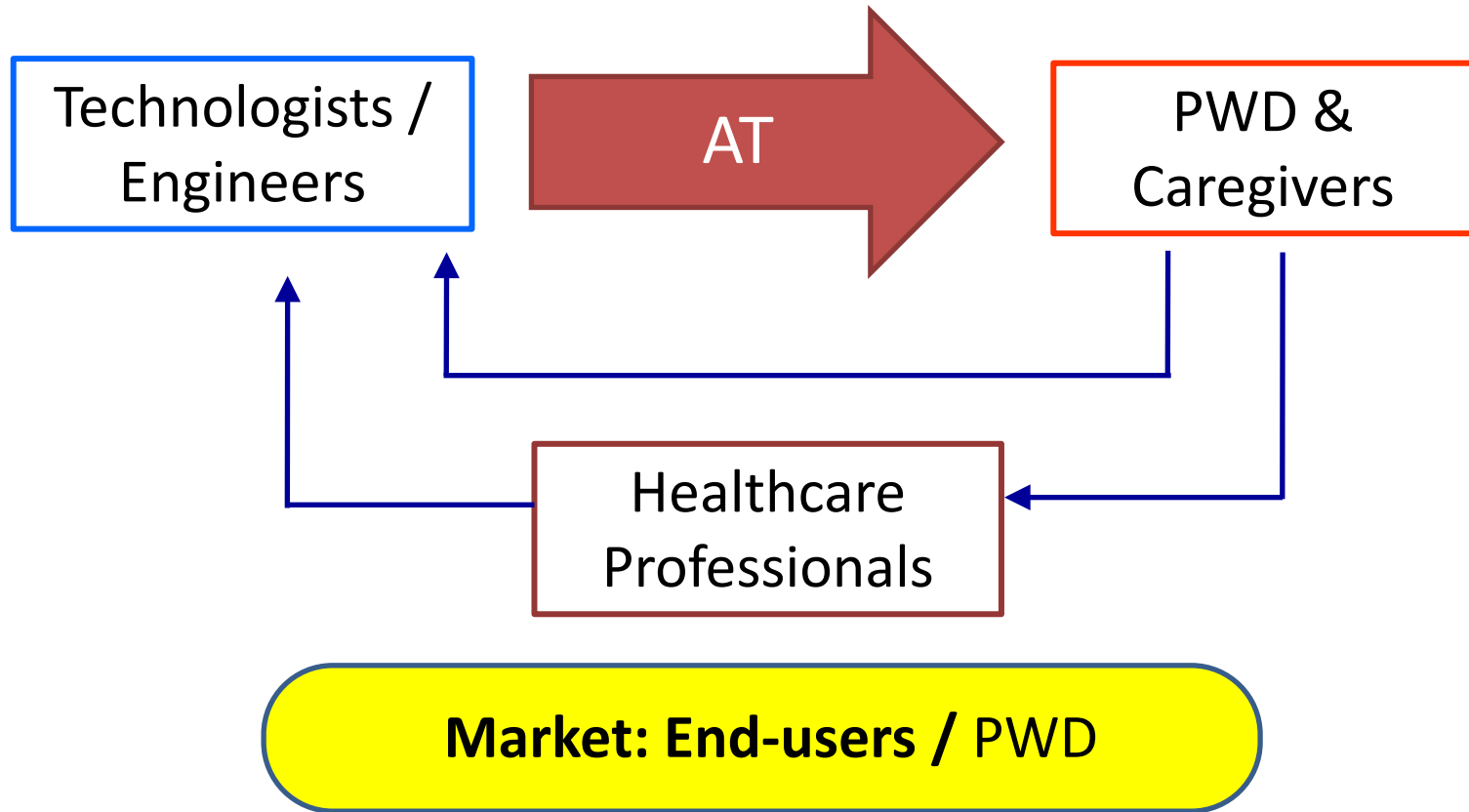# Research & Development of Rehabilitation Technology in Singapore

