

End-User Requirements

Phase B

Project identification

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Abbreviations

Abbrev.	Description
AAL	Ambient Assisted Living
ACE-R	Addenbrooke's Cognitive Examination Revised
AD	Alzheimer's Disease
ADL	Activities of Daily Living
CDR	Clinical Dementia Rating
CRIq	Cognitive Reserve Index Questionnaire
FCSRT	Free and Cue Selective Reminding Test
IADL	Instrumental Activities of Daily Living
ICT	Information and Communication Technology
MCI	Mild Cognitive Impairment
MMSE	Mini-Mental State Examination
TMT	Trail Making Test

Executive Summary

This document revolves around the end-user requirements for the Memento hardware and software system design. It describes more common topics, such as design principles for people with dementia, and concentrates on the specific issues at hand in the course of the document. The requirements per se are based upon the aforementioned principles and topics, completing a user centered design research approach.

The results of the requirement engineering research processes are distilled in a list of functional and non-functional requirements, each for the hardware and software side of the system. In Italy, particular features are collected for an extra application for Dementia Monitoring.

This information is the second and final iteration after experts and end-users' collected feedback along the lab trials. The starting information to be reviewed in this version is based on *D2.2. End-Users Requirements Phase A*.

The final decision about user acceptance of MEMENTO functionalities will be describe D7.3B Evaluation report of field trials.

1 About this Document

1.1 Role of the Deliverable

This deliverable provides the final user requirements after an interactive process started with D2.2_Memento_End User Requirements Phase A.

The final user requirements definition and the functional & non-functional features obtained in lab trial implementation including an updated analysis of the dementia monitoring application (in Italy).

1.1.1 Description of Work WP2

“The objective of this work package is to investigate user’s demand on interaction preferences and aesthetics in product appearance, which is a key factor for creating an emotional experience with a product or service, and to design use cases and scenarios to ensure that the system’s services and products address user needs and fit into user’s daily routines.” (Memento DoW, p. 12).

Description of Work Task 2.2

“This task will research new methods and processes that determine the factors relevant for assessing the user needs in the early stages of the project. User requirements gathered through the qualitative value centred approach will reveal technology acceptance factors as well as emotional, haptic and aesthetic influences that are the basis for the design and the implementation of product modules. In this task, we apply a mix of qualitative methods of empirical social research and design research methods, which will be defined and prepared by BKM. Methods include Questionnaires, Interviews, Cultural Probes, Focus Groups and Design Workshops and will be presented in advance by info-talks to participants. The user-based methods shall involve 5 of users (with dementia in different stages) from Austria recruited by MUW, 5 of users (with dementia in different stages) from Spain recruited by Bidaideak and 5 of users (with dementia in different stages) from Italy recruited by UNIPG. The study – Phase A - will be conducted from month 1 – 4, the second study – Phase B - starts in month 15 - 17 of the project. The results of this task will feed directly into all work packages to ensure the strong user centred focus of the project. The outcome of this task shall be a detailed report on the second and improvement version of user requirements regarding to the MEMENTO

system in D2.4 End-user requirements – Phase B. The results of this task will feed directly into T2.5 Definition of use cases and scenarios – Phase B and will contribute later to the development of prototype I.” (Memento DoW, p. 13)

This work is directly linked, as starting information collection with D2.2 End-user requirements – Phase A and T2.3 Definition of use cases and scenarios – Phase A that contributed to the development of prototype I.” (Memento DoW, p. 13). The outcome information of this first interaction is a valuable income for further improvements in D2.4.

Also, worked performed in WP7 - Lab and Field Trials (User Testing) is directly linked with this updated version of User Requirements taking into account input from end-users (informal caregivers, assisted persons) as described in D7.3A Evaluation report of lab trials.

1.2 Relationship to other Memento Deliverables

Task 2.4 represents the second round of End-users requirements collection for certain follow-up work packages as well as the development of a second and final prototype.

Even though, D2.4 is the final outcome of all the following deliverables, the main inputs comes from:

- Initial User requirements from D2.2: Collecting the expected versus the effectively implemented due to technical constraints following Agile approach.
- Final User requirements implemented in the software confirmed or criticized based on D7.3 A

Deliverable	Relation
D2.2 End-user requirements – Phase A	The findings of this deliverable feed into the creation of a first set of user requirements.
D2.3 – Definition of Use Cases and Scenarios – Phase A	The findings of this deliverable feed into the creation of use cases and scenarios, and from there into the development of a first prototype.
D2.5 – Definition of Use Cases and Scenarios – Phase B	The findings of this deliverable feed into the improvement of use cases and scenarios described in phase A, and from there into the development of the final prototype.
D3.1 – Specification of Hardware Design and User Interface	Describes the user interface design for the software components.
D3.2 – Final specification of hardware design and user interface	Describes the final user interface design for the software components.
D4.1 – Hardware Specification – Phase A	Specifies the hardware design and user experience.

D4.3 Final Hardware Specification – Phase B	Specifies the final version of hardware design and user experience.
D5.1 – Software Specification – Phase A	Specifies the software user interface design and user experience.
D5.3 Final Software Specification - Phase B	Specifies the final version of software user interface design and user experience.
D7.3A Evaluation report of lab trials	Provides input for final requirements implementation availability after development following agile guidelines.

