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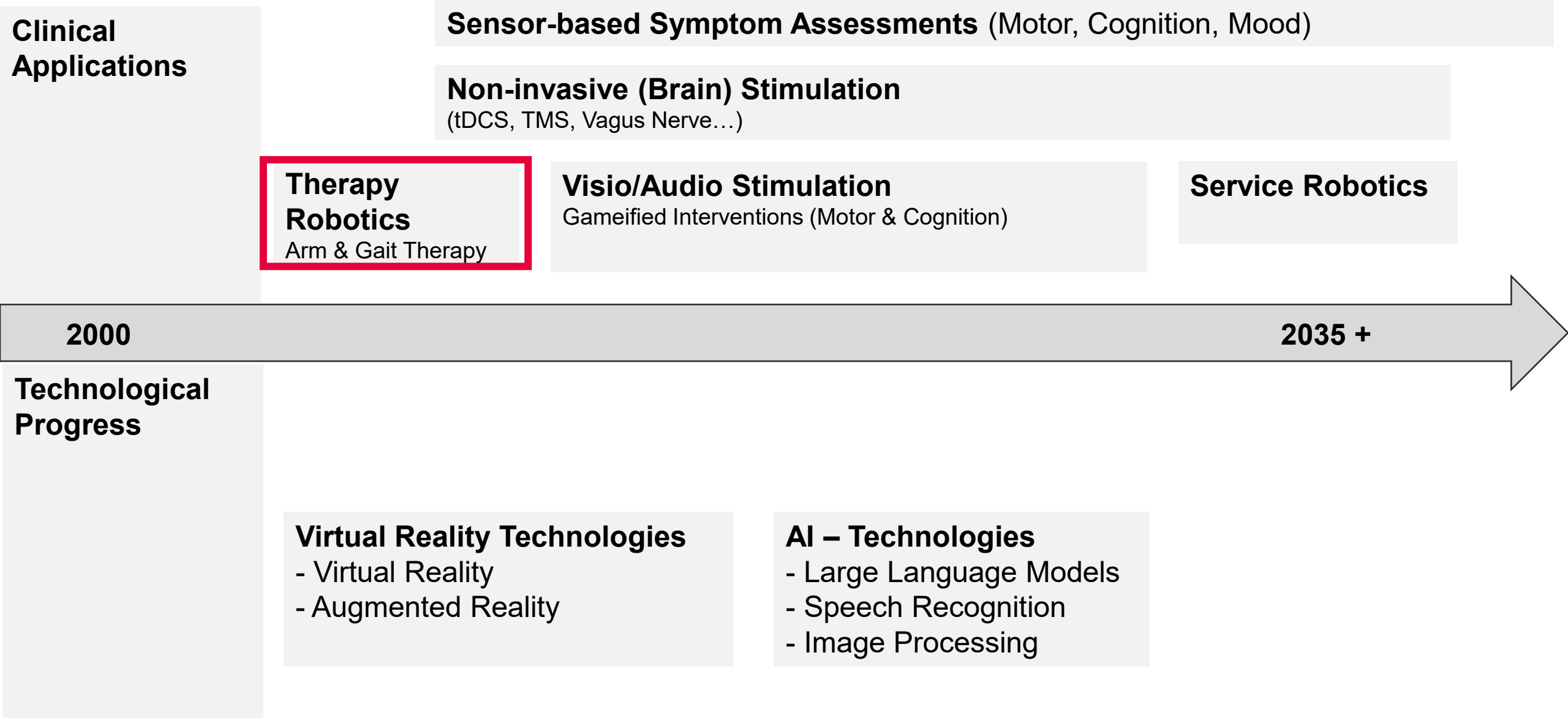
Post-stroke rehabilitation supported by digital tools, robots and telemedicine

Prof. Dr. Tobias Nef

Gerontechnology and Rehabilitation

ARTORG Center for Biomedical Engineering Research, **University of Bern**
Department of Neurology, **University Hospital Inselspital Bern**

Technology Trends & Neurorehabilitation





Nef T et al. Medical & Biological Engineering & Computing, 2013
Klamroth-Marganska et al. Lancet Neurology, 2014

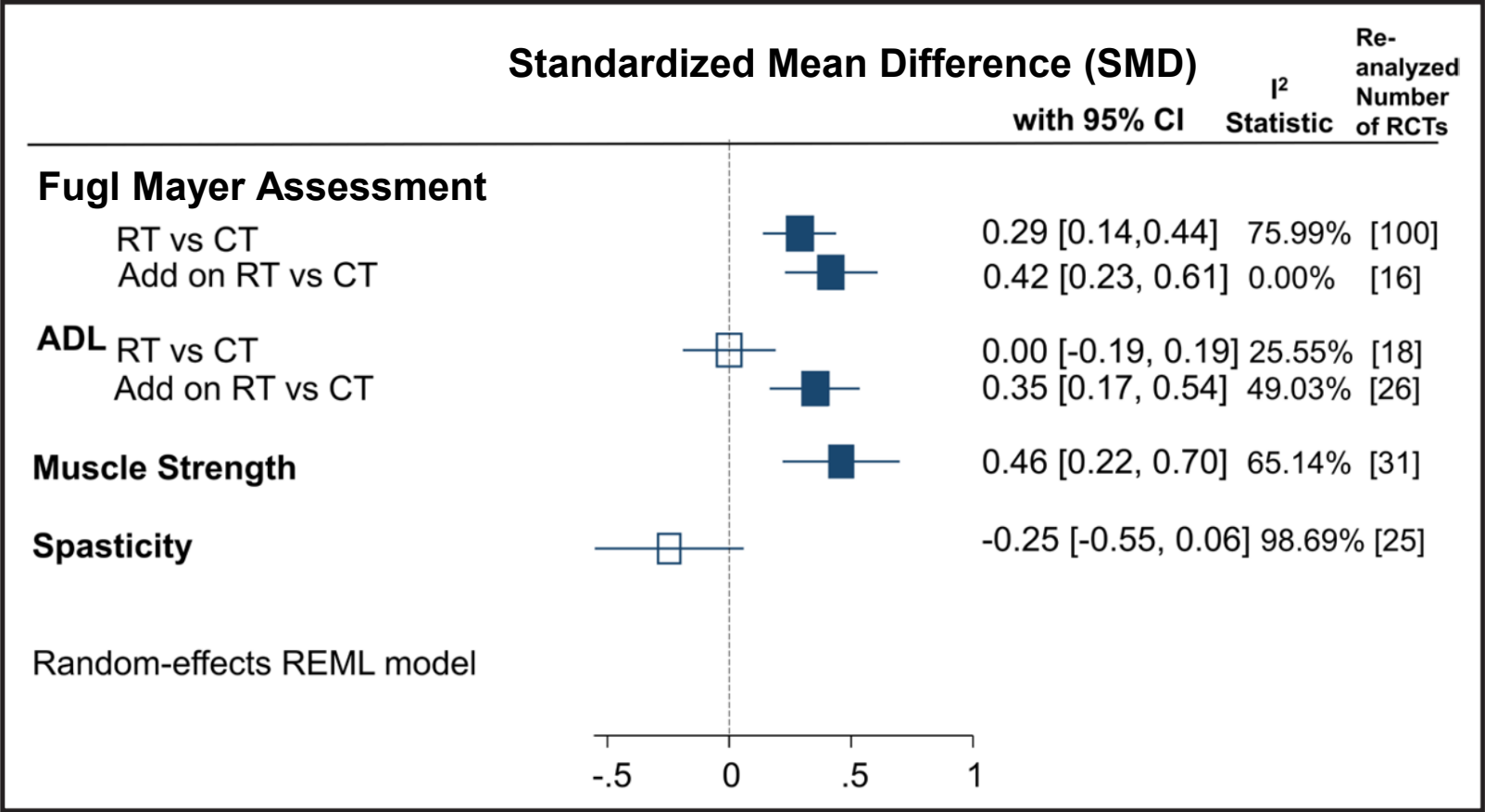


Jezernik S, Colombo G, et al., Neuromodulation, 2003

Jong Mi Park¹, MD^{*}; Hee Jae Park², MD^{*}; Seo Yeon Yoon³, MD, PhD; Yong Wook Kim⁴, MD, PhD; Jae Il Shin⁵, MD, PhD†; Sang Chul Lee⁶, MD, PhD†

