Assistive Technologies for the Cognitive Stimulation of Older Adults

Alberto L. Morán

Cuerpo Académico Tecnologías para Ambientes Inteligentes

Universidad Autónoma de Baja California, UABC

Ensenada, México

alberto.moran @uabc.edu.mx

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CA Tecnologías para Ambientes Inteligentes
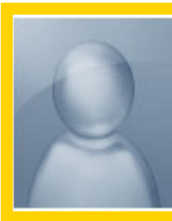## (Technologies for Intelligent Environments)

Marcela D. Rodríguez.
Ph. D. @CICESE

Mobile and Ubiquitous Computing, Human-Computer Interaction (HCI)

Eloisa García Canseco.
Ph. D. @UPS-11

Haptic systems, Control Systems, Mechatronics

Angel Andrade.
Ph. D. @CICESE

4th Generation Wireless and Sensor Networks

María Victoria Meza Kubo.
Ph. D. @UABC

Human-Computer Interaction (HCI)

Assistive Technologies for Cognition (ATC)

Alberto L. Morán.
Ph. D. @ INPG,

CSCW, Mobile and Ubiquitous Computing, HCI

Research Group Focus

- Integrate intelligence to assist people in every day activities
- Augment physical spaces through technology to facilitate or improve the experience of use, work, play, live
- Provide relevant information at the right moment, anytime anywhere

Technology… Intelligence … Environment … Where?

In our everyday environments emphasis on technology

In our everyday environments emphasis on transparent services

What is an Intelligent Environment?

"The creation of environments saturated with computer and wireless commu PERVASIVENESS *nologies, seamlessly integrated into human activity"* (Satyanarayanan, 1992)

"…highlights the use of the computer, it makes possible that many computers are available in the physical environment, an INVISIBILITY *e time, invisible to the user."* (Weiser, M., 1991)

Ambient Intelligence (AmI)

- In a world with ambient intelligence, people is surrounded by intuitive interfaces that are embeded into everyday objects, which provide services capable of recognizing and responding to the presence of individuals in a transparent, non-intrusive and invisible manner.

Source: http://guillemrecolons.com/wp-content/uploads/2009/05/ambientintelligence11.jpg
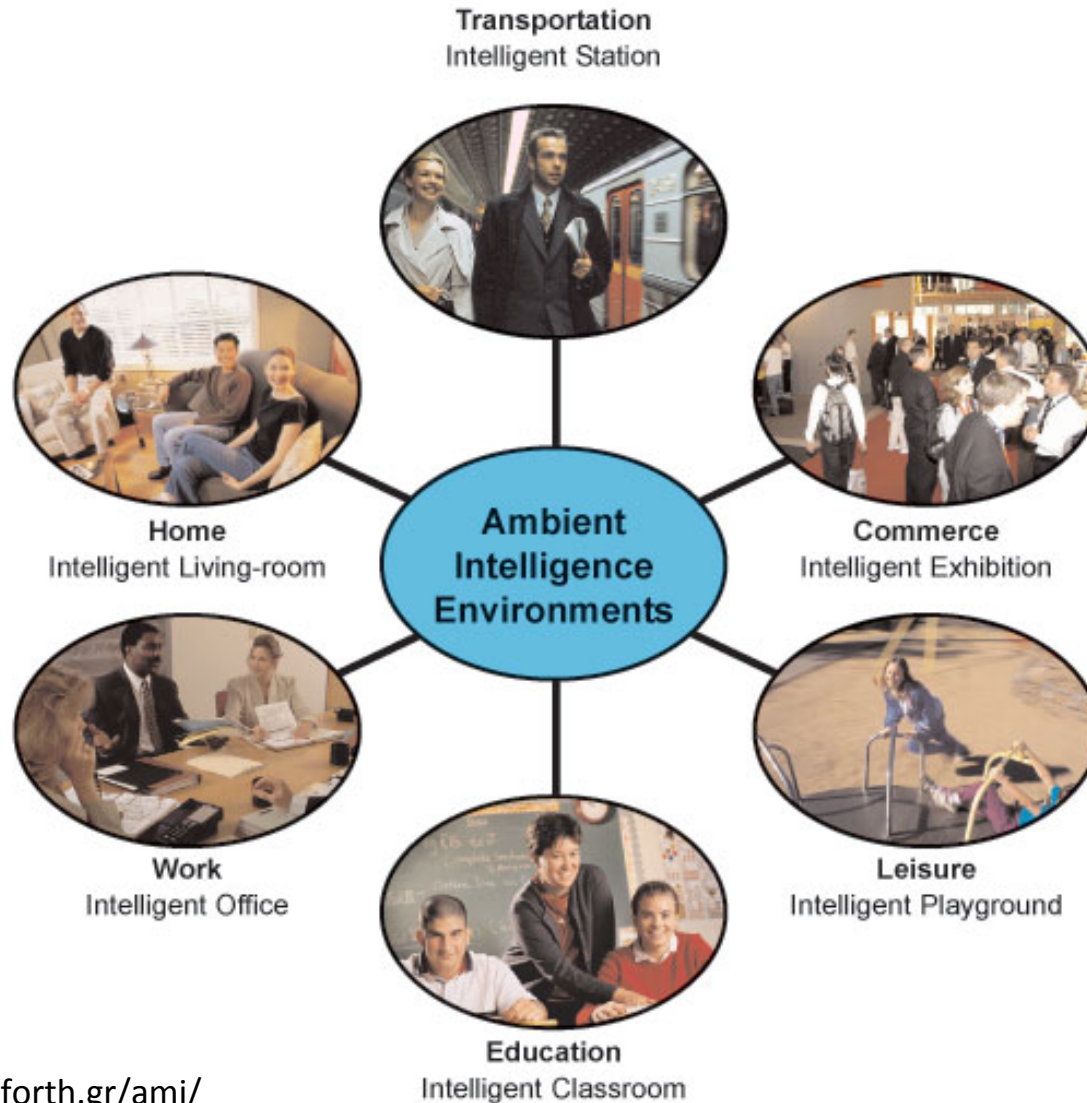
Main features

Services available anywhere and anytime

AmI Environments

Environment and objects as interfaces to the services

Services adaptable to the user's context

Some application areas

Transportation
Intelligent Station

Home
Intelligent Living-room

Commerce
Intelligent Exhibition

Ambient
Intelligence
Environments

Work
Intelligent Office

Leisure
Intelligent Playground

Education
Intelligent Classroom

How to design and evalute this type of systems?

AmI Enabling technologies

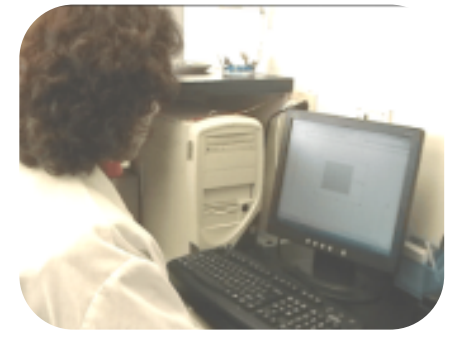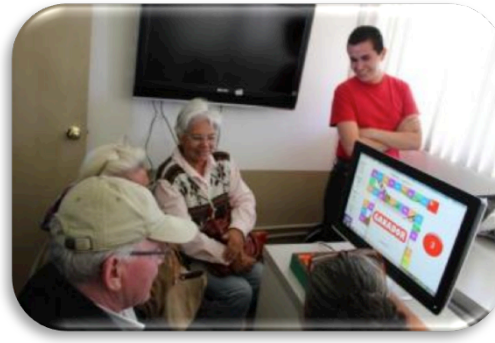**Contextual Information**

Context Inference

Context Adaptation

SERVICES

USER INTERFACES
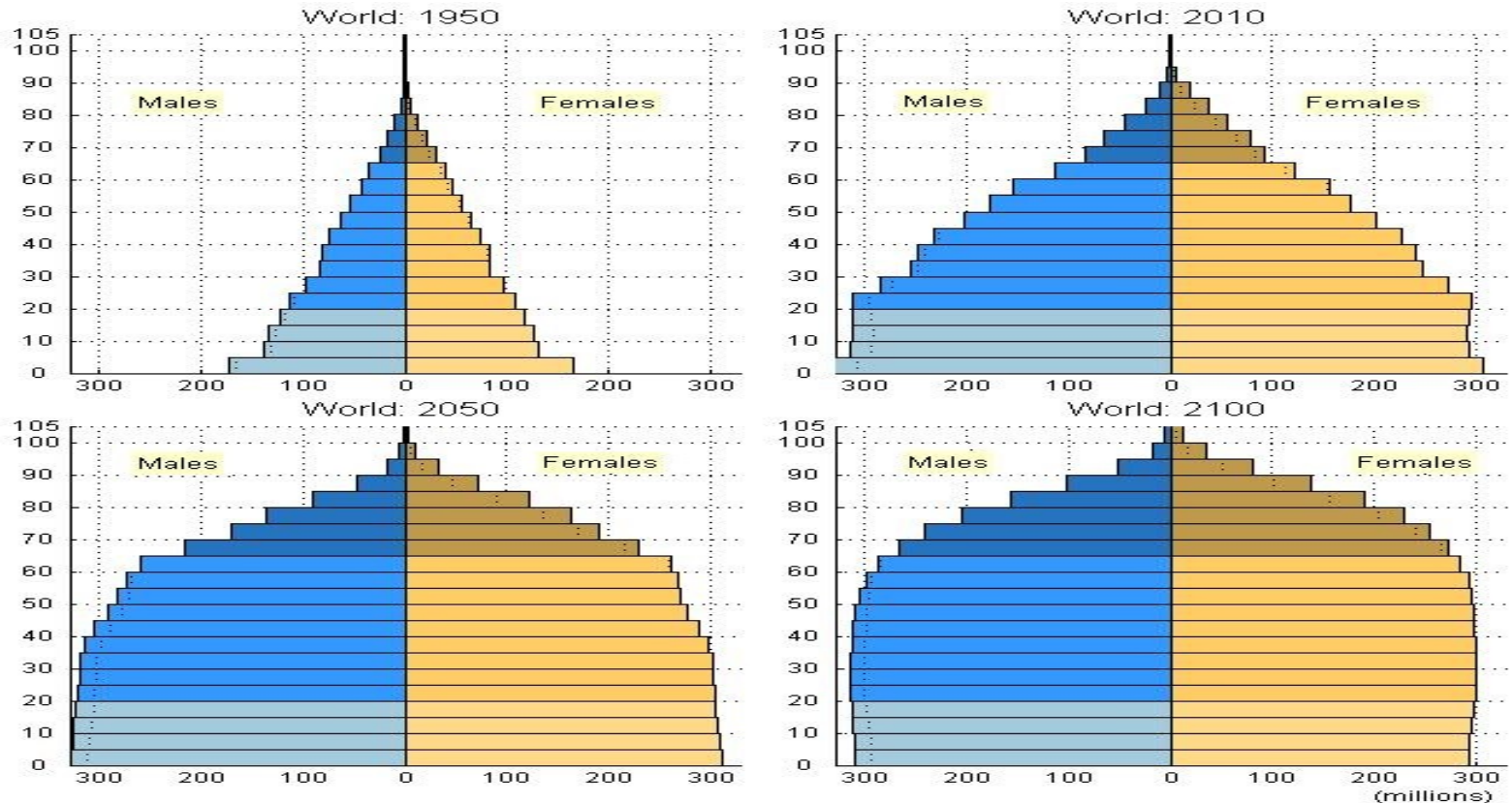
Actuators and Displays

Sensors

Actors and Artifacts

Assistive Technologies for the Cognitive Stimulation of Older Adults

World population is getting older

Aging population tsunami:--younger & ++older

The elderly face different issues (medical, economic...).

Romero, N., Sturm, J., Bekker, T., de Valk, L., and Kruitwagen, S. (2010). Playful persuasion to support older adults' social and physical activities. Interacting with Computers, 22(6), 485–495.
Image: http://sites.google.com/site/neatherdgcsegeography/unit-2-people-and-the-planet/11-1-population-change/5-what-Inare-the-advantage

Improving the quality of life of elders is one of the main challenges today.

Romero, N., Sturm, J., Bekker, T., de Valk, L., and Kruitwagen, S. (2010). Playful persuasion to support older adults' social and physical activities. Interacting with Computers, 22(6), 485–495.

Efforts to promote the wellbeing of the elderly

➢Theory of the activity aging

➢Successful aging model

➢The SOC model

➢Active aging model

Theory of the activity aging

The elderly need to keep active by developing different kinds of activities:

- **Social formal Activities**
- **Social informal Activities**
- **Social solitary Activities**

- To cope with the lack of social contacts and thus keep them socially active (and cognitively fit).

Acosta, C., Davila, M., & Iribarren, M. R. (2010). Daily activities and successful aging (p. 156).

Successful aging model

Acosta, C., Davila, M., & Iribarren, M. R. (2010). *Actividades de la vida diaria y envejecimiento exitoso* (p. 156).
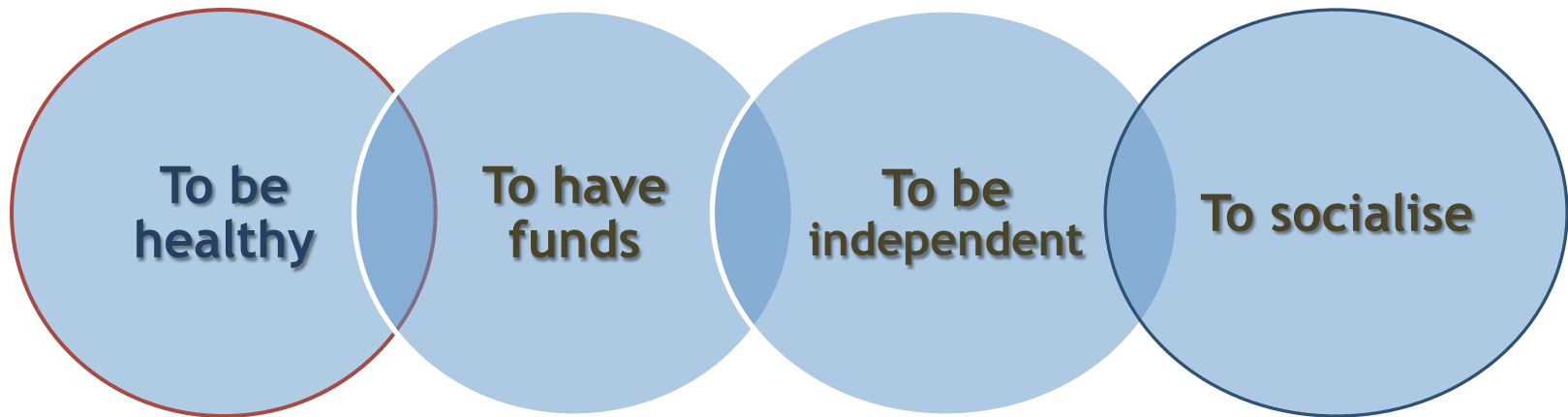
SOC model

- ***Selection, Optimization and Compensation***

➤ Maintain a balance between loses and acquisitions [1]

➤ Physical (and Cognitive) wellness

➤ Social wellness [2]

[1] Baltes, P. B. (1997). On the Incomplete Architecture of Human Ontogeny, Selection Optimization and Compensation as Foundation. American Psychologist, 52(4), 366–380.
[2] Steverink, N., Lindenberg, S., & Ormel, J. (1998). Towards understanding successful ageing : patterned change in resources and goals. *Aging and Society*, *18*, 441–467.

