Virtual human technologies for cognitively-impaired older adults' care: the LOUISE and Virtual Promenade experiments

PhD defense by: Pierre WARGNIER

Advisors: Anne-Sophie RIGAUD, Pierre JOUVELOT

Field expert: Samuel BENVENISTE

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Population aging

- Caregiver shortage.
- Disability in older adults: impact on caregivers' health.
- Costs: need for cost-efficient solutions.

Two important causes for loss of autonomy

- Dementia:
  - 25% of people over 80 have dementia;
  - over 100 million by 2050.

- Falls:
  - ~40% of people over 65 fall every year;
  - 10% of fallers injured.

"Brain aging" *by Kalvicio de las Nieves*

Assistive technologies

Products and services that facilitate seniors’ daily lives and help compensate for disabilities.

Issues:

- usefulness;
- usability;
- acceptance;
- ethics;
- costs.

Goals

- Assess applicability of virtual humans for user-friendly and pleasant assistive technologies.
- Address cognitive impairment and falls.

➢ Two experimental systems developed.

Outline

1. Designing for older adults
2. Virtual humans for older adults
3. Experimental systems:
   1. LOvely User Interface for Servicing Elders (LOUISE)
   2. Virtual Promenade
4. Future work
5. Conclusions and recommendations

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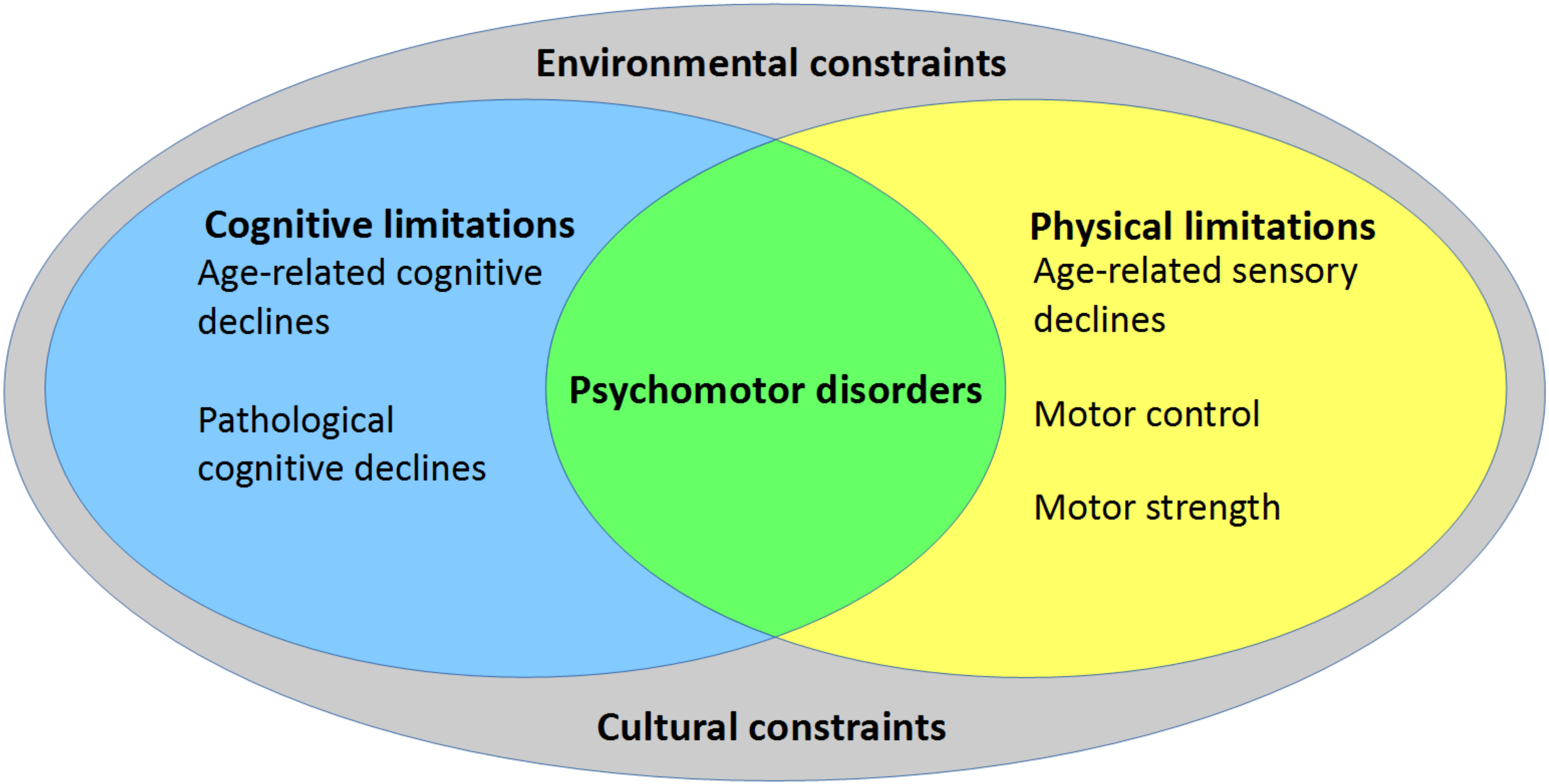
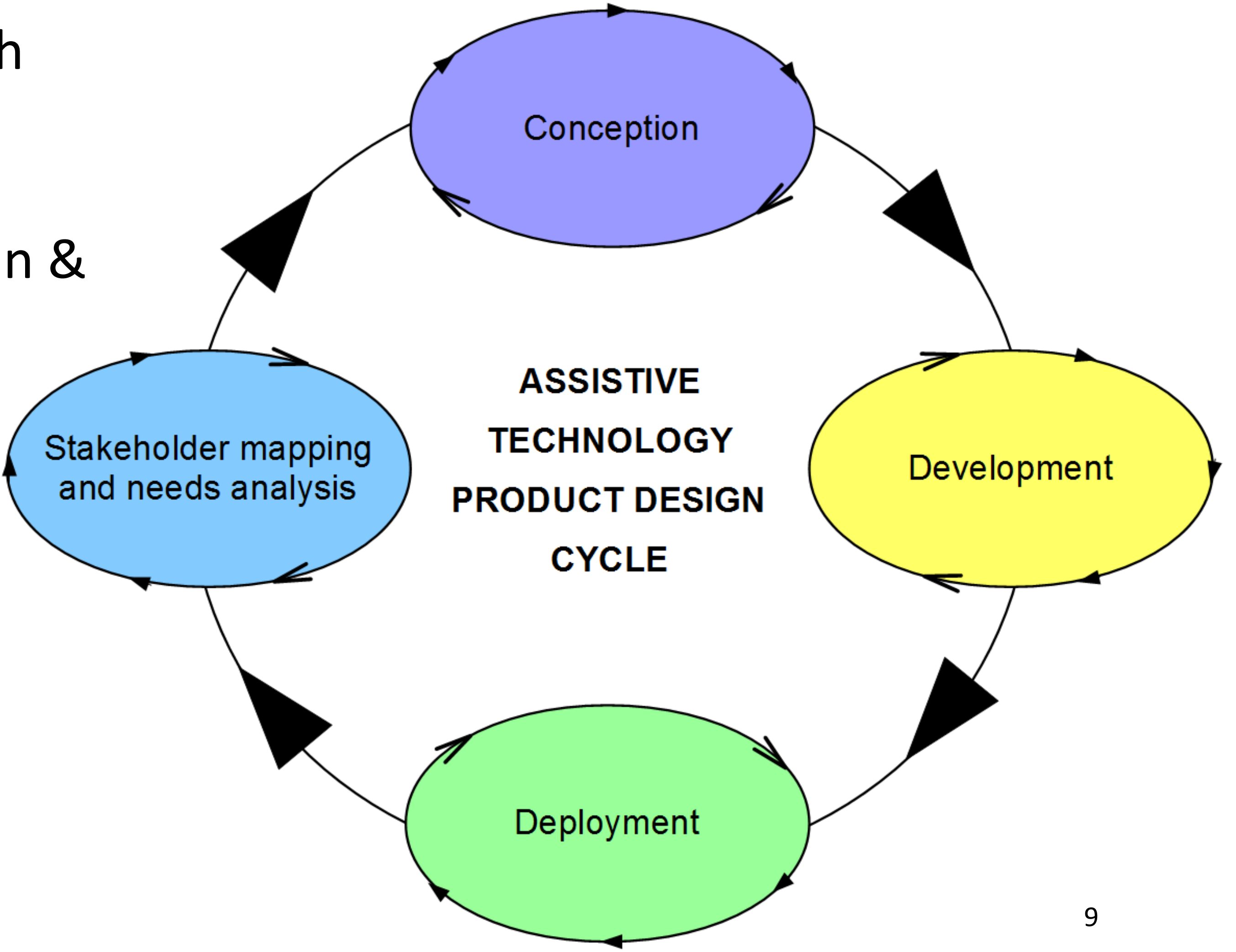
Design challenges