2 List of Requirements validated Technically

In the following list the initial User requirements obtained from D2.2 is validated versus the ones effectively implemented in the software. Highlighting those not fully implemented due to technical constraints

2.1 Functional Requirements

Table 2: Functional Requirements

Category	Requirement	Priority	User	Care-giver	Implemented?	Technical barrier
Hardware	hardware should not stigmatize the user	3	x		Yes. Off-the-shelf tablets and smartwatches are used.	
Hardware	hardware should look familiar to users	3	x		Yes. Custom case for main device allows it to look like a book or table/wall calendar.	
Hardware	batteries should last at least one day	2	x		Battery runtime cannot be guaranteed, since it depends on how much the devices are used	
Hardware	ability to record audio	1	x		Yes. Both tablet and smartwatch have microphones.	
Hardware	ability to retrieve GPS location	2	x		Yes. Smartwatch has GPS receiver.	
Hardware	ability to measure stress levels	1	x		No	There is currently no smartwatch with SIM card and stress support.
Hardware	ability to playback audio	2	x		Yes. Both tablet and smartwatch have speakers.	
System	permanent internet	3	x		Yes. Tablets are connected via	

	connection				WiFi to a LTE router. Smartwatches are LTE capable using SIM cards.	
System	There should be a fixed place (e.g. docking station) at the user's home.	3	x		Yes. We built a charger for the smartwatch. Main device can be hung on a wall.	
System	ability to disable hardware buttons	3	x		Yes. Home button is disabled using a custom frame.	
Backend	ability to synchronize data on all devices	3			Yes	
Software	user interface for caretaker	3		x	Yes	
Software	user interface for user	3	x		Yes	
Software	ability to manage user accounts of patients	3		x	Yes	
Software	ability to set a home address for a patient	3		x	Yes. Also, there is an option to set the home location as POI.	
Software	ability to set an emergency number for a patient	3		x	Yes. Multiple emergency contacts can be set.	
Software	ability to call for help	2	x		Yes	
Software	ability to see the location of a help call	3		x	Yes. Location is provided via SMS.	
Software	ability to add calendar entries	3	x	x	Yes	
Software	ability to remove calendar entries	3	x	x	Yes	
Software	ability to edit calendar entries	3	x	x	No.	Calendar entries can be removed and added again.
Software	reminder for calendar entries (depending on the location)	3	x		Partially	Location based reminders were not implemented because the

						UI would be too complicated.
Software	ability to add notes	3	x		No	
Software	ability to view notes	3	x		No	
Software	ability to edit notes	3	x		No	
Software	ability to add medication schedules	3		x	Yes	
Software	ability to view medication schedules	3	x	x	Yes	
Software	ability to edit medication schedules	3		x	Yes	
Software	ability to add medication	3		x	Yes	
Software	ability to view medication	3	x	x	Yes	
Software	ability to edit medication	3		x	Yes	
Software	reminder for medication intake	3	x		Yes	
Software	ability to add lists	3	x		Yes	

2.2 Non-Functional Requirements

Table 3: Non-Functional Requirements

Category	Requirement	Priority	User	Care-giver	Implemented?	Technical Barrier
Hardware	display(s) should be readable in sun light	1	x		Yes. eInk tablets are used, which have excellent readability in sunlight.	
Hardware	devices should resemble memorable tools	3	x		Yes. Main device resembles a book, all-day device resembles a watch.	
Hardware	ability to use a pen	3	x		Yes	

Hardware	ability to charge batteries wireless	2	x		No	No suitable devices found
Hardware	hardware buttons should be easy to find and press	1	x		No	No hardware buttons needed to use the system
System	secure authentication	3	x	x	Yes. Credentials are transmitted using TLS. An adaptable password policy is used.	
Backend	user data should be stored encrypted	3	x		No	
Backend	user data should be transferred encrypted	3	x		Yes. All data is transmitted using TLS.	
Software	users should not be able to exit the Memento software	3	x		Yes. App is in fullscreen and home button is covered using a custom frame.	
Software	operating systems should not display information unrelated to Memento software	3	x	x	Yes. App is in fullscreen.	
Software	no web browser	3	x		Yes	
Software	It should be clear what the user has to write into an input field	3	x		Yes	
Software	there should not be a screensaver	1	x		Yes	
Software	size of UI elements should be big	2	x		Yes	
Software	there should be a feasible distance between UI elements	2	x		Yes	
Software	accidental exit should be avoided	3	x	x	Yes. App is in fullscreen.	
Software	no gesture control	1	x	x	Yes	

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Software	icons should indicate the purpose of the UI element	2	x		Yes	
Software	font size should be big	3	x		Yes	
Software	buttons should be big	3	x		Yes	
Software	UI labels should indicate the purpose of the UI element	3	x		Yes	
Software	UI elements should be properly distanced from each other	2	x		Yes	
Software	there should be arrow keys for UI navigation	1	x	x	No	
Software	the display should not turn off	3	x		Yes	
Software	terms in foreign languages should not be used	1	x		Yes. All phrases were translated by native speakers.	
Software	technical terms should be avoided in the UI	1	x		Yes	
Software	there should be no advertisements	3	x		Yes	
Software	the UI should not contain more than 2 colors	1	x		Yes. eInk can only display greyscale.	
Software	abbreviations should be avoided	1	x		Yes	
Software	acronyms should be avoided	1	x		Yes	
Software	splitting tasks in multiple screens should be avoided	2	x		No. Multiple screen were used when UI elements would have to be scaled down to fit.	This directly conflicts with requirements that all UI elements should be big.
Software	there should be no modal dialogs in the UI	1	x		Yes	

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3 User feedback about the Requirements validated Technically

The following comparative table shows which User requirements implemented in the software have been appreciated (so confirmed) or criticized (so open to revision) after several workshops at pilot sites (Italy, Austria and Bizkaia -Spain) and the lab trials as reported in D7.3 A.

