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Specialization Man Machine Interaction - September 2010 – Link to VRET Wiki

Addressing Patient Motivation In Virtual Reality Based Neurocognitive Rehabilitation

In this presentation

- Problem statement and hypotheses
- Approach
- Prototype system design and implementation
- Evaluation and results
- Conclusions and suggestions

Problem statement

- Cognitive rehabilitation exercises are not designed to be motivating for the elderly population[1]

- Elderly population reports usability issues with computing technologies such as input/output devices and graphical interfaces[2]

1) See e.g. Rizzo, A. S., & Kim, G. J. (2005). *A SWOT Analysis of the Field of Virtual Reality Rehabilitation and Therapy.*

2) See Fisk, A., Rogers, W., Charmes, N., Czaja, S. J., & Sharit, J. (2009). *Designing for Older Adults*.

Main hypotheses

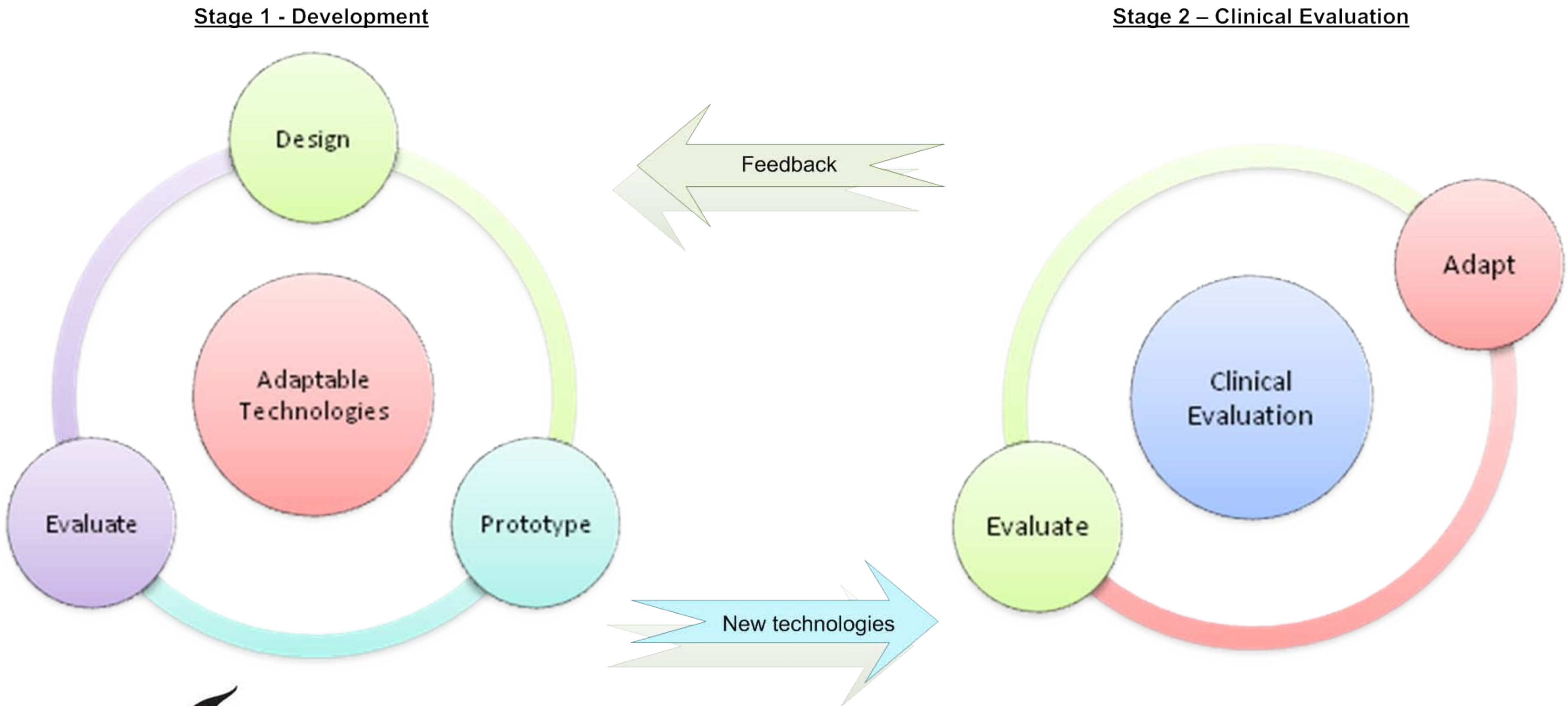
- Two main hypotheses related to problem:

H1 Rehabilitation exercises that are designed using principles of **affective gaming** increase the motivation to engage with the exercise in the elderly population.