Living lab participatory design

- Action research [Levin, 1946]
- User-centered design [Norman & Draper, 1986]



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The virtual human dichotomy

As non-self

- Embodied conversational agents (ECAs) = virtual interactive characters.
- Issues: appearance, expressiveness, interaction.

As self (avatars)

- Extensions of one's self in the virtual world.
- Issues: identification, body ownership, controls.

Virtual Human Toolkit (USC ICT)

Snowboarder avatar in Amped Freestyle Snowboarding *(Microsoft, 2001)*

As non-self: ECAs for older adults

Advantages:

- no learning;
- attention and engagement;
- easy understanding;
- personalization.

[Ortiz *et al.*, 2007; Carrasco *et al.*, 2008; Morandell *et al.*, 2008]

Applications:

- virtual assistants;
- virtual butlers;
- coaches;
- companions.

Yaghoubzadeh et al., *2013, 2015.*

As self: games for fall prevention and rehabilitation

- Strong motivational power.
- Emphasis on pre-fall prevention.
- Focus on balance, muscle strength and limb coordination.

Ogonowski et al., *2016. iStoppFalls project.*

Profitt and Lange, 2013. Fitness exercise game.

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Experimental systems

LOUISE

- Accessible ECA-based user interface;
- cognitive;
- non-self.

Virtual Promenade

- A virtual reality-based Post-Fall Syndrome (PFS) treatment tool;
- cognitive + physical;
- self.