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Assistive Technology

Technologists / Engineers → **AT** → PWD & Caregivers

Healthcare Professionals

Market: End-users / PWD

Rehabilitation Technology

Market: Healthcare Professionals
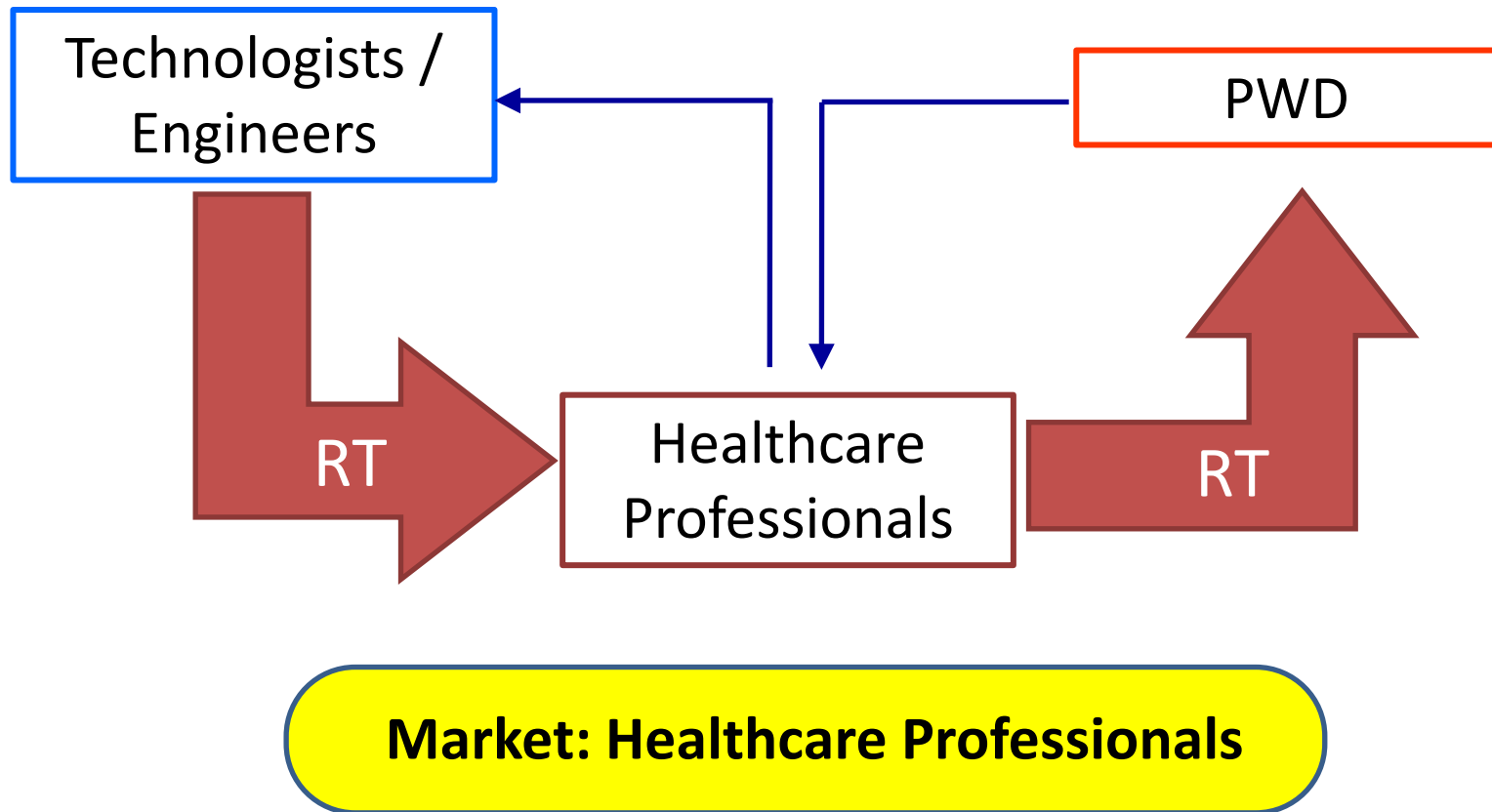
Rehabilitation Robots

Upper Limb Robot

MIT Manus

Lower Limb Robot

Lokomat

Brain-Computer Interface (BCI) & Functional Electrical Stimulations (FES)

