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Training navigation abilities with VR in children

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LA NOSTRA FAMIGLIA
CURA RIABILITAZIONE E RICERCA DALLA PARTE DEI BAMBINI

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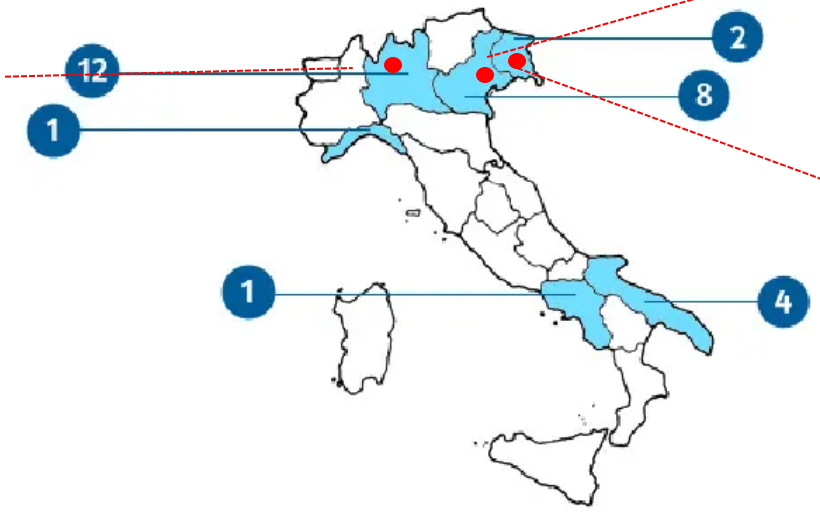
Scientific institute acknowledged by the Italian Ministry of Health

Bosisio Parini (Lc)



Conegliano (Tv)

Udine- S.Vito al T.(Pn)

Scientific section of the association La Nostra Famiglia, non-profit organization dedicated to the care and rehabilitation of people with disability, specifically children and adolescents.

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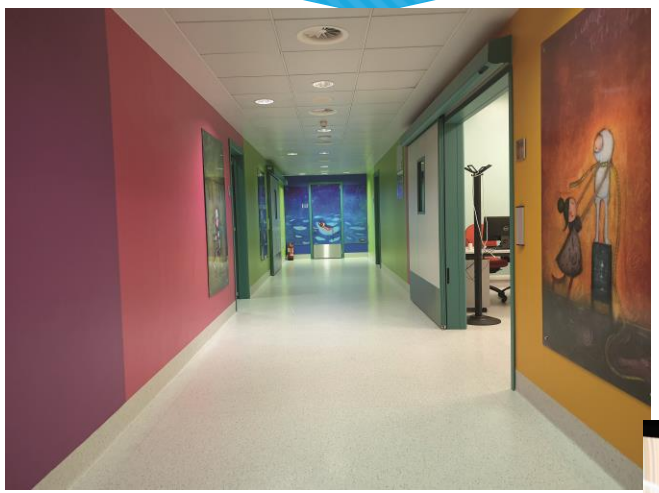

