

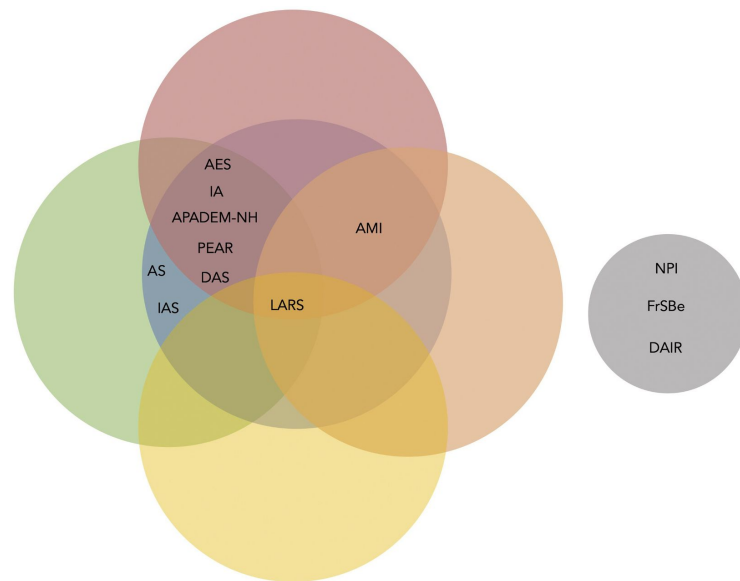
Integrated VR-tTIS targeting apathy in stroke motor rehabilitation

Advanced Methods for
Human Neuromodulation

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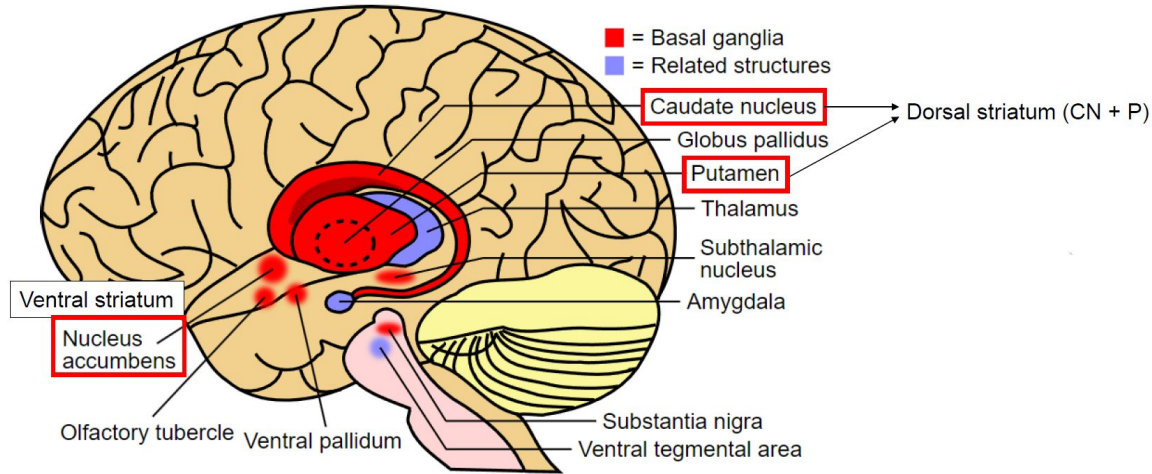
- Syndrome characterized by lack of motivation
- Different dimensions [1]
- Occurrence in various neurological disorders [2]
- Key brain region affected : striatum [3] [4] [5]

Dimension Key



[1]

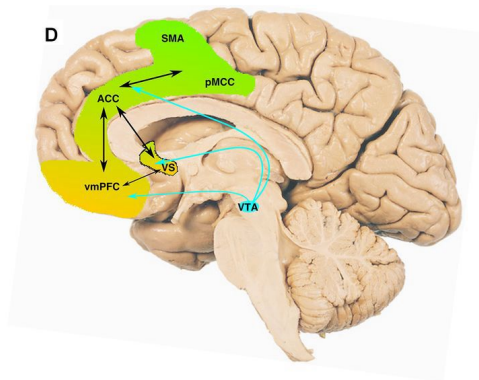
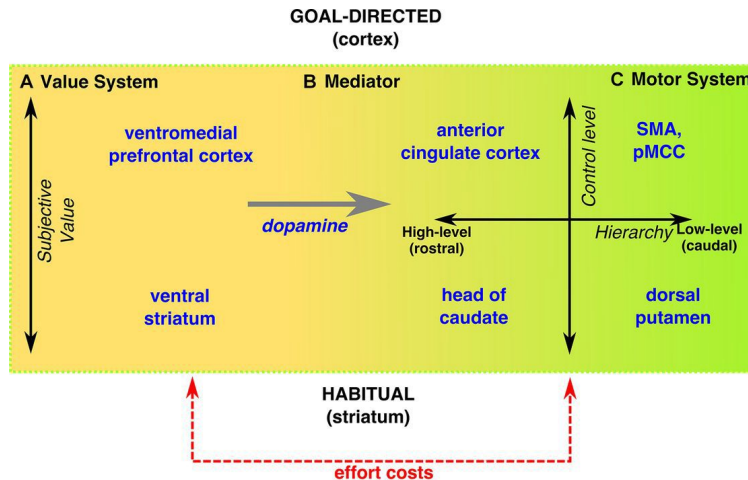
Striatum : brain anatomy