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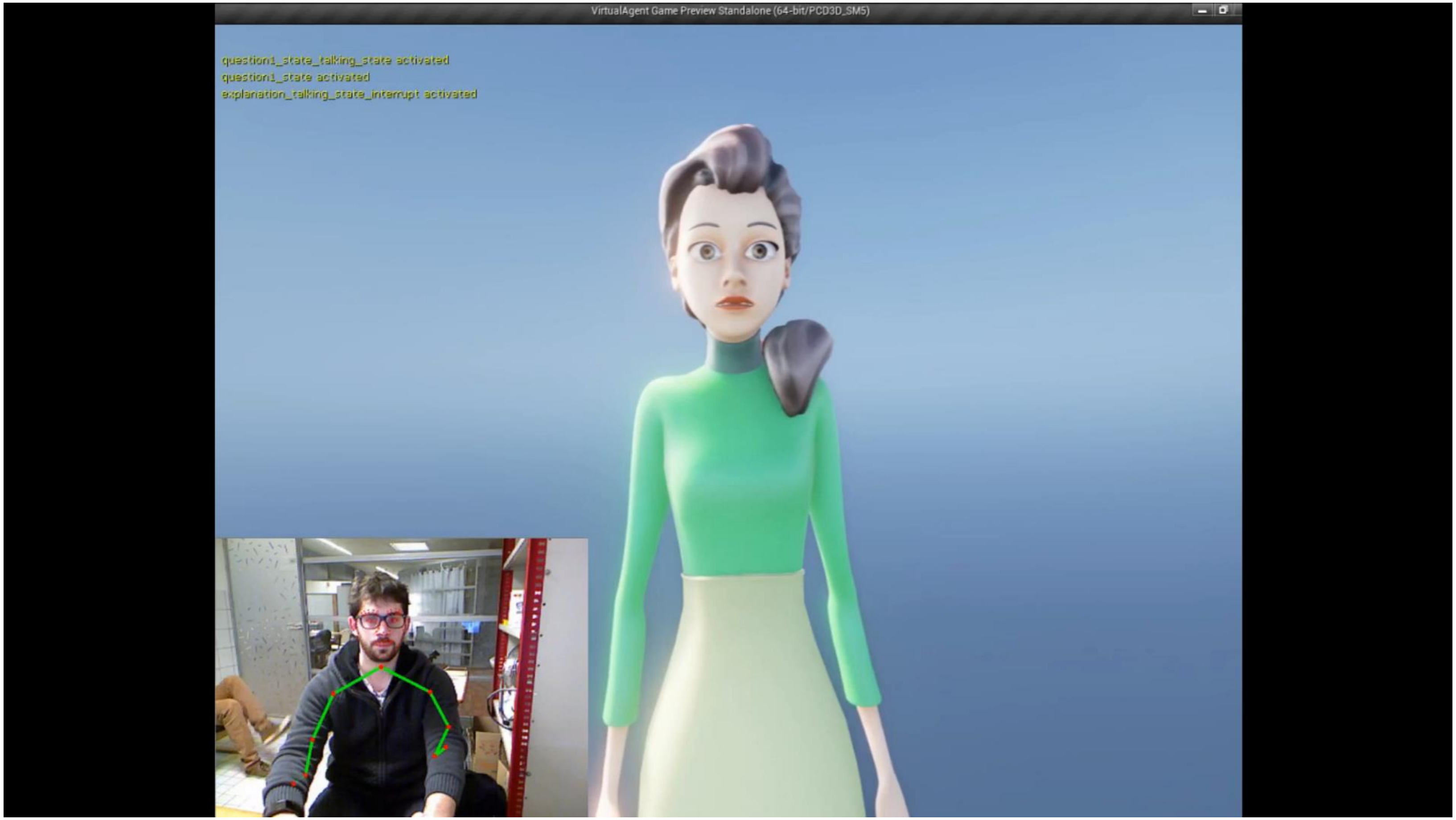
LOUISE participatory design overview

- Starting point : attentional disorders.
- Wizard of Oz (WoZ) study (14 AT pros, 8 older adults):
  - put together a first prototype;
  - create and validate attention estimation method;
  - perform anthropological analysis of videos.
- Feedback analysis:
  - questionnaires (37 respondents);
  - focus group (9 older adults);
  - staff meetings (~12 physicians + psychologists).
- Fully automatic prototype.
- Evaluation through 4 realistic use cases (14 older adults).

