D2.6
Functional requirements and scenarios v2

Dementia Ambient Care: Multi-Sensing Monitoring for Intelligent Remote Management and Decision Support

Dem@Care - FP7-288199

Deliverable Information

Project Ref. No.		FP7-288199
Project Acronym		Dem@Care
Project Full Title		Dementia Ambient Care: Multi-Sensing Monitoring for Intelligence Remote Management and Decision Support
Dissemination level:		Public
Contractual date of delivery:		Month 21, July, 2013
Actual date of delivery:		15 October 2013
Deliverable No.		D2.6
Deliverable Title		Functional requirements and scenarios v2
Type:		Report
Approval Status:		Final
Version:		11
Number of pages:		72
WP:		WP2 Requirements and Impact
Task:		T2.1 Clinical Requirements
WP/Task responsible:		DCU
Other contributors:		CHUN, LTU
Authors (Partner)		Joanna McHugh (DCU), Emma Murphy (DCU), Kate Irving (DCU), Louise Hopper (DCU), Alexandra König (CHUN), Stefan Sävenstedt (LTU)
Responsible Author	**Name**	Kate Irving
	Email	kate.irving@dcu.ie
Internal Reviewer(s)		Johan E. Bengtsson (LTU), Alex Sorin (IBM)
EC Project Officer		Gerald Cultot
Abstract (for dissemination)		This deliverable re-evaluates and updates the functional requirements outlined by D2.2 Functional Requirements & Scenarios v1 in a first step based on preliminary interviews and clinical experiences from the @Lab recording sessions, and expert evaluations described in D8.3 Initial Pilots Evaluation. Due to a delay in the completion and installation of the first prototype of the Dem@Care system the subsequent revision of the functional requirements has been delayed for each site as well. The functional requirements will be progressed within continuous evaluation activities. In this deliverable, requirements and scenarios for each main scenario (@Lab, @NursingHome, @Home) are discussed, recommendations for the Dem@care team for speech assessment based on a literature review is described, and studies of cognitive stimulation and sensor wearability are presented, which also fed into the revision of the requirements. A table representing the priorities of the different functional requirements has been created in order to inform the order of further technical development.

Version Log

	Date	Change	Author
V01	22/05/2013	First Draft	Joanna McHugh
V02	12/08/2013	Second Draft	Emma Murphy
V03	31/08/2013	Third Draft	Emma Murphy
V04	26/09/2013	Adding CHUN input	Alexandra König
V05	05/10/2013	Inputs in several sections but mostly in the @Nursing home	Stefan Sävenstedt
V06	08/10/2013	Inputs in the @Lab section and adding functional requirement v2 table	Alexandra König
V07	10/10/2013	Input in the Nursing home section	Stefan Sävenstedt
V08	11/10/2013	Input in the Home section	Kate Irving
V09	14/10/2013	Input in @Lab section and introduction	Stefan Sävenstedt
V10	15/10/2013	Final version	Alexandra König
V11	30/10/2013	Review – changes suggested	Alex Sorin
V12	31/10/2013	Update @Lab section following review	Alexandra König
V13	04/11/2013	Update @Home section and reduce redunacy across sections following review.	Louise Hopper
V14	07/11/2013	Final version for submission	Louise Hopper

Executive Summary

This deliverable represents a second iteration of the definition of functional requirements for the Dem@Care system. The deliverable is a working document that will be developed over time and be finalised when the test of the first pilot Dem@Care system has been completed.

This first version of the deliverable is based upon the experiences gained in the @Lab scenario where tests of different sensor equipment have been on-going. In the @NursingHome scenario preliminary tests of sleeping sensors have been conducted together with an expert evaluation of the functional areas of the Dem@Care system. In the @Home scenario preliminary interviews are conducted with participants, getting their feedback on the domains outlined in D2.2, and also upon further developments made by the clinical research team.

The focus in this revision is on clarifying and prioritising the functional requirements in order to inform the further technical development of the Dem@Care system.

Updated requirements are prioritised and discussed from the three pilot sites, @Lab, @NursingHome, and @Home based on the first phase of pilot evaluations. Refer to D8.3 Initial Pilots Evaluation for details on what has been tested.

Abbreviations and Acronyms

AD	Alzheimer's Disease
ADL	Activities of Daily Living
BPSD	Behavioural and Psychological Symptoms in Dementia
CHUN	Centre Hospitalier Universitaire Nice
CDR	Clinical Dementia Rating Scale
DCU	Dublin City University
DoW	Description of Work
EHPAD	Etablissement d'Hebergement pour Personnes Ages Dependantes (Nursing Home)
IADL	Instrumental activities of daily living
ICT	Information and communication technologies
LTU	Luleå Tekniska Universitet
Mx	Month x
NPI	Neuropsychiatric Inventory
NINCDS-ADRDA	National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association
Pilot@Lab	The pilot phase of the project as performed in the Lab setting
Pilot@Nursing home	The pilot phase of the project as performed in the Nursing Home setting
Pilot@Home	The pilot phase of the project as performed in the Home setting
WP	Work Package
PwD	Person with Dementia
Tx.x	Task x.x

Table of Contents

1 Introduction

The clinical objective of the Dem@Care system is an automatic and objective assessment of people with AD and related disorders. This objective will be achieved by using multiple sensors to assess the cognitive and behavioural status and daily living activities. The system is anticipated to support three different clinical settings, the @Lab setting, the @Nursing home setting, and the @Home setting. In the @lab setting the focus is on supporting the clinical assessments that are the basis for making the diagnosis of dementia in an early stage of the disease, and the periodic assessment of already diagnosed individuals. In the @Nursing home setting the focus is on supporting the assessments of the cognitive and behavioural status of people who are in a more severe stage of the disease and are suffering from behavioural and psychological symptoms. In the @Home setting the focus is on assessing behaviours in daily living in order to support and enable them to manage their lives in a better way. The system must therefore include functions that are adjusted to the setting of the clinical observation room, and to the real-life settings of a nursing home and an individual's own home.

The population to be considered will consist of elderly control subjects (for @Lab setting only), and people with mild cognitive impairment (MCI), Alzheimer's disease (AD) and mixed dementia in different stages of the disease.

In the deliverable D2.2 « Functional Requirements and Clinical Scenarios v1 » a description of five sets of functional requirements for the Dem@Care system was presented for the first two phases of testing: sleep; exercise/activity; social contact; activities of daily living and mood. Three application scenarios were examined in detail. Scenario 1, in the Lab, outlines the implementation of an objective assessment of autonomy and goal oriented cognitions using multi-sensors in an experimental design including predefined activities. This scenario will provide further objective information for clinical practitioners in order to detect behavioural disturbances. Scenario 2, in the Home, will use data gathered from a wide range of sensors using either an explicit or ambient approach to support people with early stage diagnosed dementia. Explicit approaches include both questionnaire and wearable sensor data collection, while ambient measurement encompasses any passively sensed environmental data collection. The Dem@Care toolbox approach to data collection will enable deployment of sensors specific to an individual's needs, thus maximsing the impact of the assessments made. Emphasis will be on triangulating data from different sensors to contextualise activity, and also on creating personalised datasets following consultation with individuals with dementia and their families, at point of deployment. Scenario 3, in the Nursing Home, will take some of the learning from scenarios 1 and 2 along with a full state of the art review of technologies used in Nursing and Residential Care Facilities.

This deliverable will further refine D2.2 by revising and updating the set of functional requirements and specifications. It is based on evaluation activities that have taken place in all three scenarios since the submission of D2.2, and it includes the experiences drawn from the evaluation of the first phase of pilot runs. Due to delays in the technical development the deliverable will be handled as a working document that will be developed over time. It will be finalised when the test of the first pilot Dem@Care system is conducted.

The rest of this report is organized as follows:

- Review @Lab scenarios and functional requirements.
- Review @NursingHome scenarios and functional requirements.
- Review @Home scenarios and functional requirements.
- Literature review of speech assessment and cognitive decline, with recommendations for the use of naturalistic speech monitoring in the Dem@care system.
- Feedback from a 'proof-of-concept' cognitive stimulation study of the MyLife Walkthrough game exhibited in the Dublin Science Gallery in early 2013.
- Feedback from an initial sensor wearabilty study carried out in DCU. This study focused on visibility of the SenseCam and the LARK wrist sensor.
- Concluding comments regarding this interim review of D2.2 functional requirements.
- List of prioritised functional requirments for @Lab, @NursingHome, and @Home are provided in Appendix B.

2 @Lab Scenarios and Functional Requirements

The use of the Dem@Care system in the @Lab Scenario will focus on supporting the clinicians in the assessments that are necessary in order to make an accurate clinical diagnosis that can distinguish a person with MCI from a person with early stage dementia. This will be done through clinical test procedures whereby the examined person will perform a number of pre-defined tasks at the same time as data from sensors are collected and processed by the system. The system will be developed so that it can assess and present dementia specific information that can guide the clinician in making a diagnosis.

Based on previous research protocols, CHUN defined a clinical test scenario that includes specified tasks to be performed by the test person. This research also identified markers produced by different sensors that are of interest in the assessment of dementia and that can be used when developing the Dem@Care system. Data collection to determine the performance of different sensors in the test scenarios has already taken place, the output of which has been helpful in the definition of the @Home and @Nursing Home scenarios. One step in evaluating the functional requirements and the scenario for @Lab was to ask the participants to fill out an acceptability questionnaire throughout the inclusion period (June 2012 - still ongoing). The first results are presented in D8.3. The overall outcome was that the protocol and the sensors were well accepted by participants, and they were perceived as useful additional assessment tools by the clinicians.

The functional requirements of @Lab, as outlined in the D.2.2, were based on assessment needs in clinical practice of dementia patients as well as an exhaustive literature review. As the system installation is not yet complete, and the first integrated pilot study has therefore been delayed, the revised scenario and functional requirements in this deliverable, and the prioritisation of these requirements, will be based on an @Lab scenario protocol trial with a total of 66 participants. This purpose of this trial was first to re-evaluate the assessment needs of the participants, and second, to analyse the recordings of each separate sensor component in order to validate system efficacy and user acceptance rather than system performance. Since July 2013, preliminary analyses of the collected component data has taken place, but it has only involved manually annotated data. These results are presented in D8.3. Once the software has been received to allow the collected @Lab data to be analysed off-line, more thoroughly analyses will be carried out in order to evaluate the efficacy and accuracy of the recordings compared to ground-truth manual annotations. This study is expected to provide additional information that will be fed into the review of functional requirements of the technical system.

2.1 Initial Scenario @Lab

The aim of developing and testing the Dem@Care technologies in a controlled lab environment is to implement an objective assessment of autonomy, and goal oriented cognitive function, using multi-sensors in an experimental design including predefined activities. Based on the above studies, SoA and the project's objectives, the setting will include video cameras, microphone, actigraphy and physiological sensors for recording all forms of activities, and developing from these data a computer-based recognition of events using audio, video and inertial data, as well as for extracting other biomarkers for supporting detection of dementia at early stages and supporting ongoing tracking of the dementia disease state. This scenario will provide further objective information for clinical practitioners in order to detect behavioral disturbances such as apathy.

2.2 Objectives

2.2.1 Diagnosis

Cognitive symptoms are the core feature of Alzheimer's disease. Besides these problems, behavioural and psychological symptoms (BPSD), and an impairment of activities of daily living (IADL) are frequently encountered and usually show an impact on autonomy maintenance, prognostic and care during the prodromal and early stages of the disease. Such symptoms are noticeable before the diagnosis of dementia and their occurrences as well as their intensity increase with the evolution of the disease. Apathy, initially defined as a reduction of motivated behaviours, is the most frequently observed BPSD. Apathy is clinically defined by a significant reduction or complete loss of interest, initiative capacity and emotional blunting. Accordingly, apathy is characterized by diminished goal-directed cognitions and behaviours.

Behavioural and psychological assessment relies essentially on neuropsychiatric scales. These are used to gather precise data regarding patient's clinical state from interviews with the patient, the career or from clinical impressions during the consultation. From their apparent simplicity they have made their way into daily clinical practices, yet neuropsychiatric scales are reportedly biased by the assessors' subjectivity. However, some tools that allow simple, fast and objectively valid assessments are not widely used. The use of ICT technology such as actigraphy (wearable device assessing locomotion activities), automatized audio-video recognition and signal analysis from events, may be of interest in addition to current assessment methods. In the field of independence in functional abilities, PwD commonly have problems performing tasks, which they used to perform previously such as paying bills, preparing a meal or shopping. Generally they can maintain their independence on function of daily life with minimal aids or assistance, tailored to their needs. This requires knowledge about individual's level of functioning in real life.

The primary aim of this scenario is to differentiate early stage Alzheimer's disease from healthy subjects using accelerometers and audio-video data analyses obtained during the completion of a standardized scenario of daily living oriented activities.

Different secondary aims have been also identified:

a) Differentiate early stage Alzheimer's disease or related disorder from patients with mild to moderate stages of the disease.

b) To assess the impact of behavioral disturbances, in particular apathy, on the completion of the proposed activities of daily living.

c) To assess the impact of cognitive decline on speaking behavior and voice sound characteristics

d) To assess the adjunct feasibility of the actigraphy coupled with an audio-video setting to a normal memory consultation.

e) Estimate the acceptability of this evaluation method by the participant during a standard consultation in a memory center

f) To assess the participants' acceptability to introduce a follow-up monitoring system based on the use of ICT within their own house

Translated into functional requirements the system should be able to;

a) The system should be able to identify markers or pattern in the patient's behavior when performing structured tasks that are specific for people in the early stage of Alzheimer's disease, in a mild form of the disease, and a moderate stage of the disease

b) The system should be able to identify markers or a pattern in the patient's speaking behaviour that is dementia specific.

c) The system should be able to identify markers or pattern in the patient's behavior when performing structured tasks that are specific for apathy and other behavioral disturbances related to Alzheimer's disease.

d) The system should be able to identify markers or pattern in the patient's behavior through data from sensors measuring physical activities.

e) Be part of an assessment test scenario that is acceptable for the patient, both in the clinical context and in the context of follow ups in the home.

f) The system should be able to perform follow ups of the clinical testing in labs in test scenarios developed to be performed in the natural setting of the patient's homes.

g) The system should be able to integrate and triangulate information from different sensors in order to achieve more accurate dementia specific assessments.

h) The system should be able to produce reports over the outcome of dementia specific indicators in a test session. The report should indicate similarities and differences with previous recorded tests.