SMD	Interpretation
0.2	kleiner Effekt
0.5	mittlerer Effekt
0.8	großer Effekt

I ²	Bedeutung
0–25 %	geringe Heterogenität
25–50 %	moderate
50–75 %	hohe
>75 %	sehr hohe Heterogenität



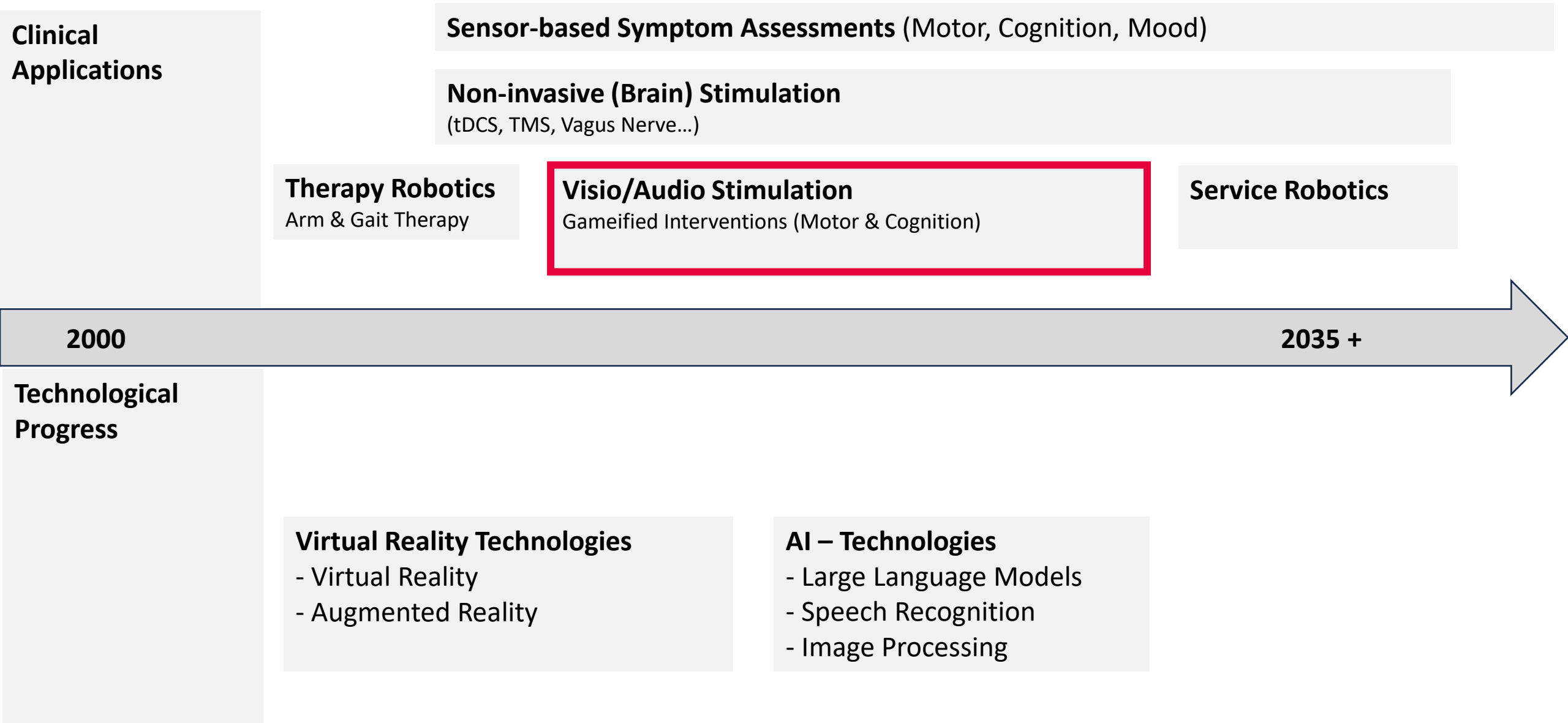
Conclusion

Robot-assisted therapy shows statistically significant improvements in motor function and muscle strength, but below the threshold of minimal clinically important change.

No adverse effects were found.

RT : Robot-assisted Therapy
CT : Conventional Therapy
ADL: Activities of Daily Living

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Immersive VR

Immersive VR

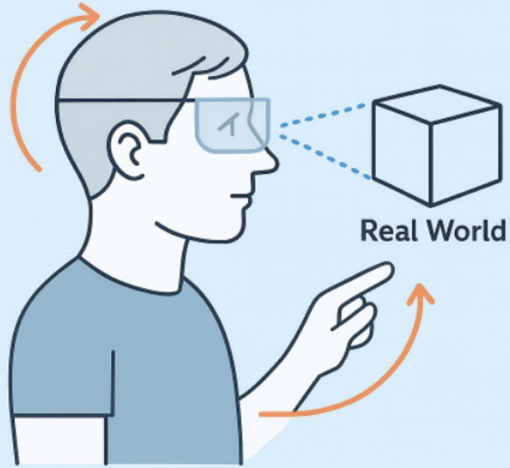


**Activities of daily
living training**



Augmented Reality

Augmented Reality



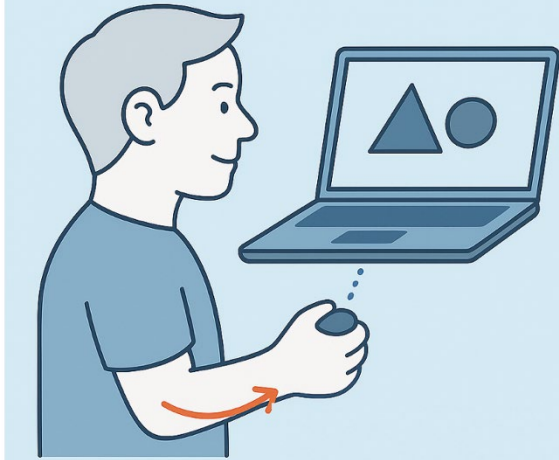
Motor-Cognitive Training



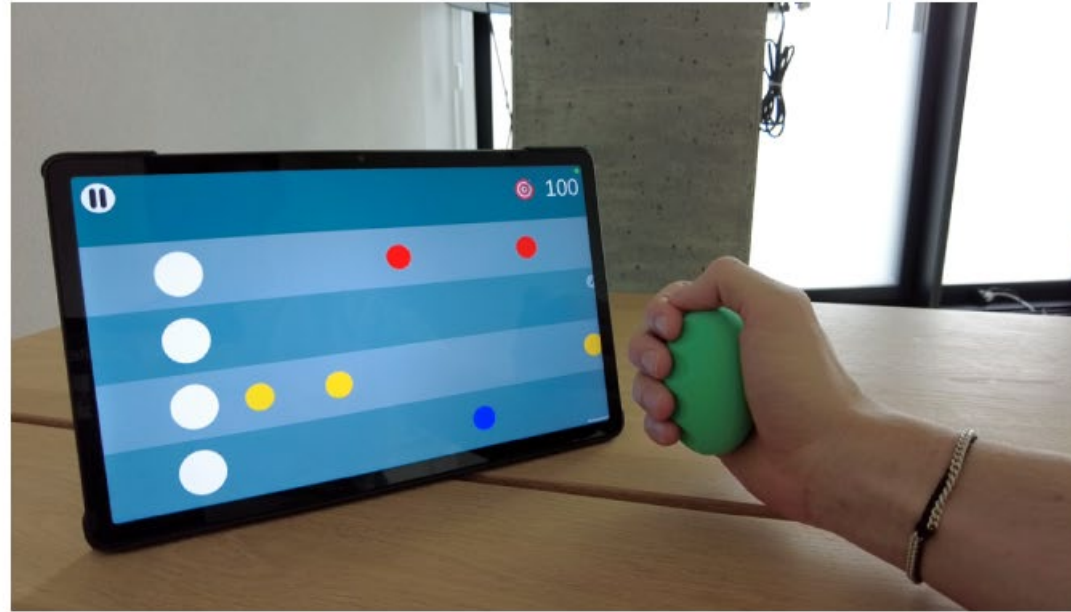
Source: *Stroll.co*
Melvyn Roerdink, VU Amsterdam
Tim VanBellingen, University of Bern