Phase 1 – Wizard of Oz study



Phase 1 – insights gained

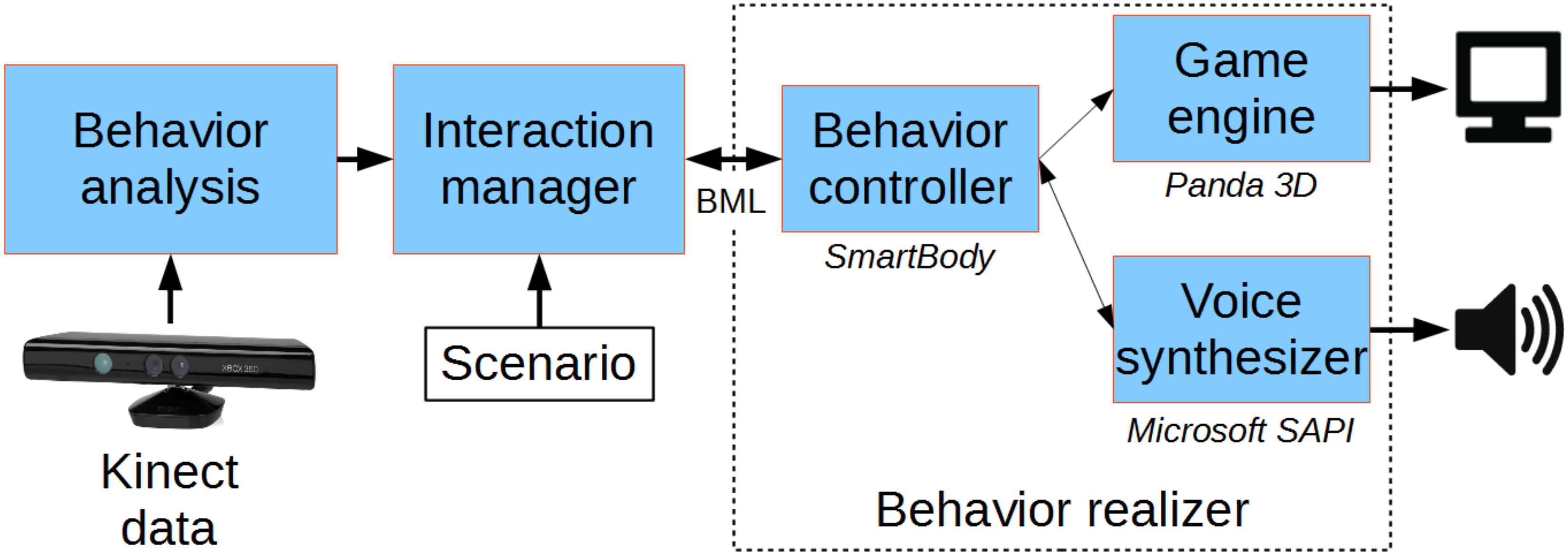
- Attention estimator:
  - over 80% of correct decisions;
  - age independent.
- Experiments:
  - positive feedbacks from older adults;
  - character not expressive enough;
  - 6/8 older participants successfully interacted;
  - attention prompting effective;
  - need for context reminders.
- Anthropological analysis:
  - elders with cognitive impairment interact in a “social” way;
  - closed/contracted questions to be privileged.

Phase 2 – questionnaires and focus group

- Questionnaires: 37 people (9 older adults).
- Focus group: 9 older adults (from 67 to 89).

Topics	Questionnaires	Focus group
embodiment (appearance)	young woman	robot
personalization	important	not discussed
personalization features	character's voice	adapt to cognitive decline
most useful applications	assistant and butler	UI and entertainment
where to display the ECA	device already owned	not discussed
privacy concerns	more for older adults	not if truly useful

Phase 3 – automation and applications



LOUISE automated system
BML = Behavior Markup Language

Assistive Interaction Scenario Markup Language (AISML)

- Scenario: <scenario> </scenario>
- Based on utterances:

<utterance id="name" type="chosen_type" wait="time" mode="mode">
... content ...
</utterance>

- Utterances contain:
  - a BML command (behavior to be played);
  - transitions (possible next utterances, depending on user's answer);
  - a "recontextualisation" BML command (to be played after attention loss).

AISML short sample

```
<scenario>
  <utterance id="start" type="statement">
      <command>
          <speech id="sp" type="application/ssml">  Hello!  </speech>
          <head id="hd" start="sp:end" type="NOD" amount="0.5"/>
      </command>
      <transition>Ready?</transition>
      <recontextualisation>
          <speech id="sp" type="application/ssml"> I was saying. </speech>
      </recontextualisation>
  </utterance>

  <utterance id="Ready?" type="question" wait="5">
      <command>
          <speech id="sp" type="application/ssml"> Are you ready? </speech>
      </command>
      <transition condition="yes">Cool!</transition>
      <transition condition="no">ComeBackLater</transition>
  </utterance>
```

Final feature set of LOUISE

- Attention management.
- User speech turn detection.
- Speech recognition.
- Context reminders.
- Image and example video display.
- Easy character addition.