In order to achieve those aims, within the five sets of functional requirements outlined in D2.2, (sleep; exercise/activity; social contact; activities of daily living and mood) specific domains were targeted for the @Lab setting and integrated in the clinical scenario protocol (see Table 1.)

After experiencing recording sessions of the protocol with separate sensors, the clinical partners decided on prioritizing domains within the requirements to help technical partners in the further process of the system development.

Table 1. Clinical @Lab Protocol

PART	DESCRIPTION	TASKS
MEDICAL CONSULTATION (T1)		
Medical consultation	- Medical consultation with the physician	➢ **Interview** ➢ **MMSE and UPDRS test (see Part6)** ➢ **Inclusion criteria checking** ➢ **Signature of the consent for the participant to Dem@Care @Lab Protocol** ➢ **E-CRF filling up**
ECOLOGICAL ASSESSMENT IN THE EXPERIMENTAL ROOM (T2)		
Preparation/ Explanation time (PrEx1)	- The assessor enters with the participant inside the experimental room and gives an overview about the assessments. - The participant is equipped with wearable devices, and ambient sensors are launched.	-
Step 1 (S1) Directed activities	- The assessor is with the participant inside the experimental room, and asks them to do different activities.	➢ **S1_P1. Physical directed tasks** - S1_P1.1. Walking (mono-task) - S1_P1.2. Counting backwards (mono-task) - S1_P1.3. Walking and counting backwards (dual task) ➢ **S1_P2. Vocal directed tasks** - S1_P2.1. Sentence repeatingtask - S1_P2.2. Articulation control task
Preparation/ Explanation time (PrEx2)	- The assessor asks the participant their difficulty to perform IADLs in the daily life. - The assessor explains to the participant the rules of the Step	-

	2, and shows where each IADL has to be performed. - At the end of the explanation time, both the assessor and participant leave the room. Then the participant enters alone inside the experimental room with the instructions sheet of paper to perform the Step 2.	
Step 2 (S2) Semi directed activities	- The participant is alone inside the room and has to perform the Step 2 following the instructions given during the (PrEx2). - The participant leaves the room when he/she feels that he/she has accomplished the Step 2, or after a time frame of 15minutes the assessor prevents that the Step 2 is finished.	➢ **List of IADLs to perform**
Step 3 (S3) Discussion with the clinician	- The assessor is with the participant inside the room. - Between the S3_P1, and S3_P2, the assessor checks that all activities were well achieved. In case of unaccomplished task(s), the assessor asks the participant to perform the related activity in order to confirm that it was due to an omission and not to any praxis difficulties.	➢ **S3_P1. Directed expression** ➢ **S3_P2. Free expression and discussion** - S3_P2.1. Verbal description of a picture - S3_P2.2. Free discussion from the picture about the interests of the participant
Preparation/ Explanation time (PrEx3)	- End of clinical scenario: sensors are stopped	-
CLINICAL CONSULTATION WITH A NEUROPSYCHOLOGIST (T3)		
Clinical Consultation	- Clinical consultation with a neuropsychologist	➢ **Battery of neuropsychological and neuropsychiatric tests**

		➢ **E-CRF filling up**

2.3 Specific Targets

Based on the presented SoA, the user studies performed, partners previous experience and activities and the project's objectives, in this scenario, diagnosis in the experimental setting will be based on the assessment of Behaviour, Cognitive abilities, Physical Activity and the Competition of Activities of Daily Life. The design of the experiments will focus on the assessment of certain functions and abilities of the participant described in the next sub-sections.

2.3.1 Motor and impact of cognitive activity on motor activities

Dem@Care will characterize motor with gait assessment, based on the measurements:

- Walking speed.
- Step length.
- Dynamic balance during the walking
- Walking speed instantaneous.
- Stops and displacements during walking.

The assessment of the effect of cognitive activity on gait will be based on the measurements of:

- Voice features indicative of speech fluency and articulation (such as pause rate, speech rate, vowel duration and voicing onset time) during mono task –cognitive activity and dual task-cognitive activity and motor.
- Correlation between walking speed instantaneous and the vocal features.

Suggested technologies: video camera, kinetic sensors (granularity level: People localization, body part detection), Accelerometers (high time resolution), wearable audio microphone.

2.3.2 Verbal reaction time and impact of cognitive load on speech fluency

Vocal biomarkers will be extracted for the assessment of cognitive load:

- Voice features indicative of speech fluency (such as pause rate, speech rate, vowel duration).
- Voice features indicative of articulation (such as voicing onset time).

Suggested technologies: wearable microphone.

2.3.3 Control over the neuromuscular mechanism of speech production

- Diadochokinetic rate (DDK) such as number of tokens per second.
- Speech regularity (such as similarity between spectral and prosodic features measured at different occurrences of the token).
- Voicing onset time statistics.

Suggested technologies: wearable microphone.

2.3.4 Executive functions and level of autonomy

The assessment of functional and cognitive abilities during a clinical scenario representing daily life activities will be based on the activity recognition and in the tracking of :

- Omitted activities
- Repeated activities
- Completed activities
- The period during which the participant has oriented behaviour to do the activity.

The assessment of functional abilities for the completion of specific activities will be based on:

- The activity recognition and more specifically in the way the participant interacts with objects (hands trajectories).
- Speech fluency and mood (Apathy).

The ability of the participant to organise with efficiency the different activities will be assessed via:

- Total walking distance.
- Trajectory of the participant inside the room.

The stress level of the participant will also need to be assessed.

Suggested technologies: Video camera (ambient & wearable), Kinect sensors (Granularity level: People localization, body part detection, posture recognition), contact sensor or ambient audio sensors (e.g: TV turnin on/off, tea kettle on/off), Galvanic Skin Response Sensor, fusion video camera.

2.3.5 Different types of memory, especially episodic memory

The assessment of memory will be done in an ecological way, thought a discussion between the participant and the assessor and will be based on the responses of the participant to questions about the recall of the activities performed, the order he/she performed these activities and on verbal picture description.

Suggested technologies: Verbal reaction time captured by an audio wearable microphones.

2.3.6 Self appraisal of the participant on his/her performances

The assessment of the participant self appraisal will be done during the same discussion (in section 5.2.5) and will be based on the responses of the participant to questions about his knowledge on the activities he/she performed, if he/she had a plan to organise these activities and if he/she met difficulties.

Suggested technologies: audio wearable microphones.

2.3.7 Verbal fluency and mood (Apathy)

During the discussion of the participant with the assessor, the assessment of verbal fluency and mood (Apathy) will be based on measurements of:

- Verbal reaction spontaneity (time between the end of assessor's speech and the beginning of participant's speech).
- Involvement of the participant in the discussion (speech rate & total time of participant's speech).
- Speech fluency (pause rate, vowel duration).
- Mood: active vs. passive (prosodic features, i.e. pitch contour statistics, energy statistics).
- *Suggested technologies:* audio wearable microphones

2.4 Revision of functional requirements

Initial functional requirements for the first pilot for the @ Lab setting are outlined in the deliverable D2.2. Due to major delays in the system integration and integrated pilot studies, an extensive system evaluation could not be completed and therefore functional requirements could not be revised based on sensor data output. However, clinical experts prioritized the different functional requirements based on a user need evaluation (see Appendix B Functional requirements v2) in order to improve guidance for technical partners.

The test scenario for the @Lab setting will remain the same but further changes based on data analyses and clinical experiences are considered if they increase event and activity detection accuracy. The preliminary results outlined in the first version of the D8.3 demonstrate the validity of the protocol for the assessment of cognitive decline. The information extracted through manually annotated video data correlates with the classical neuropsychological assessment scores and helps differentiating between healthy controls, MCI and AD patients. In a next step, the validation of the system and its sensor output has to be carried out in order to evaluate their possible benefits for clinical assessment practice.

The clinical partners agreed on updating the requirements according to each site by prioritizing them based upon the first experiences and separate sensor recordings gained in the @Lab setting. Furthermore, user needs and research interests have been also taken into consideration as well as technical feasibility. The results of this prioritisation are presented in Appendix B. In the annexed table, the different functional domains relevant to the @Lab scenario are listed in a hierarchical way whereas their user needs importance is graded on a scale from 0-5 (0=no need, 5= strong need).

In general, activity monitoring remained the most important target for the @Lab purposes, followed by the detection of BPSD and eventually mood disorders. However, recording of physical activity and speech behaviour remain a key focus for assessment and diagnosis in @Lab because it can lead to the detection of early markers for illness progression. Within the reporting period, IBM proved by two direct evaluations that speech can already enable early-stage dementia detection. A detailed description of those evaluations can be found in the deliverable D4.3.

Furthermore, recent studies have shown that decline in cognitive functioning is accompanied by a decline in motor function and may be even earlier detectable than memory problems. Therefore, the use of movement sensors such as the DTI-2 will also be emphasized in the progress of the project. The assessment of autonomy by the help of automatized video activity recognition remains a main objective, even though at the current state it is the most challenging and requires further fusion with other sensor data output in order to improve detection accuracy.

3 @Nursing Home Scenarios and Functional Requirements

The functional requirements of the @nursing home, as outlined in the D.2.2, were based on interviews of staff working in nursing homes and a review of literature. Given the delay in commencing the integrated pilot study, the revised scenario and functional requirements in this deliverable have been based on assessment of needs and experience of usability of the system by four participants that were selected to participate in the first trial. Requirements have also been updated to reflect the results of preliminary tests of sleeping sensors (May 2013), and a clinical expert evaluation of the different functions of the Dem@Care system as it was presented in September 2013. When the integrated system is ready to be tested the functional requirements will be further reviewed based on the results of the test of the first integrated pilot study.

A study of staff members' reasoning while carrying out assessments and evaluations of intervention efficacies among people with BPSD was also initiated in May 2013. This study will continue during the autumn of 2013, and it is expected to provide additional information that will feed into subsequent reviews of functional requirements of the technical system.

3.1 Nursing Home scenario

This description will highlight some interesting areas to explore in terms of the needs of people living in residential or nursing care centre. The scenario focuses on people with dementia who already are diagnosed and have Behavioural and Psychological Symptoms of Dementia (BPSD). This means they may have various degrees of problems related to mood, anxiety, sleep, performance of daily activities and social interactions. The Dem@Care system will use multiple sensors to assess the cognitive and behavioural status and daily living activities of the residents in the nursing homes. This assessment will provide valuable clinical information on their BPSD status and a tool for evaluation of medical and care interventions. In addition the system will provide support for security and enablement of daily life activities for the individual resident.

The case of Agda

The case of Agda is a condensation of the information gathered from the four participants and their carers and illustrates a possible scenario on how the system can be used.

Agda is a resident at the nursing home, 81 years old and with diagnosis of dementia. She is more often than before involved in conflicts with the other residents at the nursing home and many of the staff members are complaining that they have regular conflicts with her in many daily life situations. When the staff members discuss her problems they can sense that there are some pattern in her mood status during the day. Even though there is some understanding of her patterns there is also much information missing in order to be able to support her and enable her to manage her daily life in a better way. The conflicts with the other residents often occur during the meals and other common activities. The staffs have taken the measure to make her sit alone with a staff member when eating and make her spend more time on her own. Conflicts with staff members usually occur when they want her to do things, which she doesn’t like to do, e.g. showering. This problem has been there for some time but in resent time it has become more difficult to handle.

The staff agreed that they would use the NPI-NH screening instrument for their assessment of patterns in her behaviour in order to have a systematic approach. The domains of the NPI-NH instrument related to mood assessment are four, signs of aggression, signs of anxiety, signs of apathy, depression, indifference, and signs of elation and euphoria. In addition to the use of systematic observations of her behaviour they also use the reports that can be produced by the Dem@Care system that describe her sleep, activity, and mood pattern over time and fluctuations in them during the day.

A major challenge for the staff is to interpret what the person experiences themselves in terms of mood, and the assumption is that combining their own observations of Agda´s behaviour with the reports of the system will result in better understanding. To decide on a proper intervention to support Agda they need to answer questions such as:

- Can we confirm if there is a special time of the day when Agda is more agitated?
- Is her agitation in any way related to her sleeping patterns?
- Are there expressions of other strong emotions listed in the assessment tool?
- Is her agitation related to frequency, pattern and level of physical activity?
- Is her agitation related to the encounters of other residents?

3.1.1 Support / Feedback to nursing home staff

Feedback will be highly personalised based on the assessments made. For instance, if there is a problem with sleep it may be possible to highlight this to the staff as a problem over time, or to give real time alerts that the person does not sleep, so that the staff can make person centred interventions to support the PwD. Feedback to staff could be audio (signal), textual or visual (pictures). The target in the feedback could be the clinician, and the caring staff.

3.1.2 Specific targets

The areas of focus in the Nursing Home are: Sleep; Activity/Exercise/Movement; and Mood. Different residents will require more or less focus in the different areas.

3.1.2.1 Sleep

Degenerative neurological disorders that cause dementia are known to intensify age-related changes in sleep. These age-related changes may include falling asleep earlier and awakening earlier, more fragmented sleep patterns, insomnia and sleep apnoea-hypopnea. Behavioural or environmental factors such as light, noise, poor sleep habits, physical inactivity during the day and diet can also play a role in disrupting sleep patterns as well as anxiety, medical problems as for example pain and side effects of medication. In order to better understand the factors behind disturbed sleep and evaluate intervention to improve sleep the Dem@Care system shall:

1. Monitor daily patterns of sleep.

2. The Dem@Care system shall characterize the daily sleep pattern using the following parameters:

- Sleep onset time
- Sleep duration
- Sleep wake time (including daytime napping)
- Number of awakenings
- Average length of awakenings (Inverse of sleep duration?)
- Minutes slept by location (bedroom – sitting room etc.)
- How much deep sleep and light sleep per night and when these occure.