Fine Motor Function of the Hand

Finger Force Input

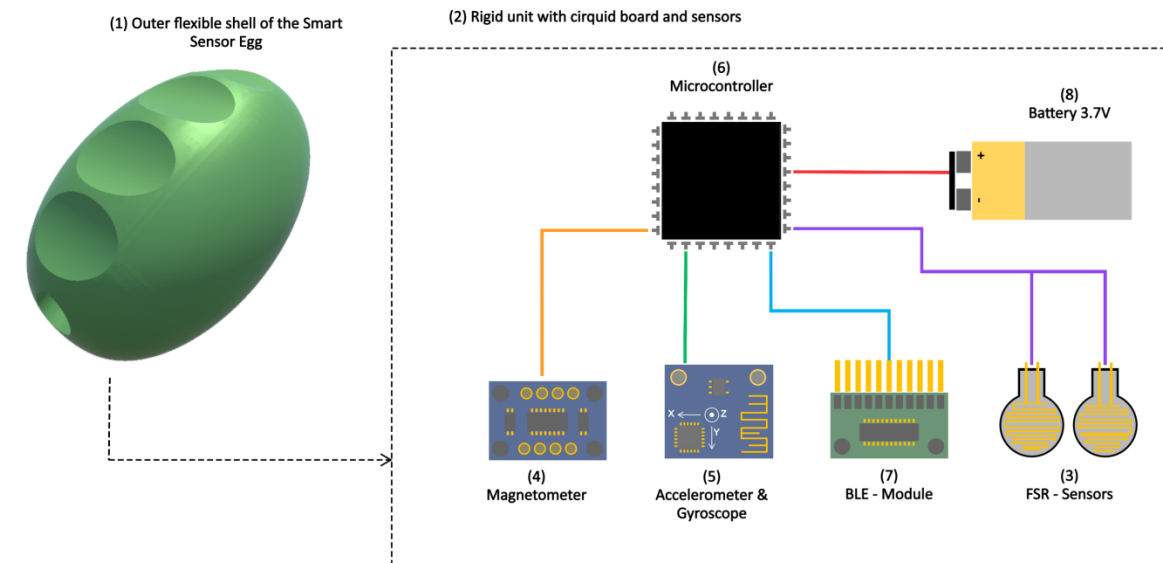
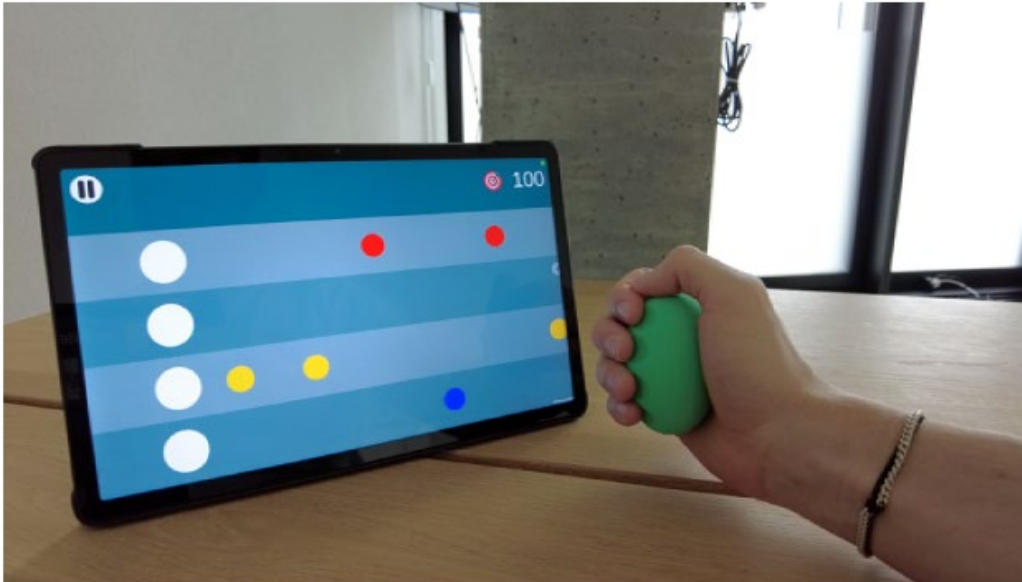


Finger Dexterity Training



Fine Motor Function of the Hand

Silicone “Egg” with Sensors

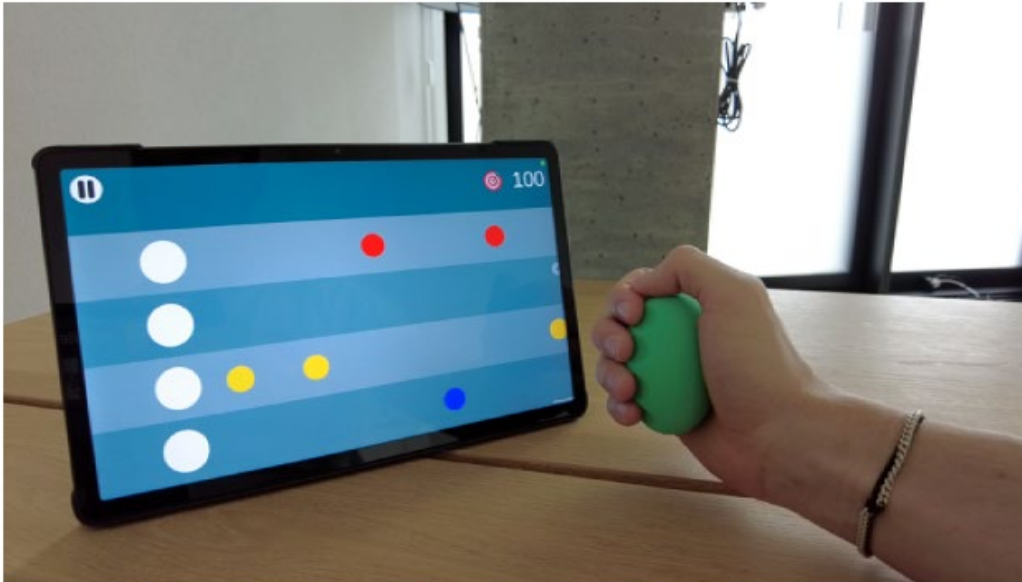


N. Krummenacher et al. Sensors, 2025

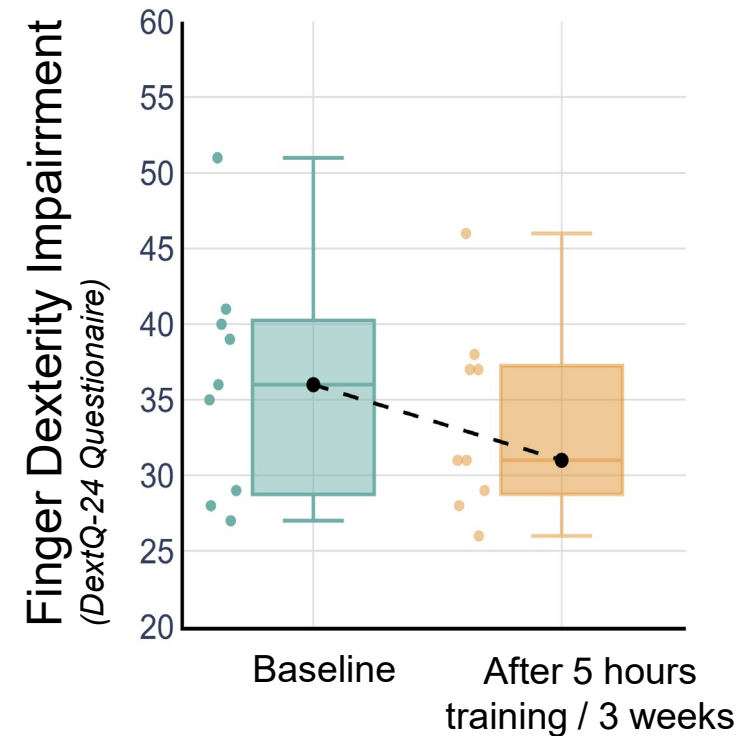
N. Krummenacher et al. European Patent Office, 2024