Active aging model

➤ **IMSS** **(Mexican Social Security Institute, for its acronym in Spanish)**

➤ **Aging Plan (4 aspirations)**

To be healthy	To have funds	To be independent	To socialise

➤ **Successful aging**

➤ **Healthy Aging**

Camacho, R. E., Gámez, C. H., Flores, A. V., & Guerrero, G. (2010). Programa de envejecimiento activo (p. 402).
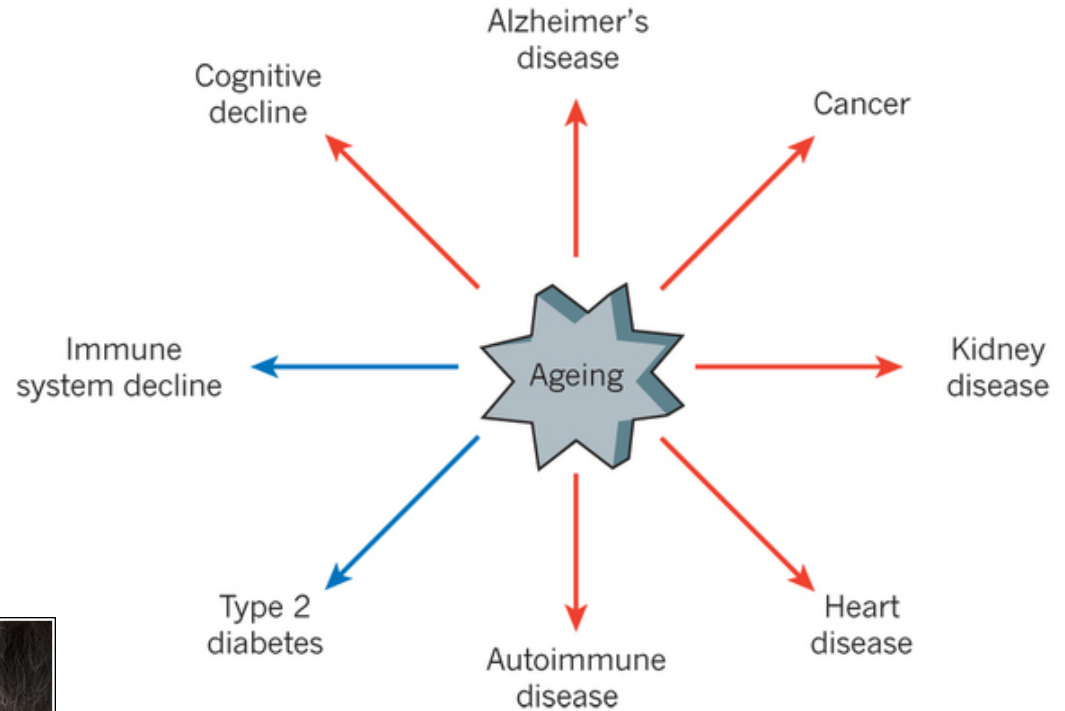
The wellbeing of the Elderly

➢ Activity theory of aging

➢ Successful aging model

➢ SOC model (Selection, Optimization and Compensation)

➢ Active aging model

Be cognitively fit

Age-related diseases

☒ Increase of life expectancy makes evident an increase of age-related diseases

☒ Some age-related diseases are accompanied by Cognitive Decline (e.g. Dementia)

Problems

- People suffering dementia will double to 34 million for 2025 worldwide [1].

- There is no cure for dementia.

- High hospitalization's costs (up to 3K $/month)

- Lack of enough personnel to attend affected people

Pharmacological and Non-pharmacological approaches are recommended

{1} United Nations, Department of Economic and Social Affairs, Population Division (2011): World Population Prospects: The 2010 Revision. New York

Cognitive Stimulation (CS)
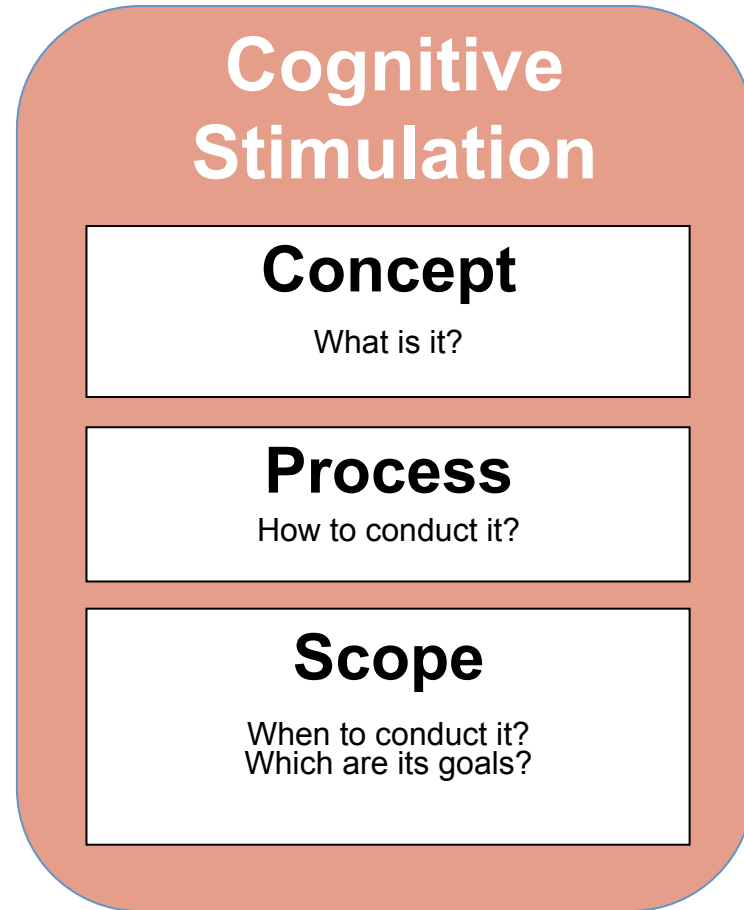# A non-pharmaceutical intervention

- A kind of "brain gymnastics"; works with the (remaining) skills of the elderly; delays the onset of disease.

- Frequent participation on CS reduces the risk of suffering dementia, or improve cognitive behavior [1].

[1] Spector, A., L. Thorgrimsen, B. Woods, L. Royan, S. Davies, M. Butterworth, and M. Orrell Efficacy of an evidence-based cognitive stimulation therapy programme for people with dementia: Randomized controlled trial. The British J. of Psychiatry, Sep 2003; 183: 248– 254.

[2] Katzman, R. Education and the prevalence of dementia and Alzheimer's disease. Neurology, 43, (1993) 13–20.

What is Cognitive Stimulation?

Cognitive Stimulation

Concept
What is it?

Process
How to conduct it?

Scope
When to conduct it?
Which are its goals?

Cognitive Stimulation

- Definition
  - Ensemble of non-pharmacological interventions systematically conducted on people that suffers a form of cognitive decline
- Aim
  - Activating and maintaining the remaining cognitive functions of the subject,
  - Delaying the cognitive decline process as well as an increase in his/her dependency [1],
- Includes
  - Stimulation activities for the memory, communication, verbal, recognition, praxis, among others
- Also know as
  - *Cognitive training* [2],
  - *Cognitive Intervention* [3].

[1] Tárraga, L. M Boada, G Modinos, A Espinosa, S Diego, A Morera, M Guitart, J. A randomised pilot study to assess the efficacy of an interactive, multimedia tool of cognitive stimulation in Alzheimer's disease. J. Neurol. Neurosurg. Psychiatry 2006;77;1116-1121

[2] Davis, R. N., Massman, P. J., & Doody, R. S. (2001). Cognitive intervention in Alzheimer Disease: A randomized placebo-controlled study. *Alzheimer Disease and Associated Disorders, 15, 1–9.*

[3] Peña-Casanova, J. 1999. Intervención cognitiva em la enfermedad de Alzheimer, manual de actividades. Ed. Fundación La Caxia.

Cognitive Stimulation: Process
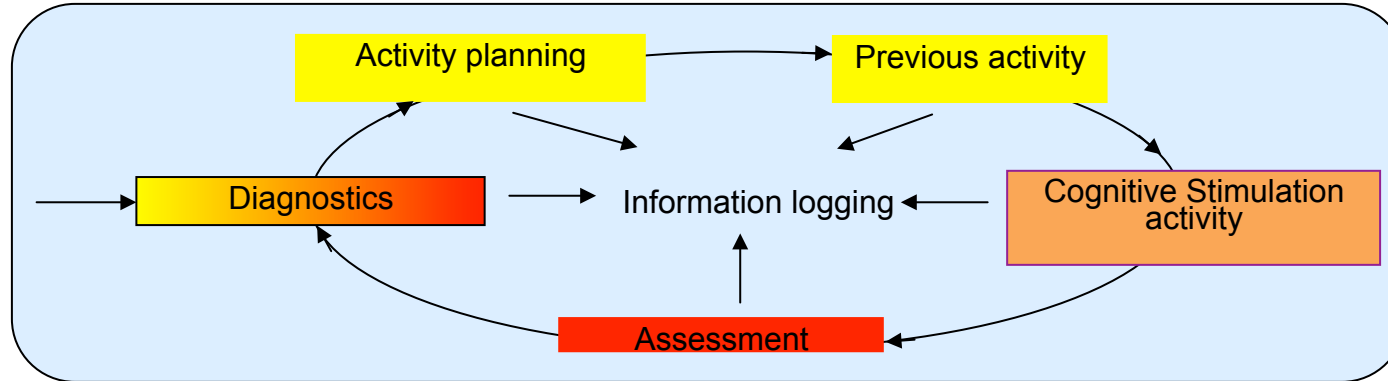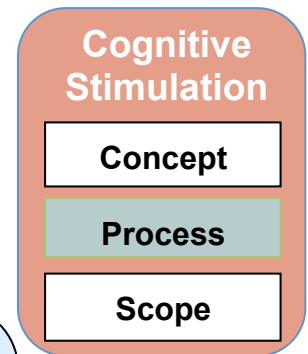
- **Diagnostics**
  - Determine presence and degree of Cognitive Decline
  - Identify kind of decline
- **Activity planning**
  - Activity selection
  - Application form

  - Duration and frequency
  - Material selection
- **Previous activity**
  - Relaxation
  - Ice-breaker session
- **Cognitive Stimulation activity**

  - Skill
  - Memory
  - Recognition
  - Language
  - Construction
  - Orientation
- **Assessment**
  - Feedback
- **Information logging**

Tárraga, L., M. Boada, G. Modinos, A. Espinoza, S. diego, A. Morena, M. Guitart, J. Balcells, O. L. López y J. T. Becker. A randomised pilot study to assess the efficacy o fan Interactive, multimedia tool of cognitive stimulation en Alzheimer's disease. J. Neurol. Neurosurg. Psychiatry 2006.
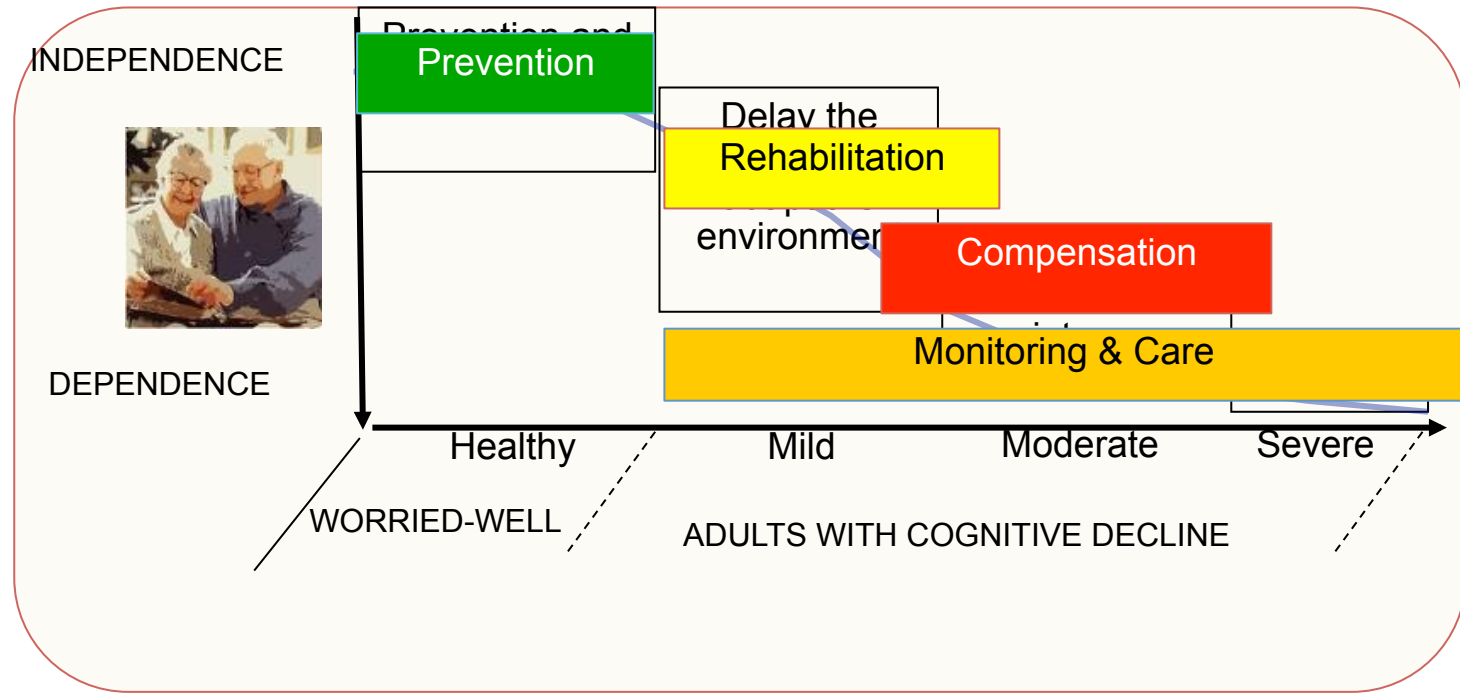
Teri, L. Behavioral Treatment of Dementia: An Overview. Semin. Clin. Neuropsychiatry; Apr.2007, 2(2): 100-101.

Mejía, Silvia, Comunicación personal, Grisolle, Argel, Comunicación personal

Cognitive Stimulation: Scope

INDEPENDENCE

Prevention and...

Prevention

Delay the...

Rehabilitation

environmen...

Compensation

DEPENDENCE

Monitoring & Care

Healthy   Mild   Moderate   Severe

WORRIED-WELL   ADULTS WITH COGNITIVE DECLINE

[Moran & Meza-Kubo, 2009]

Tárraga, L., M. Boada, G. Modinos, A. Espinoza, S. diego, A. Morena, M. Guitart, J. Balcells, O. L. López y J. T. Becker. A randomised pilot study to assess the efficacy o fan Interactive, multimedia tool of cognitive stimulation en Alzheimer's disease. J. Neurol. Neurosurg. Psychiatry 2006.

Teri, L. Behavioral Treatment of Dementia: An Overview. Semin. Clin. Neuropsychiatry; Apr.2007, 2(2): 100-101.

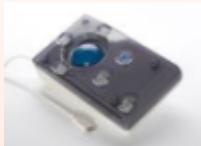Mejía, Silvia, Comunicación personal, Grisolle, Argel, Comunicación personal

Could we use technology to support CS & help older adults to be cognitively fit?

Assistive Technologies (AT)

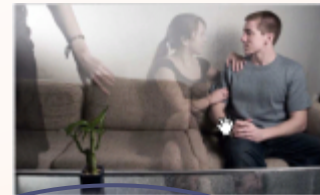Are used to increase, maintain or improve the functioning capabilities of handicap people [Bryant y Seay, 1994].

Motor

Sensory

Cognitive

# Assistive Technologies for Cognition (ATC) focused on Older Adults

Monitoring
Assure that the older adult is conducting the daily activities in a proper and safe manner, otherwise a notification is sent to the caregiver.

Compensation
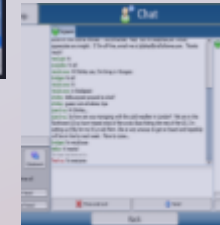Aid the older adult to compensate his/her decline, assist in the execution of activities of daily living.