3.1 Functional Requirements

Table 4: Functional Requirements

Category	Requirement	Priority	User	Car e-giver	Users' feedback	Final decision (Remove or Maintain)
Hardware	hardware should not stigmatize the user	3	x		Patients were engaged with design and don't think of it as stigmatizing	Maintain
Hardware	hardware should look familiar to users	3	x		Users like the simple design resembling familiar, analogue objects	Maintain
Hardware	batteries should last at least one day	2	x		It is essential that the device does not have to be charged too often	Maintain
Hardware	ability to record audio	1	x		Relevant for the dementia progression app	Maintain
Hardware	ability to retrieve GPS location	2	x		Patients think GPS localization would be very helpful	Maintain
Hardware	ability to playback audio	2	x		"Reading out loud" function of all-day device was appreciated	Maintain
System	permanent internet connection	3	x		Very important for the patients, technical problems are experienced as very frustrating	Maintain

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System	There should be a fixed place (e.g. docking station) at the user's home.	3	x		Patients did neither emphasize nor contradict that this is an important factor	Maintain
System	ability to disable hardware buttons	3	x		This point was not discussed with the users, home button is disabled for the prototype	Maintain
Backend	ability to synchronize data on all devices	3			Fast and reliable synchronization is crucial, e.g. for medication reminders	Maintain
Software	user interface for caretaker	3		x	Caregiver interface was not received well (too complicated and confusing) but the function is generally appreciated	Revise and maintain
Software	user interface for user	3	x		Interface was received quite well	Maintain
Software	ability to manage user accounts of patients	3		x	Important feature for caregivers, but a "going back" button would be appreciated; user friendliness was considered to be bad	Revise and maintain
Software	ability to set a home address for a patient	3		x	Important feature for orientation; due to the wish of users to define POIs, ability to insert additional addresses would be appreciated	Maintain
Software	ability to set an emergency number for a patient	3		x	This feature is very important to define different persons to call in case of panic	Maintain
Software	ability to call for help	2	x		Was considered to be very important	Maintain

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Software	ability to see the location of a help call	3		x	Was considered to be very important in order to provide support by the caregivers	Maintain
Software	ability to add calendar entries	3	x	x	Appreciated by both patients and caregivers	Maintain
Software	ability to remove calendar entries	3	x	x	Was considered to be very important	Maintain
Software	reminder for calendar entries (depending on the location)	3	x		Was considered to be very important, reminders have to be very reliable	Maintain
Software	ability to add medication schedules	3		x	Appreciated by both patients and caregivers	Maintain
Software	ability to view medication schedules	3	x	x	Was considered to be important	Maintain
Software	ability to edit medication schedules	3		x	Was considered to be very important to respond to changes in medication	Maintain
Software	ability to add medication	3		x	Was considered to be very important to respond to changes in medication	Maintain
Software	ability to view medication	3	x	x	Was considered to be very important	Maintain
Software	ability to edit medication	3		x	Was considered to be very important to respond to changes in medication	Maintain
Software	reminder for medication intake	3	x		Was considered to be very important, reminders have to be very reliable	Maintain

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Software	ability to add lists	3	x		Was considered to be very important in order to create personalized shopping and getting ready lists	Maintain
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3.2 Non-Functional Requirements

Table 5: Non-Functional Requirements

Category	Requirement	Priority	User	Care-giver	Users' feedback	Final decision (Remove or Maintain)
Hardware	display(s) should be readable in sun light	1	x		Was considered to be very important, especially in case of the all-day device but also for the main-device	Maintain
Hardware	devices should resemble memorable tools	3	x		Users like the simple design resembling familiar, analogue objects which they use daily	Maintain
Hardware	ability to use a pen	3	x		Most of the patients were very engaged with the possibility to write with a pen, some patients had problems with handwriting	Maintain
System	secure authentication	3	x	x	Patients rather emphasized that the authentication should be uncomplicated Simplify authentication process. (password complexity).	Revise and maintain

Backend	user data should be transferred encrypted	3	x		Patients did neither emphasize nor contradict that this is an important factor	Maintain
Software	users should not be able to exit the Memento software	3	x		Depending on the users and their technical proficiency, exiting the software is thought to be confusing	Maintain
Software	operating systems should not display information unrelated to Memento software	3	x	x	This point was not discussed with the users	Maintain
Software	no web browser	3	x		This point was not discussed with the users	Maintain
Software	It should be clear what the user has to write into an input field	3	x		No issues reported	Maintain
Software	there should not be a screensaver	1	x		This point was not discussed in detail with the users, however the all-day device changes too fast into screensaver mode when tested with the patients	Maintain
Software	size of UI elements should be big	2	x		For many users, big elements are essential due to bad eyesight	Maintain
Software	there should be a feasible distance between UI elements	2	x		Patients did neither emphasize nor contradict that this is an important factor	Maintain

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Software	accidental exit should be avoided	3	x	x	Depending on the users and their technical proficiency, exiting the software is thought to be confusing	Maintain
Software	no gesture control	1	x	x	This point was not discussed with the users	Maintain
Software	icons should indicate the purpose of the UI element	2	x		Was considered to be very important, for some users there were problems with recognizing icons	Maintain
Software	font size should be big	3	x		For many users, big font is essential due to bad eyesight.	Maintain
Software	buttons should be big	3	x		For many users, big buttons are essential due to bad eyesight	Maintain
Software	UI labels should indicate the purpose of the UI element	3	x		Was considered to be very important, for some users there were problems finding the right button to start an action	Maintain
Software	UI elements should be properly distanced from each other	2	x		Patients did neither emphasize nor contradict that this is an important factor	Maintain
Software	the display should not turn off	3	x		Patients did neither emphasize nor contradict that this is an important factor	Maintain

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Software	terms in foreign languages should not be used	1	x		Was considered to be very important to fully comprehend functions, input fields and information	Maintain
Software	technical terms should be avoided in the UI	1	x		Was considered to be very important to fully comprehend functions, input fields and information	Maintain
Software	there should be no advertisements	3	x		This point was not discussed with the users	Maintain
Software	the UI should not contain more than 2 colors	1	x		Most of the patients were very engaged with the simplicity of the black and white design, some patients wished for a signal color (e.g. red) for important information and input fields	Maintain
Software	abbreviations should be avoided	1	x		Was considered to be very important to fully comprehend functions, input fields and information	Maintain
Software	acronyms should be avoided	1	x		Was considered to be very important to fully comprehend functions, input fields and information	Maintain
Software	there should be no modal	1	x		The reminders are set-up as	Maintain

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	dialogs in the UI				modal dialogs where you have to confirm or delay before starting or continuing an action. This feature is appreciated by the users.	
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4 Final User Requirements validated Technically

Final list of User requirements that, after the analysis of technical constraints, confirmed and fixed for final version of the prototype.