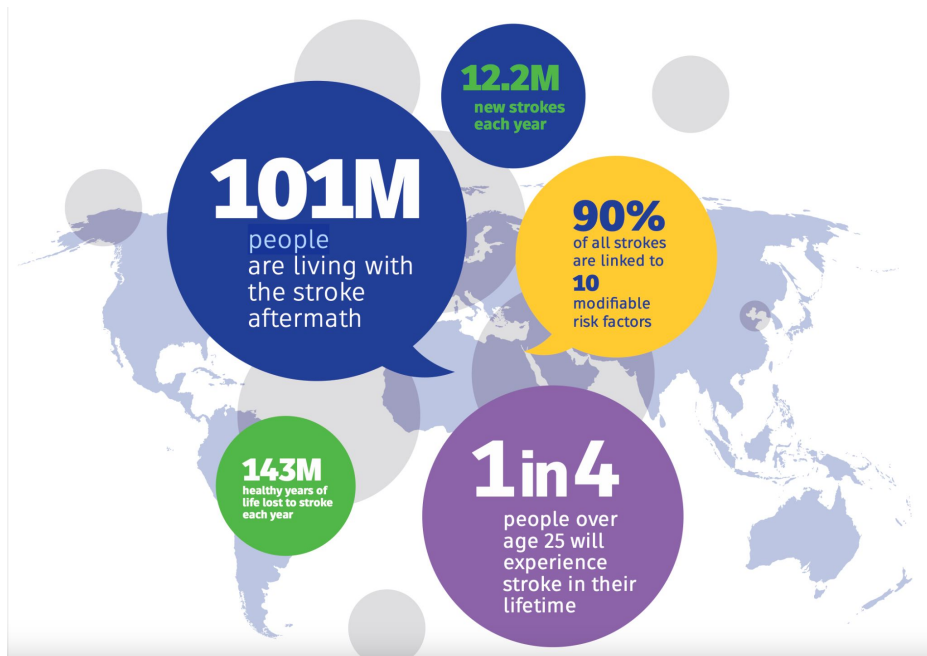
[2]

[3]

Striatum in motivated behavior



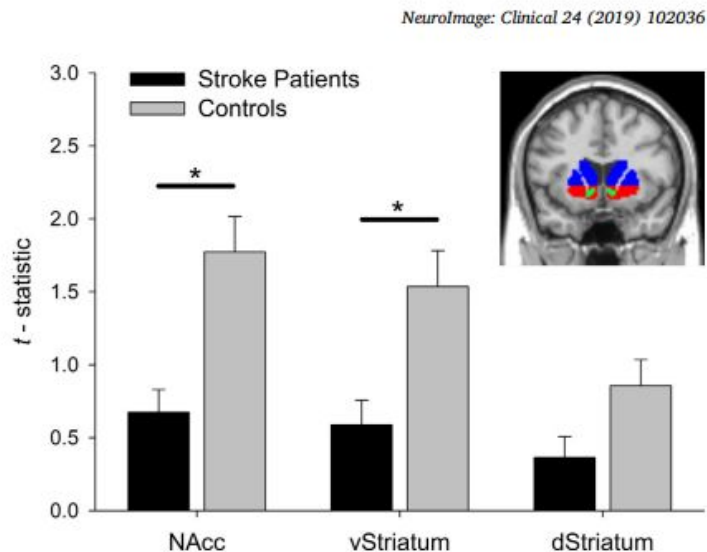
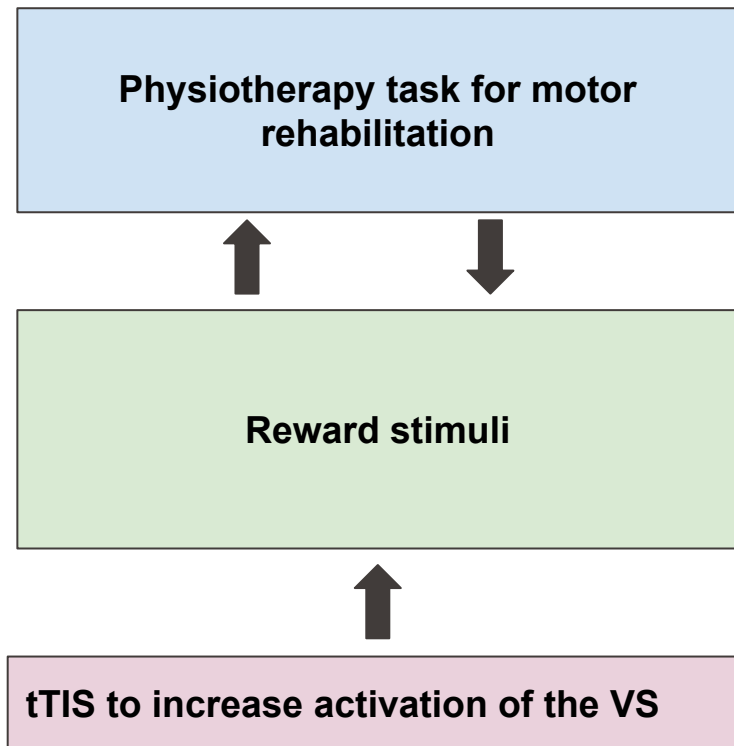
Apathy & stroke motor rehabilitation