Prevention
Help older adults to maintain their cognitive functioning.

(Pederson, 2007; Consolvo;) 2003)
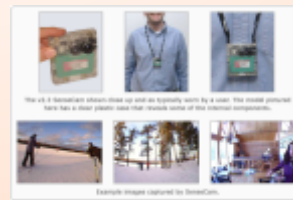
(Wu 2006; Cohene, 2005;)
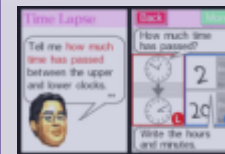
(Tarraga, et al. 2006; Plasaint 2003; Jimison, 2006; Gowans 2003)

ATCs for Prevention
Cognitive Stimulation (CS)

CS Exercises

Videogames

Social Information and Communication Technologies

These proposals have in common that they require direct interaction with the computer or console, through the mouse or keyboard, or using the stylus pen of the BrainAge.

(Tarraga, et al. 2006; BrainAge)

(Jimison, 2006; Torres 2008)

(Plasiant 2006; Gowans, Dickinson 2005)

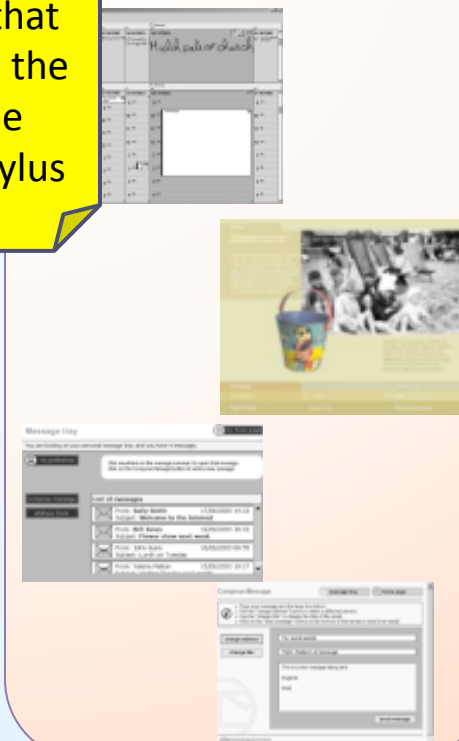# Older adults' capability limitations on the use of technology

Perception Problems

- i) Decline in sensory abilities.
- ii) Decline in the auditory abilities, they have problems to hear, distinguish or recognize sounds.
- iii) Decline in visual abilities, they have problems to see, distinguish or recognize text or images.(Salthouse, 1996; Coren 1994; Charness and Dijkstra 1999).

Cognitive Problems

- i) Reduction in working memory processing and spatial abilities.
- ii) Decline in the abilities to organize information.
- iii) Difficulty to maintain focus or split attention.
- (Hebb, 1942; Salhouse et al., 1989; Salhouse, 1996; Horn, 1982).

Motor Problems

- i) Elderly people tend to show a low performance in the control of their movements.
- ii) This decline makes them difficult to use a mouse to handle the pointer in the computer.
- (Walker, Philbin et al. 1997 Fitts 1992)

- The main problems that older adults face when using the computer or related technologies include (Hancock, Fisk et al. 2001):
  - Motor problems (94%),
  - Perception problems (51%),
  - Memory problems (48%),
  - Text comprehension (26%) y
  - Symbol comprehension (23%).

Proposed solutions

Changes to the configuration of the display

- i) Design guidelines to cope with the older adults' visual sensory limitations, e.g. use Sans Serif fonts only, black on white text, easy to see hyperlinks and with enough space between them.
- ii) Guidelines to optimize information perception, e.g. provide redundant information channels, use blinking information for important messages.
- iii) Maintain consistency on the location of elements on the screen and of the provided functionalities.

- (Ellis and Kurniawan 2000; Fisk, Rogers et al. 2009; Sandres & McCormick, 1993).

Changes on the functionality

- i) Avoid background music or sound effects that cause distraction (split attention).
- ii) Provide immediate feedback when required.
- iii) Avoid the need to memorize the meaning of the controls and consider the use of labels as required.

(Fisk, et al, 2009; Wickens 1992).

Changes in the interaction with devices

- i) Changes on application and device configurations, e.g. reducing mouse pointer acceleration and adjusting the radius of the mouse pointer location.
- ii) Selecting adequate input and output devices.
- iii) Alternative and more natural means of interaction, e.g. tangible user interfaces.

- (Ullmer and Ishii 2000; Walker, Philbin et al. 1997; Fisk, Rogers et al. 2009).
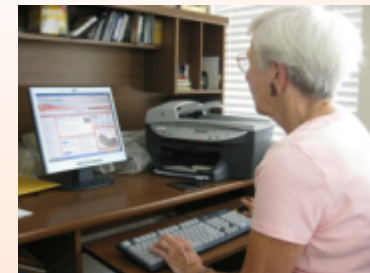
Alternative interaction solutions for CS

Multimedia Biographies
(Cohene, Baecker et al. 2005)
A video disc (DVD) was created for the older adult, which could be used for reminiscence theraphy.

Older adults preferred to use the computer …"Perhaps due to the awkwardness of the album design"
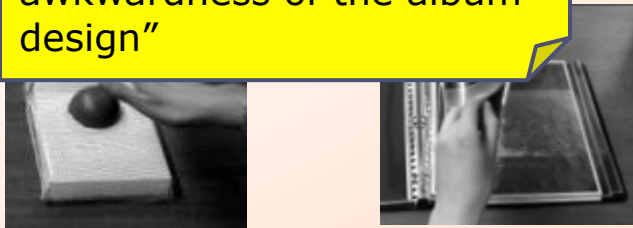
ElderMailBUI
(Davidoff, Bloomberg et al. 2005)
A Book User Interface (BUI) using tangible interfaces and RFID readers was created. The older adult used it to send and receive emails in a simpler way.

The use was designed and the interaction was accessible for basic functionality; however, the user experience failed! Users did not perceived as a natural way to do it.

How to support CS with Technology?

- Which features from the CS domain?
  - Participants?
  - Activities
  - Materials?
  - …
- Which features from the Technological domain?
  - Mechanisms?
  - Models?
  - Tools?
  - …
- Which features of the actual CS application to render it … ?
  - Useful
  - Easy to use
  - Enjoyable
  - Learnable
  - …
- How to aid developers to design and build applications that consistently include all these features?

Software Design

AREAS
Goals

HCI
Usefulness/
Ease of use

ID
User
Experience

SE
Requirements/
Usefulness

SE– Software Engineering
HCI- Human-Computer Interaction
ID– interaction Design
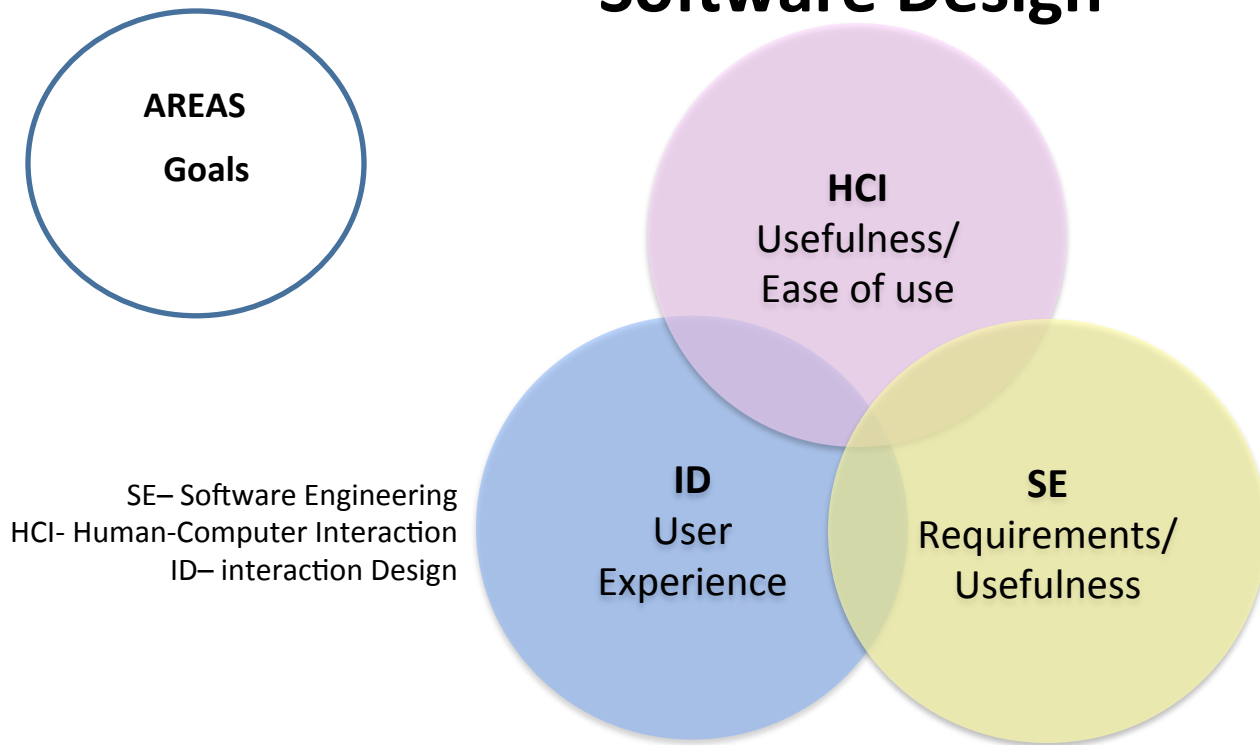
Decide which areas are required for the design, will depend on the kind of application and the user at whom the software is aimed.

Cognitive Stimulation (CS)

- It is a kind of gymnastics for the brain[1].

- Prevents or improves the cognitive state[2,3].

- However, there are some limitations to its application.
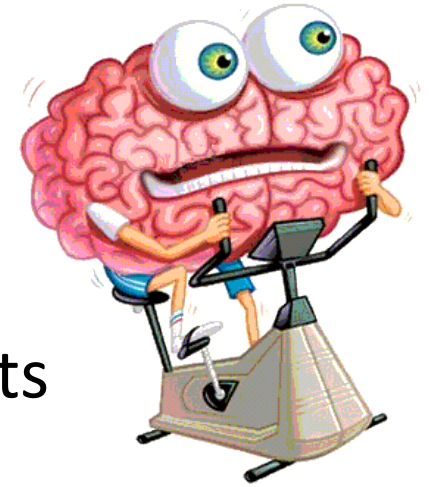
> Information and communication technologies may be used by specialists to support CS therapy

[1] Tárraga, Boada et al. 2006
[2] Spector, A., S. Davies, et al. (2000)
[3] Ball, K., D. B. Berch, et al. (2002)

Assistive Technologies for Cognition

- ## Advantages:
  - Benefit a greater number of older adults.
  - Automatically evaluate performance and log data.
  - Facilitate collaboration with other participants.

- ## Sample applications for CS

HCI
Ease of use

ID
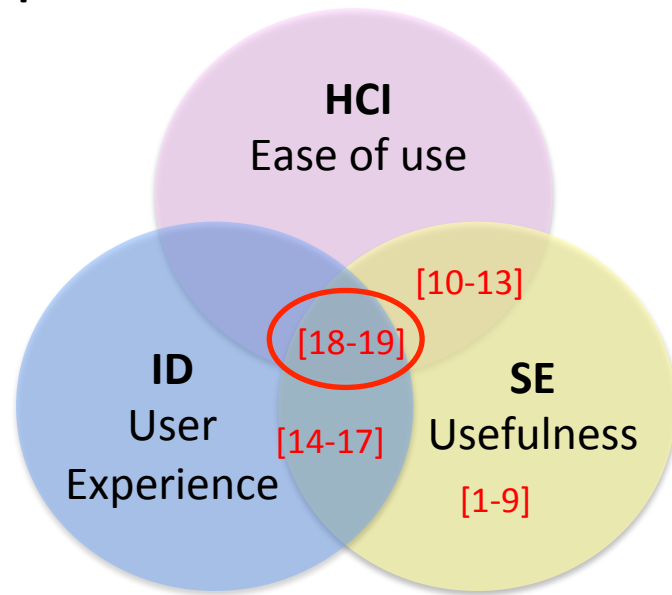User
Experience

SE
Usefulness

[10-13]

[18-19]

[14-17]

[1-9]

Not all designs cover or consider the three aspects

[14]Torres, 2006	[10]Cohene, 2005	[1]Tárraga, 2006	[6]Saunders, 2004	[18]Gamberini, 2008
[15]Jimison, 2006	[11]Davidoff, 2005	[2]Rasmusson, 1999	[7]Belleville, 2008	[19]Buiza, 2009
[16]Wilkinson, 2008	[12]Facal, 2009	[3]Farina, 2002	[8]Smith, 2008	
[17]Annet, 2009	[13]Pantelopoulos, 2010	[4]Namazi, 2003	[9]Barnes, 2009	
		[5]Günter, 2003		

- Usable Cognitive Stimulation Applications (**UCSA**)
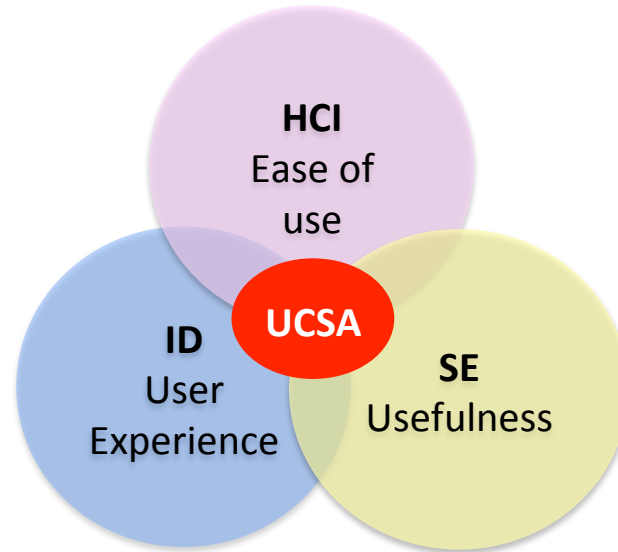
- The design of UCSA applications requires:
  - Multidisciplinary groups.
  - Designers with knowledge and experience on the three areas.
  - Knowledge transfer from expert designers through specialized design tools.

- ¿Which design elements should be considered to guide the development of CS application for older adults, so that these applications are accessible and atractive for them?

- How to include these elements, measure them and analyze them?

Propose and evaluate guidelines for the design of applications that are useful to older adults, ease to use by them, and which provide them with pleasurable user experiences (UCSA applications).

Specific objectives

1. Identify the main characteristics of older adults, which hinder their use of technologies for CS.

2. Identify design solutions that should be considered to address the needs and preferences of the older adult, so that they could increase their interest on the use of CS applications.