4.1 Functional Requirements

Table 6: Functional Requirements

Category	Requirement	Priority	User	Care-giver	Users' feedback	Solution
Hardware	hardware should not stigmatize the user	3	x		Patients were engaged with design and don't think of it as stigmatizing	No change
Hardware	hardware should look familiar to users	3	x		Users like the simple design resembling familiar, analogue objects	No change
Hardware	batteries should last at least one day	2	x		It is essential that the device does not have to be charged too often	No change (eInk displays are already used to save power. Power saving techniques in software were used where applicable)
Hardware	ability to record audio	1	x		Relevant for the dementia progression app	No change
Hardware	ability to retrieve GPS location	2	x		Patients think GPS localization would be very helpful	No change
Hardware	ability to playback audio	2	x		"Reading out loud" function of all-day device was appreciated	No change
System	permanent internet	3	x		Very important for the patients, technical problems are	Internet connection is provided via

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	connection				experienced as very frustrating	LTE routers during trials
System	There should be a fixed place (e.g. docking station) at the user's home.	3	x		Patients did neither emphasize nor contradict that this is an important factor	No change
System	ability to disable hardware buttons	3	x		This point was not discussed with the users, home button is disabled for the prototype	No change
Backend	ability to synchronize data on all devices	3			Fast and reliable synchronization is crucial, e.g. for medication reminders	No change
Software	user interface for caretaker	3		x	Caregiver interface was not received well (too complicated and confusing) but the function is generally appreciated	It was improved by using better UI elements and hiding unnecessary information
Software	user interface for user	3	x		Interface was received quite well	No change
Software	ability to manage user accounts of patients	3		x	Important feature for caregivers, but a "going back" button would be appreciated; user friendliness was considered to be bad	Back button was implemented
Software	ability to set a home address for a patient	3		x	Important feature for orientation; due to the wish of users to define POIs, ability to insert additional addresses would be appreciated	Multiple POIs can be defined on a map, instead of manually entering addresses
Software	ability to set an emergency number for a patient	3		x	This feature is very important to define different persons to call in case of panic	No change
Software	ability to	2	x		Was considered to be	No change

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	call for help				very important	
Software	ability to see the location of a help call	3		x	Was considered to be very important in order to provide support by the caregivers	No change
Software	ability to add calendar entries	3	x	x	Appreciated by both patients and caregivers	No change
Software	ability to remove calendar entries	3	x	x	Was considered to be very important	No change
Software	reminder for calendar entries (depending on the location)	3	x		Was considered to be very important, reminders have to be very reliable	No change
Software	ability to add medication schedules	3		x	Appreciated by both patients and caregivers	No change
Software	ability to view medication schedules	3	x	x	Was considered to be important	No change
Software	ability to edit medication schedules	3		x	Was considered to be very important to respond to changes in medication	No change
Software	ability to add medication	3		x	Was considered to be very important to respond to changes in medication	No change
Software	ability to view medication	3	x	x	Was considered to be very important	No change
Software	ability to edit medication	3		x	Was considered to be very important to respond to changes in medication	No change
Software	reminder for	3	x		Was considered to be very important,	No change

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	medication intake				reminders have to be very reliable	
Software	ability to add lists	3	x		Was considered to be very important in order to create personalized shopping and getting ready lists	No change

4.2 Non-Functional Requirements

Table 7: Non-Functional Requirements

Category	Requirement	Priority	User	Care-giver	Users' feedback	Solution
Hardware	display(s) should be readable in sun light	1	x		Was considered to be very important, especially in case of the all-day device but also for the main-device	No change
Hardware	devices should resemble memorable tools	3	x		Users like the simple design resembling familiar, analogue objects which they use daily	No change
Hardware	ability to use a pen	3	x		Most of the patients were very engaged with the possibility to write with a pen, some patients had problems with handwriting	Fixed several bugs related to handwriting
System	secure authentication	3	x	x	Patients rather emphasized that the authentication should be uncomplicated Simplify authentication	Password complexity was lowered and maximum session length was increased

					process. (password complexity).	
Backend	user data should be transferred encrypted	3	x		Patients did neither emphasize nor contradict that this is an important factor	No change
Software	users should not be able to exit the Memento software	3	x		Depending on the users and their technical proficiency, exiting the software is thought to be confusing	No change
Software	operating systems should not display information unrelated to Memento software	3	x	x	This point was not discussed with the users	No change
Software	no web browser	3	x		This point was not discussed with the users	No change
Software	It should be clear what the user has to write into an input field	3	x		Some users had difficulties to insert the time in hh:mm – format.	Placeholder text was added
Software	there should not be a screensaver	1	x		This point was not discussed in detail with the users, however the all-day device changes too fast into screensaver mode when tested with the patients	No change. (The time before the All-Day Device switches to ambient mode is set by the OS. It's not possible to change this)
Software	size of UI elements should be big	2	x		For many users, big elements are essential due to bad eyesight	No change

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Software	there should be a feasible distance between UI elements	2	x		Patients did neither emphasize nor contradict that this is an important factor	No change
Software	accidental exit should be avoided	3	x	x	Depending on the users and their technical proficiency, exiting the software is thought to be confusing	No change
Software	no gesture control	1	x	x	This point was not discussed with the users	No change
Software	icons should indicate the purpose of the UI element	2	x		Was considered to be very important, for some users there were problems with recognizing icons	No change
Software	font size should be big	3	x		For many users, big font is essential due to bad eyesight. Some users overlooked prompts and were confused on what to do.	The font size of the prompts were increased as much as possible without breaking the design to make them more prominent.
Software	buttons should be big	3	x		For many users, big buttons are essential due to bad eyesight	No change
Software	UI labels should indicate the purpose of the UI element	3	x		Was considered to be very important, for some users there were problems finding the right button to start an action	Button was renamed from "new note" to "new entry"