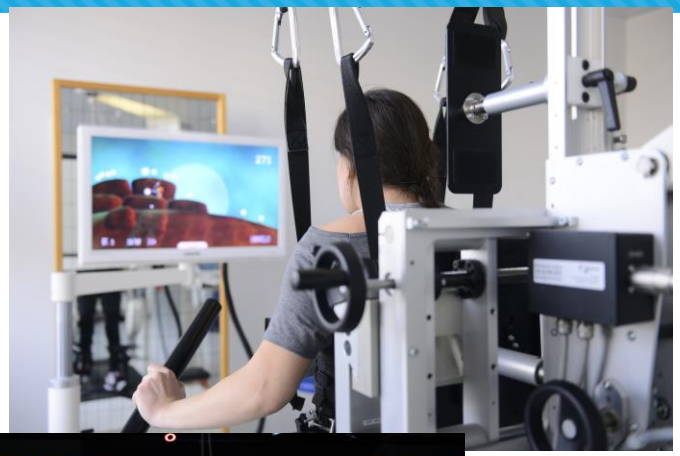

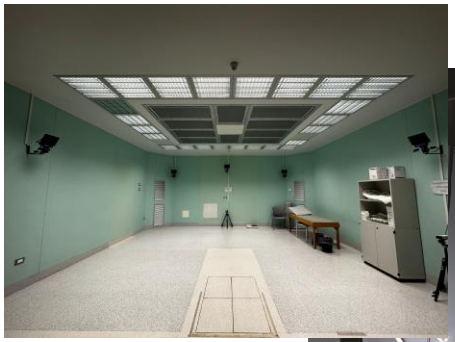

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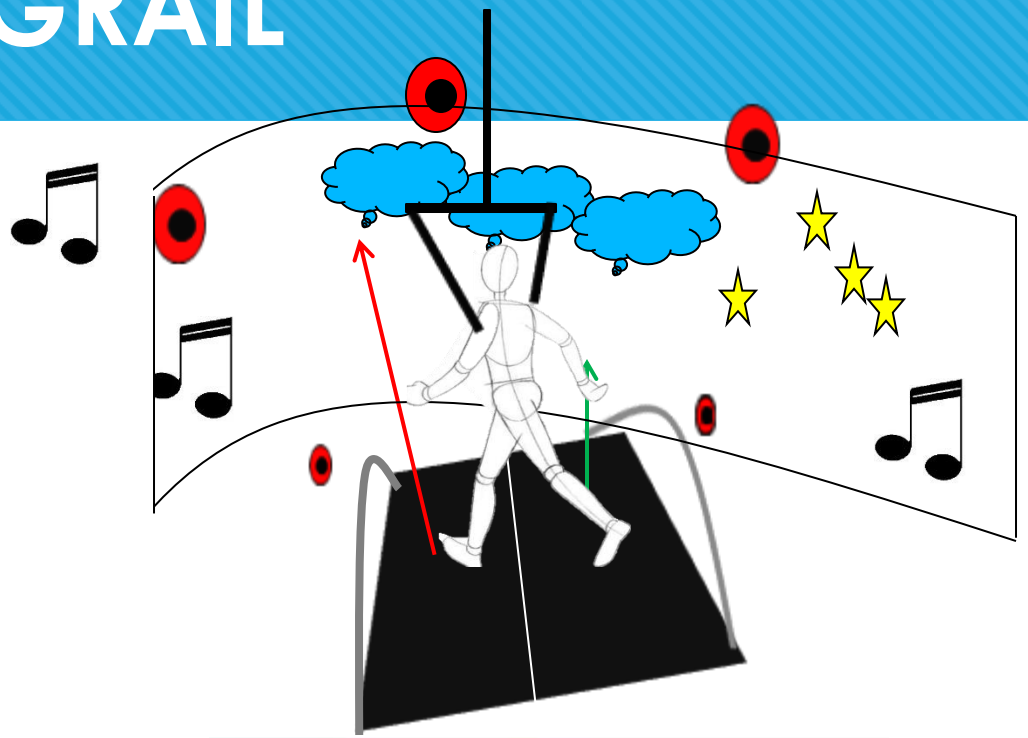
GRAIL system @ ASTROLAB

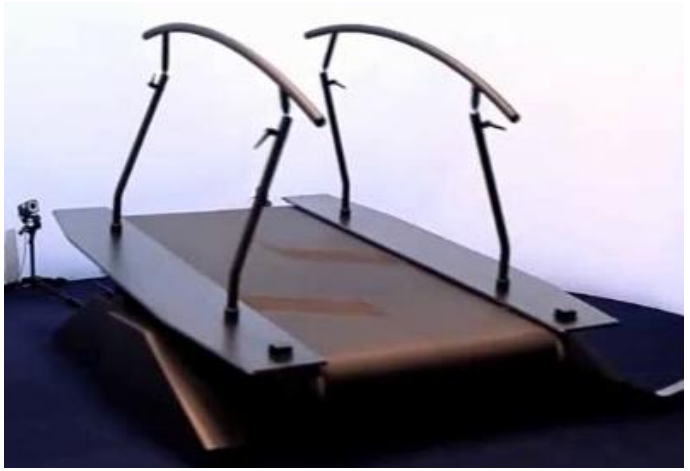
Gait
Real-time
Analysis
Interactive
Lab

Dedicated solution to the gait analysis and training

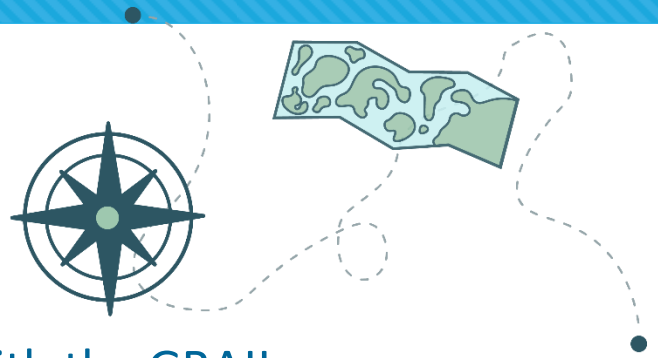
GRAIL

- Dual-belt treadmill
- Integrated force plates
- 10 optoelectronic cameras and 3 video-cameras
- 180°cylindrical screen
- Dolby surround
- Dynamic weight bearing system
- Motion frame with pitch and sway
- Software to develop new VR applications





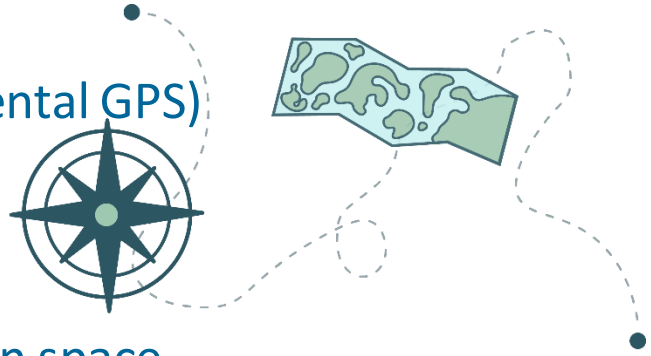
Outline



- ✓ Navigation abilities and their rehabilitation with the GRAIL
- ✓ Navigation training with low cost and portable devices

Navigation abilities

What does it mean to navigate the space?