3. Establish the Usable Cognitive Stimulation Applications (UCSA) concept.

4. Propose a set of guidelines for the design of applications with UCSA features.

5. Evaluate the impact of applications created with the design guidelines from the older adults' perspective.

6. Evaluate the impact of the design guidelines from the developers' perspective.

Methodology

Stage 1: Understanding

Literature review and Field studies → Identify older adults' limitations on the use of computers → Needs and preferences
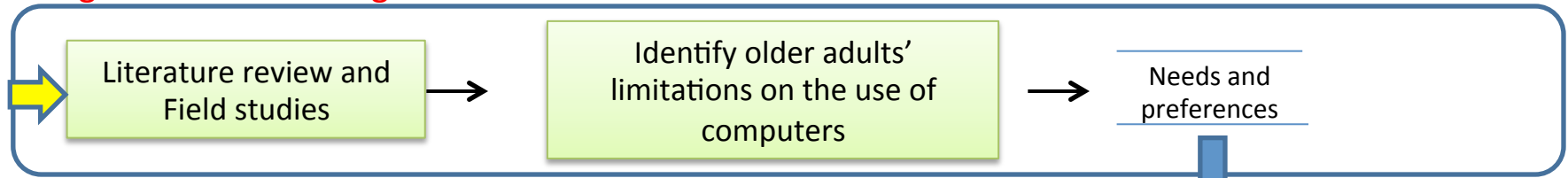
Stage 2: Initial Prototypes

Propose design solutions → Initial design recomendations → Prototype design → Prototypes: IntouchFun → IntouchFun evaluation → Results
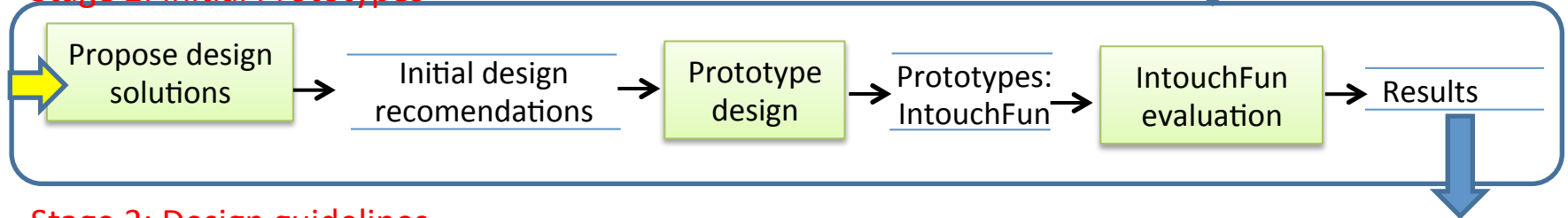
Stage 3: Design guidelines

Define teh concept of UCSA applications → Propose design guidelines → Design guidelines
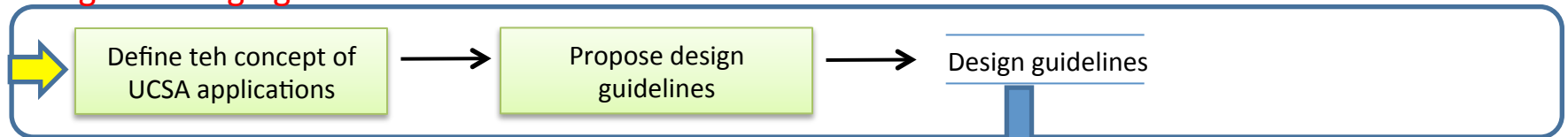
Stage 4: Design guidelines validation

Proof of concept design → Prototype: Abueparty → Usability and User experience evaluation → Usability and User experience results → Design guidelines validation

Prototype design by external developers → Prototypes → Quality of product, use and perception of use evaluation of the design guidelines → Usefulness and perception results → Design guidelines validation
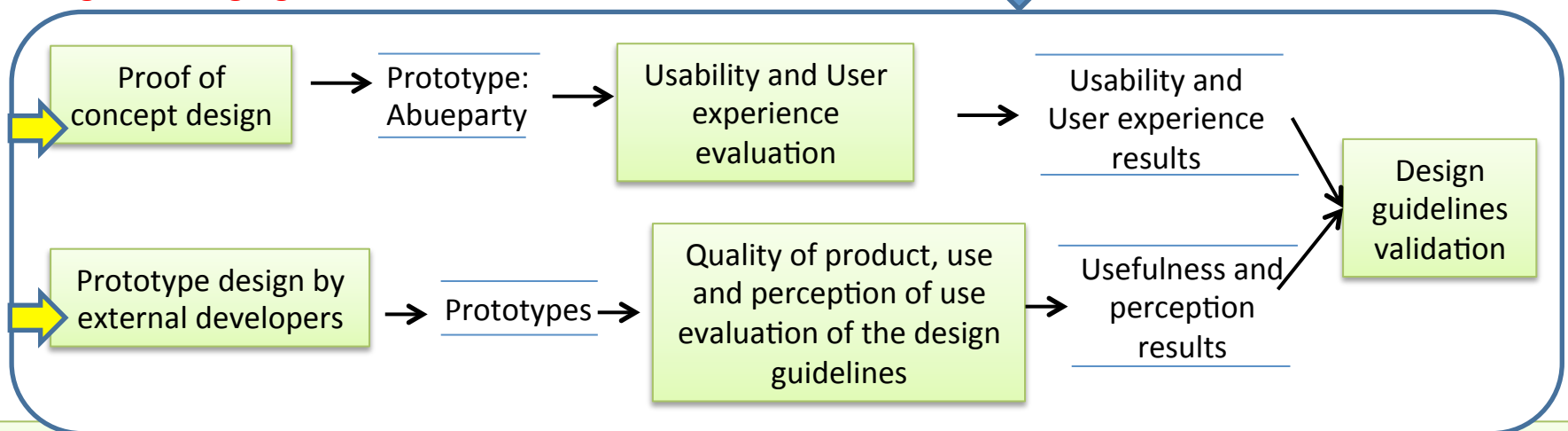
Understanding

Literature review

Interviews

CS session observation

Physical vs digital materials
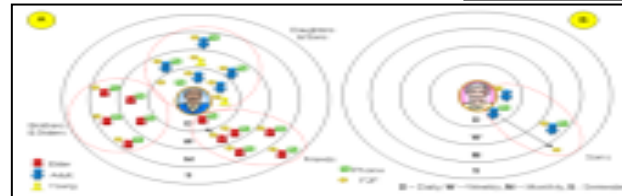
Older adult SFN

- Observational study in a residence for elders with Alzheimer disease and other dementias

- Data acquisition using unstructured techniques

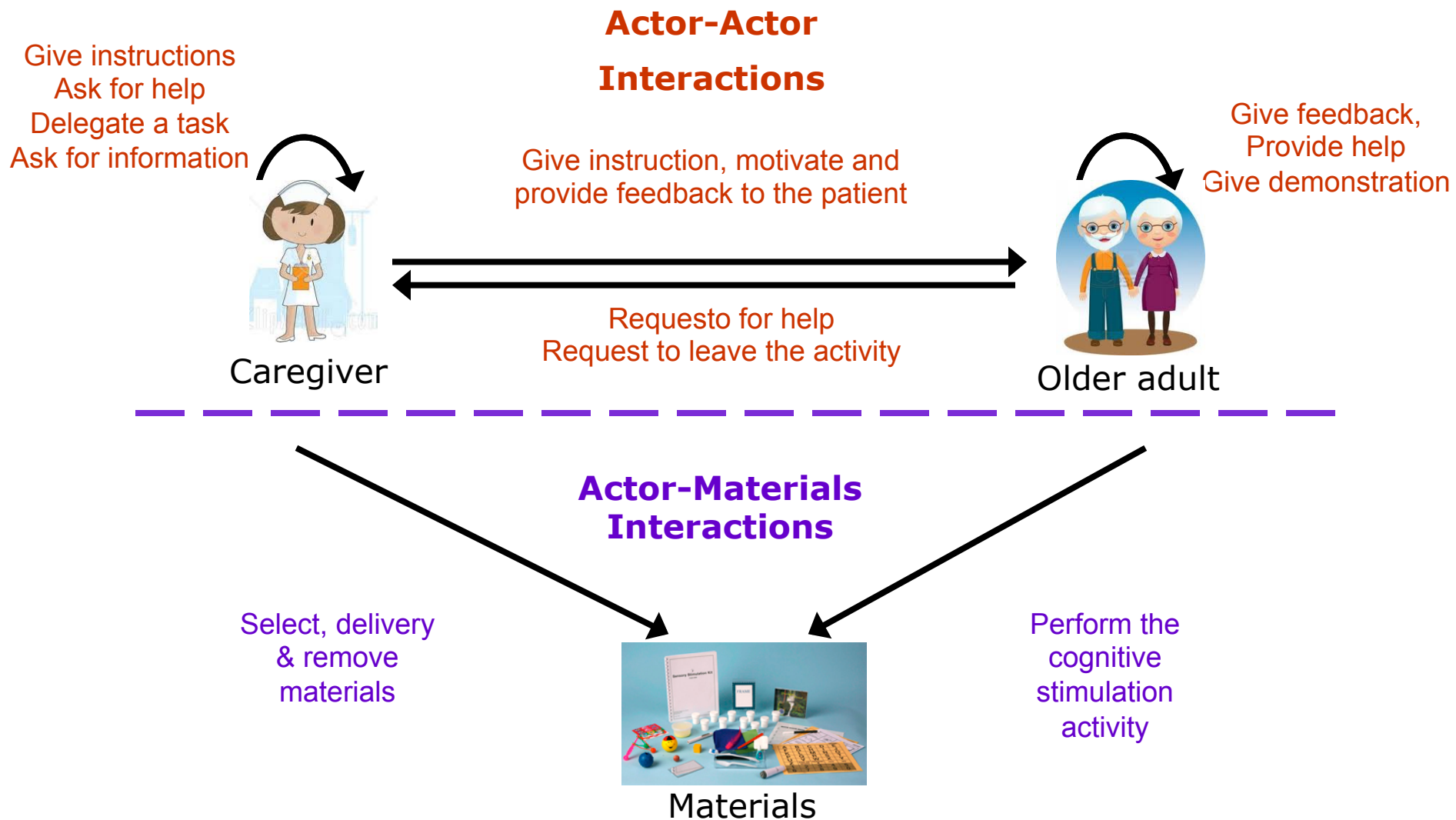- CS session lasted about 40 minutes

- Actors participating
  - 10 patients,
  - 3 caregivers

Identified Actors & Interactions

Actor-Actor Interactions

Give instructions
Ask for help
Delegate a task
Ask for information

Give instruction, motivate and provide feedback to the patient

Give feedback, Provide help
Give demonstration

Requesto for help
Request to leave the activity

Caregiver

Older adult

Actor-Materials Interactions

Select, delivery & remove materials

Perform the cognitive stimulation activity

Materials

Meza-Kubo V. y A.L. Morán. Form and Function of the Interactions of a Cognitive Stimulation Session of Elders with Alzheimer's Disease. Taller Mexicano de Interacción Humano Computadora, MEXIHC'o8 (ENC'o8)
Moran, A. and Meza-Kubo, V. Towards a tele-assistance service for the cognitive stimulation of elders with cognitive decline. To appear in eTELEMED 2009 IEEE Proceedings.

- C1 has provided P1 with the materials required for the CS activity, and given her instructions on how to perform it. However, 3 minutes later she notices that P1 has not started putting the pieces of the puzzle together. She approaches her, while saying:

P1 c'mon, start solving the puzzle! Look, these, you have to put them in the places that look like them… this one in here; you know how to do it.

We conducted an empirical study on the execution of CS activities, with 13 elders using physical objects vs. digital objects.

- Interaction modality:

Physical objects,
manipulated with their hands

Digital objects,
manipulated with the mouse

- Process:
  - On-Entry questionnaire (MMSE).
  - CS activity using physical objects.
  - CS activity using digital objects.
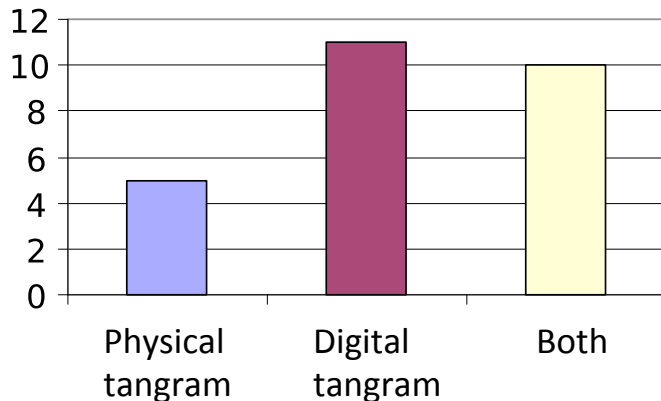 - On-Exit questionnaire.

- We quantified:
  - Number of completed exercises
 - Completion time
  - Number of errors

Results of the comparative analysis

- Elders complete more exercises (5:1), and in less time (1:14), using physical than digital objects.

Physical objects	Digital objects
Direct manipulation (both hands)	Indirect manipulation (mouse)
+ Simple	+ Difficult
Attention focus: reference Image + pieces	Attention focus: reference image, pieces + cursor+ mouse buttons + mouse
Experience in object manipulation	Lack of experience
Better performance	Poor performance

Use preferences:

Manipulation of physical objects → TUI ← Use of computer
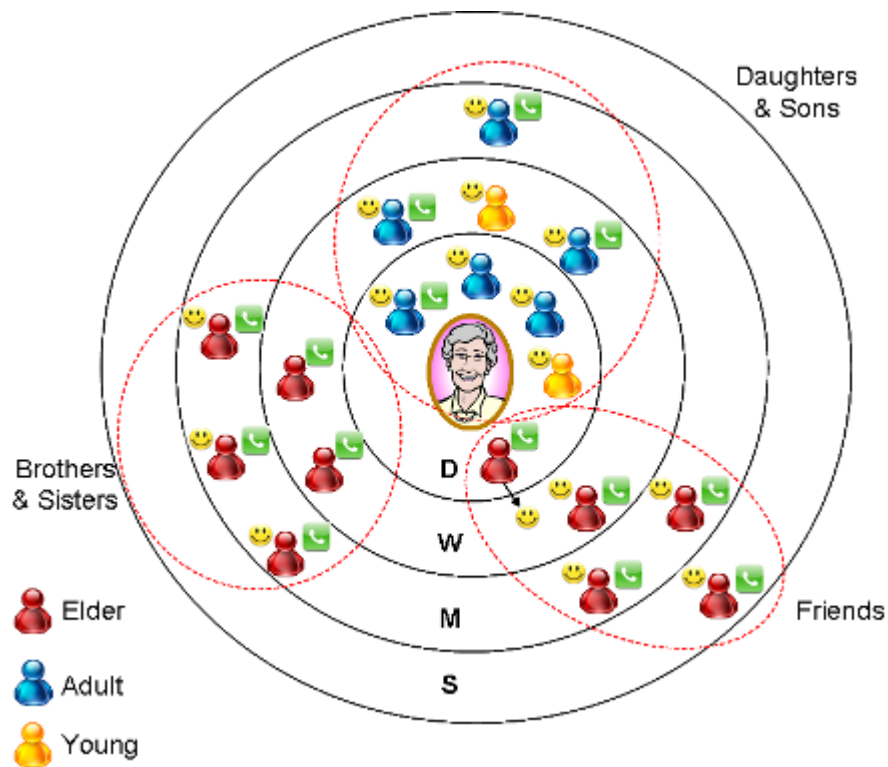
(performance + preference)
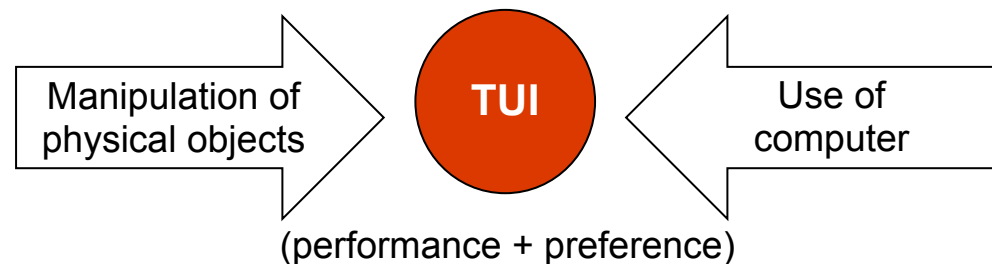
Identifying the Social Family Network of an older adult and its evolution [1/2]

- Participants: 11 older adults
  - 7 healthy,
  - 1 with CD at home and
  - 3 with CD at a elderly care residence.
- Questions [1]:
  - Whom do older adults communicate with?
  - Who communicates with them?
  - How frequently do they communicate with them?
  - Which tools do they use to communicate with them?
  - How large/small is their SFN?