mə'mento
keeps my mind

Software	UI elements should be properly distanced from each other	2	x		Patients did neither emphasize nor contradict that this is an important factor	No change
Software	the display should not turn off	3	x		Patients did neither emphasize nor contradict that this is an important factor	No change
Software	terms in foreign languages should not be used	1	x		Was considered to be very important to fully comprehend functions, input fields and information	No change
Software	technical terms should be avoided in the UI	1	x		Was considered to be very important to fully comprehend functions, input fields and information	No change
Software	there should be no advertisements	3	x		This point was not discussed with the users	No change
Software	the UI should not contain more than 2 colors	1	x		Most of the patients were very engaged with the simplicity of the black and white design, some patients wished for a signal color (e.g. red) for important information and input fields	No change. (additional colors are not possible with the display used)
Software	abbreviations should be	1	x		Was considered to	No change

	avoided				be very important to fully comprehend functions, input fields and information	
Software	acronyms should be avoided	1	x		Was considered to be very important to fully comprehend functions, input fields and information	No change
Software	there should be no modal dialogs in the UI	1	x		The reminders are set-up as modal dialogs where you have to confirm or delay before starting or continuing an action. This feature is appreciated by the users.	No change

5 Specific User Requirements adapted to Pilots' needs

Specific user requirements were adapted to the older people, a segment of population expected to increase in the next future and particularly at risk of dementia.

In fact, the risk of mild cognitive impairment and dementia increases with advancing age as epidemiological studies show (Alexander et al., 2015; Prince et al., 2013; Wu et al., 2016).

Considering the “Advancing the Aging and Technology Agenda in Gerontology” (2015), the Italian experimental context, as geriatric clinic, deepened this topic with the aim to develop a specific feature involving older users.

Monitoring, screening and intervention have been considered technology functions relevant in different life domains as mental health and leisure activities.

The intent was to develop a functionality able to inform an older individual or a caregiver about the cognitive status, detect significant changes, and motivate interventions to address a problem identified by the monitoring system. At the same time, it was important to dispose of a functionality to deliver interventions such as cognitive stimulation in a pleasure manner.

An important indication of work was derived from the Italian User Workshop. In particular, Italian caregivers suggested games to stimulate cognitive functions and increase leisure activities of older people with mild cognitive impairments. This aspect it has been evidenced by Way (2006) who affirmed that assistive technologies has, among others, the potential role to support the person's memory and to involve and occupy the person during the day. The research on Natural Language Processing (NLP) technology (e.g. Bucks et al., 2000) together with the demonstration that the retention of a personal past gives a sense of narrative identity and well-being to sufferers of dementia (Mills, 2018), convinced the Italian partners to collaborate to create a specific feature to monitor the progression of cognitive symptoms and stimulate autobiographical memory at the same time.

Putting together these needs, the dementia monitoring application was developed in the Italian context.

Finally, the dementia monitoring application, described below, it could be a strategy for strengthening an emotional bonding to the Memento system preventing his abandonment. In particular, we searched to include the

dimension of the pleasure in the use of technology by means of episodic and autobiographical memories.

5.1 Dementia Monitoring Application

Memento use the Natural Language Processing (NLP) technology to extracts from voice recordings relevant information, that will be further used to monitor the progress of dementia over time. In particular, the NLP technology is used to perform, in the context of Memento, an automatic textual analysis (i.e. it calculates lexical features) and to evaluate the results to track the level of cognitive deficit and memory decline of the users. This chapter describes the development of the dementia monitoring feature. Users are invited to use a preliminary version of the feature in an environment that simulates the one they would use with the tested technology during their everyday life. Observation method, thinking aloud and questionnaires are proposed to collect data on systems' effectiveness and users' satisfaction. Evaluations are performed during ad hoc test phase of the feature development and results are used to improve the application according to a User-Centered Design methodology.

5.1.1 Study description

5.1.1.1 Rationale

Major and mild neurocognitive disorders are characterized by impairments in cognitive functions and functional status (DSM V, American Psychiatric Association 2013). Communication disorders are a common feature of dementia and mild cognitive impairment (Bayles, McCullough, & Tomoeda, 2018; Johnson, & Lin, 2014).

The automatic analysis of speech is a natural and useful low-cost tool for diagnosis and monitoring dementia progression (Bucks et al., 2000; Fraser, Meltzer and Rudzicz, 2016; Fraser et al., 2014; Lopez-de-Ipina et al., 2018; Kavè and Dassa, 2018).

Different methods were proposed to assess spontaneous speech in samples of persons with MCI and AD:

- the “Cookie Theft” picture description task from the Boston Diagnostic Aphasia Examination (Fraser et al, 2016; Kokkinais et al., 2018; Kavè and Dassa, 2018);
- oral descriptions of common objects (Hernandez-Dominguez, García-Cano, Ratté, & Martínez, 2016);
- semi-structured interview format in which they were encouraged to talk about themselves and their experiences (Bucks, Singh, Cuerden, & Wilcock, 2010;)
- semi-structured interview in which they were talked about different arguments (occupation, last dream....) (Beltrami et al., 2018)
- verbal picture descriptions (Thomas, Keselj, Cercone, Rockwood, & Asp, 2005).

In general, the spontaneous speech is transcribed and analysed using a series of objective, clearly defined linguistic measures.

Different linguistic characteristics are selected to evaluate patients' language functions (Hernandez-Dominguez et al., 2018; Beltrami et al., 2016).

5.1.1.2 Aim

The main aim of his chapter is to investigate user's requirements for the Memento dementia monitoring feature.

5.1.1.3 Description of the feature

“Dementia monitoring” is a feature that allows users to monitor their communication abilities through an activity that stimulate the spontaneous speech. The aims are to stimulate the autobiographical memory and to monitor the cognitive impairment progression eliciting spontaneous speech by means of questions and personal photos of different periods of life.

The idea is that persons with MCI or AD could select a series of significant photos of different period of their life or answer to questions about autobiographical memories (e.g. “Tell about a happy holiday”; “Tell about your occupation”; “What did you remember about this event?”).