To understand the sense of position while moving (mental GPS)

- ✓ Orient yourself
- ✓ Perceive distances
- ✓ Plan the path to take to reach a direction
- ✓ Mentally map the position of objects (landmarks) in space

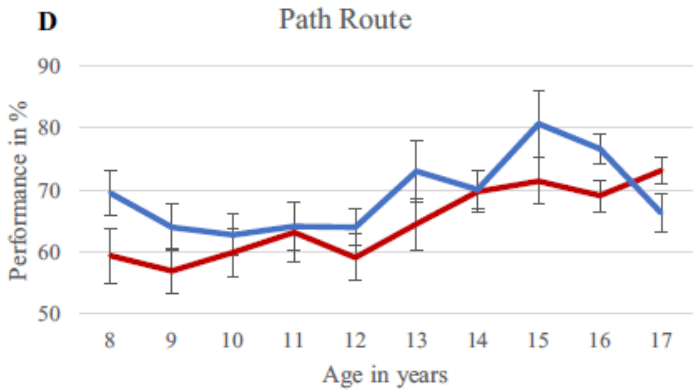
Needs of

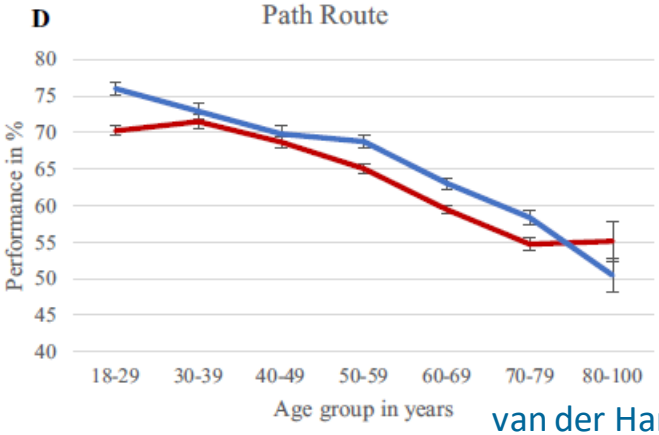
- ✓ Integrity of the spatial neural network: occipital, parietal, frontal and temporal lobes
- ✓ Cognitive skills: long-term memory, executive functions, ability to process multisensory experiences

Navigation abilities

The navigation

- ✓ changes with age/development,
- ✓ has interindividual variability,
- ✓ it is influenced by the maturation of the motor and sensory system, by gender and by previous experiences





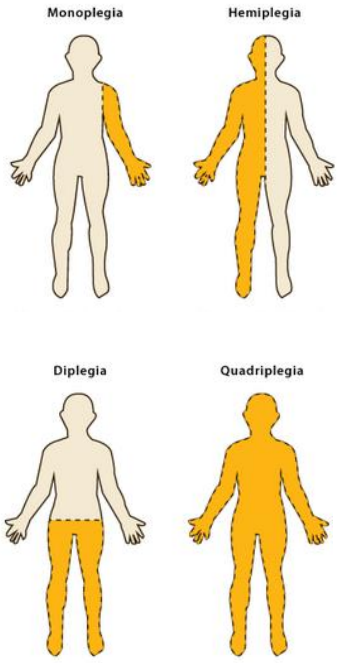
van der Ham et al 2020, Scientific Report

2 main strategies

- ✓ Allocentric strategy based on landmarks
- ✓ Egocentric strategy based on the self

Efficient navigation integrates both strategies!!

Navigation in CP



Cerebral Palsy (CP) is the most common congenital disorder and is one of the leading causes of disabilities in children in western countries, affecting 1–2.5 per 1000 live births.

Several impairments (e.g. motor, cognitive) among which visuo-spatial and navigation difficulties

Previous studies on typically developing children

J Exp Child Psychol. 2010 Nov;107(3):337-50. doi: 10.1016/j.jecp.2010.05.010. Epub 2010 Jul 3.