Fine Motor Function of the Hand

Silicone “Egg” with Sensors



9 Persons with Parkinson's Disease



Mean Age (years): 67 (64-72)
Gender: 2 female, 7 male
Normal cognitive abilities

N. Krummenacher et al. Sensors, 2025

N. Krummenacher et al. European Patent Office, 2024

Virtual Reality



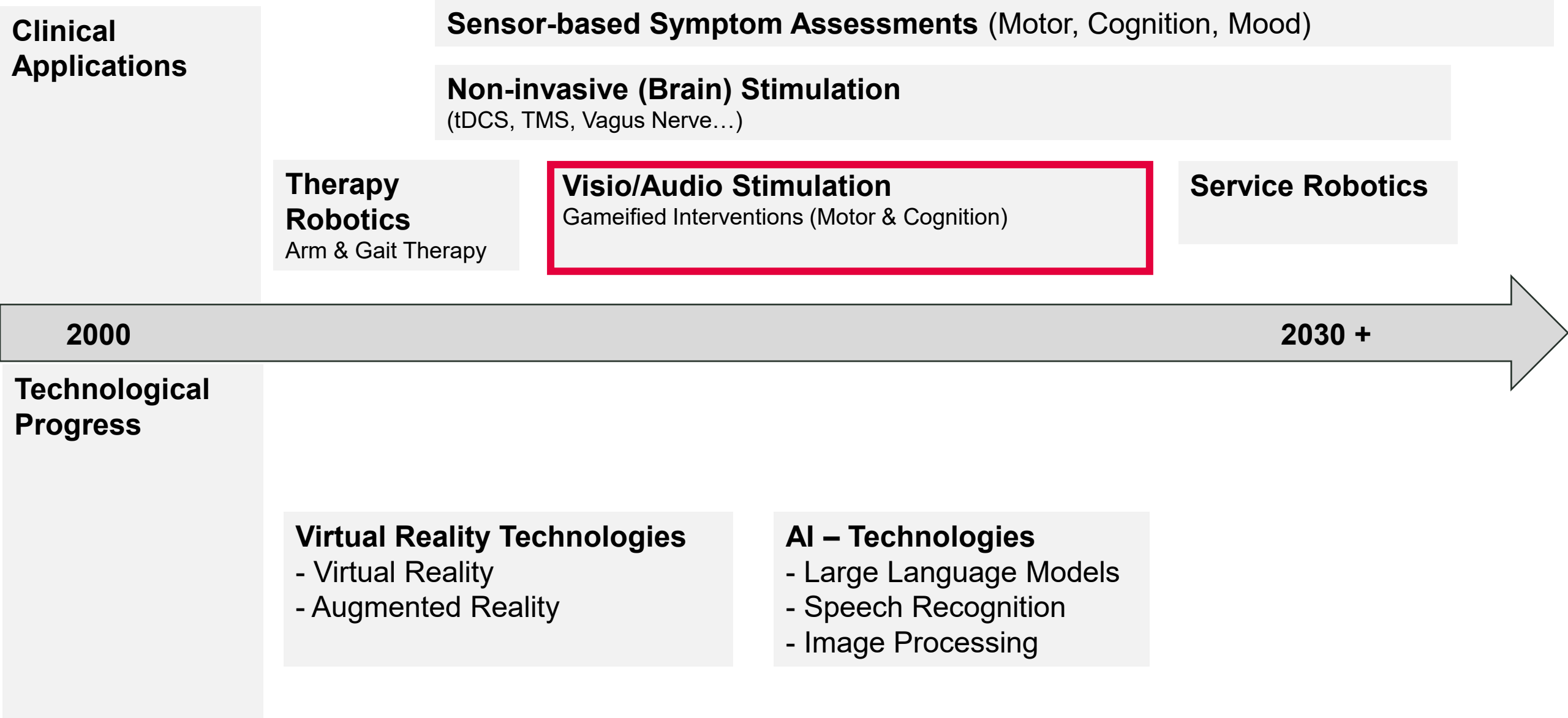
Published

20 June 2025

Laver KE, Lange B, George S, Deutsch JE, Saposnik G, Chapman M, Crotty M

- Main finding: VR probably improves arm and hand function slightly compared with conventional therapy.
- When VR is used **in addition** to usual therapy — extending total therapy time — the effects on arm function tend to be larger.
- Possible positive effects are also seen for balance and activities of daily living (ADL). However, data on gait speed, mobility, participation and quality of life are uncertain or inconsistent.

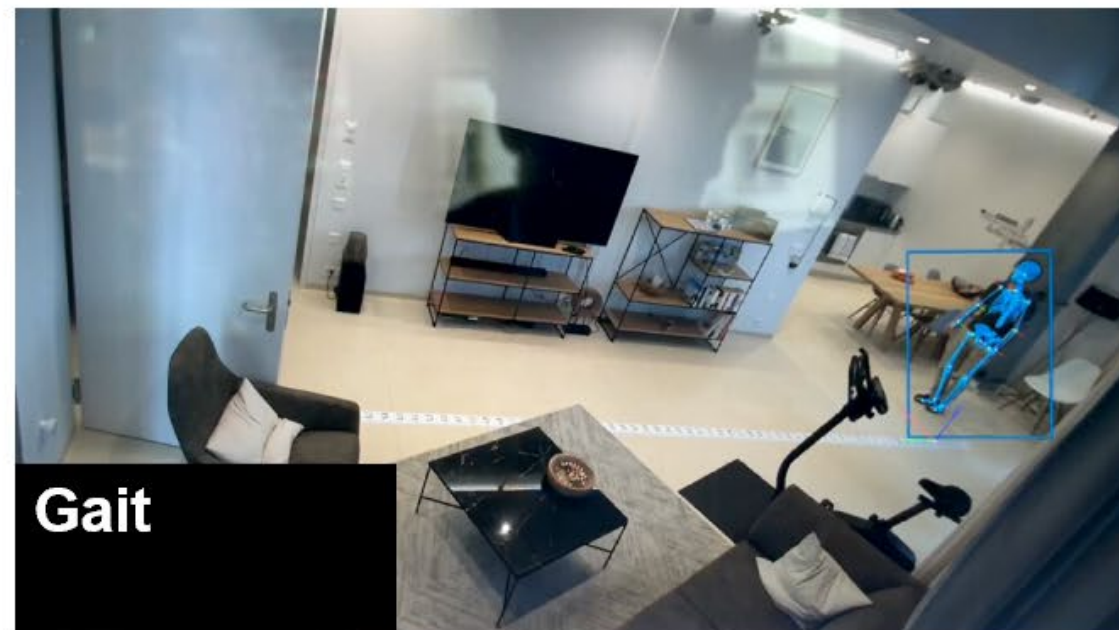
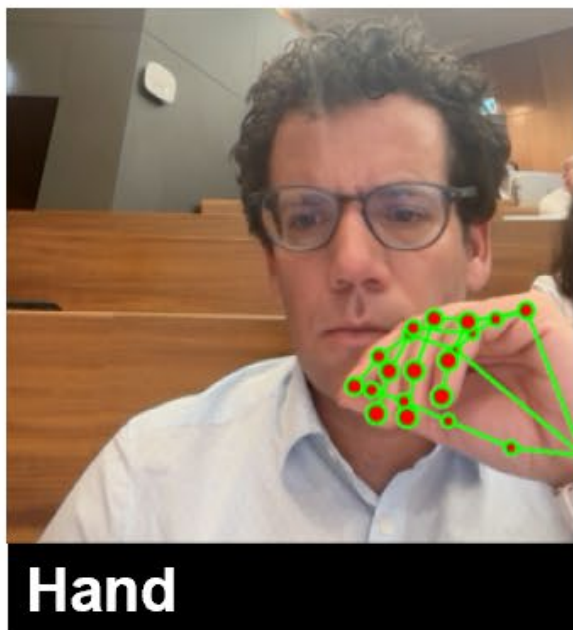
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Virtual Reality