BCI-controlled
FES

G. Pfurtscheller, et al, Austria, 2000
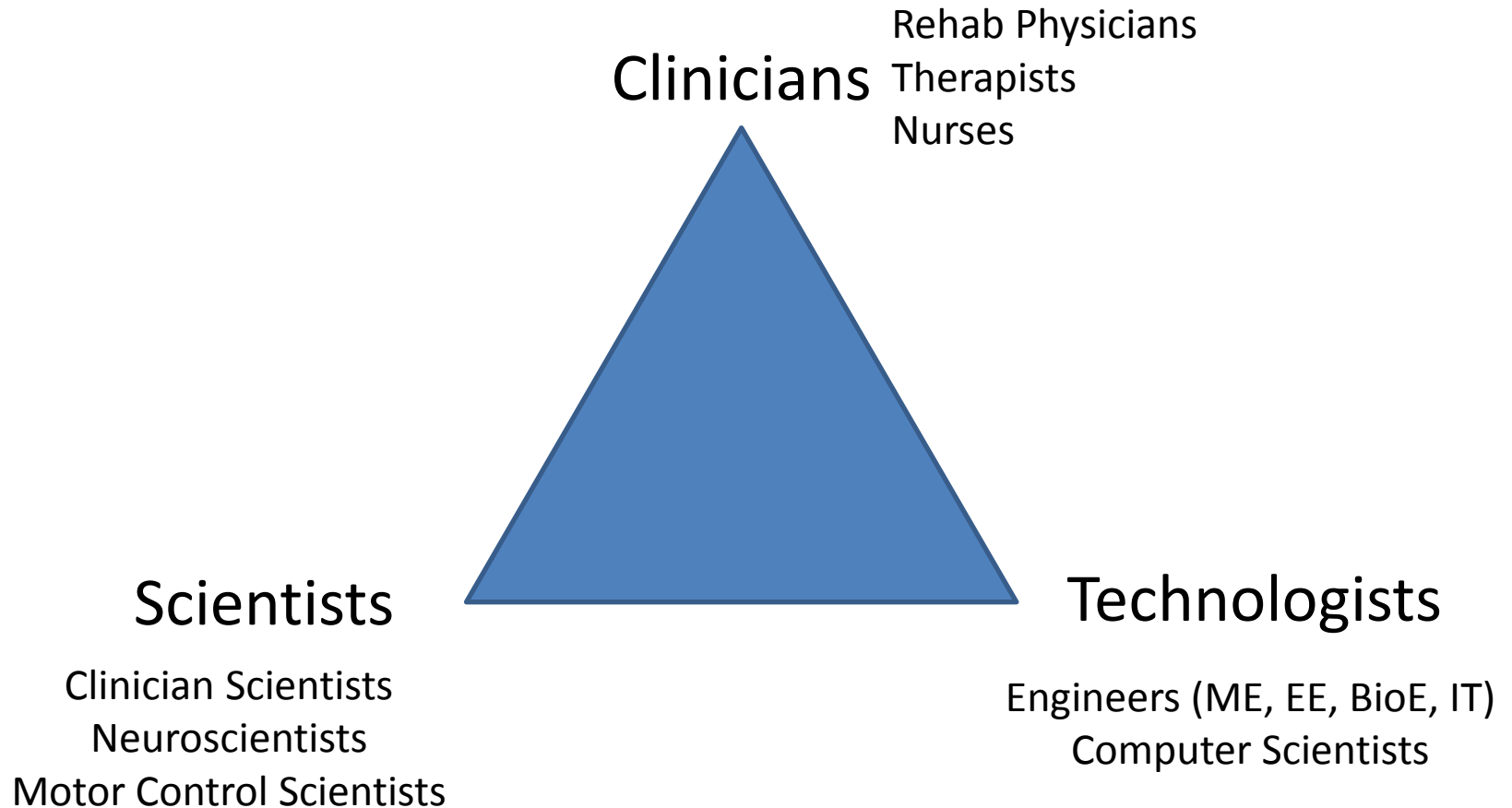
Mixed Reality Rehabilitation

MIXED REALITY (MR)

REAL ENVIRONMENT

AUGMENTED REALITY (AR)

AUGMENTED VIRTUALITY (AV)

VIRTUAL ENVIRONMENT
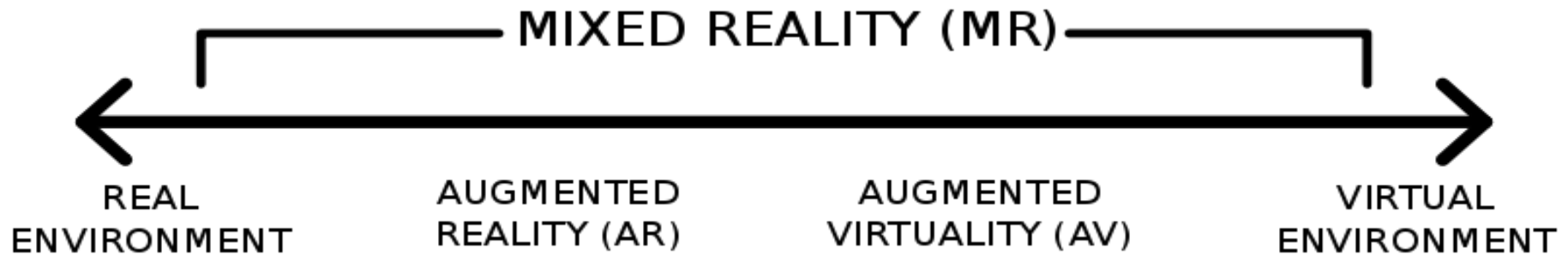
Interactive Rehabilitation and EXercise system (IREX)