3. Clinician/staff will be involved in setting initial parameters for normal sleep habits. The Dem@Care system must be able to account for "napping behaviour" in/outside the bedroom as well as nocturnal sleep patterns.

Suggested technologies for Dem@Care monitoring of sleep patterns

Gear4, actigraph, 3d modeling of sleep/activity using kinect.

The Dem@Care system shall characterize long term patterns of sleep based on time series data:

- Daily pattern in comparison to earlier days
- Weekly pattern in comparison to earlier weeks
- Monthly pattern in comparison to earlier months

The Dem@Care system shall provide information on the quality of sleep based on patterns of the general sleep parameters.

4. The Dem@Care system shall give real time alerts to staff when the PwD is awake for XX minutes (individual) without falling asleep. The Dem@Care system should provide staff with the option to just turn the alert off, rather than having to go into the PwD. As the intervention is personalized, the best solution may be to let the person be awake in the bed, or the staff may simply be occupied elsewhere. The system should then give a new alert in XX minutes if the PwD has not subsequently fallen asleep.
5. The Dem@Care system shall give real time alerts to staff when the PwD is awake and moving around in the room.

3.1.2.2 Exercise/Physical Activity/Movement

One problem for staff in Nursing Home is to know what the PwD are doing when they are in their apartment which leads to reduced independency and little time to be alone since the staff feel the need to "check up on" the person. Either the risk of the PwD falling is high or the person may undertake activities that are harmful to him or her. Our system intends to enable people to maintain activity and general independence maintenance but in a way that preserves security.

1. The Dem@Care system shall monitor the movement of the PwD when he or she is in the apartment and additional monitor the activity level during the day (and night). The Dem@Care system will also monitor lack of activity as a measure of time spent in sedentary activity.

2. Both exercise and general activity are of significant interest in the Dem@care program. Exercise may take place outside or inside the home. A variety of monitoring techniques may be required to characterize activity/exercise taking place in different locations.

3. The Dem@Care system shall characterize the daily activity/exercise using the following types of parameters:

- Accelerator counts per minute
- Walk speed
- Stride length
- Onset times of exercise
- Exercise duration, intensity
- Distance travelled
- Intensity through HR monitor etc
- Numbers of spent kilocalories
- Give real time alerts when the person is moving in a undesired way/place
- Give real time alerts when the person is not moving in a place in the room that is abnormal (i.e. indicate fall)

4. The Dem@Care system may monitor physical activity in many possible ways, duration of exercise in minutes/hours percentage of day spent exercising. E.g. Cut off figures on actigraphs are frequently used in such research. Clinician/staff/realtives will be involved in setting initial parameters for normal exercise/activity levels. This may also be used to set targets for the participant to attempt to maintain or improve exercise habits.

5. Suggested technology for Dem@Care monitoring of physical activity/movement:

Actigraphy, pedometers, portable heart rate monitors, 3d modeling of activity/movement using kinect.

The Dem@Care system shall characterize long term patterns of activity, exercise and sedentariness based on time series data:

- Daily pattern in comparison to earlier days

- Weekly pattern in comparison to earlier weeks

- Monthly pattern in comparison to earlier months

- Daily logging of spent kilocalories with a option to summarise and get an average for X days (optional how many days).

6. The Dem@Care system shall give real time alerts to staff when the PwD is moving around in the apartment in an undesired way/place for XX minutes (individual). The Dem@Care system should provide staff with the option to just turn the alert off, rather than having to go into the PwD. As the intervention is personalized the best solution may be to let the person be alone, or the staff may be occupied elsewhere. The system should then give a new alert in XX minutes if the PwD still or again is moving in a similar way.
7. The Dem@Care system shall give real time alerts to staff when the PwD is not moving for XX minutes (individual) in a place in the room that is abnormal (i.e. indicate fall). The Dem@Care system should provide staff with the option to just turn the alert off, rather than having to go into the PwD. As the intervention is personalized the best solution may be to let the person be alone, or the staff may be occupied elsewhere. The system should then give a new alert in XX minutes if the PwD still is not moving.

3.1.2.2 Mood

A person with dementia is affected in different ways as the condition progresses. There may be changes in memory, cognitive ability, and behaviour. In the early stages of dementia, low mood and depression and apathy are common as loss of capacity to live independently or to maintain ones established role in a long term relationship may occur. These kinds of profound changes in a person's life may have serious knock on effects on mood and thereby on motivation for keeping up with daily activities. In later stages of dementia, cognitive problems with remembering, thinking, interpretation and understanding their life world can for example lead to arousals of anxiety and angry outbursts. This is some of the mechanism behind what is labelled as Behavioural and Psychological Symptoms in Dementia (BPSD). BPSD is clinically often divided into symptoms of delusions, hallucinations, agitation, depression, agitation, euphoria, apathy, irritability, aberrant motor behaviour, sleep problems and eating problems. It is important in the @Nursing home monitoring system to have an element of mood assessment present. This can be used to observe peaks and troughs in a person's mood and to contribute information as to how and when to design interventions to support mood and activity levels. It can also be used for clinicians to evaluate treatment and measure effect of care interventions.

1. The Dem@Care system shall characterize the mood of the participant using the following types of parameters (Table 5, Appendix A7):

- High restlessness on actigraph (e.g. notable levels of pacing or fidgeting with hands outside of ordinary) and 3 d camera (kinect) (e.g. moving around in an abnormal way)

- HR monitor etc (e.g. high heart rate can indicate anxiety and such)
- Measuring of skin conductance (e.g. indicating anxiety)

2. Suggested technologies for mood assessment:

Portable heart rate monitors, 3d modelling of activity/movement using kinect, skin conductance and actigraphy.

3. The Dem@Care system shall characterize long term patterns of the participant's mood based on time series data:

- Daily pattern in comparison to earlier days
- Weekly pattern in comparison to earlier weeks
- Monthly pattern in comparison to earlier months

4. The Dem@Care system shall give real time alerts to staff when the monitoring of mood is indicating higher levels of stress/anxiety/restlessness for XX minutes (individual). The Dem@Care system should provide staff with the option to just turn the alert off, rather than having to go into the PwD. As the intervention is personalized the best solution may be to let the person be alone, or the staff may be occupied elsewhere. The system should then give a new alert in XX minutes if the PwD's mood has not changed.

4 @Home Scenarios and Functional Requirements

The first step in evaluating and updating the functional requirements outlined by D2.2 took place in the preliminary interview phase of the @Home pilot. These interviews took place in early 2013, with 5 caregiver-patient dyads. The interview format is available below (Appendix A: Interview Schedule). We report feedback gained from participants with reference to the 5 domains (sleep, exercise/physical activity, social contact, instrumental activites of daily living, and mood). Two of these dyads remain involved in the project as lead users. The next step in our evaluation involved further clinical assessment interviews with these users to assess individual functional requirements and design a personalised sensor toolbox.

Functional requirements for our two lead users are presented in detail based on both preliminary and assessment interviews. While sensor toolboxes for both users are presented in detail in D8.3 (Interim version) justification for personalised toolboxes are presented in relation to clinical assessments for both lead users. Results from preliminary interviews are presented for participant dyads 3, 4, and 5 (Appendix A). While these three users are no longer involved in the project the results from their interviews offer valuable insights into the ways that our end users need to be supported with the Dem@Care system.

4.1 Preliminary Interviews

This section describes the @Home Lead Users, their needs assessment interviews, functional requirements, and personalised toolboxes.

4.1.1 Needs assessment interview with Lead User Dyad 1: Michael and Patricia

Michael is in his 80s and lives alone in Dublin city centre, in the family home. His wife is alive but has sufficient physical limitations to have been moved to a local nursing home. Michael has seven children, all of whom visit regularly. Michael's primary caregiver is his daughter Patricia, who also lives in Dublin and has two children. He is very active and independent, attends day centres locally, and has care assistants visit his home 4 days a week and also receives Meals on Wheels. Preliminary and follow up assessment interviews were conducted with Michael and his daughter Patricia at Michael's home in May and June 2013. The results from these interviews are presented below according to each area of functional requirement.

Mood

Mood was preliminarily investigated via the semi-structured interview format, but no issue with mood was detected, in direct conversation with the PwD or following consultation with the relative. Therefore the mood questionnaires were not used in the assessment.

ADL/IADL

ADL was investigated by asking the PwD if they had any day-to-day difficulties with chores. A recent incident was reported whereby the PwD had burned rubbish in the back garden, which is not permitted in Dublin, and the relative had received some complaints from the neighbours. Therefore chores may be an area in which the PwD is beginning to deteriorate. To assess this further, the researcher completed the Bristol ADL scale with reference to the interview. The Bristol ADL scale is a test to reveal the everyday ability of individuals with memory difficulties, and has 20 statements, with which one can agree on a scale of 1-5 (a to e). The statements should be considered with reference to the previous two weeks of the life of the individual with dementia. Michael scored 18 out of a possible 60, with 0 indicating total independence and 60 indicating total dependence. A cut-off score of 20 indicating clinical levels of dependence has been suggested (Umaya et al., 2010) indicating that Michael is displaying above threshold independence at baseline. The areas in which he demonstrates sub-optimal performance are; food, spatial orientation, temporal orientation, communication, telephone use, housework and gardening, shopping, finances, games and hobbies, and transport.

The Everyday Competence Questionnaire was completed with reference to the interview also. The Everyday Competence Questionnaire is a 17-item scale designed to assess functioning in a broad array of activities. Michael scored 21 on the ECQ (possible scores 0-51 with higher scores indicating better functioning). The average score for a dementia population has previously been shown to be 3.69 (in institutionalised older adults; Kalisch et al., 2011) so the score Michael attained indicates above-average functioning. His scores were lowest in the leisure domain, housekeeping domain, manual skills, and general linguistic usage. Functioning in sports, subjective wellbeing, daily routine, and mobility were higher.

No dietary issues were reported with Michael so the researchers did not complete the Mini Nutritional Assessment.

Sleep

Sleep was indicated as being an area in which Michael may benefit from support – he mentioned that he was prone to waking up disoriented during the night. The Pittsburgh Sleep Quality Index (PSQI) was administered. This is a 19-item questionnaire that gives scores in 7 domains as well as an overall score that indicates sleep pathology (if over 5, scale score range 0-21 where 0 indicates good sleep). Michael attained an overall score of 4, indicating no presence of pathological sleep quality. There were no issues reported in the domains of sleep duration, sleep latency, daytime dysfunction, sleep efficiency, overall sleep quality, but some sleep disturbance, and regular use of sleep medications, were noted. The researcher skipped the Epworth Sleepiness Scale and Insomnia Severity Index as there was no evidence of daytime dysfunction or of insomnia following the use of the PSQI. The Horne Morningness Eveningness Questionnaire was also used following the interview data, to give an indication of Michael's sleep phase type. Michael received a score of 67, indicating that he is a 'moderate morning' type. The Scale of Older Adults' Routine was not assessed, as Michael's attention at this point was waning.

Physical activity and exercise

Physical activity and exercise were noted as a potential problematic area since Michael doesn't get out and about as much as he used to, mainly since he often has to be monitored. The researcher calculated a score for the Rapid Assessment of Physical Activity scale, referring to the interview data, and scored 3, which indicates that he is underactive. The Physical Activity Scale for the Elderly was not completed due to Michael's attention waning at this point in the assessment.

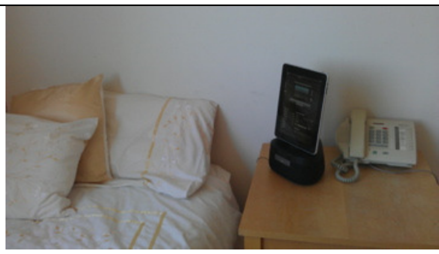
Social interaction

Social interaction was not noted to be an area in which Michael required support, as he is very socially active. These scales were not used in the assessment.

Personal Sensor Toolbox for Lead User 1

The assessment interview indicated that physical activity and exercise, and ADL/IADL were two areas in which Michael could benefit from support. Sleep was mentioned as a difficulty, despite the lack of evidence of this from using the clinical questionnaires. However since both Michael and his relative were worried about his sleep, the sleep domain was added to Michael's toolbox.

Table 2. Sensor Toolbox for Lead User 1 (Michael)

Functional Requirements	Feedback for Lead User 1	Sensors
Sleep	Sleep was mentioned as a difficulty, despite the lack of evidence of this from clinical questionnaires. Since both Michael and his relative were worried about his sleep Michael could benefit from support in this area.	 Gear4 Sleep sensor will be installed beside Michael's bed
ADL/IADL	Michael could benefit from support.	The ASUS Xtion sensor will be installed in the kitchen/living room area of Michael's house. We will also ask Michael to wear the GoPro camera when his daughter is visiting for approximately 30 minutes. While wearing the camera, he will be required to carry out a series of tasks that he regularly undertakes such as making tea, making a phone call, listening to the radio.
Physical activity & exercise	Michael could benefit from support.	**WIMU Sensors and DTI-2** As the WIMU sensors may be cumbersome to wear for long periods due to their size and fit we propose

		following a protocol to assess walking movements for a short period of time in the presence of a researcher.

4.1.2 Assessment Interview with Lead User Dyad 2: Seán and Catriona

Catriona and Seán are married and live with Seán's mother in their own home outside Dublin. They have two dogs. Seán was a carpenter and Catriona works 4 days a week in administration. Seán is just post-diagnosis, and has taken part previously in research with the DCU team, using the SenseCam technology to explore lifelogging. Seán is active and independent and has comorbid epilepsy, which is being successfully managed pharmaceutically. Preliminary and follow up assessment interviews were conducted with Sean and Catriona in their home in May and June 2013. The results from these interviews are presented below according to each area of functional requirement.