Memento could propose the sequence of the stimuli at fixed time (e.g. every month) and calculate different indexes for syntactic and semantic analysis,

or, on the other hand, the Dementia Monitoring can require the start of the feature in a specific moment. This feature could be presented as a game with a final message or score for the users based on the indexes.

Natural Language Processing (NLP) technology is used to extract important information from vocal registration and/or written text. Furthermore, techniques of automatic text analysis are carried out to track the level of cognitive deficit and memory decline of users. Syntactic analysis is focused on statistically significant variations in the syntactic structures of spontaneous speech considering use of Nouns, Pronouns, Adjectives, and Verbs. Semantic analysis is based on statistically significant variations in the semantic content (lexical richness) of spontaneous speech measured using Type-Token Ratio, Brunét's Index, and Honore Statistic Statistic.

As recommended by Andreason and Pfohl (1976), A minimum of 1000 words is necessary to carried out the analysis.

Users interact with Memento by means of Main device (written verbal commands, speech and touch screen). Information about analysis are delivered both patients than caregivers.

5.1.1.4 The workshop

In order to develop the feature dementia monitoring, a workshop was conducted with real elderly users during the preliminary lab trials phase. Research and innovation processes were integrated throughout the development, exploitation, experimentation and evaluation of scenarios, concepts, products in real-life utilization.

This section is focus on the development of the feature dementia monitoring. The methodology and the results are described.

5.1.1.4.1 **Aims of the workshop**

To collect data on a specific number of words used in the spontaneous speech with a set of stimuli;

To test the indexes calculation;

To consider the users point of view with respect to the feature.

5.1.1.4.2 **Methodology**

Users were selected according to the selection criteria indicated in D2.3 Deliverable (End Users requirement, Phase A). An age major than 75 years,

it was considered a relevant aspect to evaluate the application in this segment of population.

Data Collection

All data were collected through direct observation and interview. For direct observation, two tasks were predefined by the development team composed by a geriatrician, a psychologist and experts in Ergonomics and Software Engineering. From this, an observation form was developed to collect data on task execution time, task completion rate (and how easily the participant completed the task), assistances during task completion, and the participant's visible emotional state (according the signs of Lawton, Van Haitsma, and Klapper, 1999). Demographic data were collected. A questionnaire ad hoc was developed by the project team and managed after the completion of the tasks.

Procedure

Usability testing was performed considering a task-oriented analysis in which participants were asked to perform different tasks. Individual sessions were planned. If necessary (new participants), the Consent Form was signed. After then, users filled out a demographic questionnaire together with a technology-related question. Then, a facilitator presented to the participants the Memento study and the dementia monitoring feature. In this phase, the facilitator given instructions to perform the task. Two tasks were proposed: Task 1 and Task 2. The Task 1 was necessary to familiarize with the possibility to see a series of images on the screen.

After the Task 1, the Questionnaire 1 was proposed to both users and caregivers. In the same way, after the execution of Task 2, the Questionnaire 2 was proposed to both users and caregivers.

Task 1: *“Imagine that you decide to see your photos/notes into Memento. Your task is to start the presentation touching the screen. When the presentation starts, you can move to next photos/page touching the screen. Go on until appears the word end.”*

A series of photos of Italian cities were given.

Questionnaire 1 concerned opinions and preferences on the possibility:

- 1) to see photos on the Memento;
- 2) to record users' comments on the photos;

- 3) to monitor the progression of cognitive deficits starting from the analysis of the recorded comments;
- 4) to receive a feedback on the analysis;
- 5) that formal (e.g. clinician) and informal caregivers would receive the results of the analysis).

During the Task 1, the observational form was compiled regarding difficulties.

Task 2: “Imagine that you decide to monitor your communication ability and stimulate your memory. Your task is to use your tablet to see a series of photo and questions about historical facts and autobiographical memories. Your task is to start the presentation touching the screen key. When the presentation starts, a written instruction appears, and your task is to talk about yourself and your experience. Talk as much as you can. When you finish with an argument you touch the same key to go on. Go on until appears the word end”

In this phase, images of historical facts (e.g. Moon Landing, Aldo Moro's assassins), historical figures (e. g. Papa Giovanni XXIII, Totò) and questions about autobiographical memories (e.g. “Tell about your work”; “Tell about an holiday”; “Tell about an heart quake”) were presented. Stimuli were chosen based on the Italian cultural context. For each task, the participants received instructions on what they were expected to do given a fixed scenario.

Questionnaire 2 concerned opinions and preferences on the possibility:

- 1) to execute this task;
- 2) to record own comments;
- 3) to monitor the progression of cognitive deficits starting from the analysis of the recorded comments;
- 4) to receive a feedback on the analysis;
- 5) that formal (e.g. clinician) and informal caregivers received the results of the analysis).

During the Task 2, the Observed Emotional Rating Scale and the observational form (execution time and difficulties) were compiled. According the Bucks et al procedures (2010), responses were not corrected, and no stimulus or interruption was provided unless the participant was finished the task or clearly becoming distressed by his or her inability to respond.

Testing

The evaluation took place in Perugia (IT) at Santa Maria della Misericordia Hospital. It simulated a regular house living room, in which participants will simulate the interaction with Memento with a tablet.

Automated analysis of picture descriptions

Interviews were recorded with a tablet and a small microphone. The result of each single interview, mainly consisting in an audio file, was opportunely elaborated, by the Developing Team at Integris, for the evaluation of the syntactic and semantic analysis.

As recommended by Andreason and Pfohl (1976), it was considering important to reach transcription consisted of approximately 1000 words.