Wii-Hab

Rehabilitation R&D Partnerships

Clinicians

Rehab Physicians
Therapists
Nurses

Scientists

Technologists

Clinician Scientists
Neuroscientists
Motor Control Scientists

Engineers (ME, EE, BioE, IT)
Computer Scientists

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Rehabilitation R&D Project Types

Clinicians ← → Technologists

Rehabilitation Practice

- Principal Investigator
  - Usually Clinicians (MBBS, MD, PhD)
- Scope
  - Validate new treatment/protocol with existing technology
  - Clinical trials (Phase 0-2)
- Outcome
  - Publications
  - New treatments, new protocols

Rehabilitation Technology

- Principal Investigator
  - Technologists (PhD) & Clinicians
- Scope
  - New gadget, equipment, system
  - Healthy subject trials
  - Clinical trials (Phase 0)
- Outcome
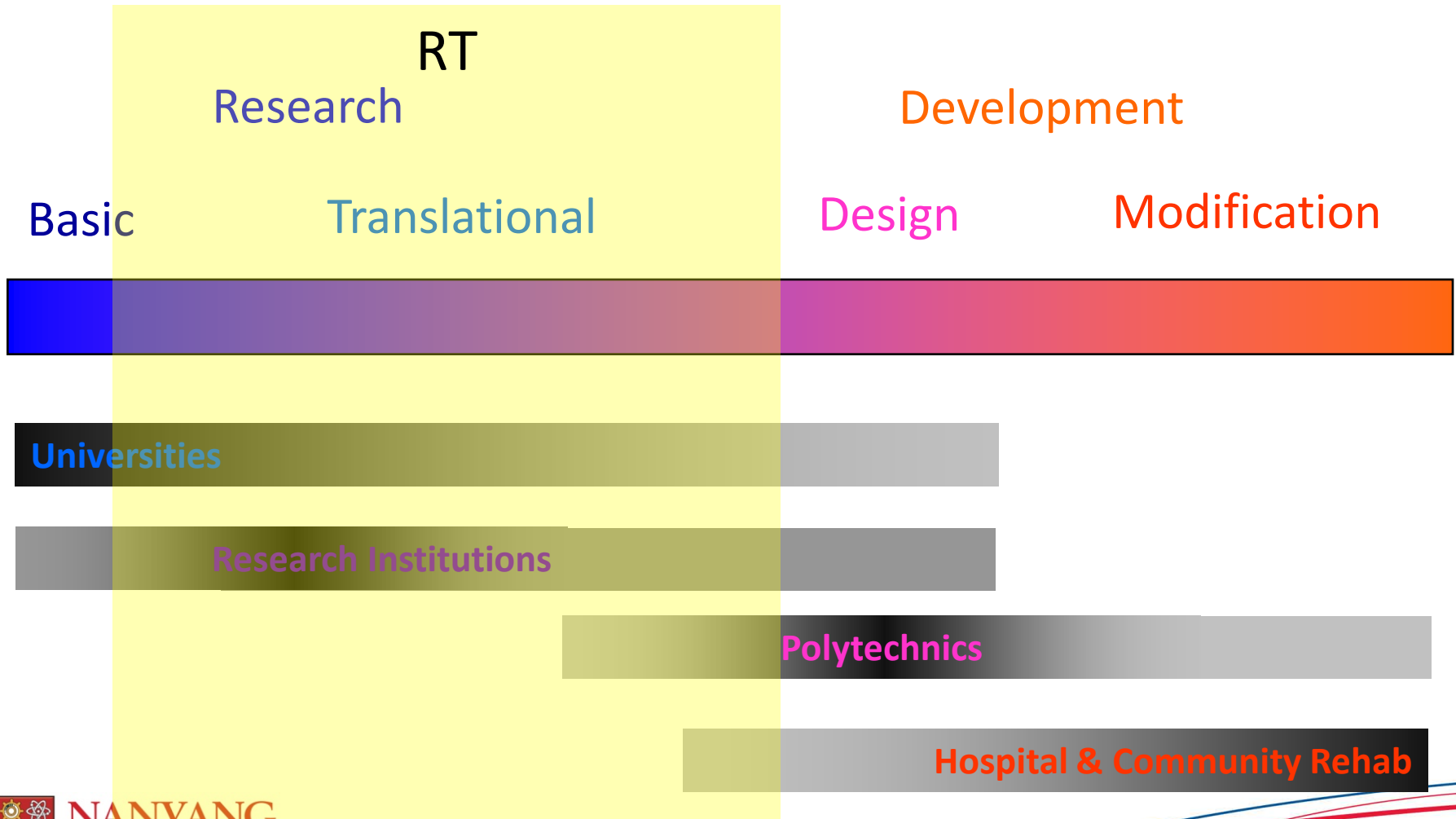 - Publications, patents
  - New systems, products, etc.