Mood

Mood was preliminarily investigated via a semi-structured interview format and no issue with mood was detected, in direct conversation with Seán. Therefore the mood questionnaires were not used in the assessment.

ADL/IADL

No issues related to ADL or IADL were reported by Sean so the researchers did not complete the relevant scales as part of the assessment interview. Following the assessment interview Catriona raised concerns that Sean was having difficulty operating their CD player. Sean used to be a keen music listener and has a substantial music collection on CD. Catriona speculated that he has stopped listening to music, as he can no longer operate the CD player. This is a task that could be supported with the @Home sensor toolbox

Sleep

Sleep was indicated as being an area in which Sean would benefit from support. The Pittsburgh Sleep Quality Index (PSQI) was administered. Sean attained an overall score of 6, indicating issues with pathological sleep quality. While Sean estimated that he was having approximately 10 hours of sleep a night, he rated his quality of sleep as very poor and suffered from sleep disturbances. Sean indicated that he was prone to sleep late into the morning but he explained that this was due to his medication for epilepsy that has made him sleep for longer. His spouse, Catriona also discussed that she had problems with insomnia and sleep quality. We propose supporting both Catriona and Sean with their sleep issues and have designed their toolbox to reflect this.

Physical activity and exercise

Physical activity and exercise were not noted as a problematic area for Sean as he is very active and achieves at least the recommended amount of exercise per week (30 minutes of light exercise per day, 5 days a week). However Sean indicated that he would be interested in improving his fitness levels. While he is a regular walker he mentioned that he would like to take up running.

Social interaction

As part of the assessment interview, social interaction was not noted to be an area in which Sean required support. After the assessment interview Catriona expressed some concern in this area as while she considered Sean to be very social she has noticed that he was initiating conversation less that he used to. We propose using Sean's sensor toolbox to explore this during the @Home pilot.

Table 3. Personal Sensor Toolbox for Lead User 2

Functional Requirements	Feedback for Lead User 2	Sensors
Sleep	Both Sean and Catriona would like support in this area	**Gear 4 and DTI-2** Gear4 Sleep sensor will be installed beside Seán and Catriona's bed and Seán will be asked to wear the DTI-2 wrist sensor as often as possible.
ADL/IADL	While general eating, cooking and chores are no problem for Sean, Catriona indicated that certain tasks may need support (CD Player)	**GoPro Camera and ASUS Xtion**  Seán will wear the GoPro camera to conduct regular tasks such as preparing a meal, making a phone call and operating the CD player. The Asus Xtion sensor may also be deployed in the kitchen/living room area of Sean's home. This proposal will be re-

		evaluated if additional monitoring is required beyond that provided by the GoPro.
Physical activity & exercise	No issues detected, Sean indicated interest in having support in this area	**WIMU Sensors and DTI-2** As the WIMU sensors may be cumbersome to wear for long periods due to their size and fit we propose following a protocol to assess walking movements for a short period of time in the presence of a researcher.
Social Interaction	Catriona indicated that Sean may benefit from support in this area	**Dem@Care Microphone** In order to monitor and support Seán's levels of communication and interaction we propose that he wear the Dem@Care microphone for short but regular periods of time.

4.2 Functional impact of lead user assessment and feedback

In the Home different users will have different areas that require more or less focus, and the specific lead users working with the Dem@Care system at any point in time will determine the sensors and functional requirements that can be evaluated at that point in time. Issues in the areas of sleep and activity/exercise/movement are common to both of the current @Home lead users, so requirements can be evaluated in both of these areas. We propose to deploy additional sensors in the coming months that will allow us to monitor social interaction and to examine IADLs in somewhat constrained circumstances, similar to the lab activities. Requirements specific to these functional areas can then be evaluated in subsequent versions of this deliverable.

4.2.1 Sleep

The @Home functional requirements for sleep overlap to a large extent with those of @Nursing Home, so they will not be repeated here (see section 3.1.2.1 for details). Separate prioritisation of these requirements has been provided in Appendix B. This section describes additional requirements that are unique to the @Home setting, and instances where the requirements differ from those required in the nursing home.

1. At home, the initial parameters for normal sleep habits will by set by the PwD, or by the carer. The Dem@Care system must also be able to account for:
   - "napping behaviour" in/outside the bedroom
   - noturnal sleep patterns

   Suggested technologies for Dem@Care monitoring of sleep patterns are:

Gear4, actigraph, 3d modeling of sleep/activity using kinect.

2. The Dem@Care system shall provide information on the quality of sleep based on patterns of the general sleep parameters. No alerts will be required.

4.2.2 Exercise / physical activity / movement

One problem for assessment clinicians is to know what the PwD is doing in terms of physical activity. Personal accounts often do not corroborate with collateral accounts of relatives. Our system intends to enable people to maintain activity and general independence but in a way that preserves security. Again functional requirements overlap with those required in the @Nursing home setting (see section 3.1.2.2). Items specific to @Home include:

1. The Dem@Care system shall monitor the movement of the PwD when he or she is at home and additionally monitor the activity level during the day (and night). The Dem@Care system will also monitor lack of activity as a measure of time spent in sedentary activity.
2. No alerts will be required,

4.2.3 Instrumental activities of daily living

The above two priority areas have good standing in terms of the lead users, however there are additional recordings that can usefully serve as training data for the technology partners and the lead users are happy to collect some additional data. In some semi-constrained situations users will wear a jacket with the Go-pro and the audio sensor in place. The user will be asked (in the presence of the researcher or carer) to go through a protocol that to some extent replicates the lab experiment and additionally requires the user to perform some activity that they have begun to find difficult. This will happen twice a week – once with the researcher present and once with only the carer present. The researcher will collect this data on a weekly basis and the team will be able to evaluate the usefulness of this additional data. It is expected that this data collection can commence in November 2013. Feedback from these assessments will be incorporated in the next iteration of this deliverable.

5 Speech and Cognitive Decline

Speech analysis forms an integral part of the @Home functional scenarios related to social interation (see D2.2 section 6.3.3) and to mood (see D2.2 section 6.3.5). These analyses include: frequency and variety of speech utterances; speed and cadence of speech; and tone and volume of voice. A literature review was carried out to further examine the potential use of naturalistic speech monitoring as a means of assessing cognitive functioning in the home. The key findings from this review are described below, and recommendations for the best functional use of this analysis are suggested.

5.1 Literature Review

Previous research has investigated the potential use of speech as a means of differentiating between healthy controls and individuals with Alzheimer's disease. Some research has focused upon naturalistic speech, and other research has elicited speech excerpts in a controlled, standardised fashion. Each approach has benefits; the naturalistic speech segments present the individual while relaxed and engaged and is ideal for those who find formal testing stressful, while the elicited speech segments are comparable across individuals. Bucks, Singh, Cuerden and Wilcock (2000) collected naturalistic, spontaneous conversational speech from individuals with dementia and controls, in a semi-structured interview format. They found that individuals with dementia had lower rates of noun use, adjective use, and verb use (per 100 words) than the individuals without dementia. The individuals with dementia also had lower lexical richness, indicated using Brunet's index and Honore's statistic, indicating that their vocabulary was more limited than the individuals without dementia. There was also an interesting trend for individuals to use pronouns ("I") more than the healthy controls, and the researchers concluded that this may be a substitute used when the participant experienced word finding difficulties. Other researchers have used standardised tasks to elicit spontaneous speech, as in picture description tasks such as the Boston cookie theft task. This task was employed by Bschor, Kuhl and Reischies (2001) to investigate linguistic disturbances in individuals with mild to moderate dementia. Compared to controls, the individuals with dementia were less descriptive and less fluent in their speech than individuals with mild cognitive impairment, or the healthy controls. The Boston cookie theft task was also found to elicit simpler sentences from individuals with dementia than from those without (Croisile et al., 1996). These tasks can even be delivered in the home, using interactive teleconferencing 'kiosks' to deliver the tasks and record the response (Coulston, Klabbers, de Villiers & Hosom, 2007).

Researchers have pointed out that tasks such as these may not accurately represent the earlier and subtler communicative changes that can occur with dementia progression. These changes occur so early that they may also be a marker of the onset of mild cognitive impairment (Fleming & Harris, 2008; Roark, Mitchell, Hosom, Hollingshead & Kaye, 2011). Language production in general appears to decline just before individuals receive a diagnosis of Alzheimer's disease (Garrard, Lambon Ralph, Patterson, Pratt & Hodges, 2005). Thomas, Keselj, Cercone, Rockwood and Asp (2005) looked at developing automatic detection of dementia by analysing spontaneous speech, and found that the automatic analysis performed on word usage rates did successfully differentiate between individuals with dementia and those without.

Sajjadi, Patterson, Tomek and Nestor (2012) acknowledged the difference between using a standardised picture description task, and a more naturalistic semi-structured interview methodology, in assessing the speech of individuals with AD, and found that the two methods are differentially efficient in spotting different impairments; interviews are more likely to reveal impairments of morphological and syntactical structure, whereas picture description tasks are more likely to reveal semantic and word retrieval difficulties. Thus it may be the case that different methodologies are recommended according to the goal of the assessor.

Orange and Lubinski (1996) did an interesting analysis of more pragmatic-level linguistics, looking at conversational repair used by individuals with dementia. They found that individuals with moderate stage dementia spent more of their conversational time engaged in repairing utterances and communicative breakdown. Another good example of a more pragmatic-level parameter was given by Meilan, Martinez-Sanchez, Carro, Sanchez and Perez (2012) when they showed that measuring percentage of voiceless segments as related to fluency predicted overall scores in neuropsychological testing for individuals with dementia. Other non-verbal aspects of speech also present possibilities as dementia-related markers: for example, individuals with dementia have been shown to use a flat prosodic profile in a reading task, compared to healthy controls (Martinez-Sanchez, Meilan, Perez, Carro & Arana, 2012). Other features such as the periodicity of speech, or the naturally fluctuating temporal cycles of speech fluency, may also help to differentiate speech produced by individuals with and without dementia (Pakhomov et al., 2011).

It is important to note that while verbal communication may be impaired in individuals with AD, nonverbal communication tends to be for the most part preserved (Rousseaux, Seve, Vallet, Pasquier & Mackowiak-Cordoliani, 2010). This may represent an area which compensates for verbal impairments, indicating that naturalistic monitoring should ideally take into account both auditory and visual communicative cues made by the individual with dementia.

Recording spontaneous conversational speech in the home may be best done at particular times of the day. Hopper, Cleary, Baumback and Fragomeni (2007) notes that meal times provide a convenient context for conversation for individuals with dementia, particularly when meaningful prompts are employed by the conversational partner.

In individuals post-diagnosis, speech can also serve as a marker of cognitive decline. Tomoeda and Bayles (1993) followed three individuals with dementia over the course of 5 years, deploying the cookie theft task each year, and found that over time, the number of total words used, the information units used, and the general conciseness of speech all decreased over time, while the number of circumlocutions used, as well as the revisions and repetitions of phrases, all increased in this time.

5.2 Recommendations for the use of naturalistic speech monitoring

1. Spontaneous conversational speech (SCS) may be more informative than a more standardised speech analytic method, in the home.
2. Mealtimes may serve as an ideal context in which to collect SCS data.
3. Metrics indicating lexical richness and speech rates (e.g. verb rates, pronoun rates, noun rates) should be informative, as well as overall conciseness of speech, as this is predicted to decrease over time.

4. Meta-linguistic features of speech, such as circumlocution, revision, periodicity of speech, and prosody of speech, may all be informative about cognitive decline over time.
5. It may be interesting to attempt to triangulate verbal communicative attempts with non-verbal attempts (e.g. body language and facial expression) to see if the latter is maintained in individuals with dementia over time.

6 Cognitive stimulation as a social connectivity tool

The functional requirements document (D2.2 section 2.3.5) identified cognitively stimulating activites as a potential means of monitoring and enabling optimal social connectivity between the PwD and other family members. Using technology to deliver game-based cognitive stimulation was explored by Dem@Care researchers through the development of the MyLife Walkthrough game, which was exhibited in the Dublin Science Gallery in early 2013. A brief literature review, feedback from the MyLife Walkthrough exhibition, and other potential avenues for delivering cognitively stimulating activities via the Dem@Care system are discussed in this section.

6.1 Literature review

Cognitive stimulation therapy (CST) can be described as an adaptation of reality orientation therapy, which aims to provide spatial and temporal orientation for individuals with dementia who are often suffering with confusion (Taulbee and Folsom, 1966). CST extrapolates the principles of reality orientation to involve cognitively stimulating tasks, such as managing financial transactions, or map-reading, for small groups of individuals with dementia (Spector et al., 2003). CST has been found to improve cognition and quality of life in individuals with dementia (Spector et al., 2003). CST advocates a person-centered approach to the individual, where tasks are contingent on the abilities of the individuals in the group (who are all at a similar stage of dementia progression), and a failure-free approach where individuals are encouraged to exercise preserved abilities rather than those abilities which may be in decline.

Music therapy (MT) is another means of engaging the individual with dementia in a comforting and pleasurable experience, and has been shown to increase communicative attempts and improve mood (Ashida, 2000). Using music relevant to particular life stages, as is done in reminiscence therapy, is a common way of optimizing relaxation and interaction among individuals with dementia.

Reminiscence therapy (RT) is another psychosocial intervention involving discussions among groups or individuals, this time focusing on the past activities, events and experiences, either shared or personal, of individuals with dementia (Woods et al, 2005). RT involves the use of prompts such as photographs or songs to engage the individual with dementia in a discussion about their past. This type of therapy draws from Butler’s life review work (Butler, 1963), whereby the individual is encouraged to integrate and review past experiences and events. RT has previously been found to improve mood and cognition, though these effects may not persist (Woods et al, 2005).