[5]

- Apathy in 36% of stroke patients [6]
- Linked to worse functional recovery and quality of life [7]
- long-term impairments of upper extremities in 50% of stroke survivors [8]

Targeting Reward Sensitivity in Stroke Motor Rehabilitation



Stroke patients display reduced activation in the ventral striatum compared to healthy patients upon being shown performance feedback after a motor rehabilitation task [9]

Overview of technology

tTIS

Target reward sensitivity:

Stimulate ventral striatum during introduction of reward stimuli

VR

Effort stimuli:

Gameplay involving motor rehabilitation exercises

Reward stimuli:

Point system
Performance feedback

**Pupil
dilation
sensors**

Primary outcome:

Measure reward sensitivity

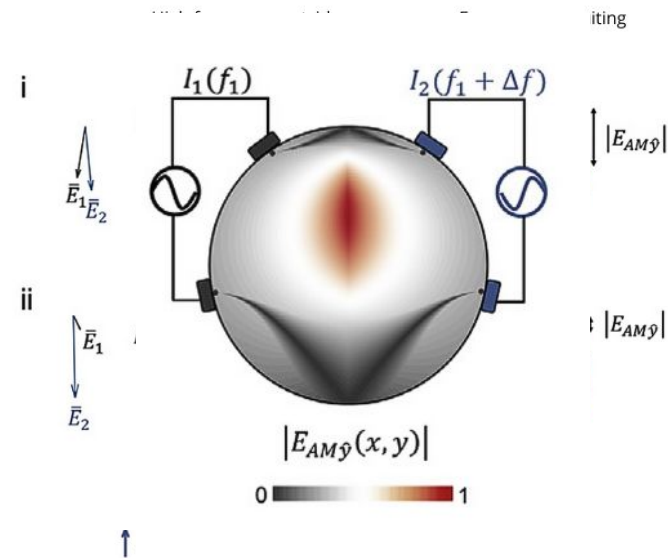
**IMU
sensors**

Secondary outcome:

Measure motion data for motor

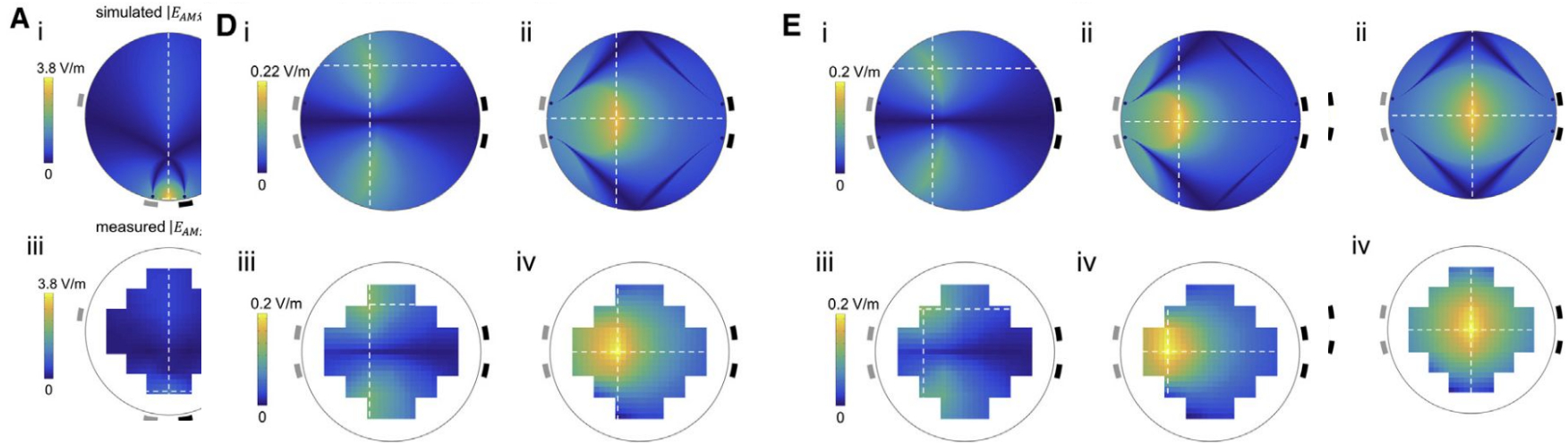
Transcranial temporal interference stimulation

- 1) Apply high-frequency electric fields that are higher than the typical range of frequencies of normal neural operations
- 2) The difference in frequencies creates an envelope with a different frequency and amplitude
- 3) The envelope has a lower frequency, allowing neural operations



Electrode configuration

- By alternating the locations of electrode and setting the current appropriately : can enable the interferential envelope modulation to be targeted to specific location.
- Electrode size play a minor role
- Possibility of “live steering”



Protocol: Theta burst pattern stimulation

Why Theta-Burst Stimulation ?

This form of stimulation has been shown to induce **long-term potentiation-like effects**
Carrier Frequency: Two AC currents were delivered at high frequencies: which are essential for enhancing synaptic strength [ref]

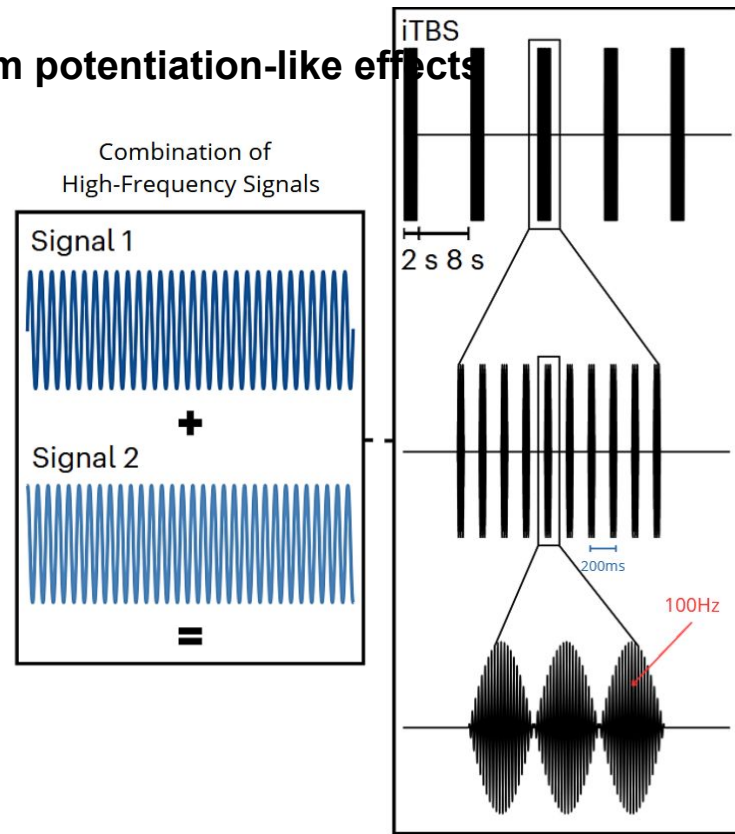
- **Signal 1:** 2.0 kHz.
- **Signal 2:** 2.1 kHz.

Patterned Stimulation:

- **Delivery:** A train of theta-burst pulses (2 s long) was repeated every 10 s.