[1] Adams, P. (2007). Communication mapping: understanding anyone's social network in 60 minutes, New York, NY, USA, ACM.

SFN of a healthy older adult   SFN of an older adult with CD
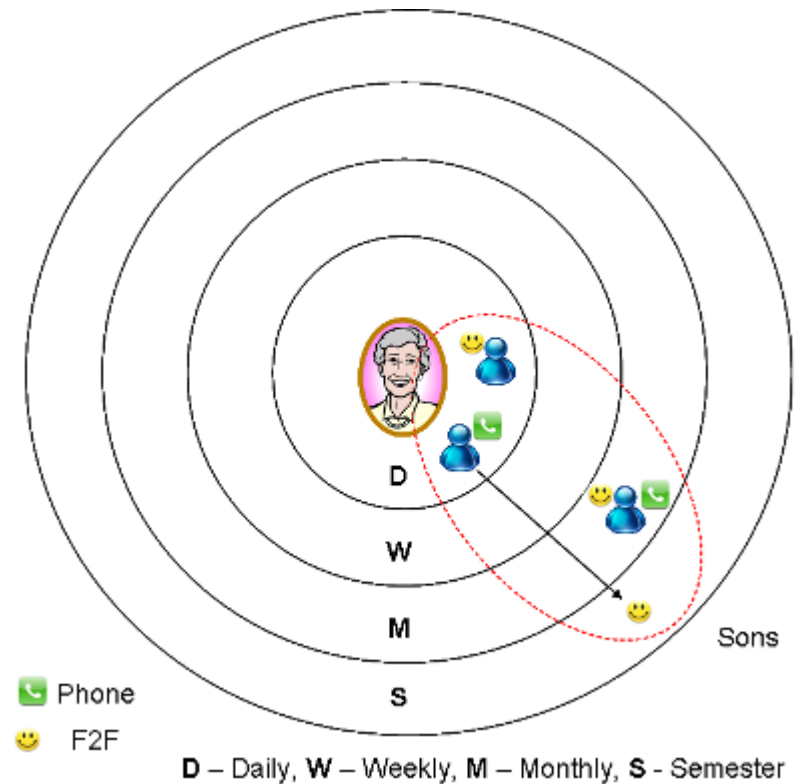
[1] Representation similar to Neustaedter, C., K. Elliot, et al. (2006). Interpersonal awareness in the domestic realm, New York, NY, USA, ACM.

Findings	Proposal
1. Benefits of direct manipulation and preference for the use of technology.	Use TUIs or NUI for CS activities.
2. During CS, there are different interactions between patients and caregivers.	Need for coordination and collaboration mechanisms.
3. Caregivers miss some of the situations faced by older adults during CS sessions.	Need for awareness mechanisms for the caregiver.
4. CS activities are part of a whole process, including planning and evaluation activities, and information logging.	Consider the provision of support for the whole CS process
5. The most benefit of CS occurs when it is applied as a preventive measure or at the beginning of Cognitive Decline.	Early detection of cognitive problems.

- Limitations:

Physical aspects

Visual and hearing decline

Slower body movements

Difficulty to perform fine movements

Cognitive Aspects

Processing speed decline

Spatial skills decline

Difficulty to maintain split attention

Memory decline

Isolation

Loss of self-confidence to learn the use of technology

Lack if interest due to ignorance the benefits on the use of technology

Other aspects

Initial design recommendations

Older adults' needs and preferences	Design recommendations	
1. Provide support for the prevention and early diagnostics of cognitive decline.	1. Design activities for the CS of the older adult. 2. Evaluate performance and give immediate feedback.	Usefulness aspects
2. Provide support to compensate a decline of the perceptual abilities.	3. Design with perception problems in mind.	Ease of use aspects
3. Provide support to compensate a decline of the cognitive abilities.	4. Reduce interface complexity and simultaneous tasks. 5. Give clear instructions. 6. Select activities known to the older adult.	
4. Provide support to compensate a decline of the motor abilities.	7. Design interaction mechanisms that allow for direct manipulation of materials. (TUIs, TI)	
5. Provide support for the inclusion of motivators according to older adults' preferences and capabilities.	8. Introduce digital elements to enrich activities. 9. Design activities that could be adapted to preferences. 10. Design activities that allow for the integration of SFN members.	User experience aspects

Identification of needs and requirements elicitation

Field studies

Model / Protytpe Validation

(Re) Design

Concept and Model

Evaluation

Iterative construction

Prototypes

Final product
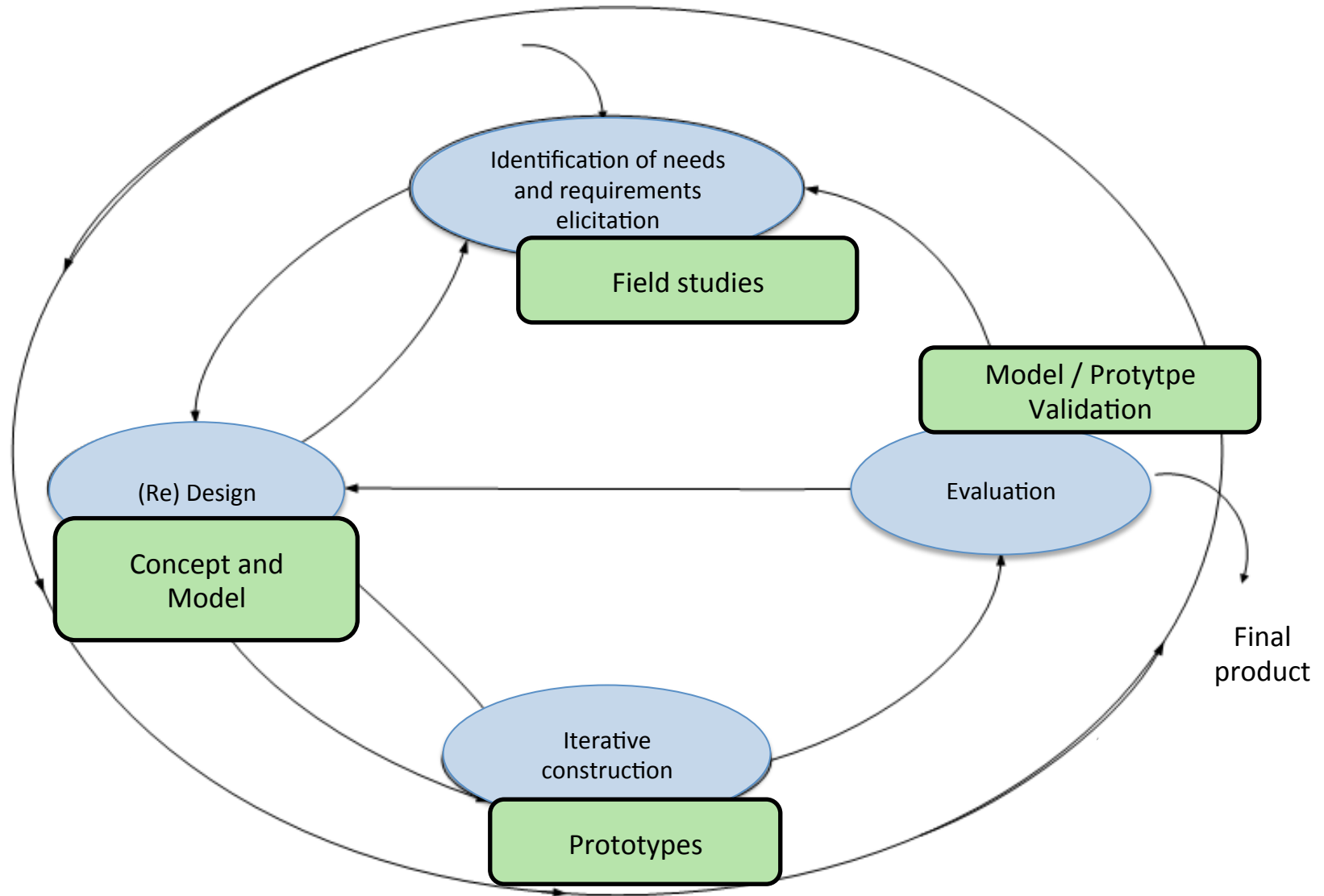
Sharp, H., Rogers, Y., Preece, J. (2006)

Main features:

- Use of games to promote CS.

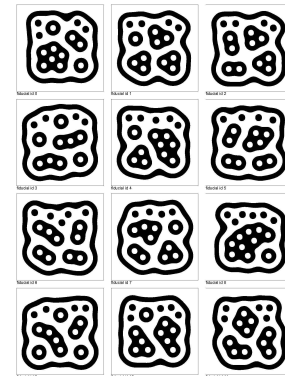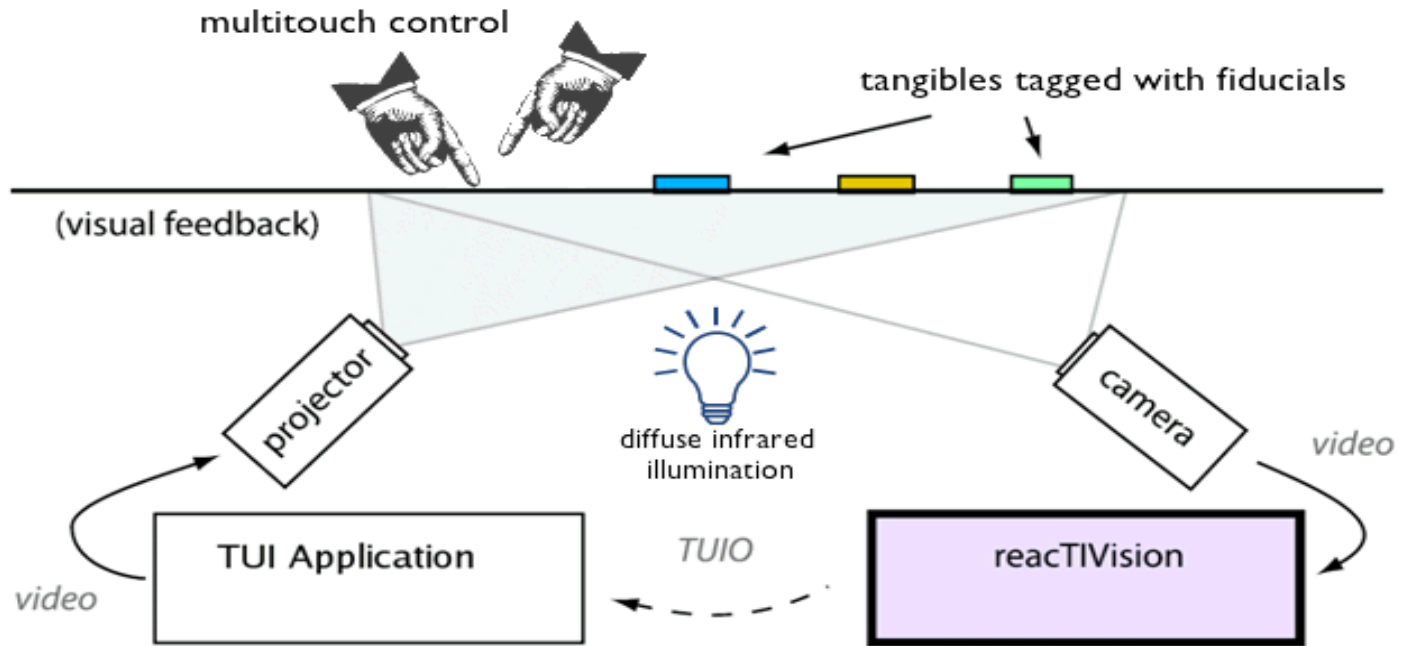- Allows for the integration of a member of the Social Family Network (SFN) into de CS activity.

Older adult interface (Tangible)

Audio channel
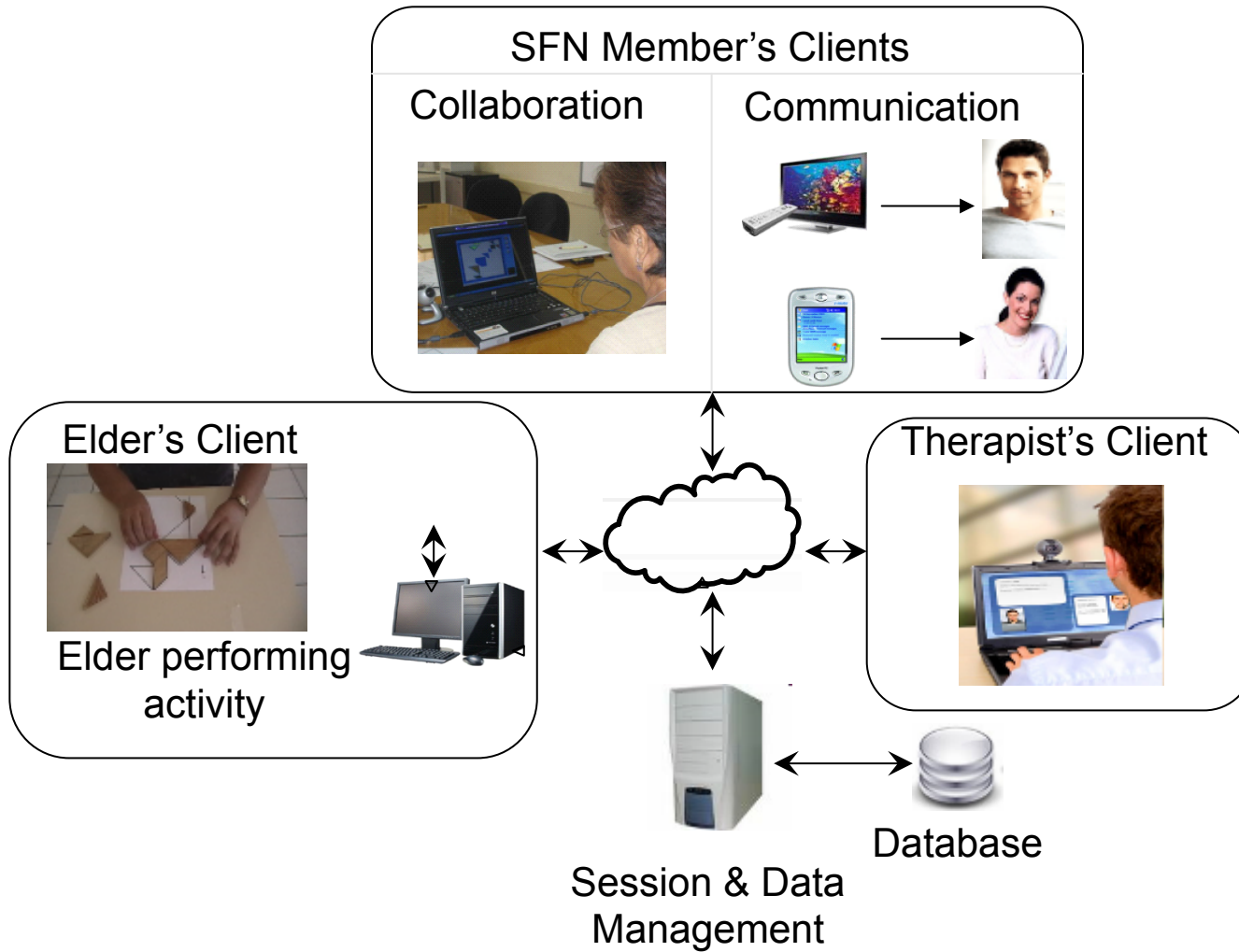
SFN member interface (Traditional)

SFN Member's Clients

Collaboration

Communication

Elder's Client

Elder performing activity

Therapist's Client

Session & Data Management

Database

Reactivision Server

Fiducials interpreter

TUIO Protocol

Older Adult Client (FlashApp)