Rehabilitation R&D Project Types

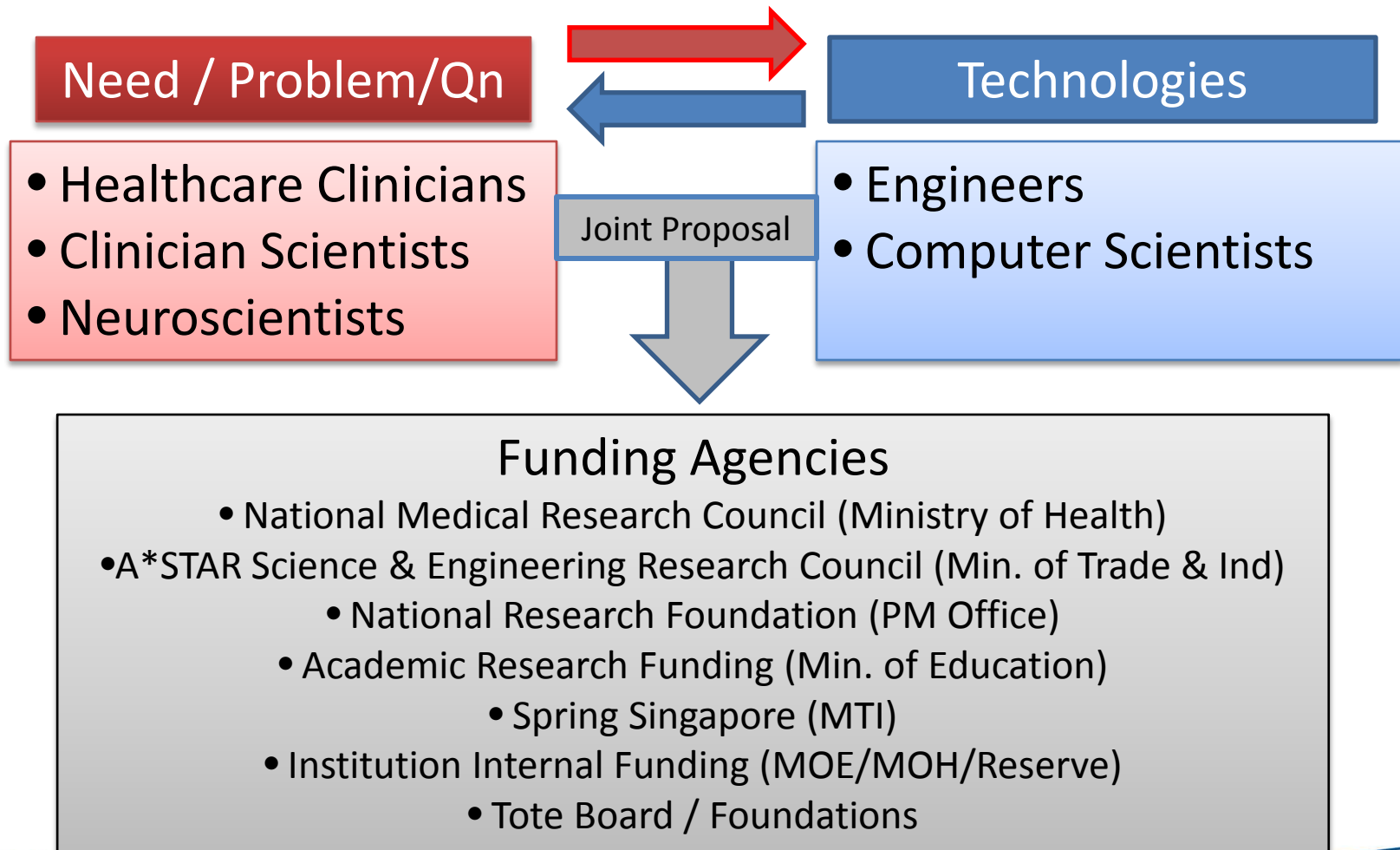## Clinicians ⟷ Scientists ⟷ Technologists