Structure of Each Burst

- **Pulses:** 3 pulses of amplitude-modulated current at **100 Hz**.
- **Interval:** Bursts delivered at **5 Hz**, 200 ms interval

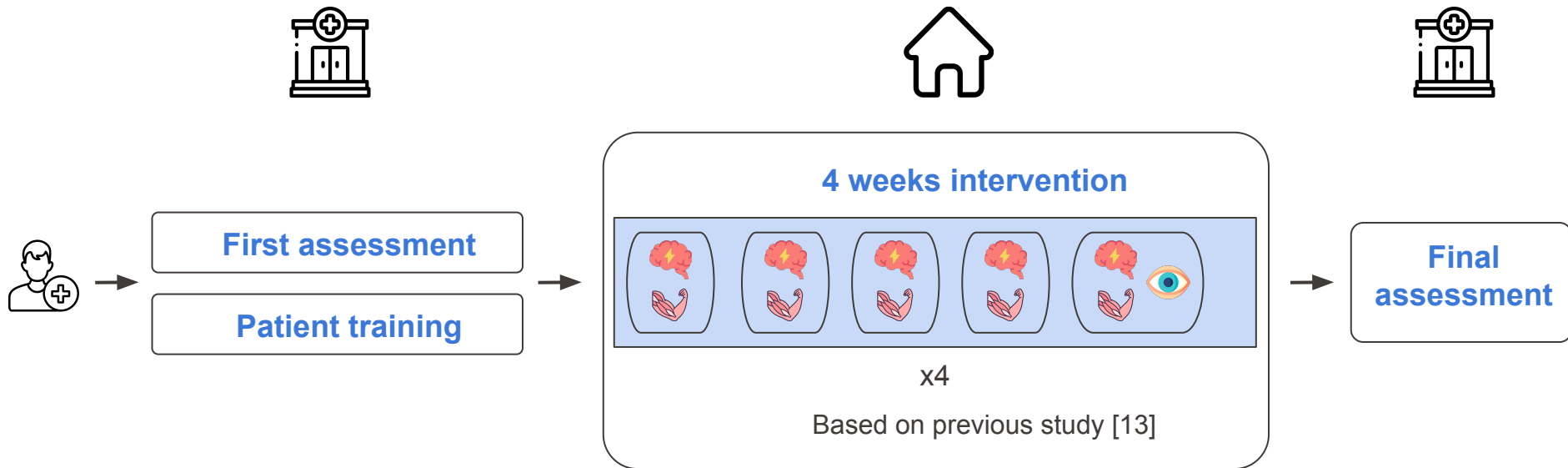


Study population and control groups

Inclusion / exclusion criteria :

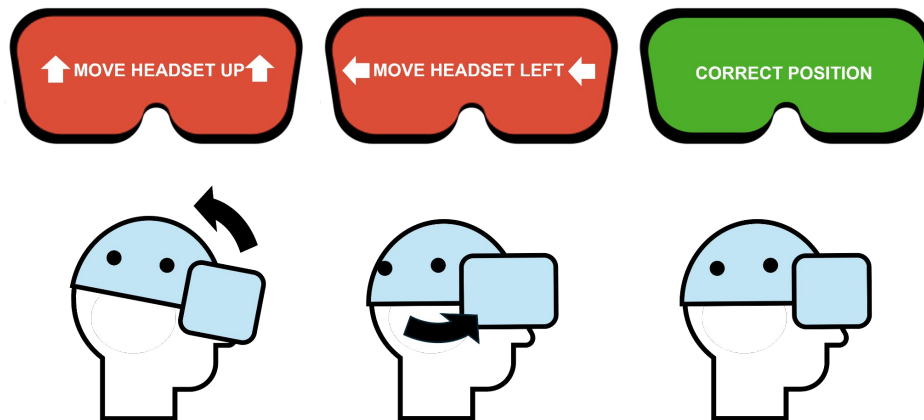
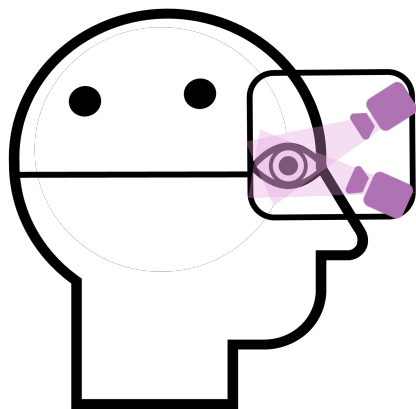
- Inclusion (based on [12]):
 - Over 18 years old
 - hemiparesis of the arm due to cerebrovascular ischemia
 - Subacute stroke (max. 100 days after stroke)
- Exclusion :
 - Drugs
 - History of seizures / epilepsy

