to neuroimaging companies, clinicians and researchers

test-retest reliability measures and robust **data-analysis pipeline**

RESPONSIBILITY

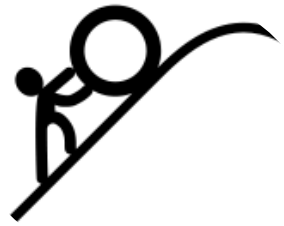
responsibly disseminate findings to neuroimaging companies, clinicians and researchers

1. **focus groups** with families of neurodivergent children
2. **interdisciplinary dissemination** event

EXPECTED CHALLENGES:

A. define goals that can be **realistically** met by the researchers and the neurotechnologies company.

B. make the **neurodiverse community** been heard and acknowledged.



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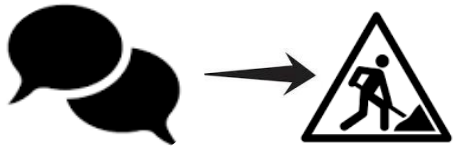

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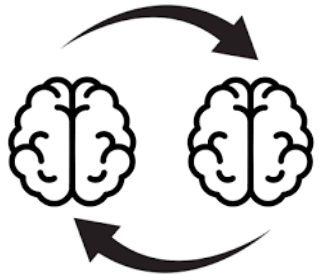

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impact on:

- strategies of interventions
- future research grants applications
- fNIRS companies for future products design

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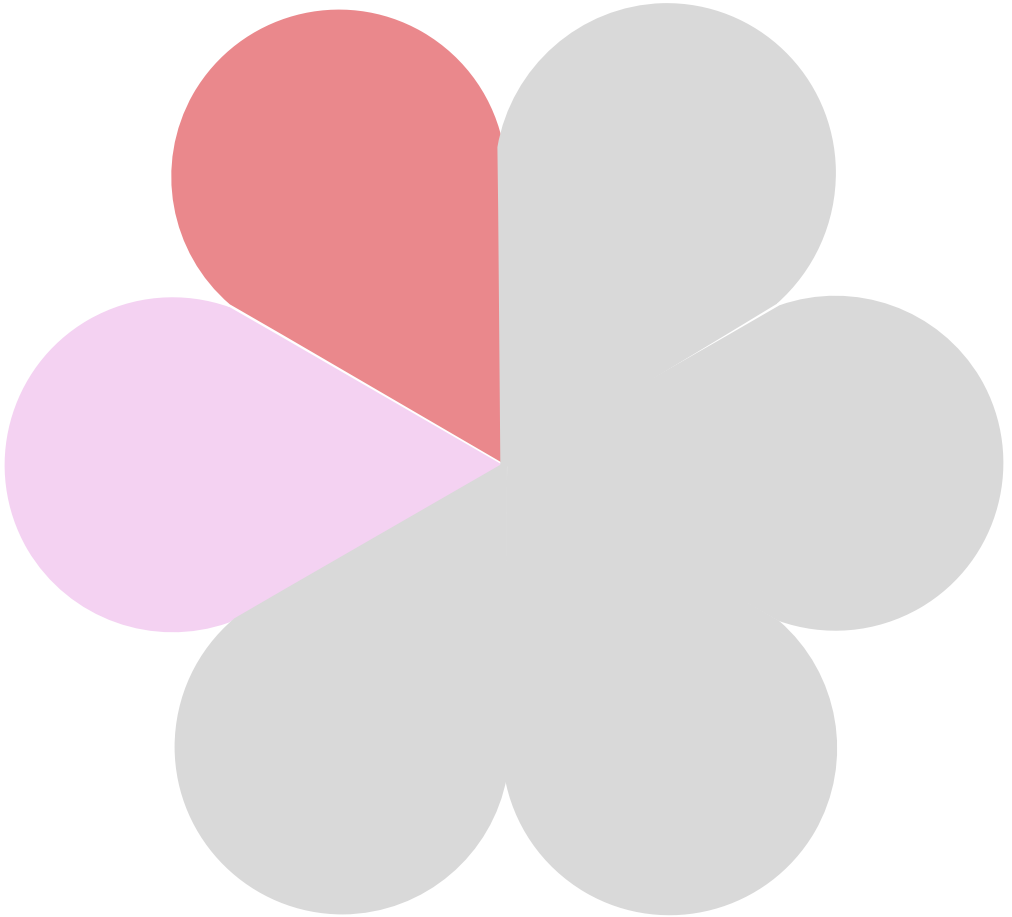
PE & LINK WITH FAMILIES

Dr. Dalvit-Menabe (Babybrains)



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SUPERVISION

Prof. Hamilton

Prof. Viding

BENEFIT FOR NEURODIVERGENT COMMUNITY

- **personalised testing protocols** for neurodivergent children
- **involve families** of neurodivergent children into research
- **discuss with clinicians** preliminary results from an inhibitory control task
- inspire **similar research projects** with other modalities (i.e., EEG)

SCIENTIFIC AND NON-SCIENTIFIC DISSEMINATIONS

GUIDELINES & DATA-ANALYSIS PIPELINE

ANONYMISED DATA AVAILABLE FOR OTHER RESEARCHERS

NEW COLLABORATIONS INSIDE AND OUTSIDE THE NETWORK

Thank you for listening!
Questions?

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Medical Research Council

4 NEURODEVELOPMENT

Engineering and Physical Sciences Research Council