- Principal Investigator
  - Clinician or Scientist
  - May not involve technologist
- Scope
  - Validate new theories, test hypotheses
  - May use off the shelf technologies, e.g. motion capture system
  - Clinical trials
- Outcome
  - Publications, new models

- Principal Investigator
  - Usually Scientist
- Scope
  - Validate new theories, test hypotheses
  - Use new or customized technologies for experiments
  - Healthy subject trials
  - Clinical trials
- Outcome
  - Publications, new technological systems, new models

RT R&D Activities in Singapore
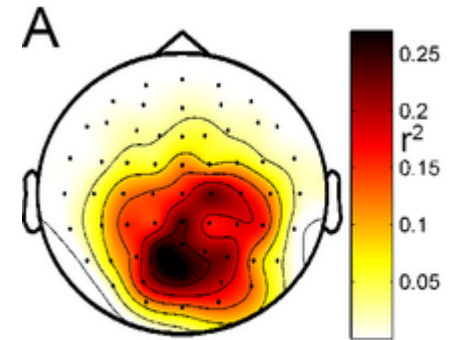
RT

Research   Development

Basic   Translational   Design   Modification

Universities

Research Institutions

Polytechnics

Hospital & Community Rehab

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RT R&D Activities in Singapore

Need / Problem/Qn		Technologies
• Healthcare Clinicians • Clinician Scientists • Neuroscientists	Joint Proposal	• Engineers • Computer Scientists

Funding Agencies
• National Medical Research Council (Ministry of Health)
• A*STAR Science & Engineering Research Council (Min. of Trade & Ind)
• National Research Foundation (PM Office)
• Academic Research Funding (Min. of Education)
• Spring Singapore (MTI)
• Institution Internal Funding (MOE/MOH/Reserve)
• Tote Board / Foundations

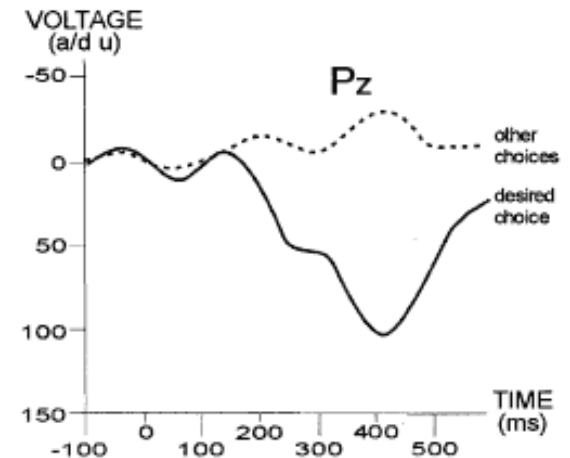NANYANG TECHNOLOGICAL UNIVERSITY

Brain Computer Interface

- To use Electroencephalography (EEG) or brain-wave to control devices via a computer

- Synchronous BCI
  - P300: a spike in EEG signal 300ms after an anticipated event occurs
  - Choices are displayed on a computer screen one after another, once a spike in EEG is detected, the choice displayed 300ms ago would be the intended target

A

P300 EVOKED POTENTIAL

VOLTAGE
(a/d u)

Pz

other choices

desired choice

TIME (ms)

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Asynchronous BCI

- Movement / imagination of limb movements will invoke self-induced variations of EEG over the motor cortex