Game

Digital UI

Communication (text & audio)

SFN Member Collaboration Client (FlashApp)

Game

Digital UI

Communication (text & audio)

SFN Member Communication Client (C#App)

Context-aware Notification Agent

Custom XML Protocol

Custom XML Protocol

TCP/IP Server (C# sockets)
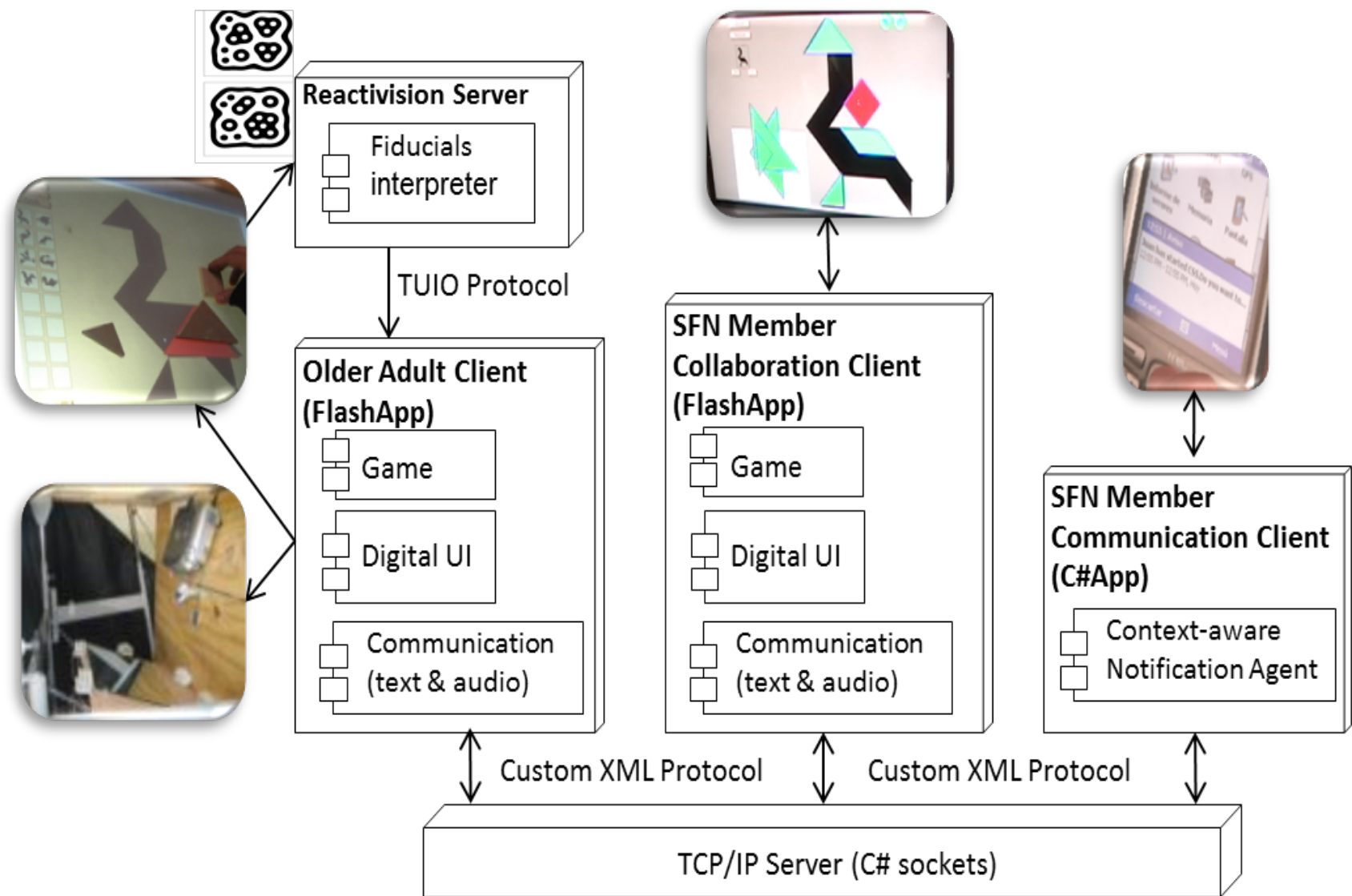
Goal

– Analyze the impact of integrating some of the initial design recommendations for CS applications, as well as identify new design elements that should be considered to this end.

Participants

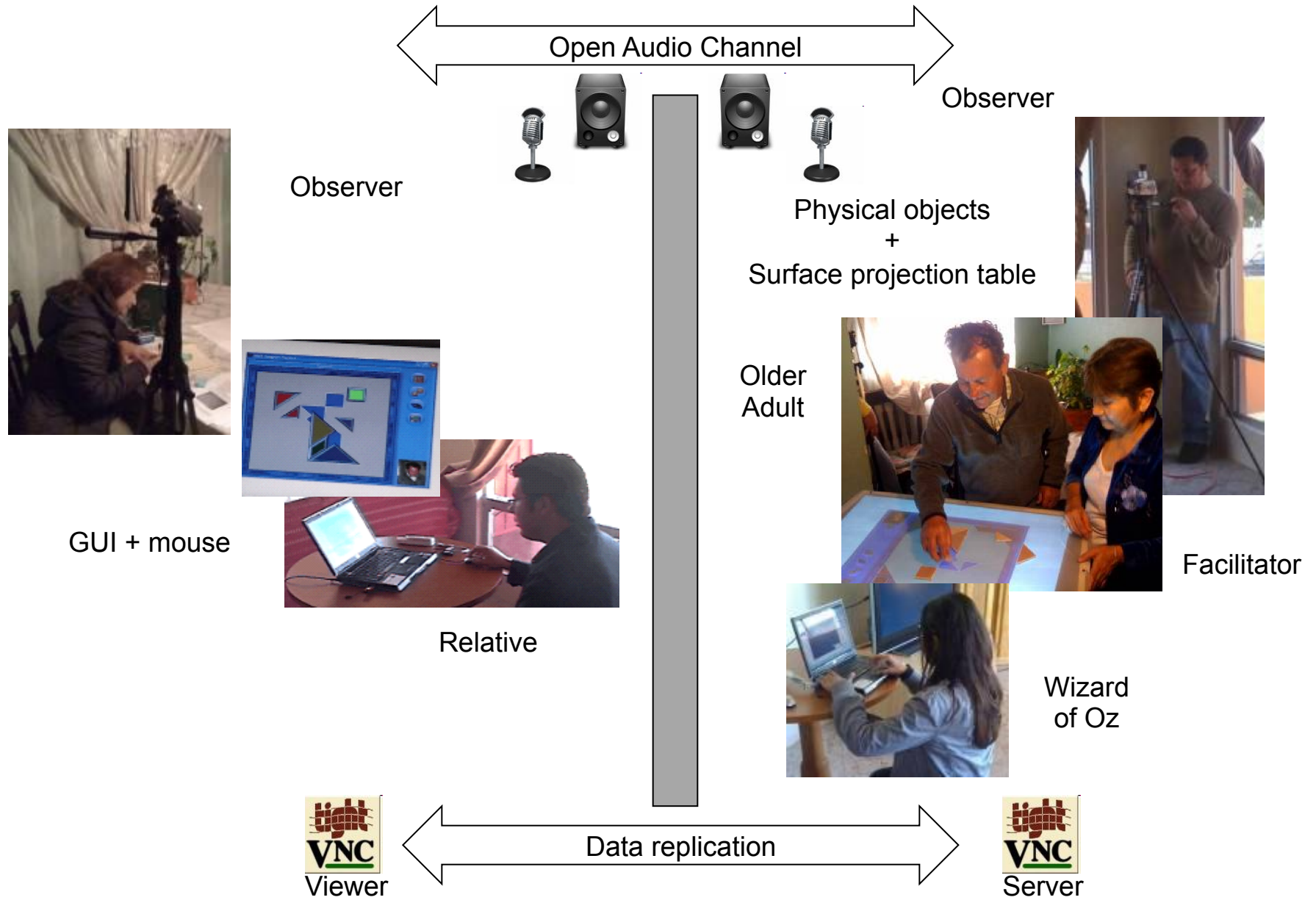– 6 healthy older adults and their 6 respective relatives.

Data acquisition using conventional non-structured techniques

– Non-participatory observation and indirect observation through video,

– Questionnaires (TAM-based)

Procedure

- Introduction (4 min)
  - Motivation and Goal
  - Signing of consent form
- Video scenario presentation (8 min)
  - Video projection
  - Facilitator explained goal and solved doubts
- CS activity (25-30 min)
  - The facilitator explained the goal and use of the interfaces
    - Older adult: Tangible objects + custom surface computer,
    - Relative: GUI + mouse
  - Activities (within-subjects)
    - Cognitive activity (10 min max)
      - Tangram (4 figures)
    - Entertainment activity (10 min max)
      - Board games (Tic Tac Toe, Checkers, Connect-4)
- On-exit questionnaire (10-15 min)
  - The facilitator applied the TAM (OA & R)
  - The facilitator solved doubts and supported the OA by writing their responses

Setting

Open Audio Channel

Observer

Observer

Physical objects
+
Surface projection table

GUI + mouse

Older
Adult

Relative

Facilitator

Wizard
of Oz

VNC
Viewer

Data replication

VNC
Server

On-exit questionnaire: TAM-Based [Davis,1989]

- We inquired about the participant's perception on :
  - Ease of use.
  - Usefulness.
  - Enjoyment.
  - Anxiety.
  - Intention of Use.
  - Expected use.

Evaluation results

Regarding ease of use, usefulness, enjoyment and anxiety as perceived by older adults and their relatives

	Older adults	Relatives	Cognitive activity Older adults	Cognitive activity Relatives	Entertainment activity Older adults	Entertainment activity Relatives
Ease of use 6.52(.35)	6.				NA	
Usefulness 6.32(.23)	6.		4(.29)	6.28(.1.)	6.25(.21)	6.23(.19)
Enjoyment 6.40(.28)	6.47(.37)	6.33(.1.)	6.14(.14)	6.23(.08)	6.80(.08)	6.42(.14)
Anxiety 2.17(1.02)	2.36(1.2)	1.80(.50)	2.61(1.49)	1.80(.50)	2.11(1.10)	1.80(.50)

Relatives perceived easier

Older adults perceived as more useful, in particular the cognitive activity

Older adults enjoy it more, in particular the Entertainment activity

Older adults felt more anxious, in particular in the Cognitive activity

Regarding intention of use and expected use by older adults and their relatives

	Older adults	Relatives
Intention of use 6.03(.29)	6.28(0)	5.78(.10)
Expected use (days per week) 4.76(.79)	5.23(.32)	4.28(.89)

Initial prototypes ... Conclusions

- Participants perceived the use of IntouchFun as useful for CS, ease to use and fun.

- The use of known activities facilitated the learning of the application.

- The natural interaction modality, by means of T&TUIs, facilitated the interaction of the older adult.

- Entertaining activities were considered apropriated for CS.

- Collaborative features allow for the participation of (remote) members of the SFN.

Design guidelines for UCSA Applications

USEFULNESS

GD1. Design activities that foster the CS of the older adult.

GD2. Assess and register the older adult's performance on the activity.

GD3. Provide awareness information on the performance of the older adult.

EASE OF USE

GD4. Present contents in an appropriate manner that eases perception and understanding.

GD5. Facilitate the application's learnability.

GD6. Afford direct manipulation of materials.

GD7. Facilitate the integration of and interaction with other participants in group activities.

USER EXPERIENCE

GD8. Select the type of CS activity and materials according to the older adult's preferences profile.

GD9. Integrate motivators as part of the activity – *internal motivators*.

GD10. Integrate motivators around the activity – *external motivators*.

GD11. Integrate different complexity levels in the CS activities.

- Each guideline includes
  - Name
    - Meaningful
  - Description
    - Proposed solutions
    - When to use
  - Motivation
    - Problem
    - Context
  - Example
    - Do's and do not's

Design guidelines … Example

GD2: . Assess and register the older adult's performance on the activity. ← Name

Description. Activities should be designed so that, when possible, those parameters that allow to analyze the older adult's performance could be evaluated in an automatic and immediate manner.

To evaluate the older adult's performance it is necessary to establish:

a) *The parameters.* …, it is necessary to identify which parameters could …
b) *Evaluation mechanisms* …, it should be established how these could …
c) *Historical log …* a historical record about the activity should be kept …

Motivation. Although there are different instruments to evaluate the cognitive state of the older adult (p.e. MMSE and Adas-Cog, etc.), these instruments could be intrusive, require the assessment of an specialist, or be monotonous if they are going to be used frequently. As stated by the specialists ….

The use of technology for CS allows to measure different parameters in an automatic manner; to do so, firstly, we should define the parameters that describe older adults performance in a specific activity, and determine how to capture it and measure it.

Example. Jimison (2004) proposes an ensemble of tools to evaluate the cognitive performance of the older adult, based on a non-intrusive data collection during the interaction with the computer. Measures are based on …..

However, in interaction modalities differente to traditionals, such as TUIs, evaluation parameters could be different and could be more complex to measure the performance of the user. For instance, in (Hodges, Kirsch et al. 2010) the cognitive state of the older adult is evaluated through the execution of activities of daily living …..

Figure 5.4. The solitary card game requires some planning in advance.

Questions for the operationalization of the design guidelines

	Questions
DG1.- Design activities that foster the CS of the older adult.	What cognitive function will be stimulated? What activities/tasks do therapists use to stimulate it? What technologies can be used to implement the activity without interfering with the CS processes? What other cognitive functions can be stimulated with the same activity through the use of technology?
DG2.- Assess/register the older adult's performance.	What parameters should be measured to evaluate their performance? How to get the value of each parameter? What action should be executed when changes in the performance of the elderly appear?
DG3.- Provide awareness information on performance of the older adult.	What mechanisms and means are appropriate to inform the elders about the results of their activity? Who should be notified about their performance results? What means are most suitable for this notification? What privacy issues should be considered?

Questions for the operationalization of the design guidelines

	Questions
DG4.- Present contents appropriate;y to ease perception & understanding	What type, size and color of the graphical elements (e.g. Font, buttons, wallpaper) should be used to ease perception? What physical or digital means are most appropriate to present information to ease understanding?
DG5.- Facilitate application learnability	What content, materials, tasks and means of interaction from the activity are familiar to the elderly? What metaphors can be used to facilitate the learnability of the application? What mechanisms are used, where they are placed and how do they work? Is consistency maintained in the use of the design elements throughout the application?
…	…

- ## We conducted three evaluations:
    - Evaluations with **older adults**:
        - Usability evaluation (inquiry)
        - User experience evaluation (observation)
    - Evaluation with **developers**:
        - Prototype design
        - Heuristic evaluation and questionnaries.