Reminiscence therapy often calls upon the use of the life story (McKeown et al., 2006, Moos et al. 2006). This method involves translating the individual’s life stories into conversations and interactions with the caregivers and families, and again emphasizes the function of reminiscence as an integrative exercise. The function of life story work is to preserve the self throughout the course of dementia progression and to support the process of integration and review that older adults must undergo (Butler, 1963). Life story work involves creating a narrative, typically in a scrap book, about the individual’s life and past events, including major things like marriage, children, occupational information, and leisure information. Researchers have found that cueing this type of information (e.g. “tell me about your schooldays") is more effective in eliciting reminiscence than a more open-ended approach (Fromholt et al., 2003).

6.2 Games and the life story review

This proof of concept is based on the approach of gamifying the life story review — turning the creation of the narrative into a game, with achievements and actions — which would make for a more elaborative and engaging encoding process, which in turn produces a beneficial cognitive effect for individuals with dementia.

Games, insofar as they present a manageable challenge for individuals with dementia, could constitute CST. Being a medium typically associated with younger generations, games also offer a medium through which to provide increased opportunities for interaction, which is important since individuals with dementia are often socially isolated (Alzheimer's Society UK, 2013). Benveniste et al. (2010) found that participants were interested in the game but to a large extent the pleasure they received from the game was secondary to that of the opportunity for social interaction with the researchers. Thus successful Serious Games for dementia populations should enable the involvement of a second person, acknowledging that caregivers are under time pressures and therefore also making the game sufficiently simple to be mastered by the individual alone. Reminiscence tools are social experiences and any game that focuses on the process of reminiscence should facilitate this interaction. This may be particularly pertinent for family members, who will have a personal interest in the past lives of the individual, and for care staff, who may wish to get to know the individual better. Furthermore games represent an attractive pastime for younger generations and grandchildren, which could present a chance for intergenerational interactions with younger children in the family in particular.

Our work in this area is based on the principle that creating a game designed specifically for a dementia population is an attempt to create mastery experiences. Once the individual has completed the game, they should experience a sense of achievement. This should be encouraged without the punitive potential of losing the game, however. It is vital that the player must complete the game feeling masterful and competent, rather than feeling frustrated at a game that is too challenging. McCallum (2012) discusses the concept of 'flow' in games as a state where the ability level of the individual matches the challenge put forward by the game — it is not a frustrating experience but pleasurable. This flow is mirrored, he notes, in personalized health, where the intervention must match with the functional level of the individual. This concept is key to providing person-centered dementia care, in an environment where failure is not possible (as in CST) and the individual is encouraged to complete accessible, achievable tasks, with little possibility of failure or a loss of self-esteem. Typically individuals with dementia will quit a task if they find they are not succeeding. Thus any game designed with this population in mind must focus instead on rewarding the extant level of ability of the individual, rather than presenting too great or intimidating a challenge. This approach is referred to as 'failure-free gameplay' by Benveniste et al. (2010), who acknowledge that the defensiveness typically expressed by individuals with dementia when facing an unfamiliar or challenging task, means that a task that is impossible to fail is preferable for maintaining motivation and self-esteem.

6.3 MyLife Walkthrough

MyLife Walkthrough was designed as a game that is part cognitive stimulation therapy, part reminiscence therapy, and part music therapy. The game fulfills criteria relevant to all three therapies, and represents an innovative and exciting direction in psychosocial intervention for individuals with dementia.

A walkthrough in a video game is a written step-by-step guide instructing the player on how to successfully navigate and complete the game. We created the MyLife Walkthrough as a digital means of touring the individual through their own past, decisions they made, historical events that happened, and popular music in the different generations. The emphasis in MyLife Walkthrough is the truly interactive nature of the game, where the player is required to make choices about their lives in order to see different scenarios played out. The game was created using JavaScript, with historical events represented in text format, and life events represented using animations which were created using the Microsoft Paint program. This method of design was chosen as it most closely matches the 8-bit colour graphic method of representing colour, which was the earliest ubiquitous colour representation available on graphics hardware. The pixelated appearance of images created in Microsoft Paint closely approximates the appearance of the 8-bit era of video games, such as that seen in the Nintendo games Super Mario Brothers and The Legend of Zelda. These iconic games appearances are the most iconic images associated with video games, and it was felt that this appearance would therefore be familiar and attractive to an older audience. Furthermore, the prototypic nature of the game limited resources for the creation of more sophisticated graphics.

At the start of the game, the player is invited to type in their year of birth. This allows the program to begin the game at the appropriate decade. We allowed for decades as far back as 1920 (representing an individual who is currently 93) to be included in the game. Entering the player’s year of birth allows the game to run through a prescribed scenario, relevant to the age of the individual and the decades in which they grew up. If the individual is aged 65 when playing, for instance, the game will choose the scenario relevant to those in the 61-70 age bin, with life events spaced out across this lifespan. If the individual is 12 (the minimum age for which the game currently caters) the game will choose the scenario relevant to those in the 12-17 age bracket, and only present life events relevant to individuals of this age. Each life event was marked during the game by presenting an image relevant to that event (e.g. having children). Images were created in 8-bit GIF (Graphics interchangeable format) files.

6.3.1 Historical Events

Historical events were categorized as either national or international, and called during the game from a library of relevant images. These images were all sourced using WikiMedia Commons and are reproducible for non- commercial purposes. Images related to well-known events linked to a given decade, such that when the timeline of the game progressed to the year of the event, its related image came onscreen. An example of this is the 1929 Wall Street Crash, which was depicted when the games timeline reached 1929. A text-based description accompanied each image.

2.3. Music

The music in MyLife Walkthrough is organised into genres that typified the popular music of the decade. For example, the popular music of the 1930s was dominated by swing music such as the big bands of Benny Goodman and Glenn Miller. The music of the 1940s moved more towards faster melodies and more complex harmonies. In the 1950s, Rock 'n' Roll and R&B dominated and defined the decade's music.

The orchestration of the music in MyLife Walkthrough had to fit with the retro 8-bit style of the graphics and overall game design. The music was written with the style of the decade in mind, however keeping within the design principle that synthesizers and lo-fi instruments would be employed. Software synthesizers such as Native Instruments FM8 and synthesizers that emulate computer game console's sound-chips like Hexter were used. This sound palette emphasises the retro feel that fits with MyLife Walkthrough's design.

In terms of composition, the popular music of each decade was analysed and elements that typified the genre were used. It was decided at an early stage that the tempos of all the compositions were to be kept fairly similar. This would keep the transitions from decade to decade more even and less jarring. As a result, the tempo range of the composed music was limited.

The mixing of a master audio was completed using REAPER digital audio workstation software4.

6.3.2 Exhibition

The game was exhibited as part of the Science Gallery Dublin's GAME exhibitions5, in November 2012 | January 2013. This exhibition had a theme of exploring the future of gaming, and potential avenues for development, which are separate to the typical profile of a successful commercial video game. 58,504 visitors attended the exhibition during this time. These visitors were aged 12+ and represented members of the general public with an interest in science and games. It was explained to visitors that the MyLife Walkthrough game's novelty lies in the concept rather than in the graphics, which were old-fashioned and simple. Generally the game was well received, although no survey data was gathered at this point.

6.4 Recommendations for Dem@Care functional scenarios

The MyLife Walkthrough game was a useful proof of concept for a simple cognitive stimulation tool that can be used both as reminiscence therapy and to facilitate social interaction with family and caregivers. Although outside the scope of the initial Dem@Care system, the use of technology to provide cognitive stimulation in a fun and socially inclusive way, is a potential area for future expansion. A more comprehensive pilot study of the game, with anaylsis of resulting data, would be required to progress this concept.

7 Sensor Visibility Study

Assistive technology has great potential to support the needs of people with dementia and enable independent living, delaying and perhaps eradicating the need for institutionalisation. Ambient assistive living and sensor technologies can help to keep people living independently in the home (Drennan et al., 2008), by monitoring their behaviour and identifying points where support may be required (Hoof et al., 2011; Orpwood et al., 2005; Biswas et al., 2010). A central difficulty in living with dementia is the associated stigma (Batsch, 2012). An important part of dementia care research, then, is to reduce the sources and impact of this stigma. However, assistive technologies may themselves constitute a source of stigma if they are considered obtrusive or even visible by the person with dementia or by their caregiver [Demiris and Hensel, 2009; Hensel et al., 2006). This obtrusiveness is particularly relevant when exploring the potential of wearable sensors to enhance independent living for people with dementia. One of the fundamental principles of responsible technology design for dementia is ensuring that sensors are not obtrusive in any way (Orpwood et al., 2003). Hensel et al. (Hensel et al., 2006) have defined obtrusiveness in this context as “characteristics or effects associated with the technology that are perceived as undesirable and physically and/or psychologically prominent”. Therefore the visibility of wearable sensors may constitute obtrusiveness. In this study we investigate the extent to which relevant wearable sensors are perceived within dyadic interactions. Using eye-tracking technologies we can quantify the visual attention given to these sensors in a controlled experimental situation, and extrapolate about the visibility of these sensors. It is intended that the results from this experiment will inform the design and choice of sensors used to support people with dementia, by minimising obtrusiveness.

Part of the Dem@Care toolbox approach involves "wearable" sensors, which are fixed to the body or clothing of the individual. These include the SenseCam (Figure 1), a camera that hangs by a lanyard around the neck, and the Philips DTI-2 sensor, an actigraphy device with accelerometer and galvanic skin response measures, which is worn as a wristwatch. As these are two of the sensors that we expect to deploy to @Home users early in this project, we were particularly interested in evaluating the subjective visibility of these sensors at this time. Later pilot studies will investigate the visibility and wearability of other Dem@Care sensors, and these results will (a) inform future iterations of this deliverable, and (b) be reported as part of the pilot evaluations in D8.3. The Philips device (a research prototype) was not available at the time of testing, so we chose to test a similar actigraphy device, the LARK wrist sensor (Figure 2).

Figure 1SenseCam

Figure 2 LARK Sensor worn on wrist

7.1 Visibility Experiment

The primary hypothesis of this study was to investigate whether the sensors worn by the researcher are visible as defined by frequency of fixations made during dyadic interaction, collected via eye tracker recordings made by the participant. In order to explore the visibility of both the neck-based SenseCam and the wrist-worn LARK sensor, we divided participants into two groups to test both sensors (10 participants in each condition). To explore general areas of fixation without a sensor we also ran a small control condition with no sensor (3 participants).

All participants wore Tobii eye tracking glasses (Figure 3), which tracked the focus point of a subject's gaze and superimposed this onto video data of their panorama. The researcher comprised part of this panorama, while wearing one of the above sensors (either SenseCam or the LARK wrist sensor, or no sensor for control group), and analytics from the recorded gaze allowed us to investigate the extent to which the sensor is the subject of visual attention, if at all. The placement of infra-red (IR) markers on the sofa around the researcher (acting as location anchors) was crucial to accurately aggregate quantitative fixation data. All IR markers were placed in the same two-dimensional plane as the sensors to enhance accuracy, because the video does not contain depth information. We attached 6 IR makers to the sofa where the researcher sat for every evaluation session (see Figure 4).

7.1.1 Participants

23 participants were recruited by email for this study from the student and staff population at Dublin City University. Researchers or students specialising in the area of sensor research were precluded from participating. Reported history of psychiatric disorders with a social dysfunctional component (schizophrenia, some personality disorders including autistic spectral disorder) precluded participation, since in many of these disorders fixation upon the face of a stranger is impaired. Participants wearing glasses were also precluded from taking part in the study, as it is difficult to calibrate and use the eye tracking glasses over another pair of glasses. 14 males and 9 females, all with normal or corrected-to-normal (with contact lenses) vision, volunteered to participate in the study, between the ages of 19 and 46 (M=28, SD=8).

Figure 3 Tobii Eye tracking glasses

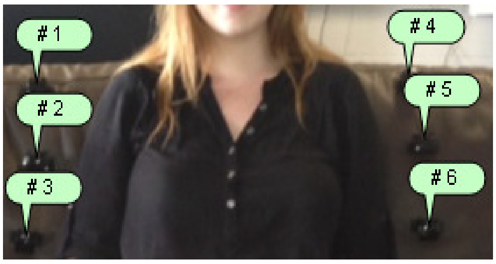


Figure 4 Placement of IR markers on sofa behind researcher

7.1.2 Protocol

At the time of recruitment and during the experiment, participants were told that the research was investigating the comfort and potential applications of the eye-tracking glasses. Before the participant was greeted, the researcher affixed the sensor to her person, in order to maintain visual environmental consistency throughout the experiment's duration. Path of entry to the experimental room, visual distractions in the room, seating arrangements, orientation, and researcher's appearance and conversation were all kept consistent throughout for all 23 participants. Following informed consent, participants were asked to complete a short visual task in order to calibrate the glasses. This involved standing 1 metre away from a yellow IR marker on a wall, and following this marker with their gaze as the researcher moved it around the wall. The researcher then invited participants to sit opposite her on a sofa. The researcher sat on the sofa opposite, with IR markers fixed around her, and proceeded to describe the Tobii glasses. The researcher then asked the participant a number of questions regarding the comfort of the glasses, how they found the calibration process and a number of open-ended questions on potential benefits and uses for the glasses. The researcher engaged with the subject at all times during this period, during which the social norm would be not to stare at clothes, jewellery or anything out of the ordinary worn by the researcher, though when not being engaged in eye-to-eye contact, quick glances at something unusual would also constitute normal behaviour. Since the eye tracked sampled gaze at 25Hz, these quick glances would be measurable. Following this, participants were thanked and told that they would soon receive a debriefing email. In the debriefing e-mail participants were informed of the true aims of the study and asked a series of questions to determine the noticeability, and extent thereof, of the sensors worn.