Video-based Motion Tracking



Real-time on computer & smartphone

Visual Attention

Hand Tracking

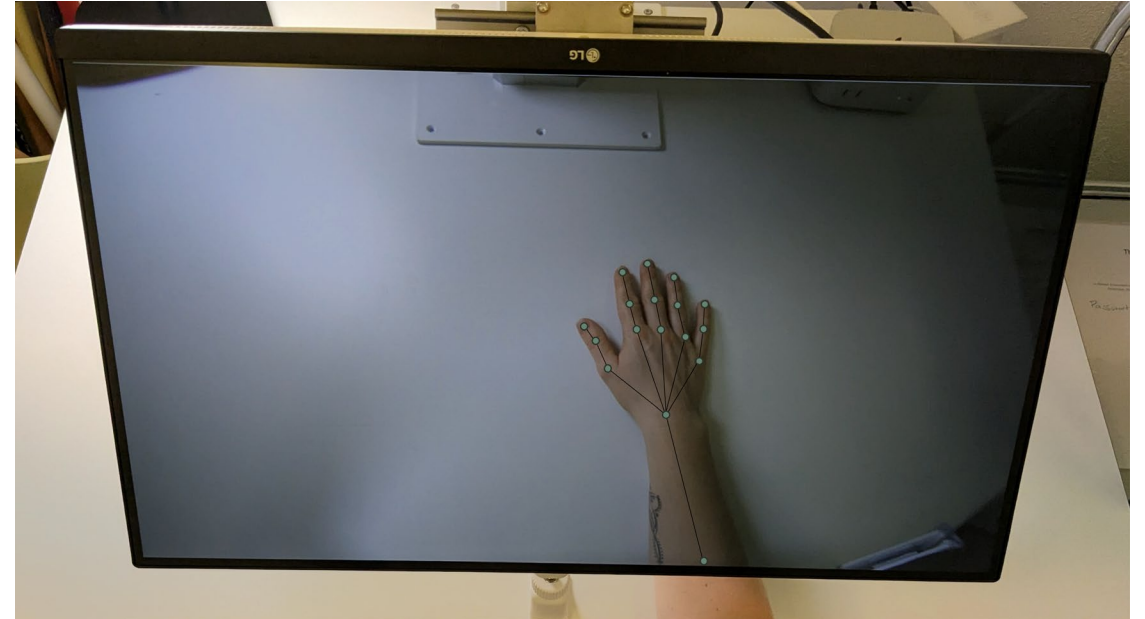


Visual Attention
Training



Digital Mirror Therapy

Current Work in Bern



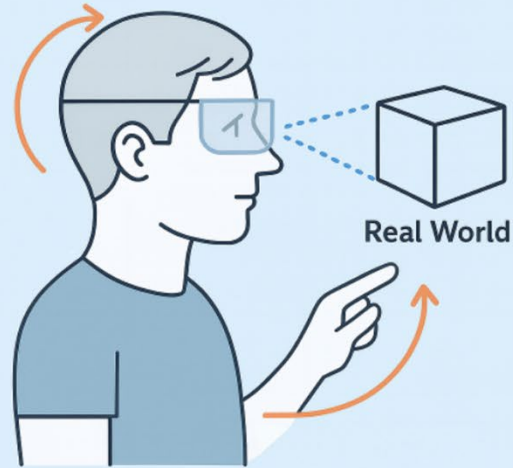
*Digital Mirror Therapy, Neurorehabilitation Bern
(J. Baumann, J. Hoppe, S. Jung et al.)*

Comparison of Methods

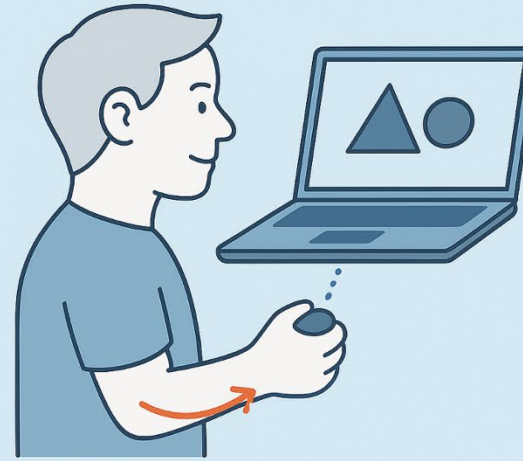
Immersive VR



Augmented Reality



Finger Force Input



Hand & Body Tracking



HIGH

Degree of Immersion

LOW

HIGH

Patient Burden and Implementation Effort

LOW

LOW

Feasibility in the Home Environment

HIGH

Immersive VR

Patients with Neglect



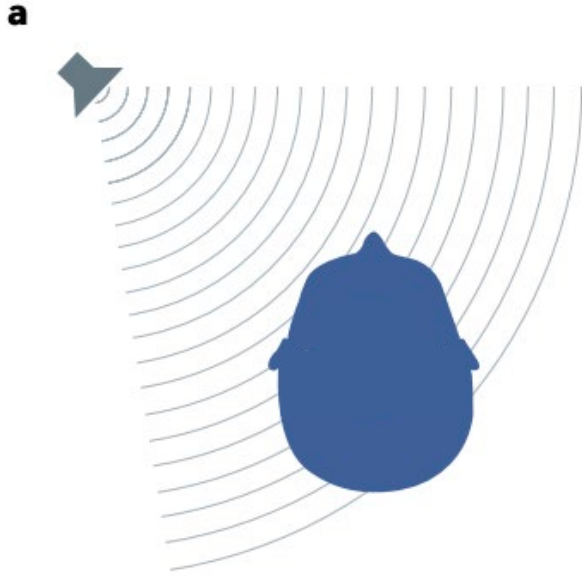
Immersive VR / Spatial Audio

Patients with Neglect



Immersive VR / Spatial Audio

Spatial Hearing

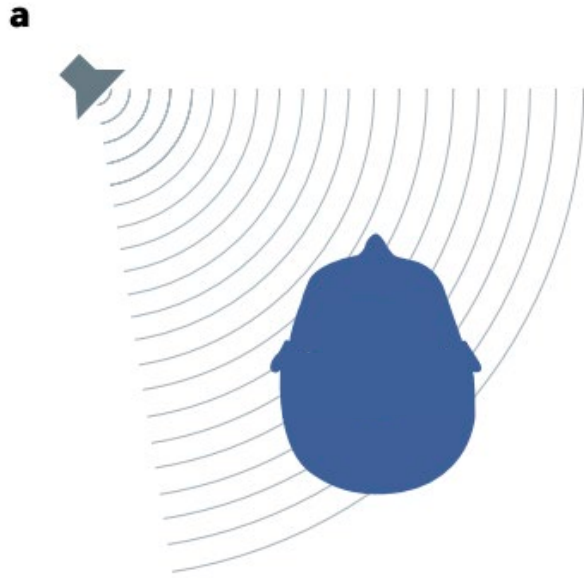


Binaural difference cues:

- Interaural time difference (low-frequency sounds)
- Interaural level difference (high-frequency sounds)

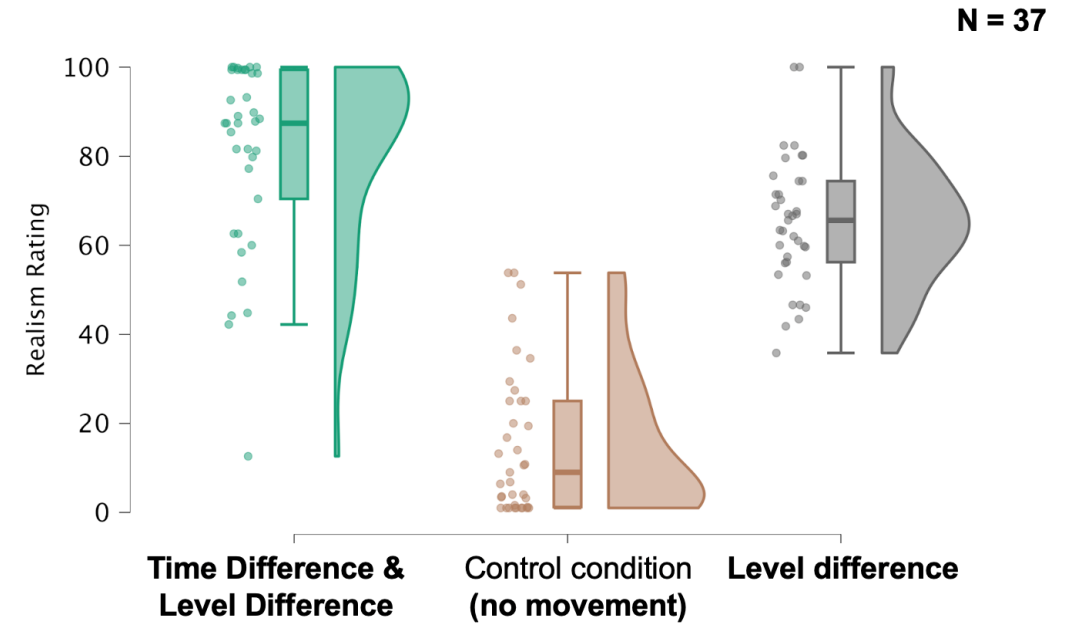
Immersive VR / Spatial Audio

Spatial Hearing



Binaural difference cues:

- Interaural time difference (low-frequency sounds)
- Interaural level difference (high-frequency sounds)



Spatial Auditory Cueing reduces neglect after Right-Hemispheric Stroke: A Proof of concept study

Kaufmann BC ^{abc}, Frey J ^a, Pflugshaupt T ^a, Knobel SEJ ^d, Nef T ^d, Müri RM ^{bd}, Cazzoli D ^{ad}, Nyffeler T ^{abd}

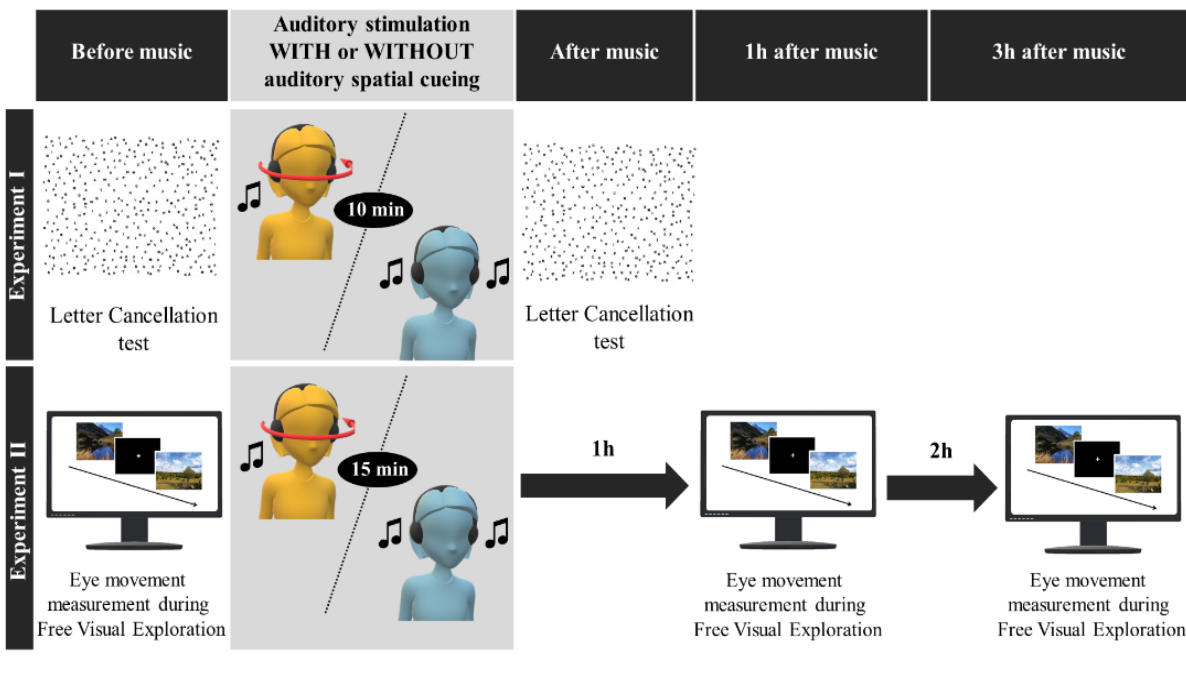
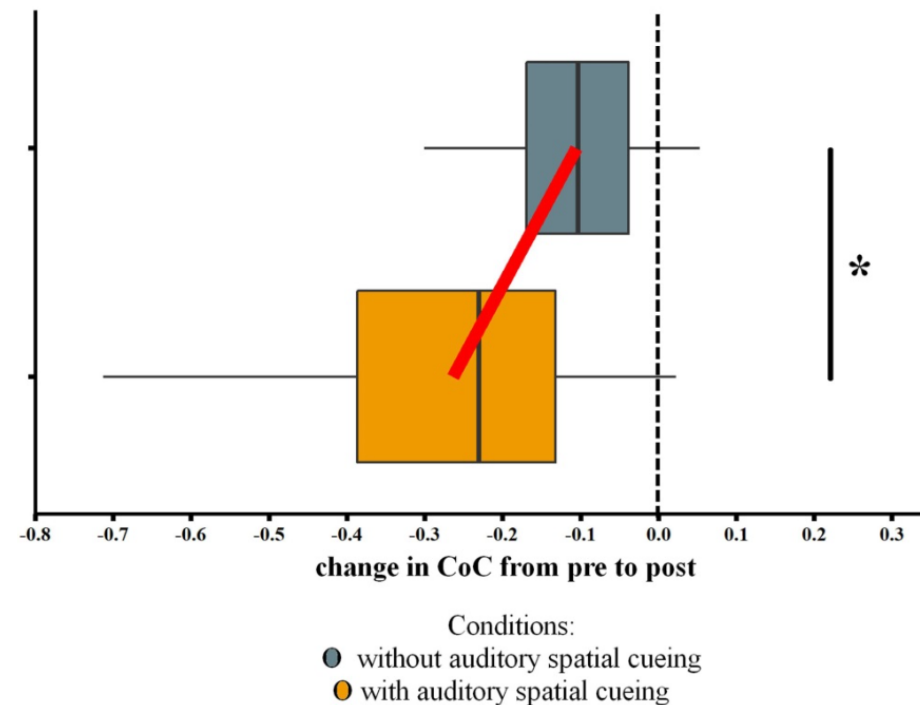
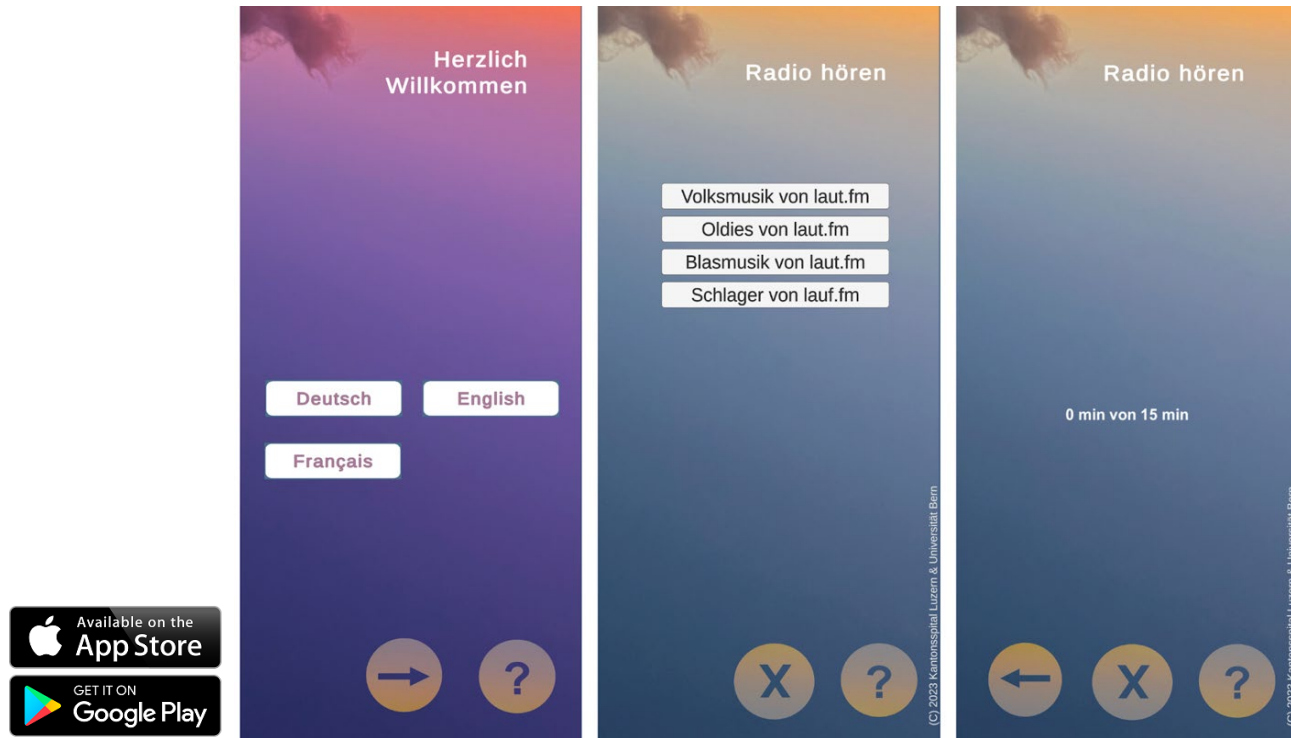