LOUISE validation study

- Goal: test interaction strategies.
- 4 realistic evaluation scenarios:
  - drinking water;
  - choosing the menu for a meal;
  - taking pills;
  - measuring one's blood pressure.
- Participants:
  - 11 females, 3 males;
  - 71 < age < 89 (mean = 78.8);
  - 8 < MMSE < 30 (mean = 23.8).

Careousel Pill dispenser.

Microlife blood pressure monitor.

Interaction strategy – step-by-step task guidance

1. Explain the action to perform while showing video example.
2. Wait.
3. Ask if completed.
4. Choice:
   - If “yes” -> next action.
   - If “no” -> go to step 5.
5. Instruct to perform the action.
6. Wait.
7. Ask if completed.
8. Choice:
   - If “yes” -> next action.
   - If “no” -> back to step 5.

LOUISE showing video instructions

Validation study settings

Validation study results

- Usability:
  - 13/14 participants successfully interacted;
  - “social” interaction of most severely impaired participants;
  - speech recognition not reliable enough;
  - positioning issues with the Kinect sensor.
- Positive participants’ feedbacks.
- **Task guidance conversation structure well adapted for MCI; more work needed for dementia.**

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Stimulation tool for Post-fall syndrome

PFS symptoms

- Psychological:
  - anxiety;
  - fear of falling.
- Psychomotor:
  - psychomotor disadaptation;
  - backward disequilibrium.

- Issue: PFS neglected in care practices.
- Observation: PFS comparable to PTSD [*Bloch et al. 2013*].
- Proposed solution: Virtual reality therapy.

Virtual Promenade participatory design overview

- User-centered game design:
  - iterative development – playtesting cycle (8 older adults);
  - choice of game controller;
  - design validation (9 older adults).
- Design refinement with professionals' inputs.
- Pilot evaluation study:
  - *in situ* testing (8 hospitalized patients);
  - changes allowed during the study.

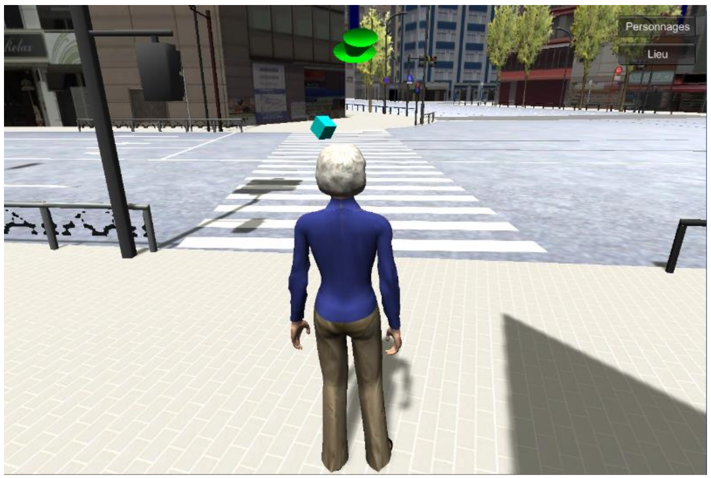
Virtual Promenade

Phase 1 – participatory design

- Participants: 8 women over 80.
- Tests with several controllers.
- Final design:
  - tutorial, free strolling in the forest, cube collection task in the park;
  - chosen controller = Nintendo 64 controller;
  - validated with 9 older adults.

Issue	Changes made
City environment is unwelcoming	Forest and park environments
Players did not identify with the avatar	7 extra character models
Flight simulator joystick is too stiff	Support for other game controllers
Older adults need time to familiarize with the controls	Tutorials that give time to adapt

Visuals



Top to bottom, left to right: city, forest, tutorial, avatars.