Mr. & Mrs. Garcia   Mr. & Mrs. Lopez
Worried well elders

··· Some minutes later ···

Intelligent system provides some game options

They played two complete games of Abueparty
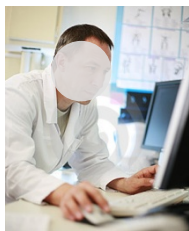
Specialist analyses the elders performance during their entertainment activitites

Flower in bloom indicates that the Garcia's are cognively well

Methodology

We used the design guidelines to facilitate the design of CS applications

Identify needs/ establish requirements

(Re) Design

Evaluate

Build an interactive version

Final product

[4] Sharp, Rogers I., Preece. Interaction Design. Beyond Human-Computer Interaction.
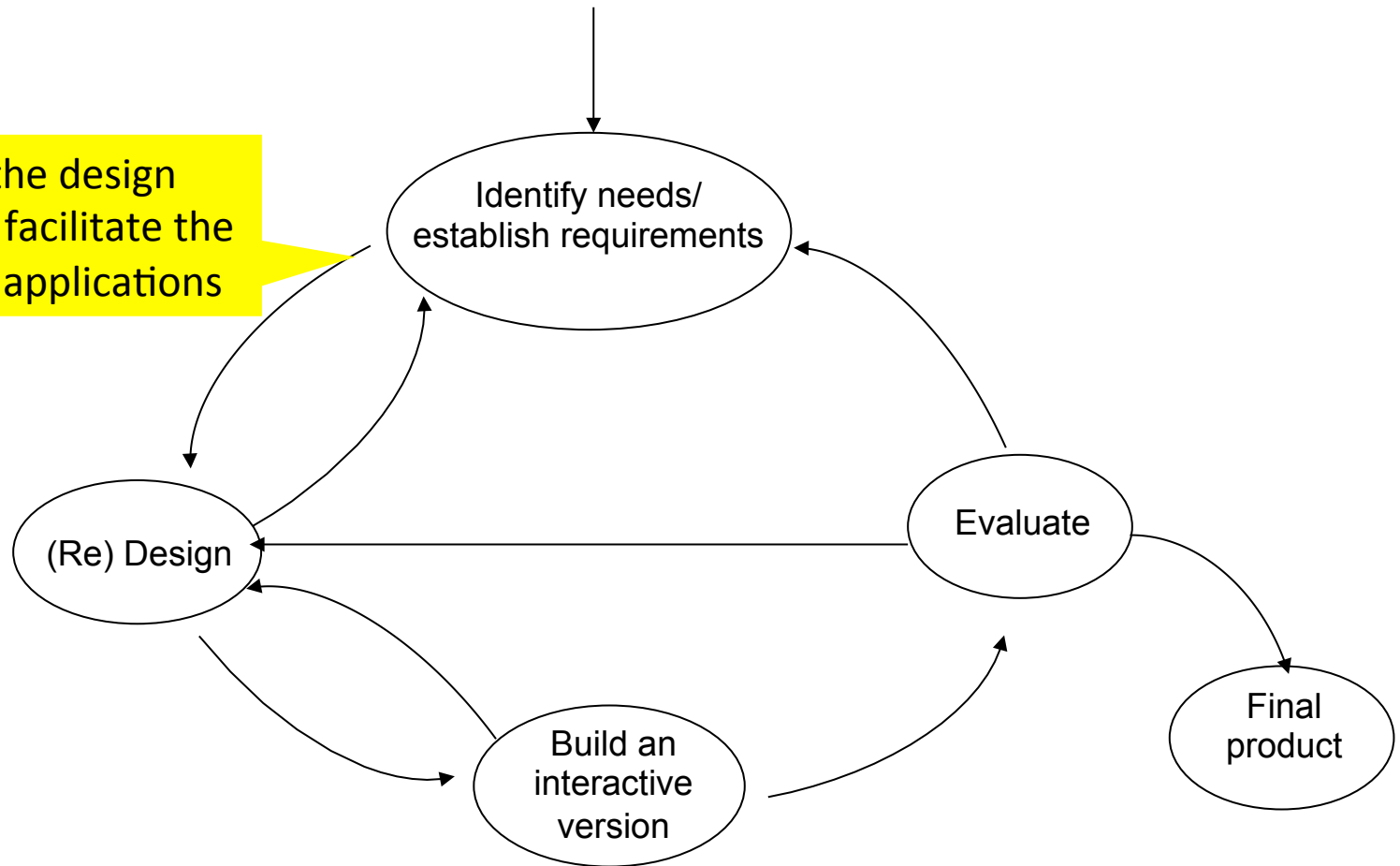
Abueparty: entertainment activity

- AbueParty is a multiplayer game similar to the traditional "Snakes and Ladders" Mexican game.
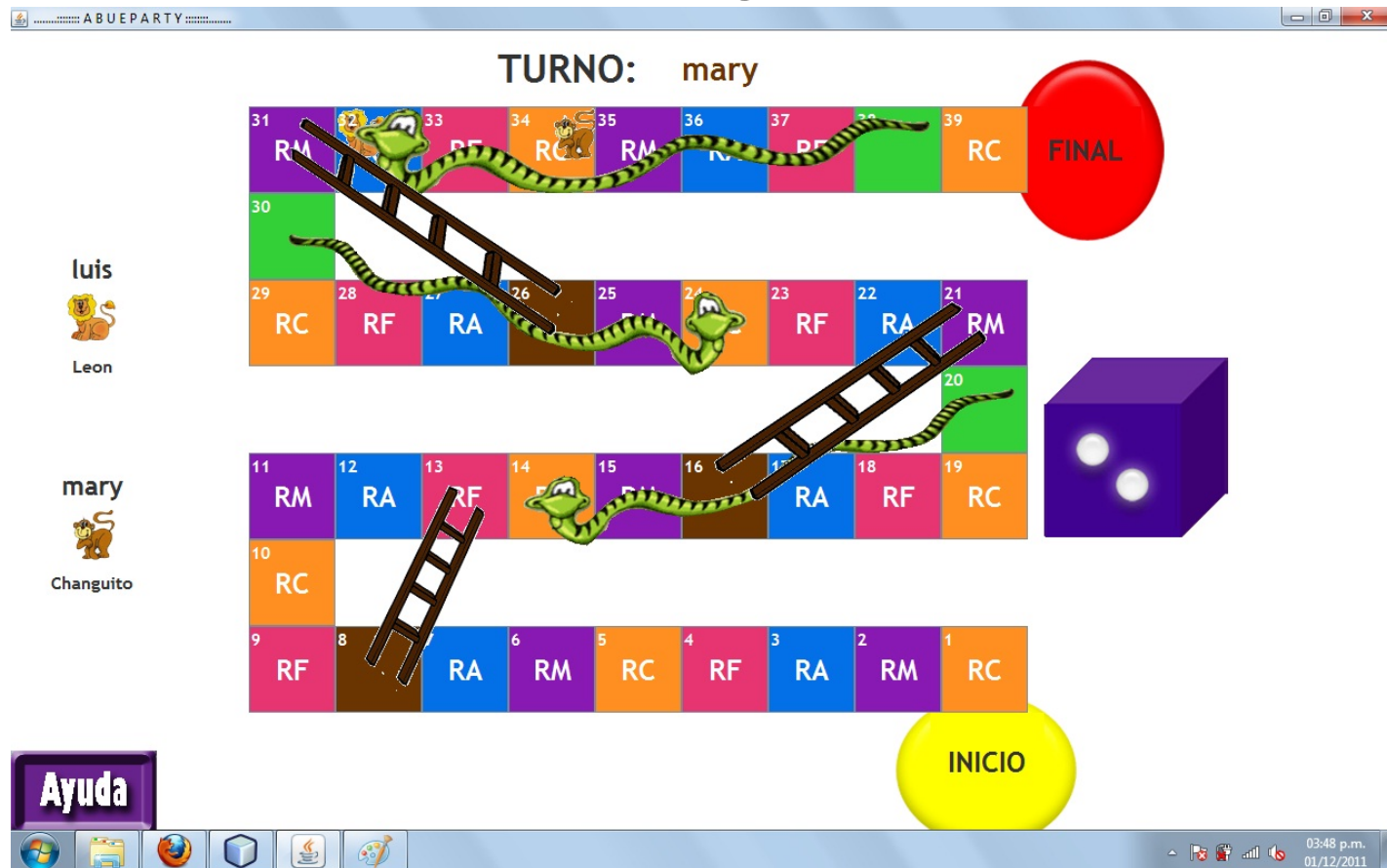
- **Abueparty** integrates different exercises to foster the stimulation of various cognitive functions.
  - Musical challenges
    - Guess-it
    - Sing-it
  - Artistic challenges
    - Draw-it
    - Act-it
  - Coordination challenges
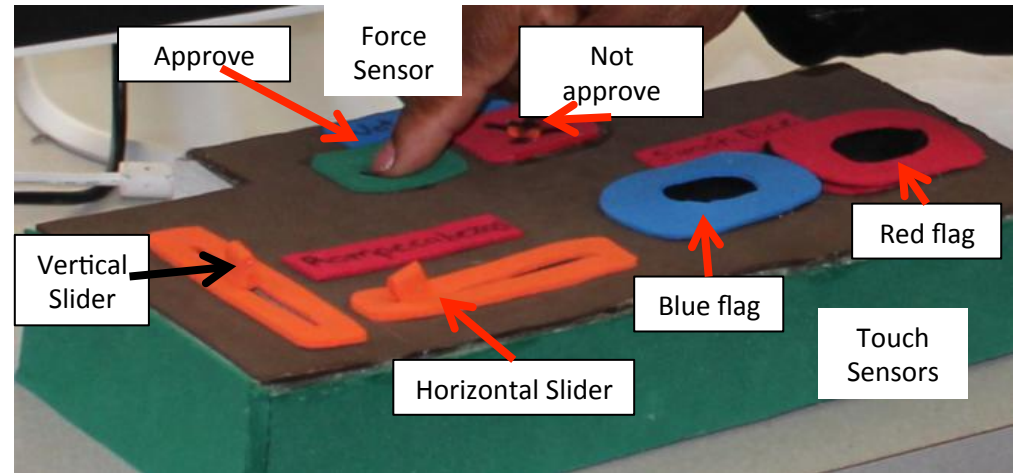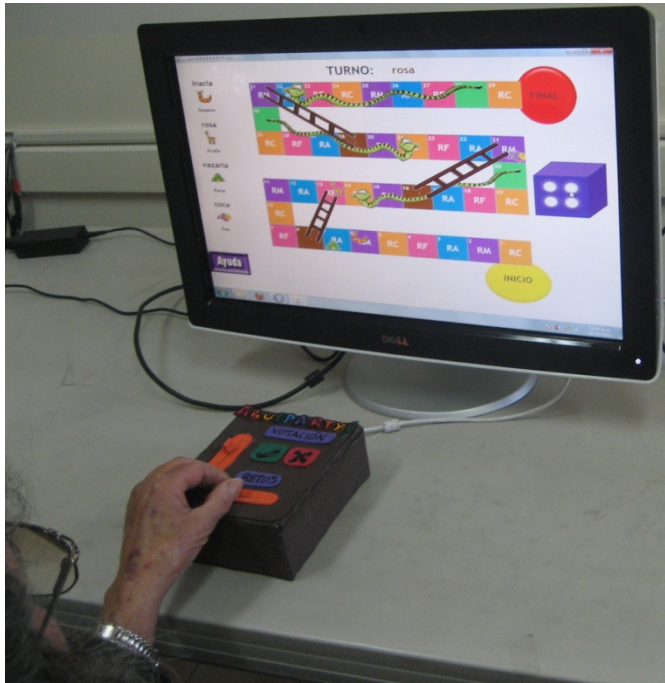   - Build-it
    - Match-it
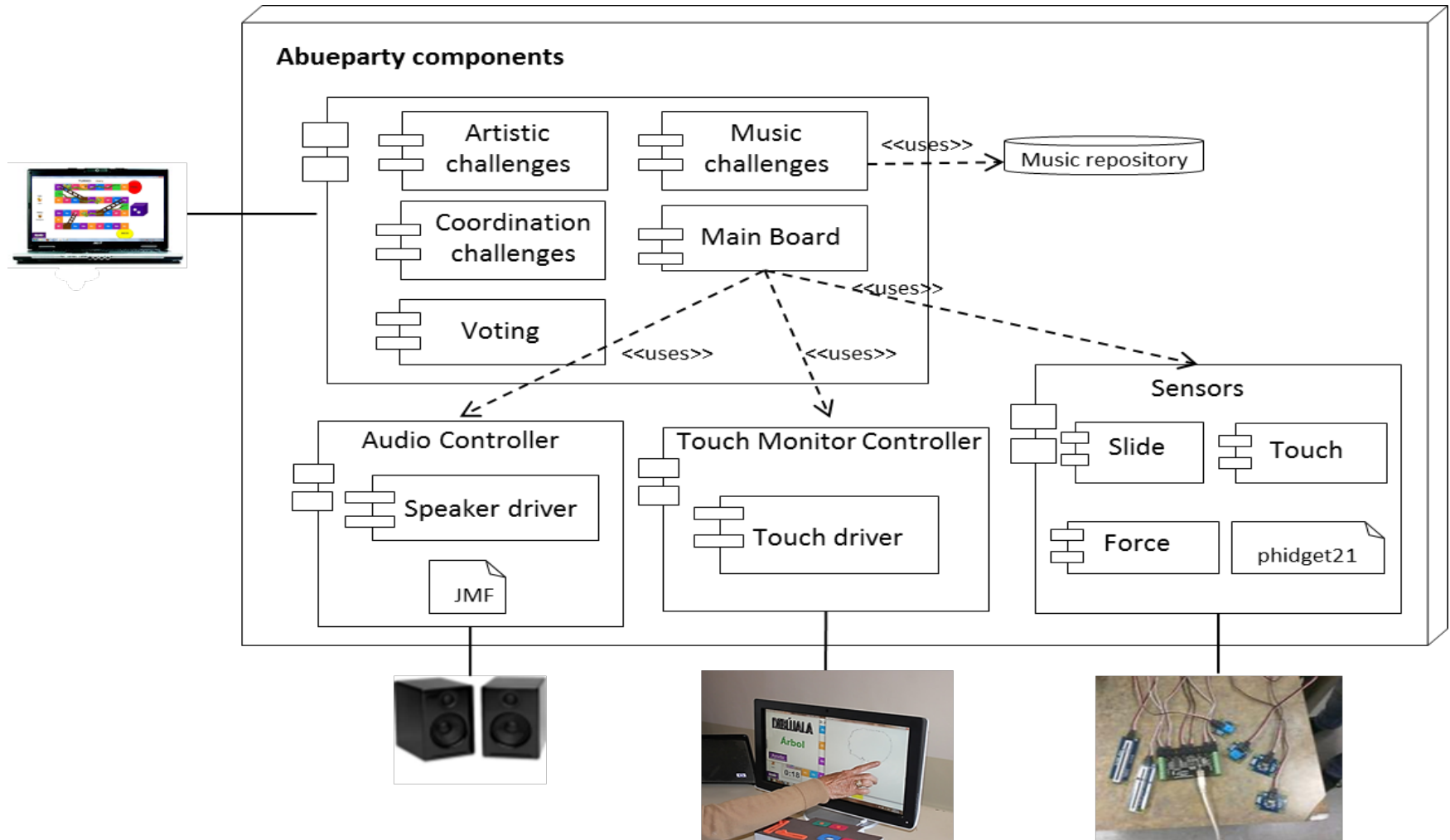
Abueparty: Main cognitive functions promoted

	Memory	Orientation	Language	Gesturing	Visio Spatial skills	Executive function
Sing-it	✔		✔	✔		
Guess-it	✔		✔			✔
Act-it	✔			✔		✔
Draw-it	✔	✔	✔	✔	✔	✔
Build-it		✔		✔	✔	✔
Match-it	✔	✔		✔	✔	✔

- AbueParty uses multimodal interaction mechanisms to facilitate elder's interaction with the game.

Abueparty: Architecture

- To obtain quantitative evidence on the elders' perceptions about: usefulness , ease of use, and enjoyment and satisfaction regarding the use of Abueparty.

- Participants: 29 worried-well elders with ages ranging from 60 to 78 years (average 67.2 years).