H2 Rehabilitation exercises utilizing **reality based interaction** increase the motivation to engage with the exercise in the elderly population.

- Goal: test these by development of prototype technology, and evaluation in clinical experiment

Approach



ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

TU Delft

- Design and evaluate prototype system for use in subsequent (clinical) experiment

Approach

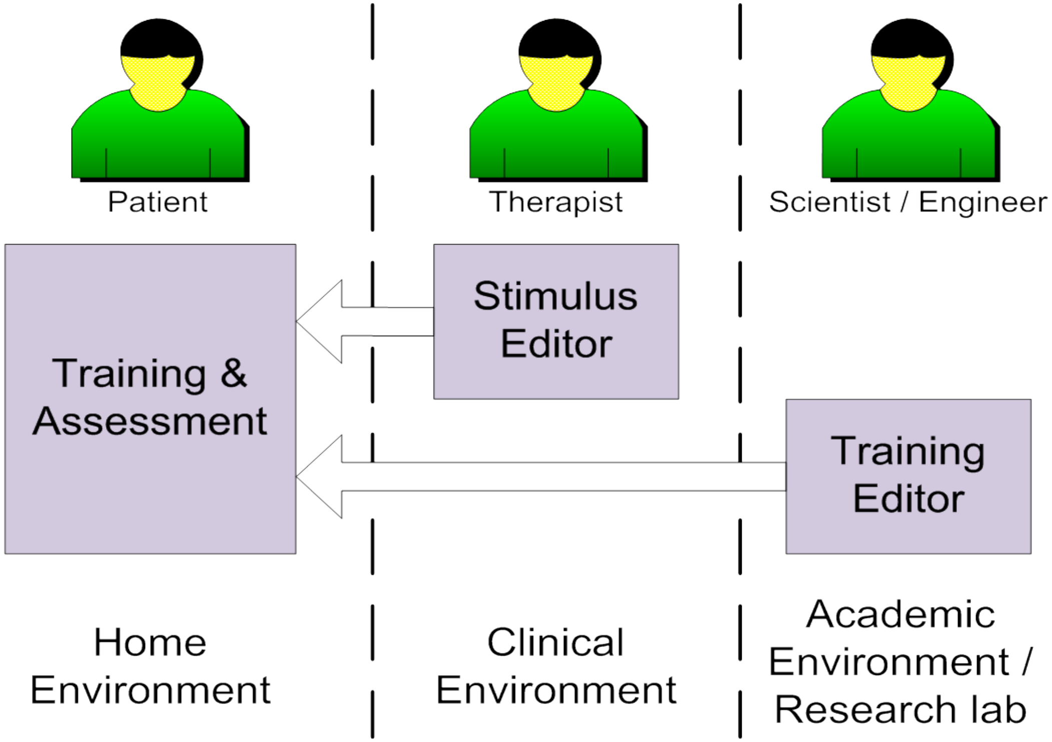
- Used the Situated Cognitive Engineering method

- Steps performed at TU Delft
  - Literature survey for WDS analysis
  - Prototype system development
  - Evaluation in pilot study

- Steps performed at ETH
  - Expert interviews for WDS analysis
  - Experiment design
  - Expert evaluation of prototype system/experiment design
  - Ethics committee approval