- EEG power in the μ (8-14 Hz) band will attenuate during movement
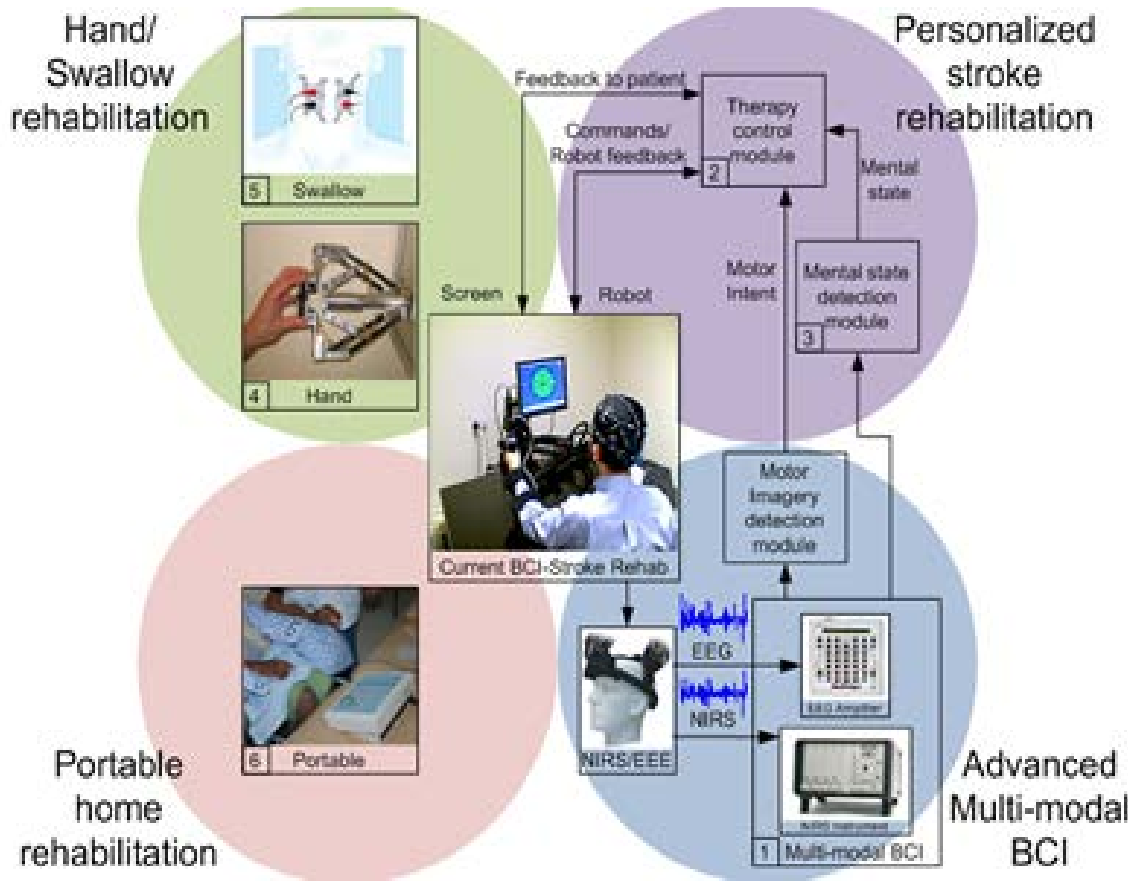 ➔ This change can be used to control a BCI

Motor cortex

Stroke patient's EEG:

Resting

Foot tapping
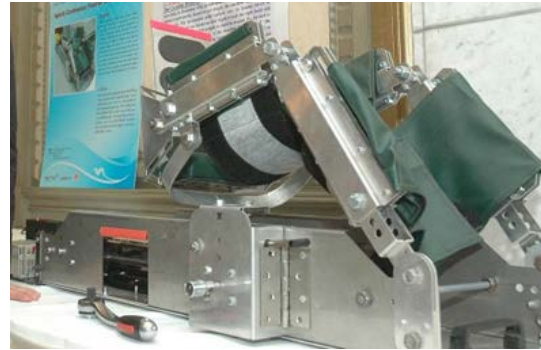
Hand grasp
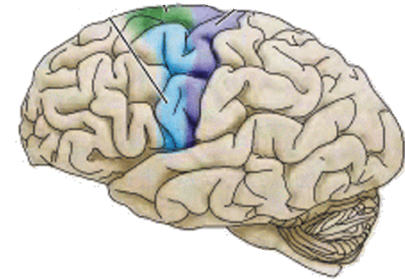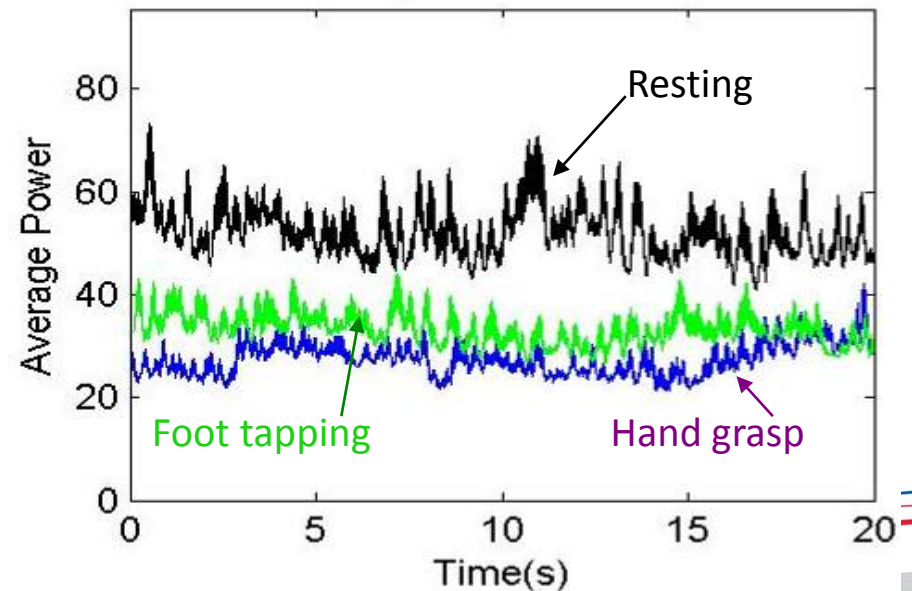
BCI Research Projects in Singapore