Figure 3 Change in CoC compared between stimulation conditions



Immersive VR / Spatial Audio

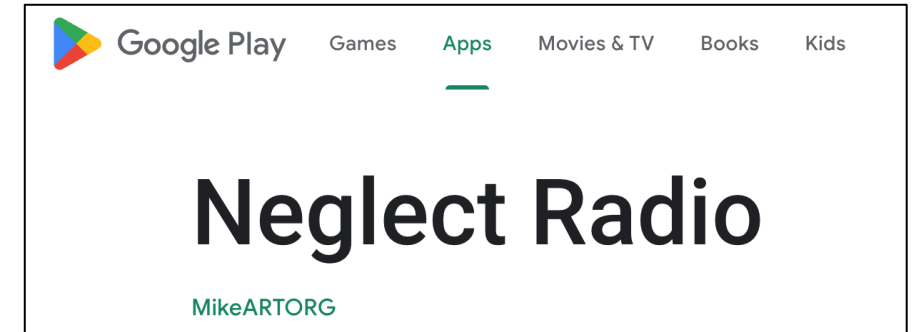
Neglect Radio App



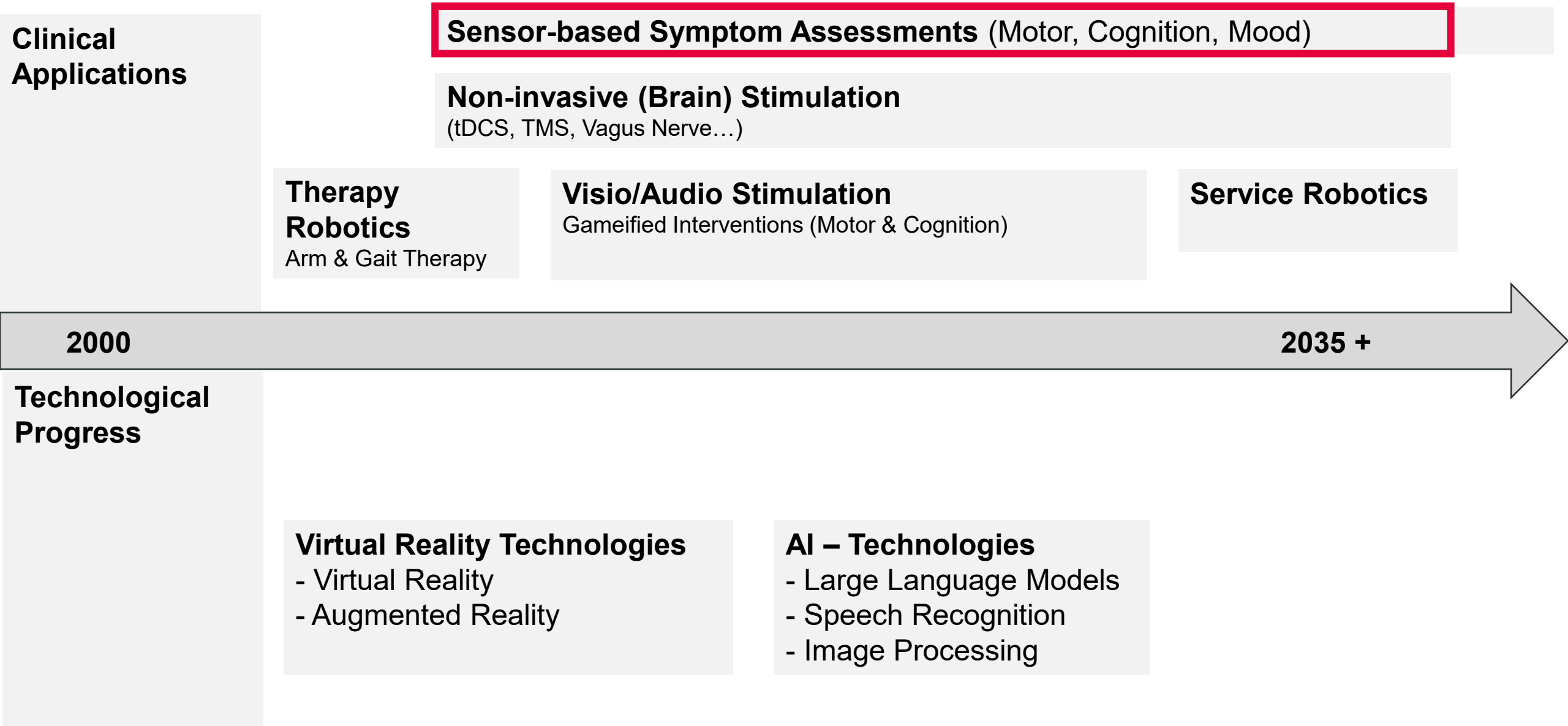
<https://apps.apple.com/ch/app/neglect-radio/id6630364857>



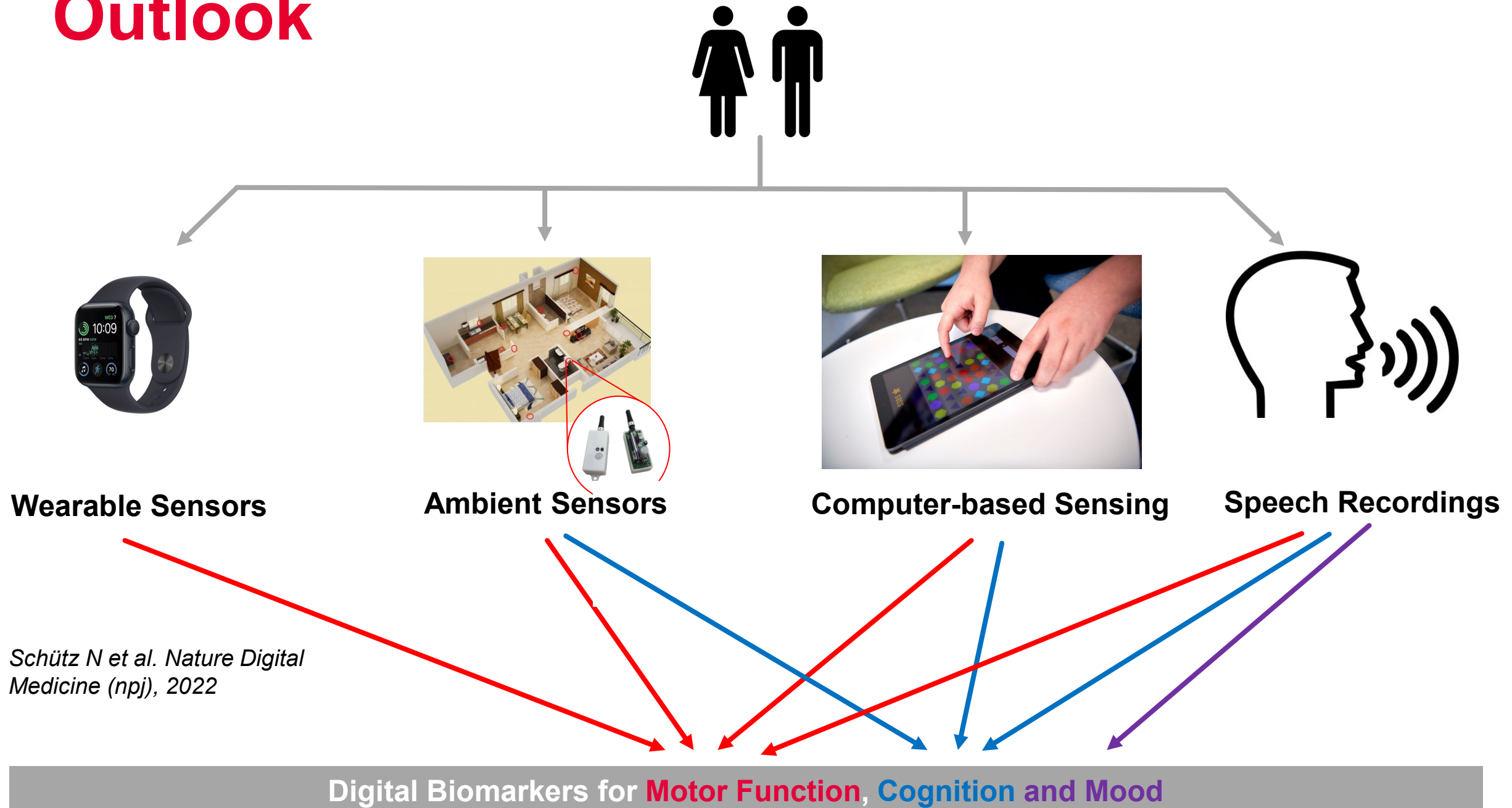
<https://play.google.com/store/apps/details?id=com.artorg.neglectRadio&hl=en>