Phase 2 – focus groups and shadowing

Focus groups

- Participants:
  - physiotherapy team;
  - psychomotricity team.
- Results:
  - positive feedbacks on the game;
  - minor changes requested;
  - cube-picking task not meaningful;
  - doubts about usability for patients.

Shadowing

- Ethnographic-like method.
- Observations:
  - 2 or 3 patients at a time;
  - very limited space;
  - use of gamified rehabilitation tool;
  - gamified activity enjoyed by patients.

Phase 3 – pilot evaluation study

- Method:
  - pre-post-intervention Fall Efficacy Scale and PTSD Checklist Scale assessment;
  - 2 to 3 sessions, ~30 minutes each;
  - questionnaire after each session.
- Participants:
  - 7 females, 1 male;
  - 75 < age < 99;
  - 12 < MMSE < 27 (mean = 20.9).

Pilot study – results

- 8 participants completed at least 1 session; 7 did 2 or more;
- Changes made:
  - use of Thrustmaster joystick;
  - “easy mode” created.
- Observations:
  - high satisfaction with the visuals;
  - easy controls;
  - mitigated impression of immersion.
  - **little or no in-session anxiety**;
  - **FES not adapted for dementia.**

Thrustmaster USB Joystick

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Future work

- Leveraging both self and non-self.
- Exploring other interaction modalities.
- Personalization to cognitive level and personal tastes.
- Investigating deployment aspects.

LOUISE:

- more flexible interaction management (extend AISML);
- more comprehensive user behavior analysis.

Virtual Promenade:

- adding VR head-mounted display;
- using body ownership measures;
- finding adapted success indicators.

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Conclusions

Experimentations:

- Ecological testing → debunk and fix usability issues.
- Participatory design → high satisfaction of target audience.
- Involving several stakeholders → useful information for current and future steps.
- Off-the-shelf elements → fast prototyping and flexibility.

Observations:

- Older adults more sensitive to aesthetics than realism.
- Importance of personalization in assistive systems.
- Older adults not reluctant to new technology.
- Perceived usefulness is key to acceptance.

Recommendations for participatory design of virtual humans

Participatory design

- Start small.
- Make changes as soon as judged necessary.
- Go see for yourself.
- Go the extra mile.
- Adapt your discourse.

Virtual humans

- Stay aware of novelties.
- Use versatile development tools.
- Carefully design appearance.

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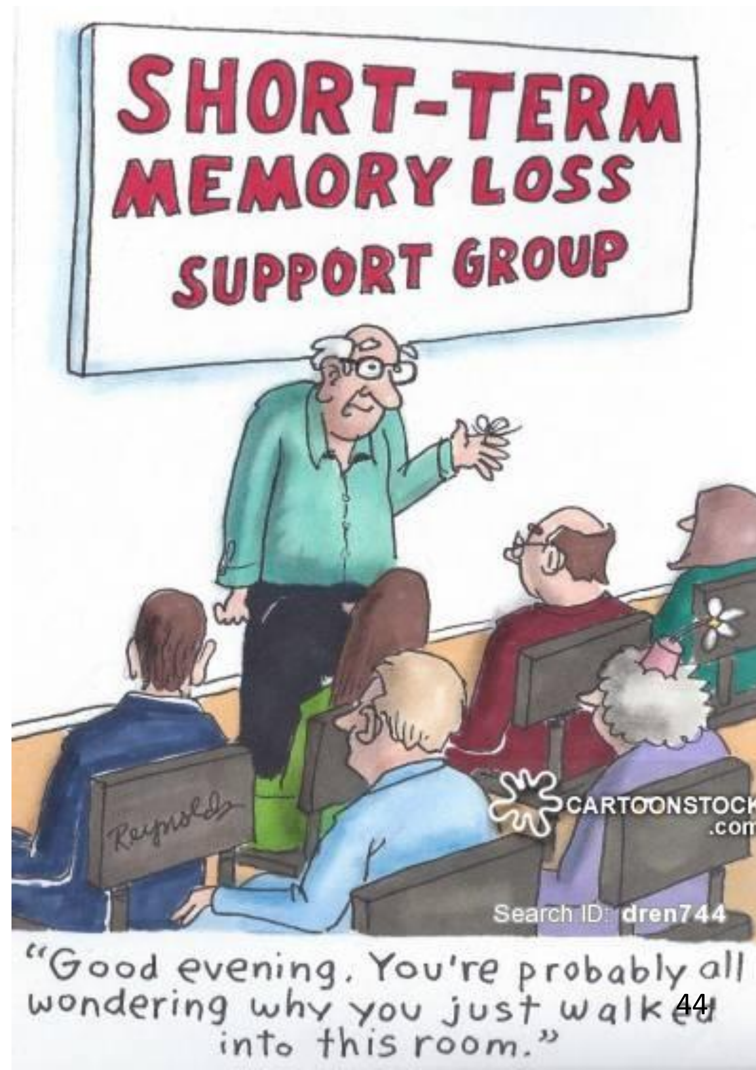
LOUISE: an ECA for cognitive support