7.2 Results

Data generated from heat map analysis revealed that the majority of participants for both sensor conditions and control group, fixated on the researchers face/head for the largest proportion of the evaluation time (Figure 5 illustrates heat map data for each condition). The average time that participants spent in conversation with the researcher and having their gaze recorded was 256 seconds (SD=64s). Participants spent an average of 73% total time fixating on the researcher's face, in comparison to less than an average of 1% of the total time fixated on sensors. When we analysed the heat maps individually, 20 participants fixated primarily on the researcher's face/head and 3 participants fixated on other areas. Of these 3, one fixated on the researcher's shoulder, one on her neck and one participant fixated on their own reflection in a glass panel behind the researcher. Data generated from the heat map analysis also revealed that participants spent approximately 1% of the overall time fixating on the researcher's hands. The average percentage of fixation time recorded on the head/face for the SenseCam condition was 74.24% (SD = 16.14%). For the LARK condition, participants fixated on the head/face 71.98% (SD = 27.60%) of the total evaluation time. The average proportion of fixation time recorded on each sensor was 0.78% for the SenseCam (SD = 1.12%) and 0.37% for the LARK (SD = 0.79%).

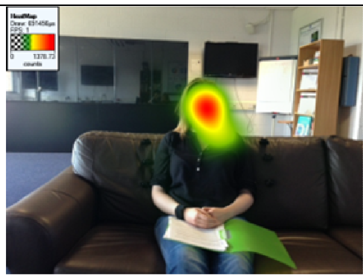
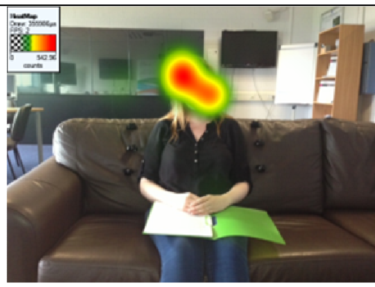
		
SenseCam (N=10)	LARK (N=10)	Control (N=3)

Figure 5 Heat map data for each condition

7.2.1 Detailed Video Analysis

To investigate in more detail the actual frequency of fixations on sensors and the researcher's hands, we conducted a fine-grained analysis of fixations on both sensors and hands in all conditions by manually analysing each participant video. Each video was played in slow motion and was paused at every point of fixation on the sensor or the hands and the time of fixation was recorded. This was repeated to reduce the chance of error. For the SenseCam condition, fixations were recorded on the SenseCam and the hands (as one score). For the LARK condition, fixations were recorded on the LARK and on the hands (as three scores: one for the hands, one for the left hand and one for the right hand). The analyst also recorded relevant comments or particulars in fixation data that were made during the videos.

Data were frequency of fixations on the sensors, as well as fixations on a secondary point in the visual field (hands). The manipulated variable was sensor type with two levels (SenseCam or LARK). Data were screened for outliers and assessed for normality of distribution. There were no outliers and both the kurtosis and skewness test indicated no serious departures from normality (all coefficients resulted in absolute values of less than 1). Levene's test for homogeneity of group variance was also non-significant. The Shapiro-Wilk test was conducted to test for normality, due to having a small sample size, and found to be non-significant, indicating normality of distribution [SenseCam: $D10= 1.90$, $p<0.05$; LARK, $D10 = 2.54$, $p<0.05$].

Number of fixations on each sensor was recorded for every participant. A mean of 5 fixations for the LARK (SD = 4.62) and of 2.87 fixations for the SenseCam (SD = 2.89) were recorded, and an independent samples t-test was then conducted, which found that there was no significant difference between fixations on the two sensor types ($t18 <1$).

A 2 x 2 ANOVA was used to investigate potential effects of gender and sensor type on frequency of fixations. There was no statistically significant interaction effect ($F_{1,18}<1$), nor was there a main effect for gender ($F_{1,18}<1$), nor sensor type ($F_{2,18}=2.247$, $p>0.05$). Female participants in the SenseCam condition (M=5.0, SD=2.65) had a higher mean frequency of fixations than the males in the SenseCam condition (M=3.14, SD=3.18), d=0.6 (See Figure 6a).

Independent t-tests were conducted to determine whether or not participants fixate on the hands in a similar way across each of the three sensor type conditions (SenseCam, LARK and control). Hands were fixated on with lower frequency when the SenseCam was worn, (M=4.2, SD=3.29), than when the LARK was worn (M=7.3, SD=5.14). However, no significant difference was found ($t_{18}= -1.6$, $p>0.05$, d=0.7). Hands were fixated upon more frequently when SenseCam was worn (M=4.2, SD=3.29) than in the control condition when no sensor was worn (M=0, SD=0) and this difference was not significant ($t_{11}= 2.142$, $p> 0.05$). In the LARK condition (M=7.3, SD=5.14), participants fixated significantly more often on the hands than in the control condition (M=0, SD=0), ($t_{11}= 2.384$, $p>0.05$). Frequency of fixations on the hands of the researcher are illustrated in Figure 6b.

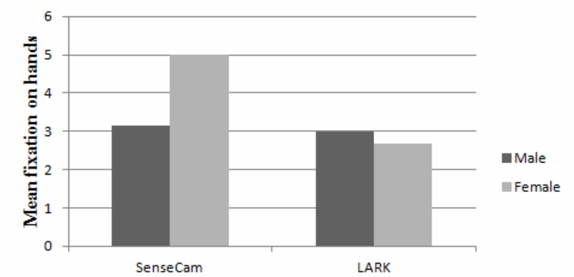


Figure 6 Mean fixations on SenseCam and LARK according to gender.

Fig. 6a. Mean fixations on SenseCam and LARK according to gender.

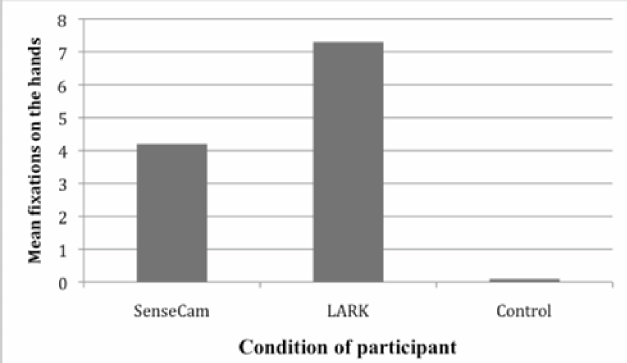


Fig. 6b. Mean fixations on hands for each sensor condition

To explore the possibility that the participant might fixate on one hand more than the other, independently of presence of the wrist-worn LARK (worn on the right wrist), the frequency of fixations on each hand was also recorded for the control group in which no sensors were worn. An independent samples t-test was conducted to investigate if participants fixated on each hand in a similar way, regardless of the researcher wearing the LARK. Frequency of fixations on the left hand were compared between the LARK condition (M = 4.3, SD = 3.16) and the control condition (Mean = 3, SD = 2.65), and no significant difference was found ($t_{11}=0.642$, $p>0.05$). Frequency of fixations on the right hand were also compared between the LARK condition (M = 3, SD = 2.54) and the control condition (M = 2.67, SD = 2.89), and again no significant difference was found ($t_{11}<1$).

7.2.1 Post study questionnaires

None of the 12 respondents to the post-study questionnaire reported seeing the sensor as worn by the researcher. 9 participants ranked the sensor as not noticeable at all. 1 participant in the wrist sensor condition reported seeing an ID badge, 1 participant mistook the IR markers for sensors and 1 participant reported that she perceived the glasses (spectacles) worn by one researcher as potentially containing a sensor. All participants responded yes when asked if they would wear one of the wearable sensors if they thought it would be of some benefit to their life. Table 4 highlights that, even though potential fixations were identified in the manual video analysis for many of the participants, they did not report noticing a sensor after the study.

Table 1 Participants who reported noticing sensor vs. actual fixations on sensor

Sensor	Gender	Noticed Sensor	Fixations on sensor
SenseCam	M	N	0 fixations
SenseCam	M	N	0 fixations
SenseCam	F	N	4 fixations
SenseCam	M	N	0 fixations
SenseCam	M	N	6 fixations
SenseCam	M	N	3 fixations
LARK	M	N	1 fixation
LARK	F	N	2 fixations
LARK	M	N	5 fixations
LARK	M	N	0 fixations
LARK	F	N	6 fixations
Control	M	N	N/A

7.3 Discussion

This investigation concerned the fixation of participants' gaze upon sensors worn by the researcher, in two conditions. Our primary aim was to ascertain whether the sensors were fixated upon at a rate significantly higher than any other area, and we conclude that they were not. The sensors do not appear to constitute a particularly visible or obtrusive item even in direct face-to-face conversations, at least with reference to the number of fixations made upon them. Further, neither type of sensor was differentially more or less visible than the other, indicating that both sensor types explored in the current analysis can be said to be non-obtrusive as measured by eye tracker fixation metrics. The sensors are worn on the wrist and around the neck on a lanyard respectively, potentially drawing attention to two different body parts. It was suspected that gender may impact area of fixation (the researcher was female). As such we investigated frequency of fixations on the sensors as a function of gender and no such relationship was found; it appears that male and female participants fixated equally upon the two sensor types. Thus the data remained pooled for the duration of the analyses.

We also investigated whether the wrist-worn sensor attracted more fixations to the hands, but there was no difference across sensor conditions in the frequency of fixations to the hands. Nor was there a difference found in fixations to the left or the right hand, indicating that the LARK sensor (worn on the right hand throughout) did not attract increased levels of fixation. The hands were nevertheless a region of significant fixation across participants, which may reflect the adaptive importance of perception of hand-related action from others. This area is responsible for the majority of instrumental actions carried out by others and is therefore an important area to accurately and sufficiently monitor (Grezes et al., 1998).

There are limitations to the heat map analyses performed. While this data shows overwhelmingly that participants spent a relatively small proportion of the time fixating on both wearable sensors in comparison to the head area, the snapshots used to generate heat maps are only assumed to be representative of the eye tracking video rather than being totally accurate, as the area that we are investigating moves relative to the IR markers. In this case, it is likely that the researcher moved her head or torso or used gestural language. The more the researcher moves, the less accurate the fixation time. As we cannot presently quantify the movements of researcher and resultant artefact in the video data, further analyses are necessary to accurately determine actual fixations on the sensors, as well as to detect quick glances.

There are a number of limitations to report in the current study, namely, sampling and environmental issues. The current study included a limited sample size, a restricted pool of participants and was not gender-balanced which means that the sample does not constitute generalisable data and could result in reduced power. Furthermore, environmental background noise was notable in the current study. The presence of infrared (IR) markers attached to the seat surrounding the researcher during the study, may have been a distraction, as several participants remarked on the IR markers after the study, fixated on them during the study or mistakenly reported them as the sensors in the follow-up questionnaire. Also, due to changes in natural daylight, reflections off the glass panelling behind the interviewer varied across participants, with one participant primarily fixating on their reflection throughout the study. These limitations related to the experimental set up are important issues to highlight for future experiments using the eye tracking glasses to explore a physical environment. Furthermore, the issues identified in the results section in relation to the accuracy of the automated heat map data analysis are also a worthwhile area of further investigation.

7.4 Conclusion

In spite of the limitations identified above, the data produced in this experiment overwhelming illustrates that participants spent a very small proportion of the evaluation time fixating on wearable sensors, in comparison to lengthy fixations on the researcher's face or other areas of the room. While the more detailed annotated video analysis revealed that some participants fixated a number of times in the areas of both wearable sensors, none of the participants reported having noticed the sensors in post study questionnaires. This is a positive result to report in the context of promoting wearable sensors to enable independent living for people with dementia. Wearable sensors can provide such support without constituting an additional source of stigma for the user. This study has revealed that while observers did minimally fixate on the two wearable sensors evaluated in this experiment, sensors were not consciously noticed by observers and therefore can be considered unobtrusive.

8 Conclusions

The system is anticipated to support three different clinical settings, the @Lab setting, the @Nursing home setting, and the @Home setting, In the @lab setting the focus is on supporting the clinical assessments that are the basis for making the diagnosis of dementia in an early stage of the disease, and in the periodic assessment of individuals already diagnosed with dementia. In the @Nursing home setting the focus is on supporting the assessments of the cognitive and behavioural status of people who are in a more severe stage of the disease and are suffering from behavioural and psychological symptoms. In the @Home setting the focus is on assessing behaviours in daily living in order to support and enable them to manage their lives in a better way. The system must therefore include functions that are adjusted to the setting of the clinical observation room and functional areas in the participants' natural environment of a nursing home and an ordinary home setting.

In the deliverable D2.2 « Functional Requirements and Clinical Scenarios v1 » a description of five sets of functional requirements for the Dem@Care system was presented for the first two phases of testing: sleep; exercise/activity; social contact; activities of daily living and mood. This deliverable was intended to refine these scenarios by revising and updating the set of functional requirements and specifications based on evaluation activities in each of the clinical settings, and based on experiences drawn from the evaluation of the first phase of pilot runs that involves the assessment of basic closed-loops feedback services for people with dementia. However, due to a delay in the completion and installation of the first prototype of the Dem@Care system the subsequent revision of the functional requirements has been delayed for each site as well. This version of deliverable D2.6 has focused on partial findings and experiences from the current state of the Dem@care system.

In this interim deliverable, requirements and scenarios for each site were discussed, speech assessment recommendations based on a literature review were described, a proof of concept for a cognitive simulation game was reviewed, and the wearability of two of the sensors that will be used in the @Home setting was presented. Feedback from each of these items fed into the revision of the requirements, and a table representing the prioritization of the different requirements was presented and explained. This interim deliverable is therefore a presentation of the current status of the functional requirements across all three sites. Following the planned installation and deployment of the Dem@Care system, the final deliverable D2.6 will contain more detailed revision of those requirements based on quantitative and qualitative analyses of data extracted by the system automatically. Those analyses will implicate possible changes and modifications of the related functional requirements.

References

Alzheimer's Society UK, 2013. Dementia 2013: The hidden voice of loneliness.

Ashida, S., 2000. The effect of reminiscence music therapy sessions on changes in depressive symptoms in elderly persons with dementia. Jour- nal of Music Therapy 37, 170–182.

Batsch, N.L., Mittelman, M.S. & Alzheimer's Disease International: World Alzheimer Report 2012: Overcoming the stigma of dementia. London, UK: Alzheimer's Disease International. (2012).