Developmental time course of the acquisition of sequential egocentric and allocentric navigation strategies

Jessie Bullens [1], Kinga Iglói, Alain Berthoz, Albert Postma, Laure Rondi-Reig

GRAIL technology

- ✓ Movement recognition through markers positioned on the back
- ✓ More ecological and immersive

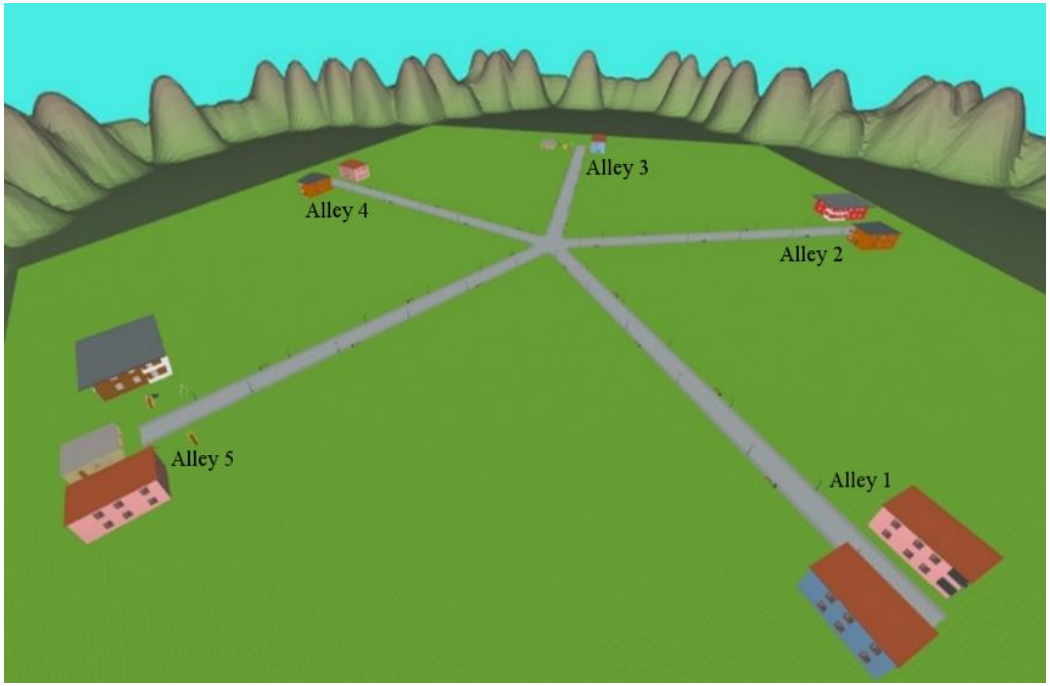
Assessment of navigation abilities

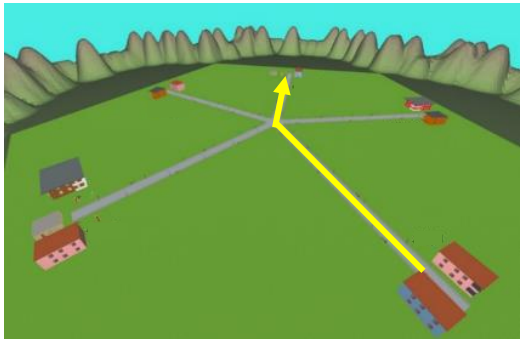
Application requirements

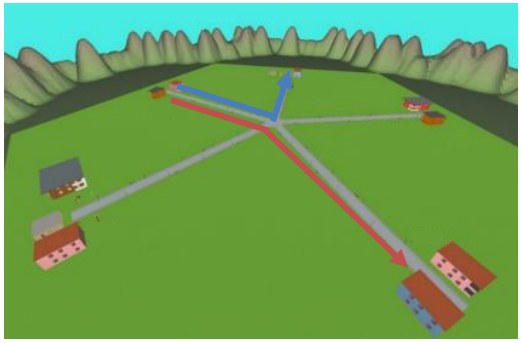
- ✓ Star maze: 5 streets that meet in the center
- ✓ Each street has specific details/landmarks but not explicitly different
- ✓ Treasure to find!