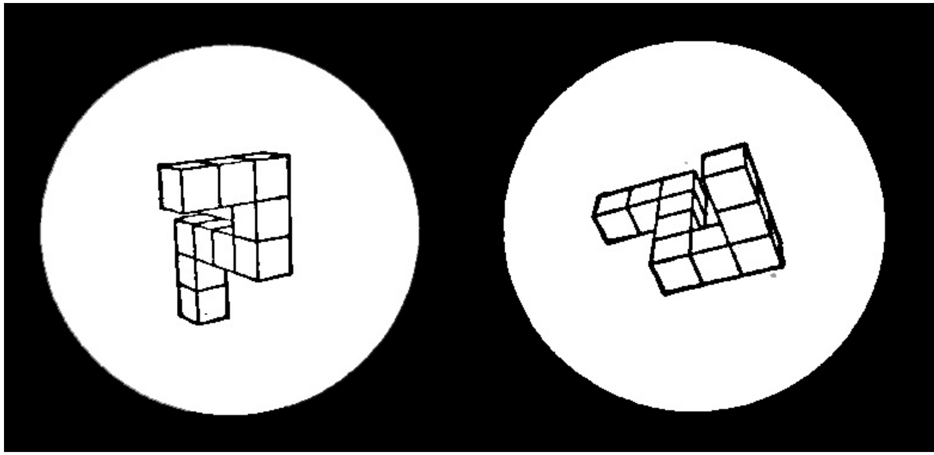
Envisioned prototype system

- Definition of system components, users and their roles



Prototype system design

- Choice of suitable cognitive task
  - Ecological validity
  - Repetitive in nature
  - Suitable for virtual reality



- Mental Rotation
  - Visuospatial skill
  - Simple task
  - Skill degradation caused by neurodegenerative disease (e.g. Alzheimer’s, Parkinson’s)
  - Skill degradation caused by typical aging (e.g. dementia)

Prototype system implementation

- Applied principles of affective gaming:
  - High level design heuristics “Assist me, emote me, challenge me”
  - Simulated virtual assistant avatar provides affective feedback based on inferred emotional state of player

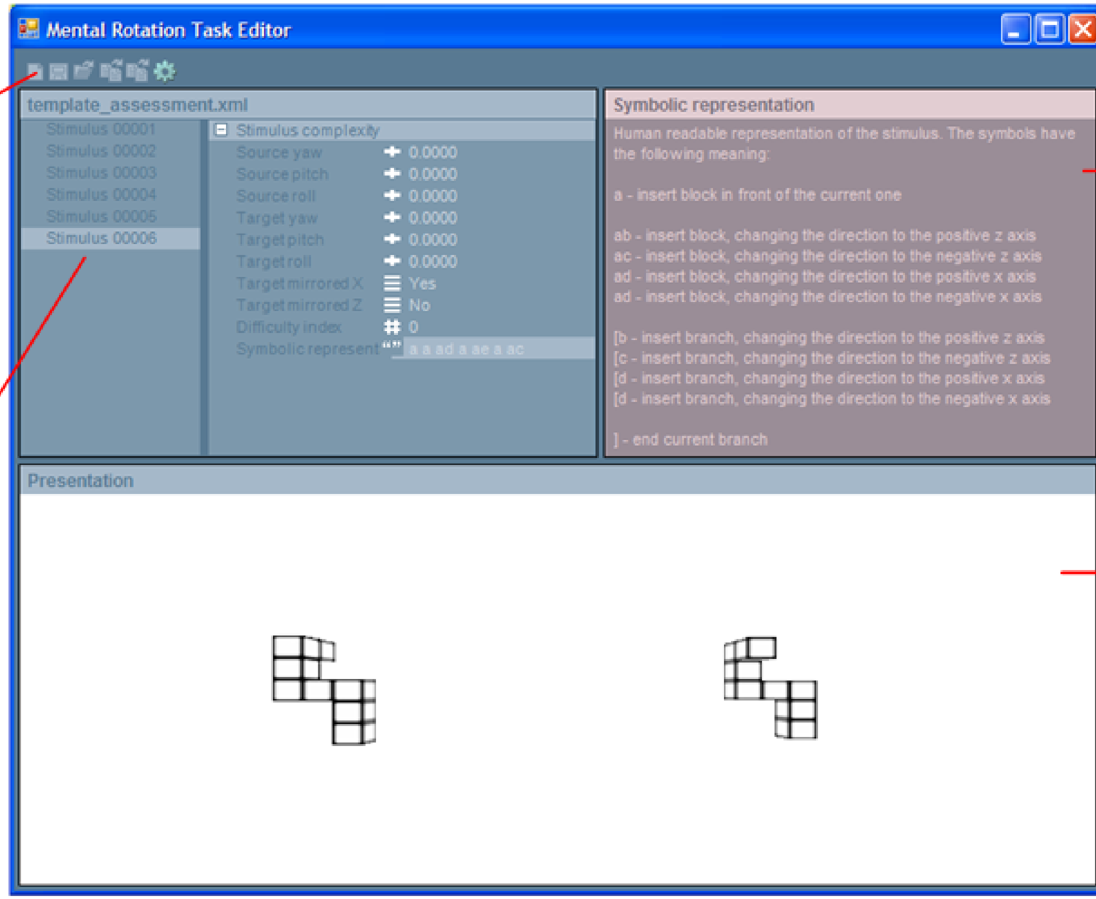
- Automatic generation of stimuli was explored:
  - Generate stimuli with parameterized complexity using L-System algorithm
  - Computationally determining the usability of generated stimulus proved to be non-trivial