Benveniste, S., Jouvelot, P., P´equignot, R., 2010. The minwii project: Renarcissization of patients suffering from alzheimers disease through video game-based music therapy. In: Entertainment Computing-ICEC 2010. Springer, pp. 79–90.

Biswas, J., Tolstikov, A., Jayachandran, M., Foo, V., Wai, A.A.P., Phua, C., Huang, W., Shue, L., Gopalakrishnan, K., Lee, J. and Yap, P.: Health and wellness monitoring through wearable and ambient sensors: exemplars from home-based care of elderly with mild dementia. Annals of Telecommunications - Annales Des Télécommunications, 65(9-10), pp.505 - 521.(2010)

Bschor, T, Kuhl K & Reischies FM (2001). Spontaneous speech of patients with dementia of the Alzheimer type and mild cognitive impairment. International Psychogeriatrics, 13(3), 289-298.

Bucks, RS, Singh, S, Cuerden, JM & Wilcock, GK (2000). Analysis of spontaneous, conversational speech in dementia of Alzheimer type: Evaluation of an objective technique for analysing lexical performance. Aphasiology, 14, 1-35.

Butler, R. N., 1963. The life review: An interpretation of reminiscence in the aged. Psychiatry 26 (1), 65–76.

Coulston, R., Klabbers, E., de Villiers, J. & Hosom, J.P. (2007). Application of speech technology in a home-based assessment kiosk for early detection of Alzheimer's disease. Proceedings of InterSpeech, 2007, available online at http://www.orcatech.org/papers/InterSpeech_07_Coulston.pdf

Croisile, B., Ska, B., Brabant, M., Duchene, A., Lepage, Y., Aimard, G. & Trillet, M. (1996). Comparative study of oral and written picture description in patients with Alzheimer's disease. Brain & Language, 53(1), 1-19.

Cuetos, F., Arango-Lasprilla, J.C., Uribe, C.M., Valencia, C. & Lopera, F. (2007). Linguistic changes in verbal expression: a preclinical marker of Alzheimer's disease. Journal of the International Neuropsychological Society, 13, 433-439.

Demiris, G., Hensel, B.: "Smart homes" for patients at the end of life, Journal of Housing for the Elderly 23 (1) 106–115 (2009)

Drennan J, Treacy MP, Butler M, Byrne A, Fealy G, Frazer K, Irving K.: Support networks of older people living in the community International Journal of Older People Nursing 3 (4), 234-242 (2008)

Fleming, V.B. & Harris, J.L. (2008). Complex discourse production in mild cognitive impairment: Detecting subtle changes. Aphasiology, 22(7), 729-740.

Fromholt, P., Mortensen, D., Torpdahl, P., Bender, L., Larsen, P., Ru- bin, D., 2003. Life-narrative and word-cued autobiographical memories in centenarians: comparisons with 80-year-old control, depressed, and dementia groups. Memory 11 (1), 81–88.

Garrard, P., Lambon Ralph, M.A., Patterson, K., Pratt, K.H. & Hodges, J.R. (2005). Semantic feature knowledge & picture naming in dementia of Alzheimer's Type – a new approach. Brain & Language, 93(1), 79-94.

Grezes, J., Costes, N., and Decety, J., Top down effect of the strategy on the perception of human biological motion: a PET investigation, Cognitive Neuropsychology, 15, 553-582 (1998).

Hensel, B. K., Demiris, G. and Courtney, K. L. Defining obtrusiveness in home telehealth technologies: A conceptual framework. Journal of the American Medical Informatics Association, 13: 428–431 (2006).

Hoof, J van, Kort H, Rutten P, and Duijnstee M.: Ageing-in-place with the use of ambient intelligence technology: Perspectives of older users. International Journal of Medical Informatics;80:310-331 (2011)

Hopper, T., Cleary, S., Baumback, N. & Fragomeni, A. (2007). Table fellowship: mealtime as a context for conversation with individuals who have dementia. Alzheimer's Care Quarterly, 8(1), 34-42.

Knopps (Eds). Assistive technology: Shaping the future. IOS Press, Amsterdam, Netherlands, 2003.

Martinez-Sanchez, F., Meilan, J.G., Perez, E., Carro, J. & Arana, J.M. (2012). Expressive prosodic patterns in individuals with Alzheimer's disease. Psicothema, 24(1), 16-21.

McCallum, S., 2012. Gamification and serious games for personalized health. Studies in Health Technology & Informatics 177, 85–96.

McHugh, J., Newman, E., Tobin, L., Smeaton, A., Irving, K. (Submitted, July 2013) MyLife Walkthrough: Gamification of the Life Story Review in Reminiscence Therapy for older adults with dementia submitted to Entertainment Computing July 19, 2013

McHugh, J.E., Smeaton, A.F., Irving, K. & Newman, E.: The Dem@Care Toolbox Approach. Position paper presented at the SIGCHI 2013 Workshop on Designing for and with Vulnerable People, CHI April 2013, Paris, France (2013).

McKeown, J., Clarke, A., Repper, J., 2006. Life story work in health and social care: systematic literature review. Journal of Advanced Nursing 55 (2), 237–247.

Meilan, J.J., Martinez-Sanchez, F., Carro, J., Sanchez, J.A. & Perez, E. (2012). Acoustic markers associated with impairment in language processing in Alzheimer's disease. Spanish Journal of Psychology, 15(2), 487-494.

Moos, I., Bjorn, A., 2006. Use of the life story in the institutional care of people with dementia: a review of intervention studies. Ageing and Society 26 (3), 431–454.

Orange, JB & Lubinski, RB (1996). Conversational repair by individuals with dementia of the Alzheimer type. Journal of Speech & Hearing Resaerch, 39(4), 881-896.

Orpwood, R., Faulkner, R., Gibbs, C. & Adlam, T., 2003. A design methodology for assistive technology for people with dementia. In GM Craddock, LP McCormack, RB Reilly and HTP

Orpwood, R., Gibbs, C., Adlam, T., Faulkner, R., Meegahawatte, D., 2005. The design of smart homes for people with dementia: user-interface aspects. Univ Access Inf Soc, 4, 156-164.

Pakhomov, S., Kaiser, E.A., Boley, D.L., Marino, S.E., Knopman, D.S. & Bimbaum, A.K. (2011). Effects of age and dementia on temporal cycles in spontaneous speech fluency. Journal of Neurolinguistics, 24(6), 619-635.

Post, S.G., Ripich, D.N., & Whitehouse, P.J. (1994). Discourse ethics: Research, dementia and communication. *Alz Dis Oth Dis*, 8:4, 58-65.

Roark, B., Mitchell, M., Hosom, J.P., Hollingshead, K. & Kaye, J. (2011). Spoken language derived measures for detecting mild cognitive impairment. IEEE Trans Audio Speech Language Processing, 19(7), 2081-2090.

Rousseaux, M., Seve, A., Vallet, M., Pasquier, F. & Mackowiak-Cordoliani, M.A. (2010). An analysis of communication in conversation in patients with dementia. Neuropsychologia, 48(13), 3884-3890.

Sajjadi, S.A., Patterson, K., Tomek, M. & Nestor, P.J. (2012). Abnormalities of connected speech in semantic dementia vs Alzheimer's disease. Aphasiology, 26(6), 847-866.

Spector, A., Thorgrimsen, L., Woods, B., Royan, L., Butterworth, M., Orrell, M., 2003. Efficacy of an evidence-based cognitive stimulation therapy program for people with dementia: a randomised controlled trial. British Journal of Psychiatry 183, 248–254.

Taulbee, L. R., Folsom, J. C., 1966. Reality orientation for geriatric patients. Psychiatric Services 17 (5), 133–135.

Thomas C, Keselj V, Cercone N, Rockwood K & Asp E. (2005). Automatic detection and rating of dementia of Alzheimer type through lexical analysis of spontaneous speech. Mechatronics & Automation, 2005 IEEE International Conference Proceedings, vol. 3, pp 1569-1574.

Tomoeda, C.K. & Bayles, K.A. (1993). Longitudinal effects of Alzheimer's disease on discourse prediction. Alzheimer's Disease and Associated Disorders, 7(4), 223-236.

Woods, B., Spector, A., Jones, C., Orrell, M., Davies, S., 2005. Reminiscence therapy for dementia. Cochrane Database of Systematic Reviews 2.

Appendix A: Preliminary interview schedule @Home

Introducing Dem@Care. Introducing the five functional domains we chose.

- Are these areas meaningful to you? (aid with use of scenarios?)
- Did we miss any important areas? Hobbies & past-times?
- Do you currently use technologies to help in these areas? Would you consider doing so?
- Technical presentation – these are the sensors we have available to support these areas.
- Do you think they would be useful? Would you accept them?
- Wearable sensors – acceptable?
- Attitudes towards technology.
- General issues with technology – pro's and cons? Confidence using technology? Current use/previous experiences of technology in other aspects of life?
- What is the role of technology/ what is required from technology in order for it to be useful?
- Spousal attitudes.
- Hardware form: Tablet size. (10" or up to 24"?)
- Feedback on screen illustrations – is this the type of data you'd want to see? What is meaningful to you?

Dyad 3: Stella and Paul

Stella and Paul live in North County Dublin in their own home in a fairly rural setting. Stella is a former nurse, and Paul is a former engineer. Stella was diagnosed with Alzheimer's disease 6 years ago and has moderate dementia. Her communicative and social skills are preserved, although her short-term memory, executive functioning, episodic memory and orientation are all problematic. Stella and Paul receive support from a care assistant who visits 3 days a week, and their children who live abroad. Stella displays some significant agitation and sundowning. Paul is in good health but has poor sleep quality manifesting as short sleep duration and impaired sleep maintenance.

Sleep

For Dyad 3, Stella's sleep appears to be fine, but Paul's sleep is very poor and he would like support for his own sleep. He particularly suffers with his sleep maintenance and evening dysfunction, and takes medications to ameliorate these problems.

Physical Activity and Exercise

Dyad 3 are not very active – while Paul does a lot of work around the house, Stella is not as mobile after her stroke 8 years ago. Furthermore their home is in quite a problematic area and one could not for instance go outside for a walk as it is on a busy road. Stella uses a cane and Paul feels that while she is not sufficiently active, she is past support.

ADL & IADL

In Dyad 3, Stella no longer completes any household chores, although she can use the kitchen appliances and make a meal. Paul now does the cooking for her. She does not want support in this area and Paul feels that she is past the point of potential improvement.

Social interaction

Socialising was a big issue for Dyad 3. Paul feels that Stella is at her best when she is socially engaged, and becomes more oriented to her surroundings, and happier. They would like some support in this area.

Mood

For Dyad 3, Stella's mood appears to be directly linked to her socialising, and a support for socialising may then improve mood also.

Other areas

Dyad 3 use a 'blue book', which is essentially a reference book and life story for Stella, which Paul is keen to have digitised as it is falling apart. Paul likes the idea of an intelligent system detecting agitation in Stella and directing her towards an engaging activity, such as computer-directed exercise.

Dyad 4: Michelle and Jack

Michelle and Jack live in North County Dublin in their own home. Michelle is a former nurse, and Jack is a former civil servant. Both are retired. Michelle received her diagnosis 2 years ago and has very mild dementia, with little progression since diagnosis. She has a neurological history also, with a brain tumour excision in 1997 and resulting auditory damage in her left side. They have 4 children (2 live in America), 7 grandchildren, and a dog. Seamus has a recent diagnosis of Parkinson's disease, which is being successfully managed.

Sleep

For Dyad 4, Michelle does not typically sleep through the night, but she tends to read if she wakes up. She does say that her sleep could be better as she wakes up quite regularly.

Physical Activity and Exercise

For Dyad 4, exercise may be an increasing issue; Michelle is a former marathon runner and has a dog to walk but has not been out much of late (although she blamed the weather, and in actual fact it may be more related to her fear of getting lost).

ADL & IADL

In Dyad 4's home, Michelle maintains the household chores as she has always done, although Jack does the cooking and the shopping, and manages bills as Michelle can no longer do these things unsupported. She requires a lot of routine in order to be able to complete chores, and needs everything to remain the same for her as evidenced in this quote;

"*Michelle: If Jack sets the table for me, it annoys me because that's my routine to come down and set the table for myself!*

Jack: I set the table for myself the night before right, and I come down and have my breakfast, wash them up and put them away and she comes down and sets her own. So she's happy enough with that, I'm happy enough with that.

Michelle: and I want to say, no don't set the table for me, because that's the start of my day, do you know what I mean, that starts my day.

Jack: well I've no problem with that, I think, if that's the way she wants to do it, let her do it."

Social interaction

In Dyad 4, socialising may be a relatively new issue. Michelle has always been a big socialiser with a large network of friends and family in the area, but since her diagnosis she is less inclined to leave the house to meet people as she is very fearful of getting lost. She is lucky as friends will now visit her but she says that she now suffers from 'verbal diarrhoea' when she does get the chance to speak to someone, so it is clear that she is not having as much social interaction as she would like. Michelle does not use the phone at all, but this is due to deafness in one side.

Mood

For Dyad 4, mood was a potential issue, since Michelle gets quite low if she doesn't see people regularly. She has often got upset about her diagnosis in recent times also. It appears that supporting her socialising would have the effect of also boosting her mood.

Other areas

For Dyad 4, routine appeared to be a significant contribution to their quality of life; Michelle needs a consistent routine or she feels that she can't function, and gets very panicked. Michelle does a lot of puzzles and crosswords to keep active (although she doesn't have the concentration to read anymore), and she would love a constant digital supply of new puzzles.

Dyad 5: Aisling and Peter

Aisling and Peter live in North County Dublin in their own home beside Dublin City University. They have two children who are in the Dublin area, as well as two grandchildren who visit regularly. Both are retired. Aisling also has celiac disease which Peter helps her to manage. Aisling lacks insight about her dementia and has significant episodic and short-term memory failure, evident in her communication.

Sleep

Dyad 5 both reported that sleep was not an issue for either the participant, Aisling, or for her caregiver husband, Peter. However, further along in the interview Peter commented that sleep was not a problem because Aisling took a small measure of alcohol each night to help with her sleep, and prior to this, sleep had indeed been an issue.