16 trials to test learning

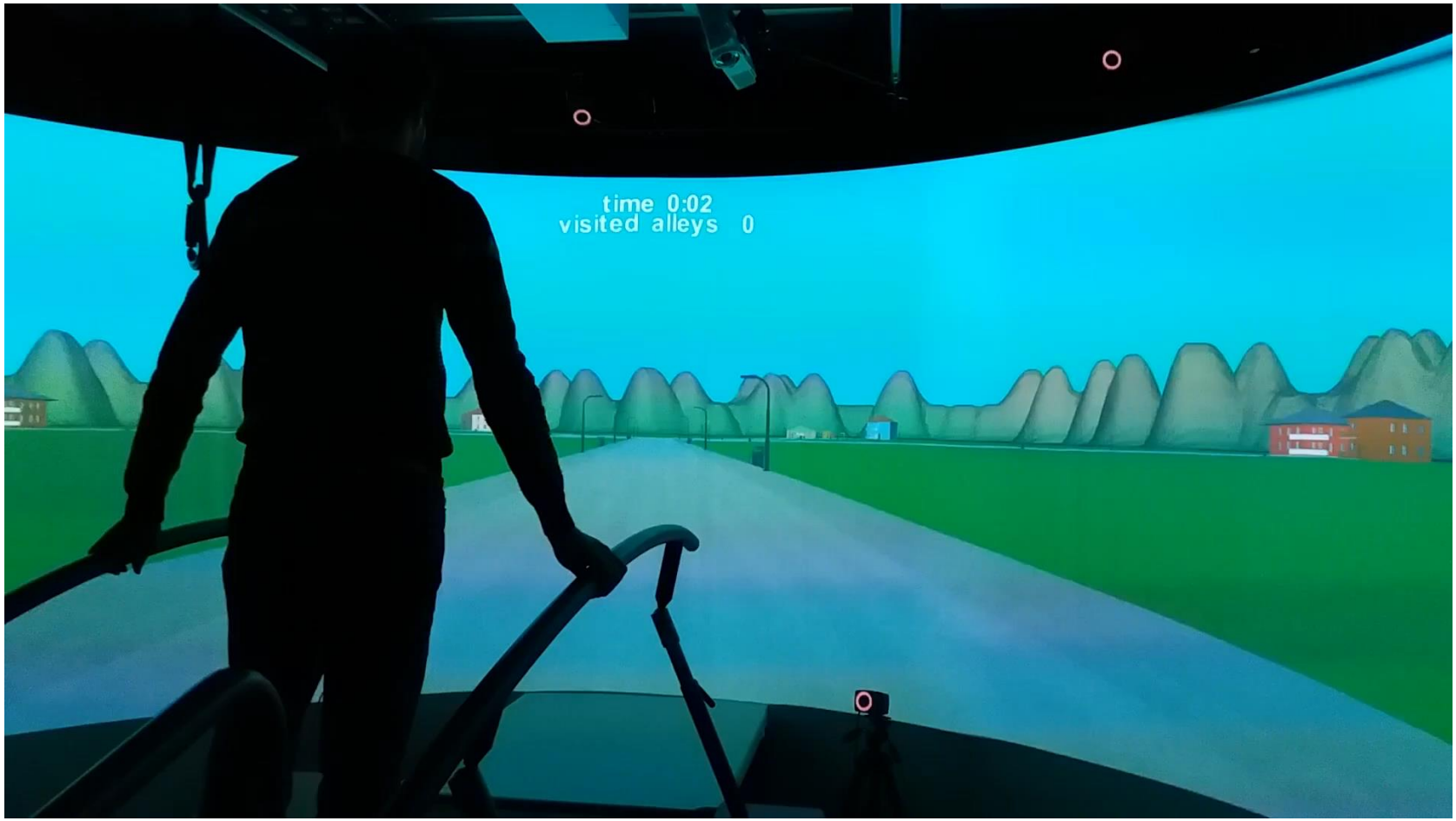
5 tests to assess the spontaneous navigation strategy







New VR environments

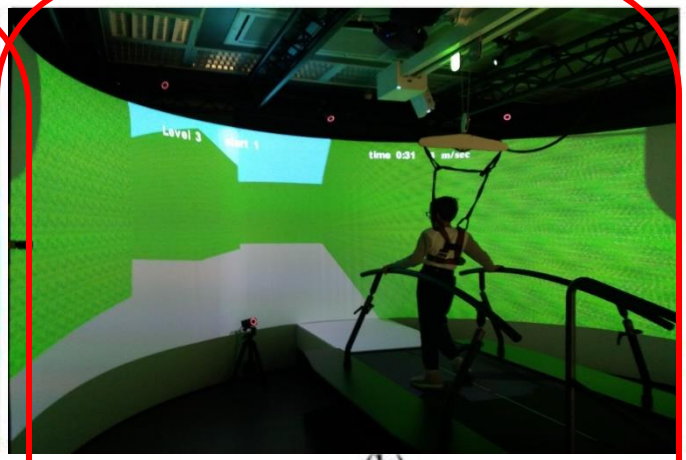


Training of navigation abilities

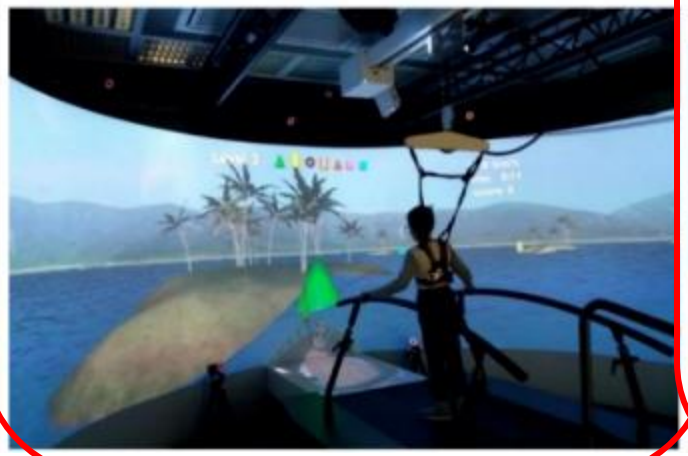
Applications to train navigation abilities have to train the allocentric strategy (explicit memory):