Prototype System – Patient interface

Prototype System – therapist interface

Loading and saving of stimulus templates and profiles (used during training and assessment)

- Edit one or more stimulus pairs, or
- Inspect generated angular variations based on previously created stimulus templates



Shows information about how to use the GUI element that is directly under the mouse cursor

Realtime preview of stimulus pair being edited

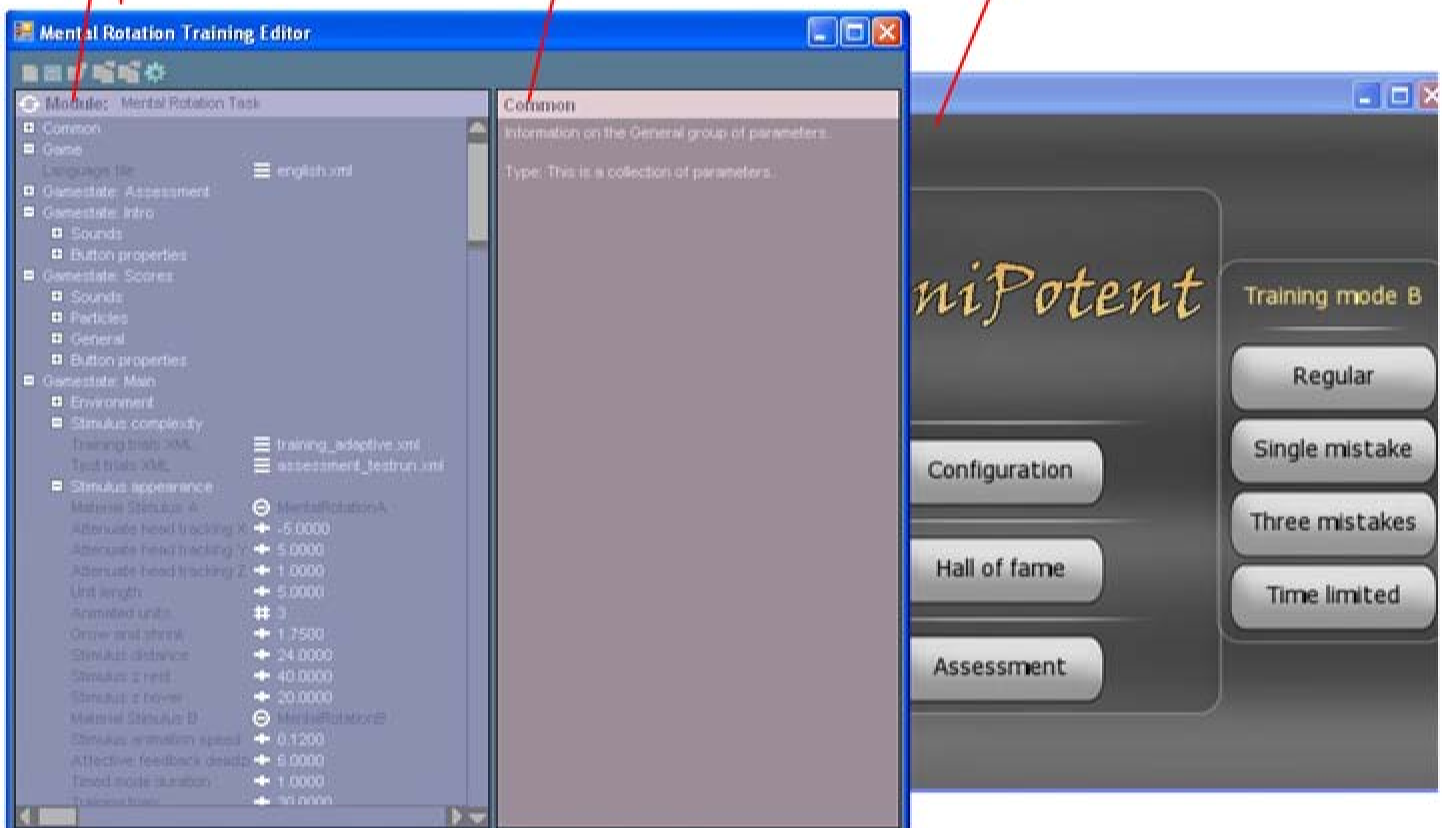
Prototype System – engineer/scientist interface