Physical Activity and Exercise

Dyad 5 felt that they were both getting sufficient exercise as Aisling takes 2 walks per day, and Peter plays golf daily. They did not feel that they would benefit from support in this area although Aisling's activity has declined significantly since her diagnosis – she used to be heavily involved in a set dancing group which she quit as she was finding it difficult to remember steps. She lacked insight into this deficit and states that she had just had enough of the dancing.

ADL & IADL

Dyad 5 felt that ADL would not be relevant to capture for them as Peter did everything around the house for Aisling, to the extent that she was completely dependent on him. He felt that there would therefore be no point in monitoring or supporting ADL and IADL since there was no independence left in this instance to maintain or promote.

Social interaction

Dyad 5 did report some problems with social interaction since the diagnosis; Peter stated that Aisling no longer socialised with her own friends, and only accompanied Peter to meet his friends, at the local pub. It appears that Aisling no longer has the confidence to socialise alone (although she lacked insight to this stating that she got too old for it). Aisling still uses the telephone to keep in touch with her two sisters and her brother. The couple's grandchildren and children call around regularly.

Mood

For Dyad 5, mood was not reported to be an issue at all.

Other areas

Dyad 5 emphasised the importance of diet, since Aisling suffers from celiac disease. Therefore a lot of their daily activity is affected by diet, although they have been dealing with it for all of Aisling's lifetime so it is not something that they feel they would need support on.

Appendix B: Functional Requirements v2

0= no need, 5= strong need

ID	**Title**	Functional Description	Function Category	@Lab needs	@Nhome needs	@Home needs	User Needs	Technical Feasibility	Project / Business Relevance	Calculated Priority	Source	Clinical Rationale	Comments
D1001	**Physical Activitiy Evaluation**	The system shall compile information about physical activities.	Physical Activities	4	4	5	4,3	5	5	4,3	D7.1		Clinician Interface supports this.
G1009	**Personalisation of Services**	The system shall be able to be personalised for each user e.g. different services (functions) should be selectable, and the look-and-feel (font sizes, colours etc) should be possible to modify too.	General Function	5	5	5	5,0	4	5	4,0		The system must adapt a person centrerd approach where as many functions as possible can be adjusted to personal needs	A Service Model (taxonomy) should be developed, as basis for the personalisation. It is much preferable to present a menu of services and then explain what sensors will be required, rather than start with asking families which sensors they would accept or prefer to have installed.
G1003	**Remote Interaction**	As much as possible of the client interaction shall be possible to do when the user (Carer, Clinician, Technician, Administrator) is somewhere else.	General Function	4	4	4	4,0	5	5	4,0	DoW		Make system available on public IP (later: Security Framework by WP7)

E1001	**Mood Evaluation**	The system shall compile information over time about emotional arousal, anxiety and stress	Mood	3	5	3	3,7	5	5	3,7	D7.1		Clinician Interface supports this.
G1000	**Alerts**	The system shall be capable of displaying alerts with text, image/video and audio components.	General Function	5	5	0	3,3	5	5	3,3	FP6 COGKNOW	Alerts are essential for closing the loop(s) with PwD and clinicians, and for direct support to PwD.	HTML is supported (including images and embedded video). A separate audio file is supported.
G1005	**Adapted summaries**	The system shall be able to produce summaries of chosen time periods, filtered by the areas of concern (the five areas + Safety).	General Function	5	5	5	5,0	4	4	3,2	D7.1		Clinician Interface
G1010	**Integration of information**	The system shall integrate data from different sensors into dementia specific information relevant for the lab, nursing home and home scenario	General Function	5	5	5	5,0	4	4	3,2			
G1011	**Evaluate integrated information**	The system shall compile relevant dementia specific information for the lab, the nursing home and the home scenario.	General Function	5	5	5	5,0	4	4	3,2			
G1001	**Patient Status Overview**	The Clinician Interface should have a overview of the status of assigned patients, for a chosen time period, and highlighted where there are new/unread	General Function	5	5	5	5,0	3	5	3,0	DoW		A new Clinician Interface screen needs to be developed. The AAL Rosetta project had something similar.

		information.											
G1007	**Automatic Data Transfer and Processing**	All transmission and compiling of data from sensors must be automatically transfered, when the relevant sensor is connected to the computer. The Technician, Carer or Clinician needs guidance on the steps required.	General Function	5	5	5	5,0	3	5	3,0			A thorough redesign of the sensor framework is needed. Now the different sensors work in very different and highly manual ways. For most sensors, software can achieve much more automation. Example: LogSync for SenseCam.
G1008	**Information and Data Security**	Only authorised persons shall be able to access the information or raw data entered into the system for a PwD. Patients, their assigned Carers and Clinicians are typically authorised. Administrators can access any Patient's detailed data in emergency situations (police business).	General Function	5	5	5	5,0	3	5	3,0			Required for ethical (and obvious) reasons. The Security and Privacy Framework should address this (WP7).
G1013	**Patient Interface Multi-language & Regional**	The Patient Interface must use the local language.	General Function	5	5	5	5,0	3	5	3,0			WP6 intends to implement this, initially with English and Swedish languages, and a method for adding more languages and regional settings.

D1000	**Physical Activity Monitoring**	The system shall collect information about the pattern of physical activity.	Physical Activities	4	1	5	3,3	4	5	2,7			The Philips bracelet supports this - more multi-sensor analysis might be needed in the Semantic Interpretation (WP5).
G1002	**Manual Feedback**	The clinician and approved family members shall be able to generate alerts to the PwD and family.	General Function	0	3	5	2,7	5	5	2,7	AAL ROSETTA, D7.1		Clinician Interface
G1012	**Adjustable presentation of collcted information**	The system shall present dementia specific information in different formats and from different perspectives, eg graphical diagrams and in different combinations, eg. Sleep combined with Physical activity.	General Function	5	5	5	5,0	4	3	2,4			
G1004	**Remote Reminder Setting**	Possibility to set reminders remotely by assigned Carer or Clinician.	General Function	0	3	5	2,7	5	4	2,1	FP6 COGKNOW		Clinician Interface
G1006	**Easy Patient Interaction**	The design and layout of screens for PwD should be extremely clear and with a very simple and intuitive structure adapted to PwD.	General Function	0	5	5	3,3	3	5	2,0	FP6 COGKNOW		A co-design with lead users is required (WP2/DCU)
A1001	**Sleep Evaluation**	The system shall illustrate sleep problems and their causes for a chosen time period.	Sleep	0	5	5	3,3	3	5	2,0	D7.1		Clinician Interface supports this.

E1000	**Mood Monitoring**	The system shall monitor emotional arousal, anxiety and stress	Mood	4	5	0	3,0	3	5	1,8			The Philips bracelet supports this (with limitations) - more multi-sensor analysis might be needed in the Semantic Interpretation (WP5).
C1005	**Eating Evaluation**	The system shall illustrate eating patterns for a chosen time period	Eating	0	2	3	1,7	5	5	1,7	D7.1		Clinician Interface supports this.
H1004	**Schedule Interventions**	Personalised schedule set by Clinician for potential Feedback, Questionnaires, Reminders - to Patient/Carer/Clinician	Clinical Requirements	0	3	5	2,7	3	5	1,6			
B1000	**Activity Monitoring**	The system shall collect information about key daily activitiy parameters.	Instrumental Activities of Daily Living	5	1	0	2,0	5	4	1,6			
H1001	**BPSD Information**	The system shall provide BPSD specific information, for assessment of BPSD symptoms	Clinical Requirements	3	5	3	3,7	2	5	1,5			WP2 must supply information about what is "BPSD specific information", so that the Semantic Interpretation (WP5) can implement suitable ontology-based analysis of it.
H1007	**Music Therapy**	Using music for optimizing relaxation and interaction among individuals with dementia. A one-click misc player (playlist) works well.		0	5	4	3,0	4	3	1,4	D2.6 draft, Cognitive Stimulation Study and FP6 COGKNOW		

A1000	**Sleep Monitoring**	The system shall collect information about key sleep parameters like for example, number of awakenings, daytime naps etc.	Sleep	0	5	5	3,3	2	5	1,3			JB: Key parameters that are currently not provided by sensors or used in the Semantic Interpretation module (WP5) should be mentioned.
H1009	**Picture Dialling**	Easy calling of another person, for example a Patient @Home calling a family member or friend, or a Carer calling a Clinician. A small number of different persons represented by on-screen photos should be supported.		0	0	5	1,7	4	5	1,3	FP6 COGKNOW		
B1003	**Activity Evaluation**	The system shall illustrate level of activity over a set time period.	Instrumental Activities of Daily Living	5	0	0	1,7	5	4	1,3			
H1006	**Reminiscence Therapy**	The use of prompts such as photographs or songs to engage the individual with dementia in a discussion about their past. See also T4.4 description.		0	4	5	3,0	2	5	1,2	DoW and D2.6 draft, Cognitive Stimulation Study		
H1002	**BPSD Intervention Evaluation**	The system shall provide systematic information for evaluation of medical and care interventions	Clinical Requirements	2	5	3	3,3	2	4	1,1			The project is not likely to register all medical and care interventions. WP2 will need to supply information about what specific summaries etc that is helpful for this.

D1003	**Physical Activity Reminders**	The system shall remind the person with dementia on physical activity	Physical Activities	0	0	5	1,7	4	3	0,8			Alerts are already supported, need to look at how Carers and Clinicians can schedule reminders.
C1002	**Eating Frequency Montoring**	The system shall monitor frequence of meals and eating activities.	Eating	0	2	2	1,3	3	5	0,8			RGBD camera is likely to be needed. The Complex Activity Recognition (INRIA) probably can detect this, but multi-sensor analysis has to be added to the Semantic Interpretation (WP5).
F1001	**Safety Evaluation**	The system shall compile information about risk behaviour	Safety	2	4	0	2,0	3	3	0,7			Clinician Interface will need to add support for it.
H1000	**Diagnostic Information**	The system shall provide relevant dementia specific information for clinical diagnosis of MCI and Dementia	Clinical Requirements	5	0	0	1,7	2	5	0,7			WP2 must supply information about what is "relevant dementia specific information", so that the Semantic Interpretation (WP5) can implement suitable ontology-based analysis of it.
A1002	**Awake Alert**	The system shall alert the carer/pwd that PwD is awake during times when sleeping is expected (after a set period).	Sleep	0	3	3	2,0	2	4	0,6			

B1002	**Activity Alerts**	The system shall alert the person with dementia when level of activities is too low.	Instrumental Activities of Daily Living	3	0	0	1,0	4	4	0,6			
D1006	**Social Activity Alerts**	The system shall alert carer when social interaction is low/absent	Social Interaction	2	0	5	2,3	3	2	0,6			
F1000	**Safety Monitoring**	The system shall monitor risk behaviour, eg. the person in the wrong place at the wrong time	Safety	3	5	0	2,7	1	5	0,5			Cameras, microphones, contact sensors or movement sensors need to be added (WP4), and risk analysis wneeds to be addesd to Semantic Interpretation (WP5).
F1002	**Risk Alerts**	The system shall alert carer when PwD is at the wrong place at the wrong time.	Safety	0	5	0	1,7	2	4	0,5			GPS needed in bracelets(PENB), more advanced and fast Complex Activity Recognition (INRIA).
D1002	**Physical Activity Alerts**	The system shall alert carer when low physical activity or too high level of activity after a predetermined period	Physical Activities	0	1	5	2,0	2	3	0,5			Online bracelets will be needed. Real-time system support needs to be added (WP7).
B1001	**Activity Reminders**	The system shall remind the person with dementia about different daily activities.	Instrumental Activities of Daily Living	1	1	1	1,0	3	3	0,4			
D1004	**Social Interaction Monitoring**	The system shall collect information about social activity/behaviour	Social Interaction	3	0	3	2,0	2	2	0,3			

D1005	**Social Activities Evaluation**	The system shall compile information about social patterns and interaction over time	Social Interaction	2	0	2	1,3	3	2	0,3	D7.1		
E1002	**Mood Alerts**	The system shall alert carer when the level of arousals, stress or anxety is starting to rise	Mood	0	5	0	1,7	1	4	0,3			Online bracelets with reliable mood detection will be needed. Real-time system support needs to be added (WP7).
H1010	**Fall Detection**	Immediate alert to Carer and emergency services when the system detects that the Patient has fallen.		0	5	0	1,7	1	4	0,3	D7.1		
C1003	**Eating Activity Monitoring**	The system shall monitor the activity process from reminder or initiation of a meal to finished meal	Eating	0	1	3	1,3	1	5	0,3			Detailed activity recognition is a difficult research problem worked on by many groups for years - with limited success.
C1000	**Eating Alerts**	The system shall alert carer when meals are delayed or skipped.	Eating	0	0	2	0,7	2	4	0,2			RGBD camera is likely to be needed. The Complex Activity Recognition (INRIA) probably can detect this, but multi-sensor analysis has to be added to the Semantic Interpretation (WP5). Real-time support needs to be added (WP7).

C1001	**Eating Reminders**	The system shall send reminder to the person with dementia when it is time to make a meal.	Eating	0	1	0	0,3	4	4	0,2			Alerts are already supported, need to look at how Carers and Clinicians can schedule reminders.
H1008	**Cognitive Stimulation Therapy**	A person-centered approach to the individual, where tasks are contingent on the abilities of the individuals in the group (who are all at a similar stage of dementia progression), and a failure-free approach where individuals are encouraged to exercise preserved abilities rather than those abilities which may be in decline.		0	1	3	1,3	1	3	0,2	D2.6 draft, Cognitive Stimulation Study		
C1004	**Eating Activity Reminders**	The system shall remind the person with dementia if the preparation of meal or eating activity is delayed, skipped or abrupted.	Eating	0	1	0	0,3	2	4	0,1			
D1008	**Social Activity Reminders**	The system shall remind about social interaction activities	Social Interaction	0	0	3	1,0	2	1	0,1			