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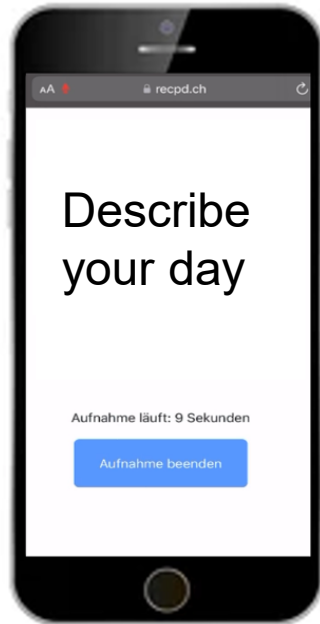
Outlook



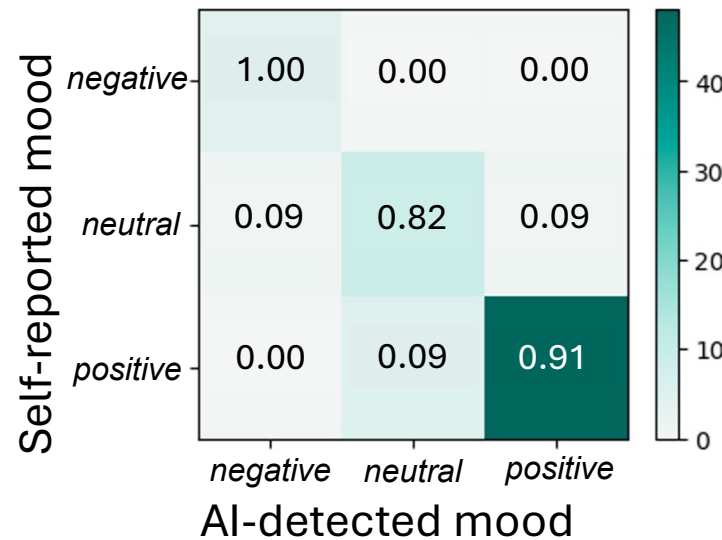
Schütz N et al. *Nature Digital Medicine* (npj), 2022

Emotion and Mood Assessments

Smartphone App to record speech

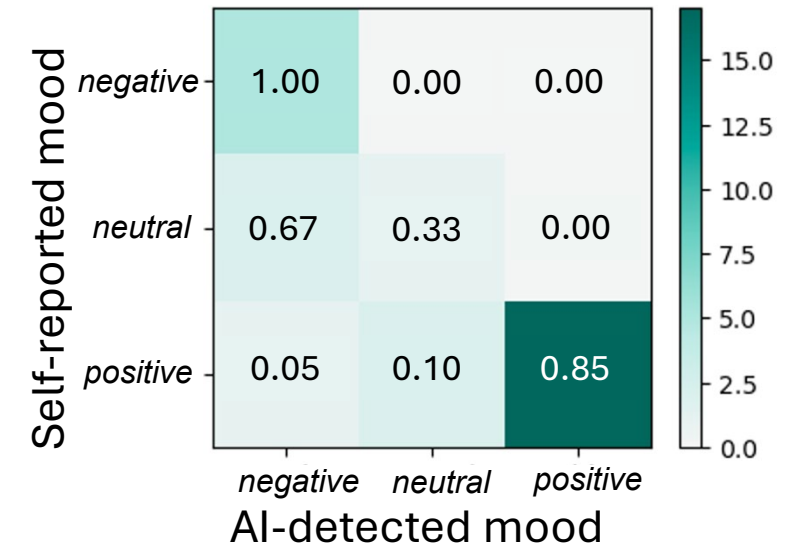


68 recordings from 22 healthy participants



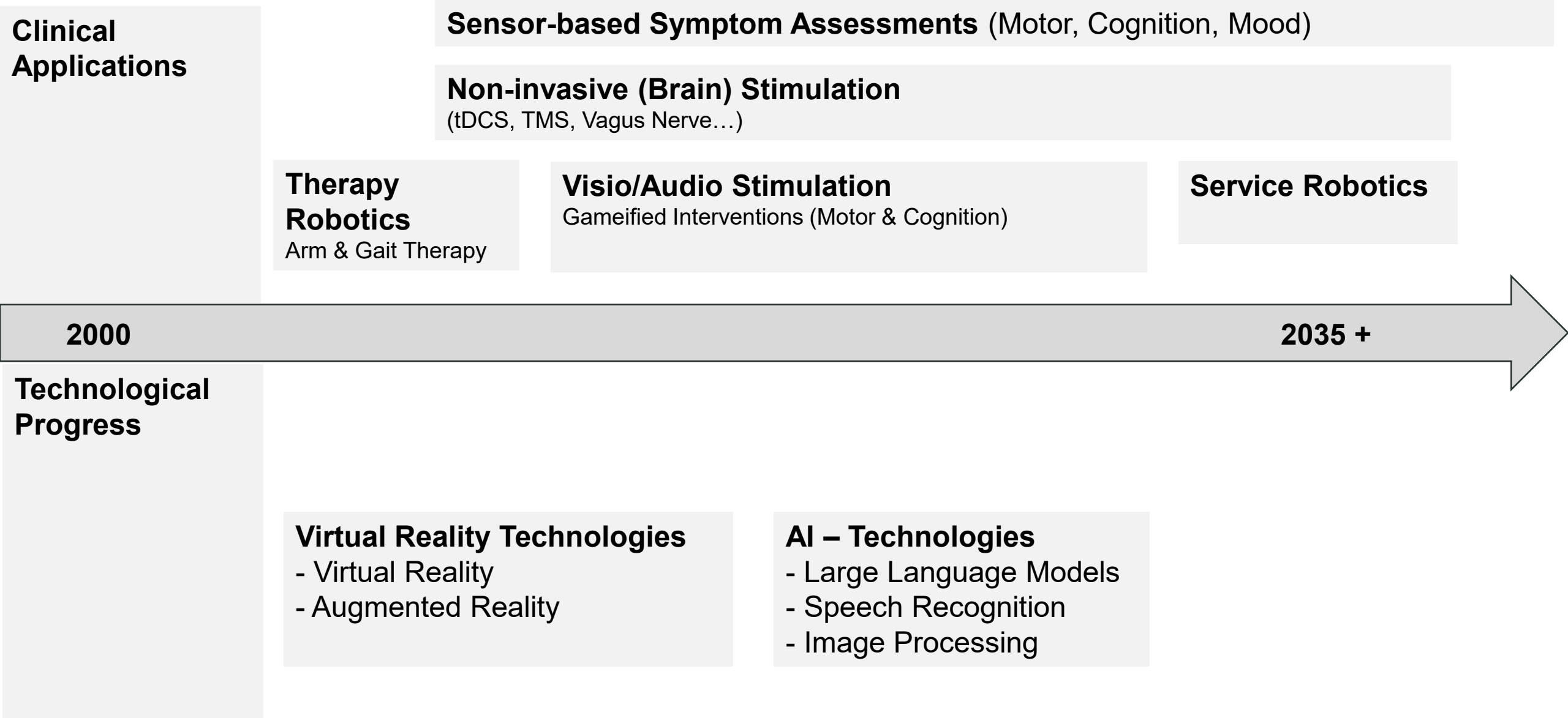
Accuracy 89.71%

28 recordings from 7 PD patients



Accuracy 82.14%

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Thank you

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BERN

INSELGRUPPE siteminsel



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