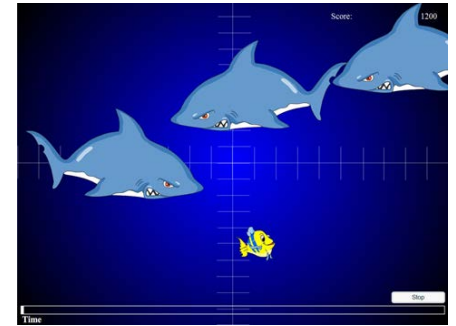Attention Deficit & Hyperactivity Disorder

RT Innovation Projects in Singapore

Upper limb tracking with MS Kinect + accelerometers with augmented reality game interface

sEMG-driven continuous passive motion (CPM) machine

Pro-Balance™ Balance training & screening machine

Wearable Sensors

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RT Research Programme for Stroke Neuro-Rehabilitation

- Joint proposal by Nanyang Technological University, Tan Tock Seng Hospital & Rehabilitation Institute of Chicago, USA

- S$10M, 5 years

- Tripartite research partnership
  - Technologists: NTU
  - Clinicians: TTSH
  - Neuroscientists: RIC

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RT Research Programme for Stroke Neuro-Rehabilitation

- Scope: Upper Limb

- Target group: sub-acute stroke patients

- To address key gaps in assessment & intervention for stroke motor recovery / relearning

  – To take a technological approach

  – To be backed empirical evidence & scientific basis

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RT Research Programme for Stroke Neuro-Rehabilitation

- Assessment
  - Technology enhanced objective assessment
    - To supplement or replace current assessment scales (Functional outcome scales, e.g. FIM, BI; Neurological deficit scales, e.g. Fugl-Meyer, NIH Stroke Scale)
    - Goals: objectivity, higher resolution, better representation/estimate of true recovery
    - Parameters to measure & study: kinematic parameters, dynamic behaviours in presence of disturbance, compensation strategy

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RT Research Programme for Stroke Neuro-Rehabilitation

- Assessment
  - Motor Synergies: adaptability & clinical significance
    - To study how CNS uses redundancy in motor synergies
    - To study the motor synergies and adaptability of stroke subjects when mobility (redundancy) is reduced
    - Quantitative assessment of motor synergies to provide diagnostic and prognostic indicators

RT Research Programme for Stroke Neuro-Rehabilitation

- Intervention
  - Adaptive interface
    - To go beyond games to encourage motivations and engagement of stroke patients
    - To keep patients involved in tasks at the neural level (even with motor inability)
    - To implement adaptive multi-agent interactions (patient, therapist, machines) in relation to the cognitive capacities of patients
    - Use of mixed reality interface & mobile devices

RT Research Programme for Stroke Neuro-Rehabilitation

- Intervention
  - Cognitive Robotic Assistant Therapist
    - UL exoskeleton with modular attachment
    - Adaptable to the dynamics of the patient and will learn from the therapist, to provide 'assist-as-needed' therapy tailored to patient-specific needs
    - To use inputs from new assessment methods for adaptation basis

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QUESTIONS OR COMMENTS?