The tool will provide separate summary results for each participant. We analyzed 5 features that reflect both lexical and grammatical aspects of language:

- **Total Number of Words** – this feature counts every letter as do standard word counts in any word-processing software.
- **Type-token ratio** – this feature counts the total number of unique words of all parts of speech and divides this sum by the total number of words. A type-token ratio of 1.0 would mean that every word in the sample was unique; a low type-token ratio would indicate that many words were repeated (Kokkinakis, 2017).
- **Brunet's index**- this feature was included because, unlike type-token ratio, it quantifies lexical richness without being sensitive to text length. This measure generally varies between 10 and 20. The lower the value, the richer the speech.
- **Honore's statistic**- this feature is based on the notion that the larger the number of words used by a speaker that occur only once the richer the lexicon. Honore's Statistic generates a lexical richness measure that establishes the number of words used only once by the participant as a proportion of the total number of words used. The higher the value of R, the richer the vocabulary used by the participant.
- **Speech Rate** - this feature the speech is calculated by dividing the number of words produced by the participant by the total speech sample time.

5.1.2 Pilots feedbacks and recommendations

5.1.2.1 Results

Three females and one male were involved.

Two users (u2 and u4) participated also to previous workshop, whereas u1 and u3 were involved for the first time.

A user (u1) did not have a caregiver.

The characteristics of the sample are resumed in Table 1.

Users are characterized by different levels of education and technical proficiency.

Interviews ranged from 10 to 15 minutes.

Table 8: Evaluation results

User codes	gender	age	education	MMSE	Users technical proficiency	Caregiver codes (specification)	Caregiver technical proficiency
u1	f	81	18	28	3	-	-
u2	f	81	5	28	6	C2 (nephew's wife)	6
u3	m	83	13	26	2	C3 (wife)	3
u4	f	77	8	28	1	C4 (daughter in law)	5

5.1.2.1.1 User feedback from the Task 1:

All users would like to have a set of photos in Memento and to use the Main device to see these. U1 appreciated the photos' fruition by means of a technical device for the possibility to have more particulars and a detailed image.

No users referred difficulties into switch from an image to another and no users imagined finding difficulties in to use the device at home to see the photos.

U1 said: *"If I thought about learning to use a technical device, I would do it without problems"*.

U3 said that they (he and his wife) have a tablet with the photos: *"Is it time to begin to use it!!!"*

All users would like to record comments on photos and monitoring cognitive deficits by means of this procedure.

U3 defined the task as *"pleasant"*.

They would like to receive a final score and that the caregivers (both the clinician than a familiar) would receive this information.

U1 would like to receive a feedback (also a negative feedback) to monitor her condition. She would appreciate also a sort of semaphore.

U2 suggested to receive marks (e.g. good, sufficient...).

U3 would like to have a feedback also if it is negative. He commented: “*It is not a guilt!!!*”. He would like that the clinician could receive the score because “*It is not possible to judge himself!!!*”.

U4 suggested to use numbers, scores and colors for the form of the final score. She said to would receive a final score also in case of worsening.

5.1.2.1.2 Caregiver feedback from the Task 1:

All caregivers appreciated the possibility to see the photos (e.g. grandchildren' photos) into main device.

C2 doesn't know if to S2 would like to see the photos of her life.

C3 said that they have a tablet with the photos at home, but they are too “*lazy*” to try to use it. Anyway, she imagines that they would like to see the photos on the tablet after dinner.

C4 noticed that S4 likes to see her photos and she is very curious to see WhatsApp photos from the smartphone of her family members.

Respect to the difficulties:

- C2 noticed slightly signals of anxiety in this phase and referred this to U2's difficulties with novelty. She imagines that C2 would ask help in case of difficulties with the use of this feature.
- C3 did not noted difficulties and she imagines that S3 would have no difficult to use the device independently.
- C4 did not note difficulties in the execution of the task 1, however she defines S4 as “*lazy*” in the technology use and she imagines that S4 would have difficulties into use the Memento without assistance.

On the possibilities to records comments on the photos:

All caregivers appreciated the possibility to record comments and to monitor language and memory impairments by means of this feature.

- C2 putted in evidence the importance to consider the emotional state. She was worried that anxiety could affect the performance.
- C4 suggested the possibility to listening the recording to put in evidence memory errors (e.g. an inexact memory linked to a photo).

Respect to the possibility to have a final score:

- C2 appreciated the possibility to have a standard; however, she expressed worried about a possible effect of a negative feedback. She proposed to insert an encouraging message in case of a negative performance (e.g. a small dog that communicate the message)
- C3 found this possibility very interesting;
- C4 said that a rewarding final score would be interesting and putted in evidence that low scores were removed also from the school for the risk of feel hurt by these. She would give the feedback to S4 only if it is positive.

Respect to the possibility to communicate the final score to the clinician:

- C2 didn't like this; It is better to decide if communicate the score and, eventually, to contact a trusted specialist.
- C3 was completely agree.

- C4 considered important to give a feedback to the clinicians;

Table 9: Observation form 1

Users	task completion	assistance	difficulties
u1	yes	no	no
u2	yes	no	no
u3	yes	no	no
u4	yes	no	no

5.1.2.1.3 Feedback from the Task 2:

All users appreciated the task and the possibility to monitor language and memory impairment by means of this procedure. They defined the task “pleasant”, “enjoyable”, “interesting”.

U1 found pleasant to express her opinions and sensations, in particular the invitation to give a message to the young generation. She referred that the task is interesting especially with pleasant stimuli (e.g. Totò’s photo) and that it’s a very stimulating task. She found interesting to repeat the task at different time especially with photos. In her opinion, the recording consents to maintain and enrich memories. She defined interesting this task both as an interactive game (e.g. “a sort of interview by Skipe”) than as a “solitary game”. At the end of the interview, she said “At the beginning I didn’t want to come but now I’m enthusiastic”.

U3 described the task as an interesting and unexpected task. He imagines that it could be a base for a memory treatment.

U2 imagines to repeat the task each week or each month.

U3 and U4 would repeat the task in the time.

In general, it was appreciated the idea to have a final score based on the language analysis and that also caregivers (both the clinician and a familiar) would receive this information.

U3 considered very important to communicate the results to the clinician in order to have an interpretation of the situation.

U2 said to prefer the open questions (e.g. “Tell about your occupation activity”) than to speak about the photos (e.g. “Moon Landing”).