	Group 1	Group 2	Group 3	Group 4
Apathy	✓		✓	
VR physical therapy	✓	✓	✓	✓
TI	✓	✓		

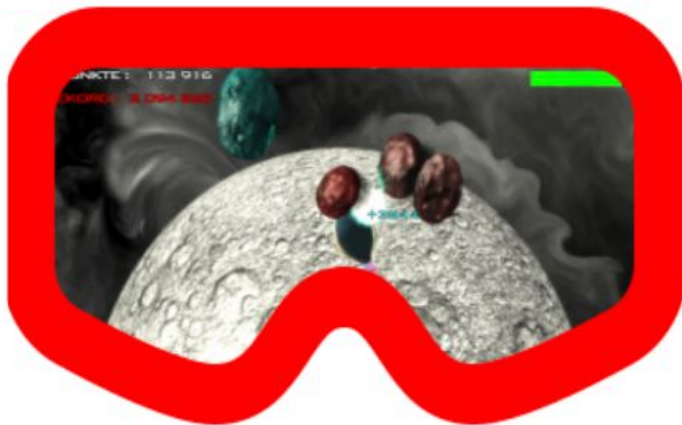


tTIS electrode placement

- VR headpieces have integrated holes for tTIS electrode placement
- The location of the holes will be adjusted for each patient at the beginning of the study
- Sensors detect position of VR headset in relation to the anatomical position of the eye for real-time adjustment feedback

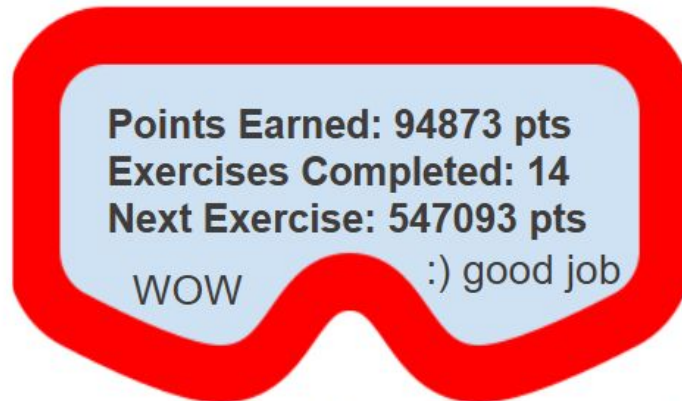


Exercise Time - Gameplay



Rest Time - Reward Information

8



2 s
tTIS

2 s
tTIS

2 s
tTIS

Exercise Time (Effort Stimuli)

- Patient performs the rehabilitation exercise as instructed by the VR video game protocol

Rest Time (Reward Stimuli)

Performance feedback:

- Show # of exercises completed
- Show # of points earned from last exercise
- Show motor rehabilitation progress using IMU data

Reward offer:

- Show # of points available for next exercise

30 s

30 s

x6

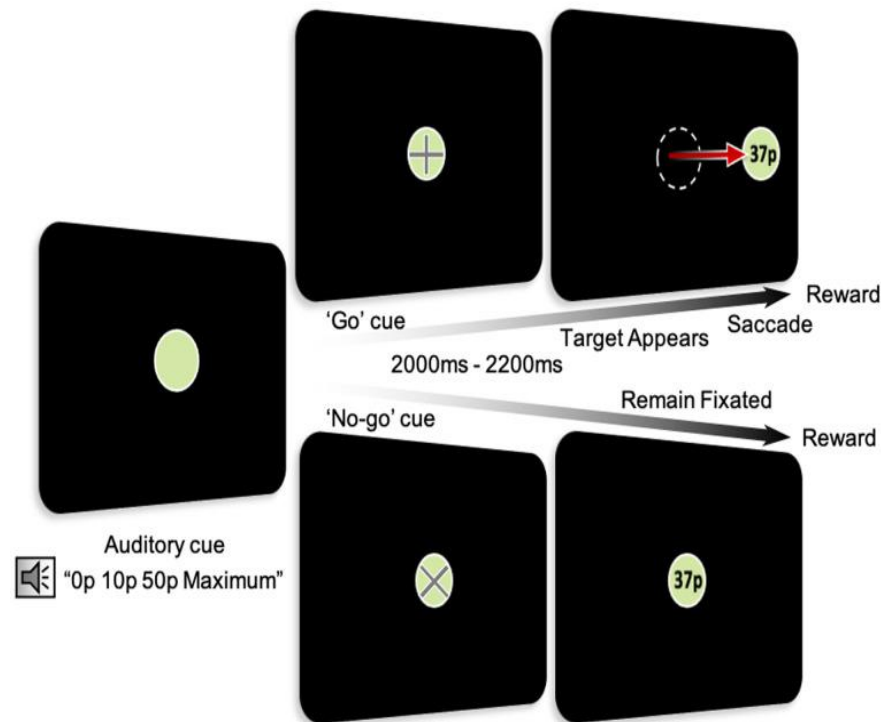
x10

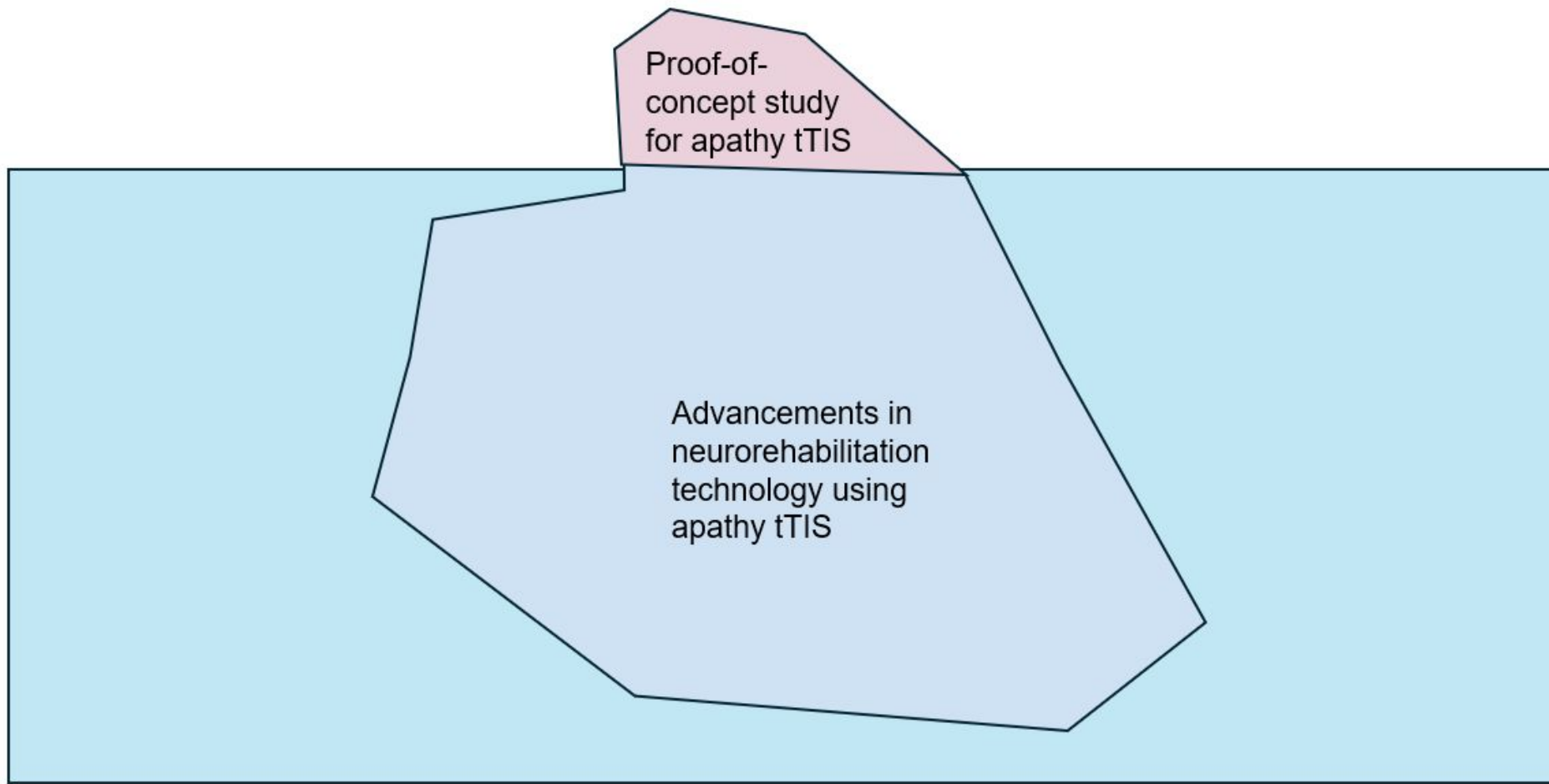
Primary measurement : reward sensitivity