- ***Procedure***

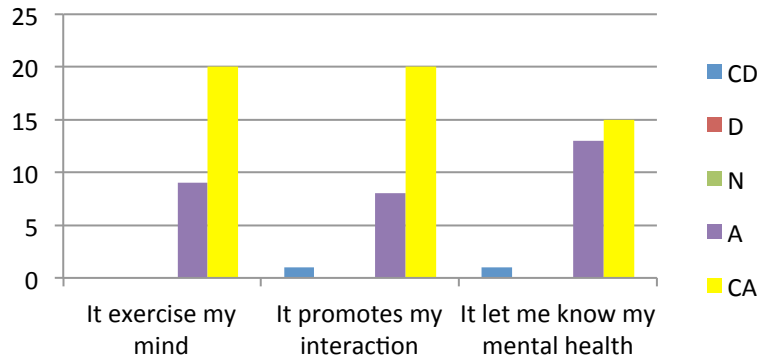   The evaluation consisted of three steps:

    i.   Introduction (5 min).

    ii.   Training and free play (5 min).

    iii.   Playing-the-game (30 min).
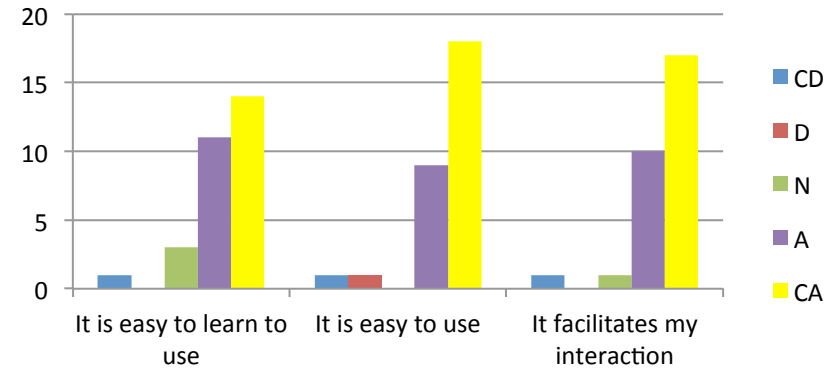
    iv.   On-exit questionnaire (10 min).

Usability Evaluation results

5 Likert scale- CD: Completly Disagree (1), **D**: Disagree, **N**: Neutral, **A**: Agree, **CA**: Completely Agree (5)
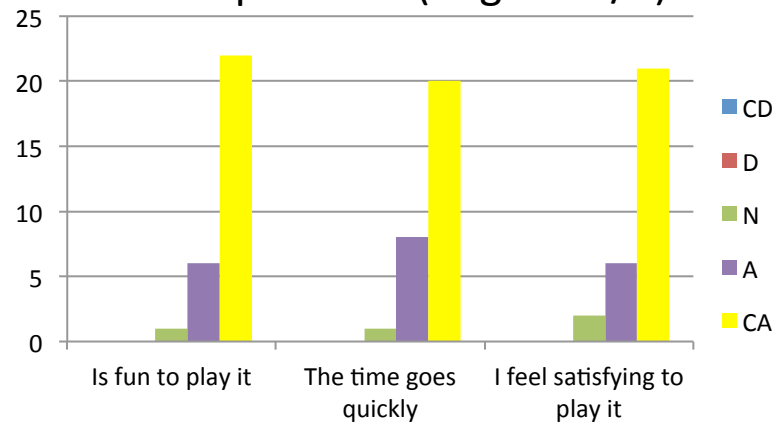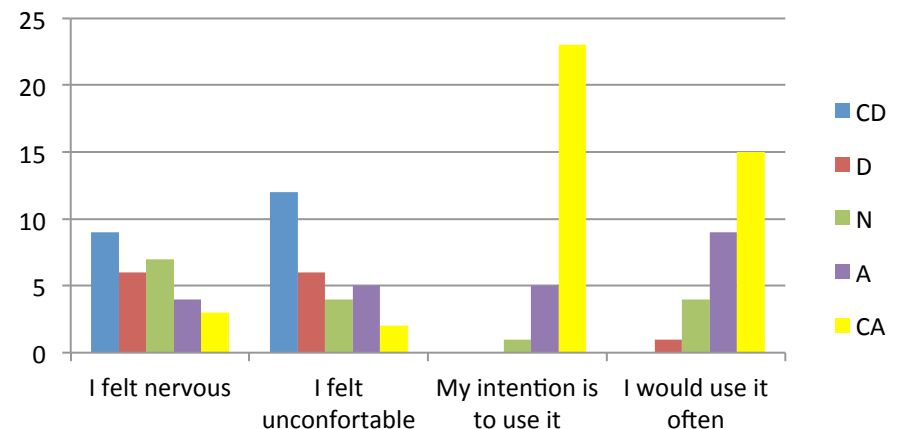
Usefulness (Avg: 4.56/5)

Ease of use (Avg: 4.39/5)

User experience (Avg: 4.67/5)

Anxiety (2.39/5) & Intention of use (4.53/5)

Usability Evaluation results (cont.)

- The most useful game was Built-it followed by Draw-it.
- The UI components that were the easiest to use were the touch "dice", the physical "sliders" and the "vote" button.
- The features they liked more were "playing in group", "competing against each other" and the "challenges".
- 89% reported that they would use the system two or more days per week, and 60% reported that for one or more hours per session

- Aim: Obtain further qualitative evidence about elders' UX, through the analysis of the interactions that occurred during CS sessions.

- Procedure:
  - Analysis of the activity of two 25-minute CS sessions (50 minute -videos). Identification of interaction form and functions they served.

Interactions observed during the CS session

- There were 127 interactions in 50 minutes (aprox. 2.54 interactions per minute)
- After identifying the different types of interactions, we quantified them based on the actors involved, and based on the functions they served.

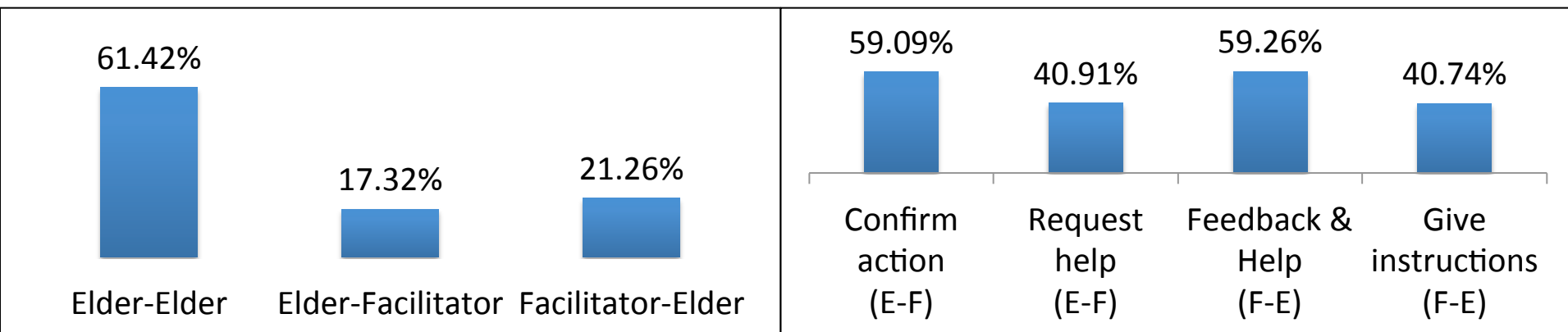| Actors involved	Interaction functions
Elder – Elder (78/127)	• Feedback and help between elders • Encouragement between elders • Turn coordination between elders • Social communication between elders • Competition between elders
Elder – Facilitator (22/127)	• Request for help • Confirm an action
Facilitator – Elder (27/127)	• Give instructions to elders • Feedback and help to elders

- Encouragement between elders.
  - During a game, L is presented with a "Guess it" musical challenge. L answers it correctly, and another elder (A), who is sitting beside her, congratulates her:
    - A: *Yes! That's it!* [While giving her a hug and patting her back].
    - Next, D and E congratulate her and give her a round of applause.
    - D and E: *Well done, L!* ... [While applauding].

- Metrics:
  - Engagement
    - Were older adults participating in the game?
    - Were they starting the interactions?
  - Satisfaction
    - Were they able to successfully solve the mini-challenges?
    - Were they able to solve doubts among them?
  - Enjoyment
    - Were they engaged, having fun, laughing and joking?
  - Anxiety
    - Did they knew what to do next?
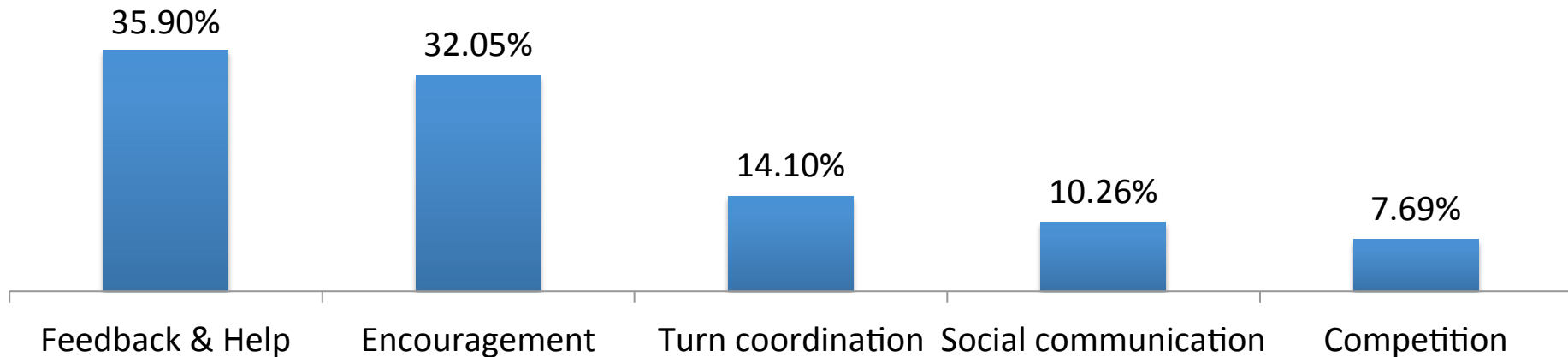   - Were they at ease as to conduct the task or to ask for help?

- Elders' **engagement** perceived as high.
  - Elders initiated most observed interactions (78.74%).
 - The application required involvement in activities.

61.42%

17.32%

21.26%

Elder-Elder   Elder-Facilitator   Facilitator-Elder

59.09%

40.91%

59.26%

40.74%

Confirm action (E-F)   Request help (E-F)   Feedback & Help (F-E)   Give instructions (F-E)

- Elders' **satisfaction** perceived as high.
  - They provided feedback & help to partners (35.9%)
  - They encouraged others (32.05%)
 - They requested help to the facilitator (7%).

35.90%	32.05%	14.10%	10.26%	7.69%
Feedback & Help	Encouragement	Turn coordination	Social communication	Competition

- Elders' **enjoyment** perceived as HIGH
  - Social communication (10.26%)
  - Competition with others (7.89%)
  - Joking and laughing most of the time

Feedback & Help	Encouragement	Turn coordination	Social communication	Competition
35.90%	32.05%	14.10%	10.26%	7.69%
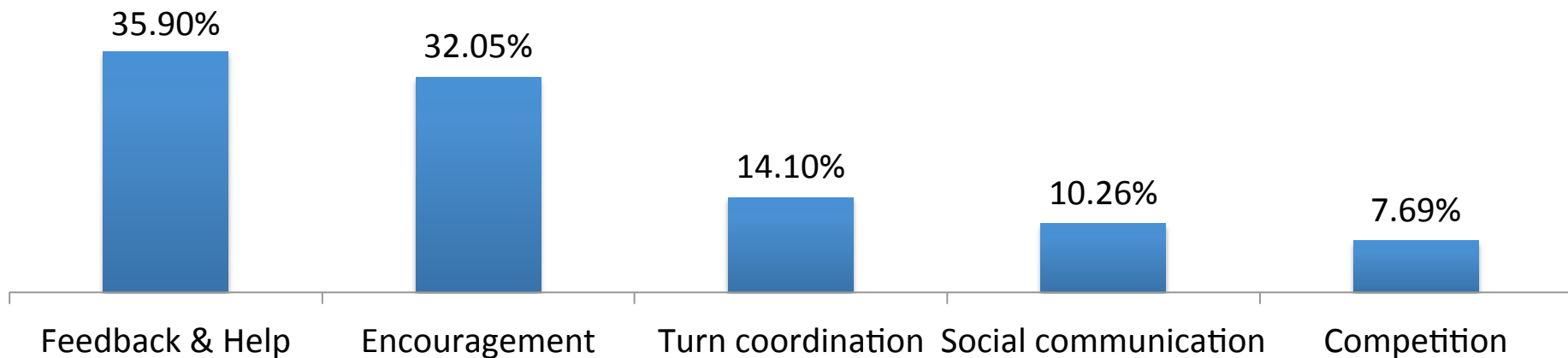
- Elders' **anxiety** and frustration perceived LOW
    - Elders interacted among them 61.42%
    - Elders understood the activities, and played by themselves
    - Elders felt at ease when confirming an action or requesting help
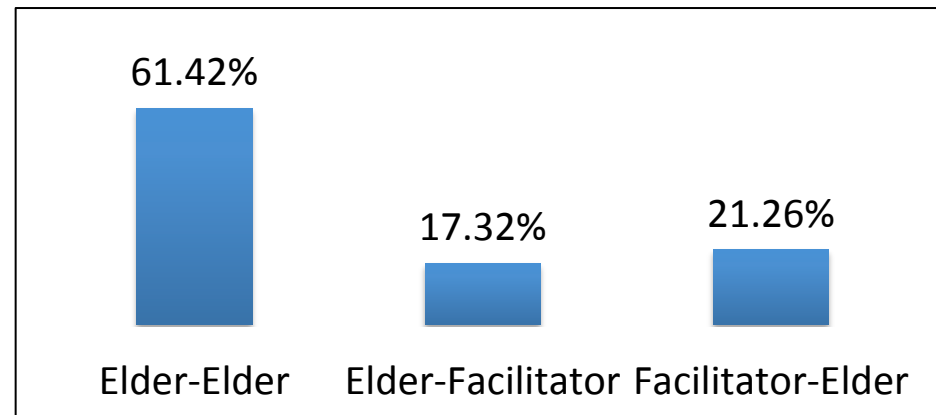
Conclusions

- Engagement, satisfaction, enjoyment and low anxiety or frustration were achieved by participants.

- We obtained further evidence about the UX results on usability evaluation, and that applications designed with the UCSA guidelines provide a pleasurable UX.

- ## Evaluation results provide evidence on:
  - We have verified that the applications designed with the guidelines are perceived as useful, easy to use and providing pleasurable experiences.
  - We have evaluated and compared prototypes designed with and without using the design guidelines, and found evidence that the use of the guidelines increases the quality of the applications.
  - Evaluation results suggest that developers have found the design guidelines as useful, and reported high intention of use if have them available.
  - From these results we may conclude that there is evidence that the guidelines:
    - Transfer in a clear way the empirical and theoretical knowledge acquired throughout this research for the design of UCSA applications

Future work

- Iterative evolution of the proposed DG.

  - Generate newer, clearer and more complete versions of the DG.

- Further develop and evaluate UCSA applications (e.g. Abueparty)

  - In situ and On the wild evaluation of the applications.
  - Evaluate along with specialists the cogntive evolution of the subjects.

- Newer applicaotion areas for the DG

  - Migrate the DG to other similar fields (e.g. from the usefulness perspective) which consider the elderly as a target population (i.e. from the ease of use and user experience perspectives – e.g. Physical rehabilitation).

In Summary

- "Technology" is a good alternative to conduct CS, if the applications consider the physical, cognitive and behavioral barriers of the elderly.

- A CS application for the elderly should provide a solution considering aspects from the three perspectives:
  - Usefulness (for CS), ease of use (by the elderly) and User experience (for the elderly)
  - To be considered as a UCSA application.

... In Summary

- Tools that aid developers on the design and development of CS applications should be provided, which:

  - Incorporate empirical and theoretical knowledge for the design of UCSA applications

  - Facilitate the design of UCSA applications

  - Transfer the knowledge to developers so that they could improve their designs.

- The resulting applications and guidelines should be further validated not only from the perspective of the elderly, but also from the perspective of the developers.

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