U3 considered important to have someone to convers. He has the impression to converse better if someone is present.

U4 suggested to insert also a game like crossing word and she also declared to prefer the open questions.

5.1.2.1.4 Caregiver feedback from the Task 2:

Differently from Task 1, C2 did not find signs of anxiety and appreciated the task.

C3 defined the task “*curious*”. She thinks that open questions are better than photos on general events. In her opinion it is important to tell about own history, possibly in a conversation, a dialogue.

C4 noticed some signals of confusion and anxiety at the beginning that disappeared during the task execution. She was surprised from this performance because S4 usually doesn't like to speak. She appreciated this feature and considered important the possibility to listen again and integrate the recording.

On the possibility to repeat the task in order to monitor the progression:

- C2 was favorable. She suggested a remind at planned time.
- C3 was completely agree;
- C4 imagines that S4 would repeat the task and she considers this feature a pleasant game noting that S4 usually played cross word at evening.

On the final score:

- C2 suggested a ranking of the different scores in the time and an animation (e.g. cartoons) that gives a positive message for the users and a row score for the caregivers. As in the Task 1 feedback, she reaffirmed the importance to decide if send the score to the clinician¹.
- C3 considered important to give the feedback to user, caregivers and clinicians.
- C4 considered important to ask to S4 if she would like to receive a final score and the comparison with the previous ones. She appreciated that caregivers (both the clinicians than a familiar) would receive a message with the final score and the previous ones.

Final comments:

C2 would like to have emergency telephone numbers to call in case of need.

C3 suggested to S3 an argument to discuss based on the stimulus material.

C4 concluded that Memento continuously improve and she said: "*Memento is evolved from the start of the project!!! It keeps you always controlled*".

¹ She affirms that this aspect is important especially if an user doesn't have a good relation with the family doctor or the specialist (neurologist, geriatrician...).

Table 10: Observation form 2

Users	task completion	assistance	problems
u1	yes	one time	yes
u2	yes	no	no
u3	yes	no	yes
u4	yes	one time	yes

Sometimes U1 forgot to go on with slide and a help was necessary for a problem with power point.

U3 spoke for a very small time (or the number of pictures were not enough to achieve the 1000 words) and it was necessary to repeat two questions at the end of the session in order to increase the number of total words.

U4 found a difficulty into execute the task without interruptions before the end and she did not achieve the 1000 words despite a second attempt. She required to stop the time to ask to the experimenter.

5.1.2.1.5 Observed Emotion Rating Scale:

From the results of the OERT appears that users expressed signs of general alertness and pleasure for most of the time. Signals of anxiety was present especially at the begging of the task. This initial anxiety disappeared during the task.

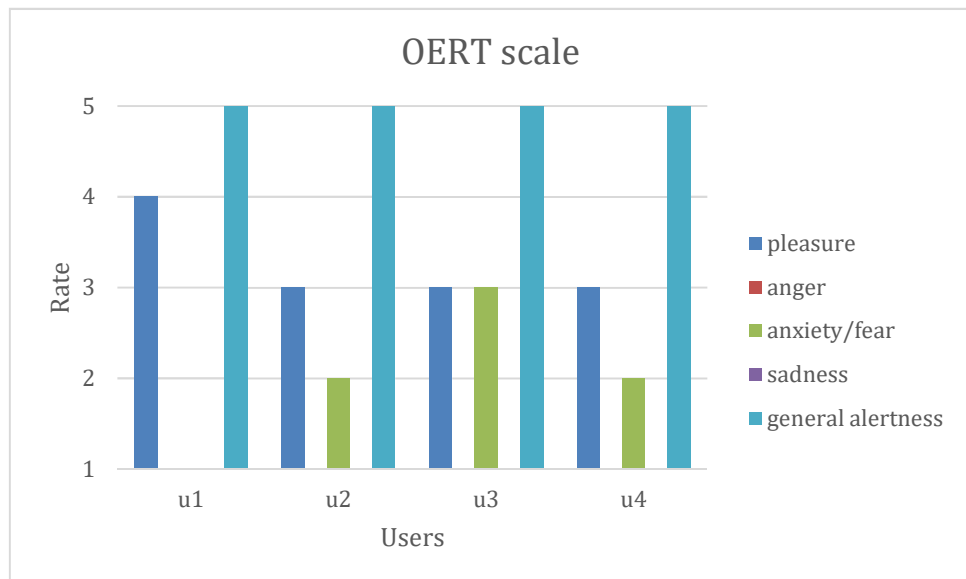


Figure 1: X axis: users. Y axis: Signs of feeling in the observation of the first 10 minutes of task execution¹.

¹ 1: never; 2: less than 16 seconds; 3: 16-59 seconds; 4: 1-5 minutes; 5: more than 5 minutes.

5.1.2.1.6 Indexes:

Table 11: Statistical indexes from the analysis of the speech.

users	Time (min)	Word/min	Brunet	Honore	Type Token Ratio	Word	Speech Rate
u1	14,49	100,2070393	6,776e-280	823,8404786	0,389233954	1452	100,2070393
u2	15,34	99,8696219	1,07e-318	543,13	0,394908616	1532	99,8696219
u3	12,49	84,70776621	3,207e-215	812,7995056	0,44	1058	84,70776621
u4	10,03	59,72083749	2,1664e-124	749,5431927	0,511744966	599	59,72083749

5.1.3 Dementia Monitoring conclusion

The “Dementia Monitoring” feature was appreciated by users and their caregivers.

6 Conclusion

Along this document, and more specifically in latest chapters the User requirements validated after lab trials are described and validated. Specific user requirements were adapted to the older people and Dementia Monitoring application it has been developed in the Italian context. Future studies will be necessary to explore the acceptance of task with users' personal photos and to establish the format of the feedback on the index analysis. Preliminary correlations between indexes and cognitive measures will require a larger cohort and trial for clinical validation after the validation of the technical results made in MEMENTO project.

The final decision about user acceptance of MEMENTO functionalities will be describe D7.3B Evaluation report of field trials.

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