Visuo-spatial abilities

(a)



(b)



Navigational abilities

Navigation assessment

Navigation assessment in typically developing children and in children with CP

Participants

15 children with CP

13 typically developing children

Assessments

Pen & pencil tests:

- ✓ visuospatial memory (Corsi Block test)
- ✓ planning ability & perceptual organization (Labyrinth subtest of the WISC-III)

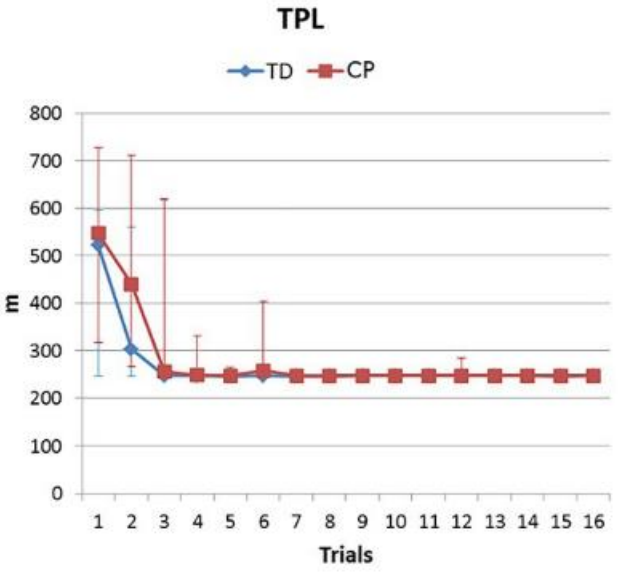
VR assessments learning

- ✓ Learning the way
- ✓ Spontaneous strategy

Navigation assessment

Results

Children with CP had reduced visuo-spatial and planning ability and impaired perceptual organization



Learning the way in VR

- ✓ CP and TD reaches a stable performance
- ✓ Comparable stable values

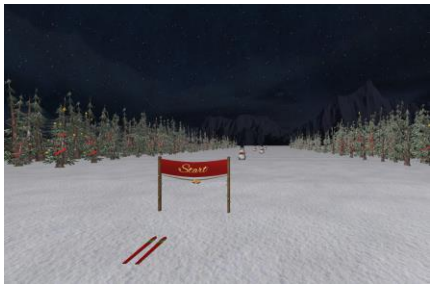
Spontaneous strategy used to navigate

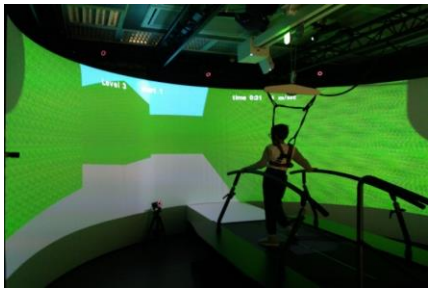
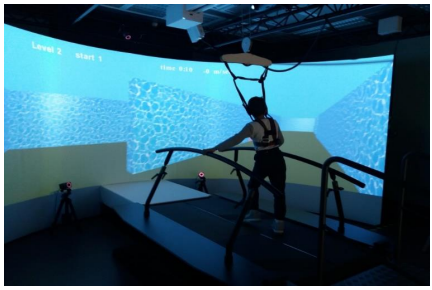
- ✓ Allocentric: 54% TD vs 27% CP
- ✓ Egocentric: 31% TD vs 53% CP

RCT navigation training

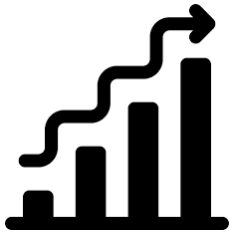
2 groups (random allocation)
Motor+ Navigation training with GRAIL (n=16)
Motor training with GRAIL (n=11)

18 sessions in 1 month, 40 minutes of training



- ✓ **Improved planning ability & perceptual organization in both groups**
- ✓ After the training children in the **motor + navigation group used more than 50% allocentric strategy**