Adjust GUI properties:
- Language
- Buttons,
- Animations,
- Sounds

Adjust Training and Assessment properties

Shows information about how to use the GUI element that is directly under the mouse cursor

Fully functional and real-time preview of Training and Assessment environment



Evaluation in pilot study

- Goal of pilot study was to evaluate:

  1. If the prototype system works in an operational environment
  2. If the prototype system is usable by the targeted population
  3. The two main hypotheses (refined)

Protocol of pilot study

- Participants were asked to:

1. Fill in questionnaire 1
2. Complete a training round using the prototype system in ‘affective’ mode
3. Fill in questionnaire 2
4. Complete a training round using the prototype system in ‘conventional computer based training’ mode
5. Fill in questionnaire 3

Collected data

- Questionnaire 1:
  - Participant background, games and computer use
  - Categorical responses

- Questionnaire 2:
  - Experience during affective gaming based training
  - Responses on 4 point Likert scale, 5th point for ‘no answer’

- Questionnaire 3:
  - Experience during conventional computer based assessment
  - Responses on 4 point Likert scale, 5th point for ‘no answer’

Pilot study participants

- 9 participants (5f/4m) recruited through friends and family:
  - Screened according to ecologically valid selection criteria:
    - Age between 55 and 80
    - Able bodied, capable of independent living
    - Ability to stand in front of a TV to play a computer game
    - …
  - Selection criteria equal to those for experiment at ETH

Evaluated hypothesis (H1, refined)

H1 Rehabilitation exercises that are designed using principles of affective gaming increase the motivation to engage with the exercise in the elderly population.

H1.1 Incorporating high scores as a game design element contributes to increasing motivation and willingness to engage.

H1.2 Incorporating achievement medals as a game design element contributes to increasing motivation and willingness to engage.

H1.3 Incorporating adaptive difficulty as a game design element contributes to increasing motivation and willingness to engage.

H1.4 Incorporating different game modes as a game design element contributes to increasing motivation and willingness to engage.

H1.5 Incorporating virtual characters providing affective feedback as a game design element contributes to increasing motivation and willingness to engage.

Evaluated hypothesis (H2, refined)