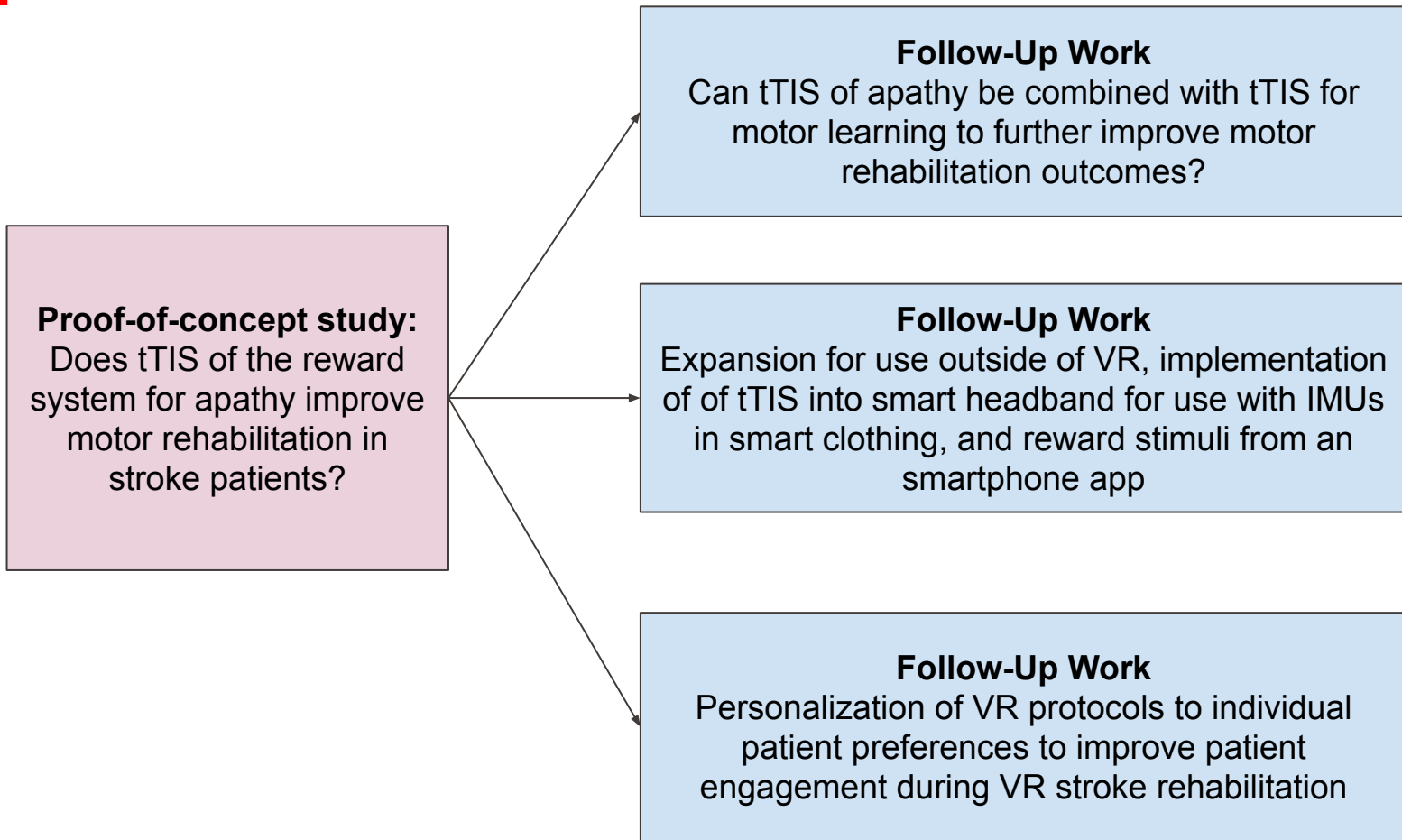
- Once a week at the beginning of the session
- Protocol based on previous studies [15] [16]
- Measurement : pupil dilation when receiving reward feedback after task

Secondary measurement : motor function

- IMUs
- Fugl-Meyer Assessment and Wolf Motor Function Test





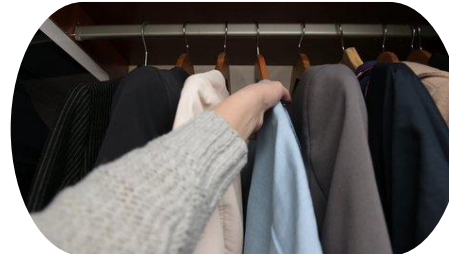




Choice of
daily activity



VR
simulation
of the
activity



Thank you.

Do you have any questions ?

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References - images

- [1] [The neurobiology of apathy in depression and neurocognitive impairment in older adults: a review of epidemiological, clinical, neuropsychological and biological research | Translational Psychiatry](#)
- [2] [Lec 8 - Basal Ganglia | Flashcards](#)
- [3] <https://en.wikipedia.org/wiki/Striatum>
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- [4] <https://jnnp.bmj.com/content/90/3/302>