Moving forward

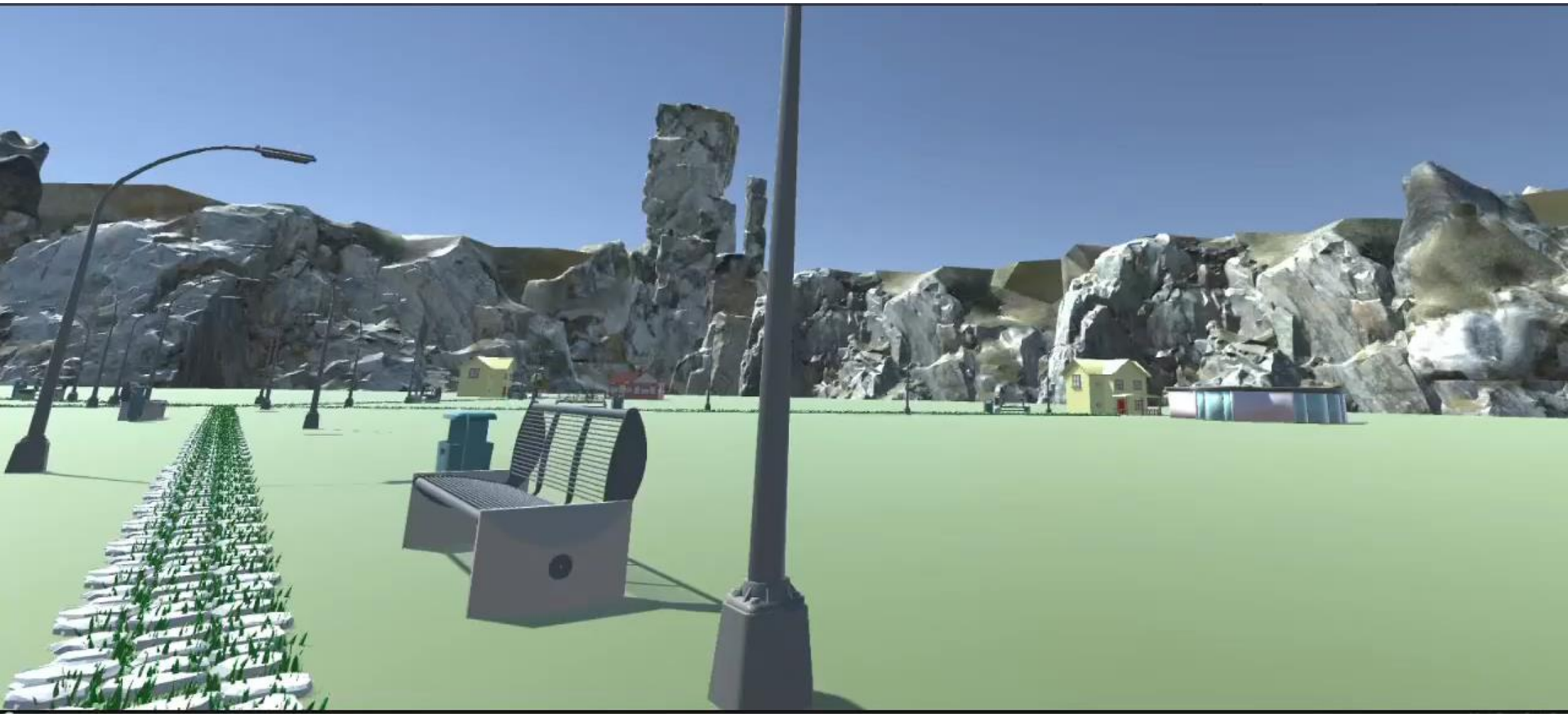
Advantages

- ✓ Wearable
- ✓ Limited costs
- ✓ Can be used in case of reduced motor control
- ✓ Movements of head and controllers to navigate
- ✓ Can be used at home or small rehabilitation centres

Disadvantages

- ✓ Cybersickness and UX must be considered

Assessment of navigation abilities using HMD



Assessment of navigation abilities using HMD

New protocol started in 2023

Main objective: to evaluate navigational skills in typically developing children and in children with CP with HMD and the new application

Secondary objective: to investigate UX in typically developing children and in children with CP in terms of usability, tolerability, and emotional well-being with structured questionnaires

- ✓ System Usability Scale (SUS)
- ✓ Independent Television Commission-Sense of Presence Inventory (ITC-SOPI)