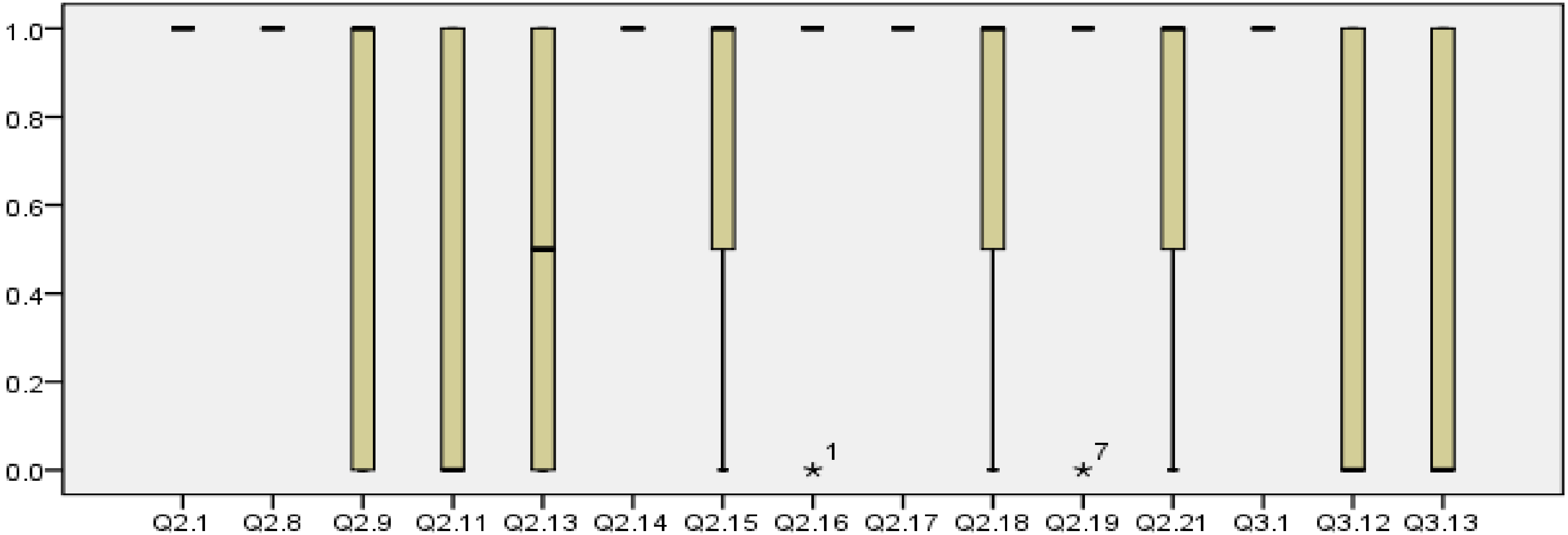
H2 Rehabilitation exercises utilizing reality based interaction increase the motivation to engage with the exercise in the elderly population.

H2.1 Rehabilitation exercises utilizing (head) tracking increase the motivation to engage with the exercise in the elderly population.

H2.2 Rehabilitation exercises utilizing gesture based interaction increase the motivation to engage with the exercise in the elderly population.

Interpreting data

- To allow significance testing, responses were recoded to dichotomous scale
- Significance testing using binomial test :
  - Test proportion = 0.50



Results

Hypoth.	Question(s)	Sig.
H1	Q2.1-Enjoyed playing the game	.004
	Q3.12-Increased motivation to play computer games	1.000
	Q3.13-Enjoyed first game more than second	.508
H1.1	Q2.9-Motivated by score	.508
	Q2.14-Wants to play to increase score	.004
H1.2	Q2.15-Wants to play to win medals	.289
H1.3	Q2.8-Noticed adaptive game difficulty	.008
	Q2.16-Wants adaptive game difficulty	.039
H1.4	Q2.21-Interested in multiple game modes	.289
H1.5	Q2.11-Motivated by encouragement	1.000
	Q2.17-Wants encouragement	.004

Results

Hypoth.	Question(s)	Sig.
H2.1	Q2.13-Motivated by head-tracking	1.000
	Q2.19-Wants 3-D gaming	.070
H2.2	Q2.18-Wants movement-based gaming	.289

Conclusions of pilot study

- After calibration, prototype system works in an operational environment (simulated living room and clinical environment)
- After minor adjustments, prototype system was usable by targeted population
- Support for H1 – using affective gaming principles increases patient motivation…
- Some support for H2 – using reality based interaction mechanisms increases patient motivation…
- ... however, more data points needed to get conclusive answers.

Recommendations

- For experimental study at ETH:
  - Two separate installations for the training rounds
  - Modify questionnaires, replace verbal Likert scale categories with numeric ones
  - Design stimuli in cooperation with therapist
  - Match duration of experimental protocol with attention span of targeted population

- For future work:
  - Evaluate therapist interface
  - Create 3d and animated virtual assistant avatar
  - Improve and validate ‘emotion knowledge base’ used by virtual assistant to infer players’ emotional states

Conclusions of project

- Limitations:
  - Only healthy participants have been tested
  - Prototype system needs setup and calibration by engineer

- Scientific contributions:
  - Generic, reusable Requirements Baseline and use case scenarios,
  - Computer based assessment environment, including content editor allowing precise control over presented stimuli
  - Affective gaming based training environment, including experiment design, can be used to investigate motivational variables