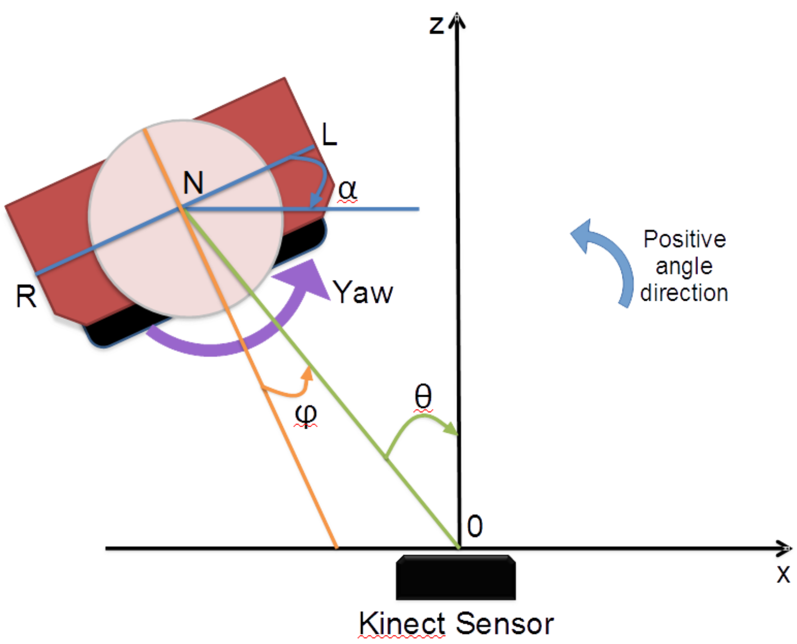
Dementia symptoms

- Short-term memory loss
- Executive dysfunction
- Attention disorders
- Aphasia
- Agnosia
- Apraxia
- Psycho-behavioral disorders



Phase 1 – attention estimator

- *A priori* assumptions:
  - attention = looking towards the display;
  - sensor placed on top of the display, in the middle.
- 3 features:
  - φ = body orientation;
  - yaw = head's rotation around vertical axis;
  - pitch = head's rotation around horizontal axis.



Phase 1 – attention estimator

- Features f_j averaged over 1-second sampling.
- Features normalized as: $\overline{f_j} = \frac{\cos(f_j) - \cos(Max_j)}{1 - \cos(Max_j)}$,

  with Max_j = 60° for φ, 30° for yaw and 20° for pitch.
- Attention value computed as : $A = \sum_{j=1}^{n} \omega_j \overline{f_j}$,

  with $\omega_{\varphi} = 3$; $\omega_{yaw} = 4$; $\omega_{pitch} = 3$; $n = 3$.
- Decision: empirical hysteresis threshold.