Preliminary results

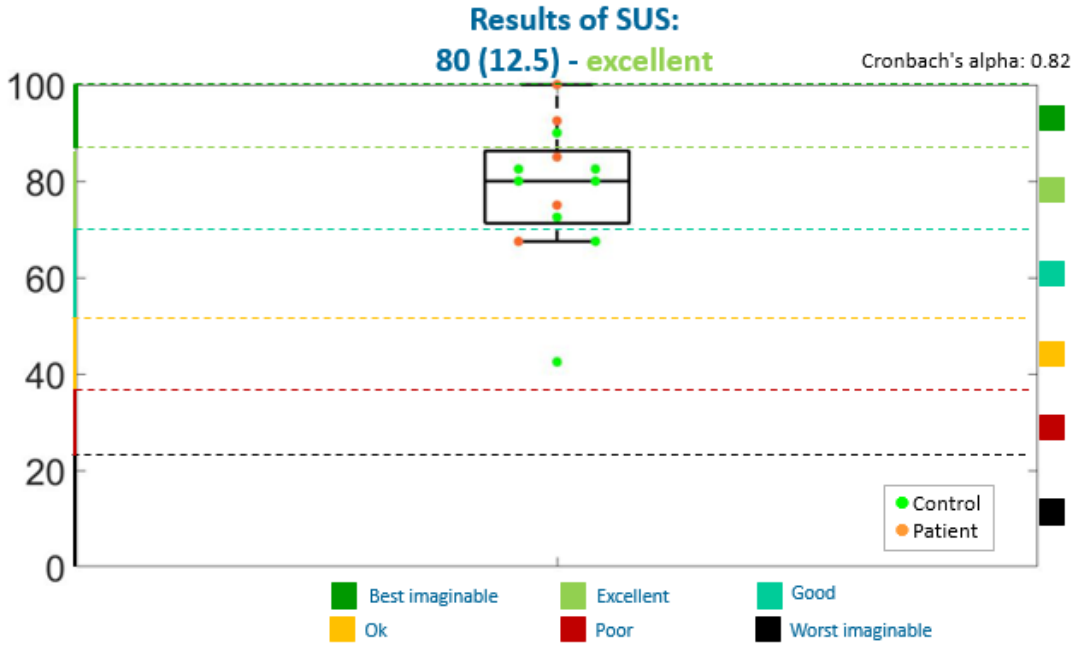
Participants

5 children with CP (4M, mean age 16.2)
8 typically developing children (3M; mean age 15.4)

Navigational skills assessment: analysis are ongoing

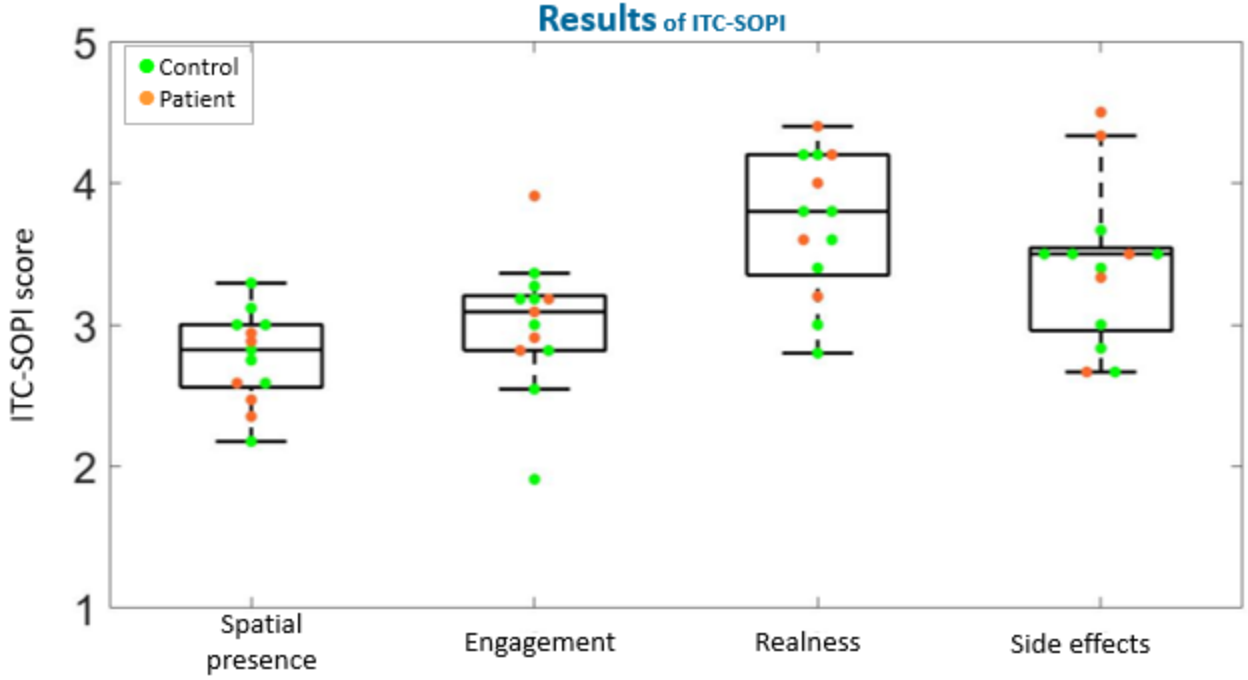
Usability assessments:

Controls 80 (11.3)
Patients 85 (17.5)



Preliminary results

Experience with the system ITC-SOPI



Patients experienced more nausea but less oculomotor disturbances than TDs

Thank you


ASTROLAB
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Ministero della Salute
Regione Lombardia
Fondazione CARIPLO
EMPATIA @LECCO
il gigante
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